UNIVERSITY OF GHANA
SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES

EVALUATION OF WASH INTERVENTIONS AND RISK FACTORS OF DIARRHOEA AMONG CHILDREN UNDER FIVE YEARS IN ANLOGA DISTRICT, VOLTA REGION, GHANA

BY

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DECLARATION

I hereby declare that this thesis is the product of my original independent research conducted in the Anloga District of Ghana under the supervision of Professor Mawuli Dzodzomenyo, Professor Ernest Kenu and Professor Duah Dwomoh. I affirm that this work is my original work and has not in whole or in part submitted to any institution for any academic award. All references made to this researchers' work have been duly acknowledged.

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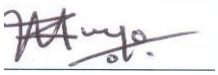

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ABSTRACT

Introduction: Diarrhoea related to inadequate water, sanitation, and hygiene (WASH) practices account for about 58% of all diarrhoea deaths in low-middle-income-countries. Despite improved WASH interventions and rotavirus vaccination, the rate of decline in diarrhoea among children under-five years has been slower, threatening the achievement of Sustainable Development Goal 3, which aims to enhance health and well-being. In Ghana, improving WASH in communities through district assemblies and Non-Governmental Organisations (NGOs) and Rotavirus vaccination program for children are interventions to control diarrhoea. Yet, diarrhoea prevalence in children under-five years in Volta Region, increased from 6.9% in 2014 to 9.1% in 2022, suggesting the need for a comprehensive assessment of factors, including nutrition, health-seeking behaviours and pathogens.

Objective: This study evaluated the implementation of WASH interventions and assessed the risk factors associated with diarrhoea among children under five years in the Anloga District of the Volta region, Ghana.

Methods: The study was conducted from August 2022 to December 2023 in three phases using multiple study designs and mixed data collection methods. Analysis was done separately for each study and interpretation drawn from all studies. In phase one, a process evaluation of WASH interventions in the 2018-2021 Mid-term development plan for Anloga District was done using a cross-sectional approach. A desk review of all relevant documents was conducted, whiles interviews with district WASH committee members, and communities were done. Phase two employed a 1:1 case-control study among children under-five years. Cases were children under-five years in Anloga District presenting with diarrhoea in the health facility from November 2022 to December 2023, while controls were children under-five years from the same vicinity of the case but without diarrhoea in the past seven days prior to the interview. Interviews and anthropometric measurements were done. Phase three was a cross-sectional analysis of case-patients stool samples testing for rotavirus A using ELISA, and additional

diarrhoea pathogens using TaqMan Array Card (TAC) PCR technology. ELISA was done for 80 samples and TAC for 38 samples. Desk reviewed data was used to develop a ten-step framework for assessment of the level of intervention implementation. Transcribed interviews and reports were used to explain the gaps identified in the implementation process. To determine factors associated with diarrhoea, binary logistic regression models was fitted through the generalized linear model with a logit link. Frequencies of pathogen types, pathogen co-infections and distribution by age and sex pathogens were generated. Diarrhoea severity was analysed descriptively by WASH interventions in the district and the pathogens present. Analysis was done with Stata version 17. All statistical tests were done at 5% significance level.

Results: The process evaluation revealed that Anloga District achieved a reach of 72.5% and 49% for construction of water sources and toilet facilities respectively. Of the ten implementation steps outlined, the district fully followed four, and showed no evidence of implementing two steps, indicating significant gaps, particularly in community engagement, post-project support, and funding. The case-control study recruited 193 cases and 193 controls. Children using household toilets had reduced odds of diarrhoea (aOR: 0.48, 95%CI: 0.31-0.73), while underweight children had a threefold increased odds of diarrhoea (aOR: 3.06, 95%CI: 1.36-6.89). Health-seeking practices showed no significant association with diarrhoea.

The other symptoms diarrhoea cases presented to the health facility with were fever (87.1%, 168/193), and mucus in stool (78.8%, 152/193). Severe cases were 7.8% (15/1939 and moderate 59% (114/193). For cases with improved water sources, 60% (114/190) had moderate diarrhoea. Majority of the case from households with improved toilet facilities were moderate diarrhoea cases (59.1%, 90/152). Of the rotavirus vaccinated children, 37.23% (70/188) had moderate diarrhoea.

The prevalence of Rotavirus A among diarrhoea cases who were tested was low (2.5%, 2/80). Bacteria was found in 86.8% (33/38) of the samples. The most common pathogens were Enteroaggressive *Escherichia coli* (53%, 20/38) and norovirus (26%, 10/38). The rate of co-infections was high (68%: 26/38) with 36.8% (14/38) co-infected with four or more pathogens. Co-infection rates by age or sex were not significantly different. Cases with four of more pathogens identified in their stool reported more moderate-severe diarrhoea (53.4%, 7/13). More cases with virus-bacteria combination had moderate-severe diarrhoea (75.0%, 12/16) compared other co-infections.

Conclusion: The WASH implementation process in Anloga District is suboptimal, with significant shortcomings in stakeholder engagement and post-implementation support. The study identified that household toilet use reduces the risk of diarrhoea, while being underweight significantly increases diarrhoea occurrence in children-under five years. The leading pathogens causing diarrhoea in children were Enteroaggressive *Escherichia coli* and norovirus, with rotavirus contributing the least. The prevalence of other diarrhoeal pathogens was high, with high rates of co-infection. The study recommends addressing community engagement gaps during implementation to increase acceptance and effectiveness of interventions. Also, collaboration between health workers and environmental health officers to intensify WASH activities can disrupt faecal-oral transmission pathways in the absence of other diarrhoea vaccines.

DEDICATION

I dedicate this work to my mother, Mrs. Mary Nuako Bandoh, for all the sacrifices and opportunities you gave up for us. This is me, achieving your greatest dream you gave up just for us. Thank you for everything.

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I am grateful to God for seeing me through this journey and bringing me to completion.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	Meaning
CHPS	Community-based Health Planning and Services
CWC	Child welfare clinic
CWSA	Community Water and Sanitation Agency
DHIMS	District Health Information Management System
ELISA	Enzyme-linked immunosorbent assay
LMIC	Low-Middle-Income-Countries
NDPC	National Development Planning Commission
NGOs	Non-Governmental Organisations
TAC	TAQMAN Array Card
WASH	Water Sanitation and Hygiene
WAZ	Weight for Age Z -score
WHO	World Health Organization
WHZ	Weight for Height Z-score

DEFINITIONS

Key Definitions used in Research Work

Term	Definition
Coastal community	A community located along the shoreline of Ghana
Diarrhoea	Passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual (World Health Organization 2017)
Basic drinking water services	Drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip including queuing (WHO/UNICEF, 2018)
Improved Sanitation facility	A toilet that is designed to hygienically separate excreta from human contact. Examples: flush or pour-flush to piped sewer system, septic tank pit latrines, ventilated-improved pit latrines, or pit latrines with slab or composting toilets (WHO/UNICEF, 2018)
Improved water source	A water source that is protected from outside contamination Examples: household connections, public standpipes, boreholes, protected dug wells, protected springs and rainwater collection (WHO/UNICEF, 2018)
Incidence	The number of new cases of a health condition that occur during a specified time period in a population at risk of developing the condition (Gordis, 2014)

Limited sanitation services	Improved sanitation facilities which are shared with other households (WHO/UNICEF, 2018)
Prevalence	Proportion of a specified population with a health condition at a point in time (new and old cases at a specific time point) (Gordis, 2014)
Sanitation	Having access to facilities for the safe disposal of human waste (faeces and urine) as well as having the ability to maintain hygienic conditions through services such as garbage collection, industrial/hazardous waste management and wastewater treatment and disposal (WHO/UNICEF, 2018).
Unimproved Toilet	A toilet facility that does not safely and hygienically separate excreta from human contact (WHO/UNICEF, 2018)
Unimproved Water	Water source of which is not adequately protected from outside contamination (WHO/UNICEF, 2018)
WASH intervention	Any activity designed to provide long-term and sustainable access to safe water and sanitation whilst promoting good hygiene practices that reduce the risk of water-related disease transmission (IOM, 2021)

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Water, hygiene and sanitation (WASH) is an integral facilitator of diarrhoea. About 58% of all diarrhoea deaths in Low-Middle-Income-Countries (LMICs) are associated with poor water, hygiene and sanitation practices (Abuzerr, *et al.* 2020; Yaya *et al*, 2018). On the other hand, good quality drinking water, proper sanitation facilities and good hand hygiene are essential in reducing the occurrence of diarrhoea in every population (WHO, 2014;). Good quality water refers to safe water free from faecal matter and other contaminants (WHO, 2023). Whiles good sanitation ensures that the environment including water bodies are not contaminated by faecal matter, hygiene ensures the individual does not contaminate themselves and other household members. In addition, nutrition, health seeking practices and behaviour patterns, type of diarrhoea pathogens and seasonal patterns can also influence the burden of diarrhoea.

Over the past three decades, a decline has been observed in both diarrhoea morbidity and mortality, especially among children under five years. From 1990 to 2015, diarrhoea prevalence has reduced from 1.8 million to 842,000 (Troeger *et al.*, 2020; WHO ,2019). This has mainly been a result of improved detection, prevention and proper treatment methods of diarrhoea (Oppong *et al.*, 2020) such as the use of the Enzyme-linked immunosorbent assay (ELISA) for pathogen testing which has contributed to improved detection and new vaccine technologies. Globally, these interventions have proven to reduce the incidence of diarrhoeal diseases in children under five years in many settings. Examples of interventions implemented include the provision of safe water to communities, improving drinking water quality in

households, provision of sanitation facilities, education on hygiene practices, nutrition interventions and the introduction of vaccines such as the rotavirus vaccine for children under five years (Darvesh *et al.*, 2017; Pickering *et al.*, 2019; Sinharoy *et al.*, 2016; Webb & Cabada, 2018).

However, the pace of decline of diarrhoeal disease occurrence has been slow and could affect the achievement of the Sustainable Development Goals (SDG) Goal 3 of improving health and wellbeing (UNICEF/WHO, 2021). Additionally, the prevalence of diarrhoea especially in developing countries remains high in spite of the decrease in other settings (Abuzerr *et al.*, 2020; Ugboko *et al.*, 2020). In 2019, almost 1.7 billion children under five years developed diarrhoea with 525,000 of them resulting in death (WHO, 2022). The greatest burden of the diarrhoea menace is borne by low-and-middle-income countries (LMICs). In sub-Saharan Africa, diarrhoea accounted for about 13 of the total disability-adjusted life years (DALYs) according to the Global Burden of Disease report (Troeger *et al.*, 2018). In Ghana, diarrhoea forms part of the top ten causes of morbidity and mortality among children under five years (Ghana Health Service, 2018a). Over 2,600 children under five died from diarrhoeal related causes in Ghana in 2019 (Dadonaite *et al.*, 2019).

For low-middle-income settings like Ghana, some of the main interventions being used for diarrhoea prevention are rotavirus vaccination, given to children under one year (Armah 2015) and WASH intervention implementation. Some WASH intervention implementations are the provision of improved water and sanitation facilities, and proper waste management handled by Local government through district and municipal assemblies and non-governmental organisations (Ministry of Sanitation and Water Resources 2021; World Vision 2024). In spite of these interventions place, diarrhoea persists in the country, an indication that there could be gaps in the existing system or other unknown factors influencing the occurrence of diarrhoea.

As issues relating to the diarrhoea burden remain unsolved in Ghana, the effects of climate change further complicate the dynamics especially for the country's coastline. Climate change is impacting human health in various ways such as influencing human behaviour patterns, which lead to flooding and affect the quality of and access to basic water and sanitation services. Thus the incidence of vector and water-borne diseases such as diarrhoeal diseases are expected to increase as the impact of climate change is felt (Gökçeku & Al-Othman, 2018; Madhav *et al.*, 2017; Met Office & World Food Programme, 2012). The coastlines in Ghana are densely populated and characterised by poor sanitary conditions and are therefore likely to experience an increase in climate sensitive health conditions such as diarrhoea (Clemenz, Boakye, & Parker, 2019). For instance, in one of the coastal regions of Ghana, the Volta region, which has recorded cases of coastal flooding (Ghana News Agency, 2022; JoyOnline, 2021), the prevalence of diarrhoea increased from 6.9% in the 2014 demographic and Health Survey (Ghana Statistical Service *et al.*, 2015) to 9.1% in the 2022 demographic and Health Survey (Ghana Statistical Service & ICF, 2022). Given that Ghana's entire south is a coast with communities characterised by dense populations with poor infrastructure (Addo *et al.*, 2011), it is necessary to understand the drivers of diarrhoea in the quest to reduce its incidence in the country as a whole.

1.2 Problem Statement

Preventable diarrhoea still remains one of the top causes of morbidity and mortality among under-five children (Dairo *et al*, 2017). In 2019, about half of the 370,000 diarrhoeal related diseases in children under five years occurred in Africa. In the same year, over 2,600 children under five died from diarrhoeal related causes in Ghana (Dadonaite *et al.*, 2019). Also, some

geographical areas such as coastal areas have been generally found to have a higher prevalence of diarrhoea compared to other locations (Das Id *et al.*, 2019; Lisafitri *et al.*, 2021).

Even though Water, Sanitation and Hygiene (WASH) and other interventions, namely diarrhoea pathogen vaccination (i.e.: rotavirus vaccination), improving child nutrition and zinc supplementation to boost the immune system of children have contributed to the reduction of under-five diarrhoea morbidity and mortality globally (Bergman *et al.*, 2021; Dhami *et al.*, 2020; Jenney *et al.*, 2021; Nonvignon *et al.*, 2018; Pecenka *et al.*, 2020; Wixted, 2015) diarrhoea still persists. This implies that the current interventions may not be fully addressing the drivers of diarrhoea in some settings.

A community-based survey in Anloga, a coastal district in the Volta region of Ghana revealed that three in ten children, (30.0%) under five years had experienced diarrhoea in the past two weeks though more than 90% of them had been appropriately vaccinated against childhood diseases including rotavirus diarrhoea. In the same region, the population with access to basic drinking water is 85% yet the regional prevalence of diarrhoea increased by 3% in the 2022 demographic and health survey (Ghana Statistical Service & ICF, 2022). Furthermore, water-borne diseases such as diarrhoea are expected to rise in coastal areas like these due to their vulnerability to climate change effects, namely flooding and drought which affect water quality (Gökçeku & Al-Othman, 2018; Madhav *et al.*, 2017; Met Office & World Food Programme, 2012).

This local finding is inconsistent with global evidence which shows that when WASH is improved, it leads to the reduction in preventable deaths from water related diseases (Darvesh *et al.*, 2017; Sundar Budhathoki *et al.*, 2016; UNICEF, 2021). It also contradicts evidence that diarrhoea prevalence is low in settings with high access to improved water and sanitation and

where rotavirus vaccination is high (European Centre for Disease Prevention and Control, 2024; Jenney *et al.*, 2021; Ngure *et al.*, 2014; WHO, 2015). Even in some settings in Ghana, the incidence of diarrhoea has reduced through improved WASH practices at the household level (Tetteh *et al.*, 2018).

Other known factors such as the child's nutritional status, caregivers' health seeking practices and even household WASH practices of caregivers have been found to influence the prevalence of diarrhoea in children under five years (Hamooya *et al.*, 2019; Kapwata *et al.*, 2018; Ogbo *et al.*, 2017).

Children under five who have diarrhoea suffer serious and complex ramifications that affect the person, the family, the community, and the nation. The broader economic impact includes decreased workforce productivity and hampered economic development (Patel *et al.*, 2013). Currently, diarrhoea is leading to a significant economic burden for the household and community at large (Niyibitegeka *et al.* 2021). This is mainly due to increase in disability-adjusted life years (DALYs), loss of productivity, continued undernutrition and persistence of poverty cycles (Hamooya *et al.*, 2019; Oates *et al.*, 2014; Sinharoy *et al.*, 2016; Sundar Budhathoki *et al.*, 2016).

To better understand the drivers of high prevalence of diarrhoea, this study set out with the goal of evaluating the implementation of existing WASH interventions available in Anloga District and also assess context specific factors that may be contributing to this persistent problem using a comprehensive approach. This study therefore evaluated the process of WASH implementation and assessed risk factors of diarrhoea in the Anloga District.

1.3 Conceptual Framework

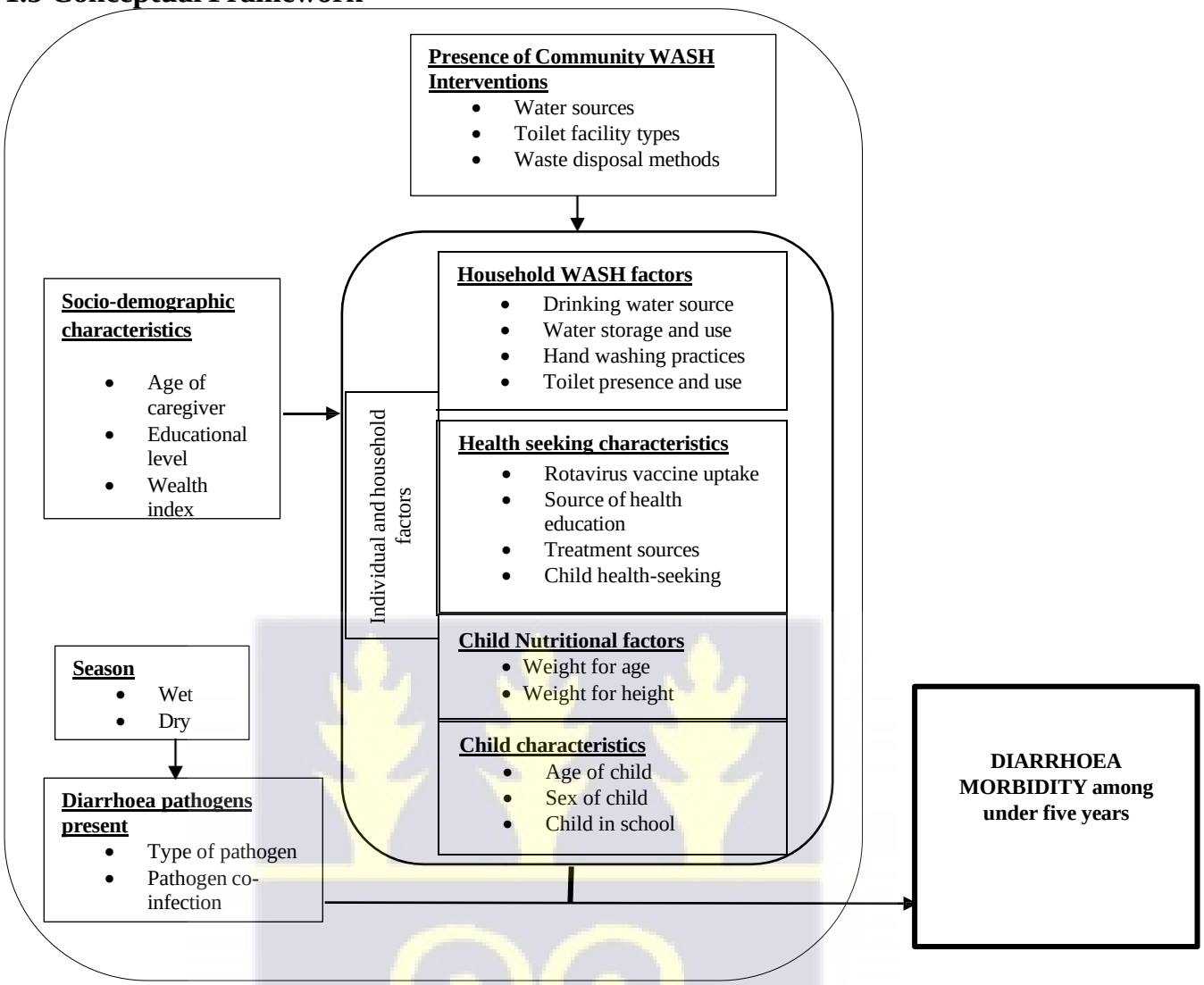


Figure 1.1: Conceptual framework for assessing risk factors of diarrhoea

1.3.1 Narrative on Conceptual Framework

Diarrhoea is a leading cause of morbidity and mortality among vulnerable groups such as children under five years (Kapwata *et al.*, 2018; Kehinde Peter & Umar, 2018; Sumampouw & Soemarno, 2015). As the burden of diarrhoea increases, morbidity and mortality also increase. Diarrhoea results from a complex relation between multiple factors such as socio-demographic characteristics of caregiver, seasons, presence or absence of community WASH interventions, WASH practices at the household level, nutrition, health seeking practices, and type of

diarrhoea pathogens present. Therefore, in settings with high rate of access to improved water and sanitation and high vaccination coverage when diarrhoea persists, interrogating all possible factors leading to diarrhoea is essential. This would require a comprehensive assessment of various factors in one study to provide a deeper understanding of the diarrhoea situation in a setting.

Based on literature, the interrelations between the various factors influencing diarrhoea and a proposed approach on how they can be assessed is explained below.

1.3.1.1 Socio-demographic Characteristics of Caregiver

A major distal factor for diarrhoea is socio-demographic status. The socio-demographic characteristics of the population influence their WASH practices, health seeking practices and their nutrition patterns. This in turn affects the occurrence of diarrhoea. Socio-demographic characteristics such as age of caregiver, educational level, occupation, wealth index, age of child, household size, have been found to influence risk factors of diarrhoea and hence the occurrence of diarrhoea (Apanga *et al.*, 2020; Asfaha *et al.*, 2018; Dairo *et al.*, 2017; Masangwi *et al.*, 2016; Sumampouw *et al.*, 2019). For example, children of younger caregivers have been found to have higher odds of diarrhoea due to their lack of experience in child care, hygiene practices and poor health seeking behaviour (Lakew *et al.*, 2024). Furthermore, caregivers with higher educational level are found to have children with lower odds of diarrhoea because of their understanding of diarrhoea transmission and prevention (Lakew *et al.*, 2024). For wealth index, children from poorer households have a higher risk of diarrhoea due to limited access to clean water and sanitation, proper nutrition, and good quality healthcare (Lakew *et al.*, 2024).

1.3.1.2 Seasons

Seasonal variations have been found to influence Diarrhoeal diseases (Aik *et al.*, 2020) and also confirmed in a study in Ghana (Asare *et al.*, 2022). When rainfall occurs above the normal

pattern or temperatures recorded are above average temperatures, childhood diarrhoea has been found to also increase especially in the tropics (Azage *et al.*, 2017). Increase in rainfall leads to high moisture enabling pathogen spread through contaminated water sources. This is seen in the events of flooding. Similarly, in extreme temperatures, leading to conditions such as drought, lack of good quality water could influence poor sanitary practices resulting in the spread of diarrhoea pathogens. Again, the seasonality of diarrhoea also affects the type of pathogens causing the diarrhoea (Chao Id *et al.*, 2019). Thus, knowing the pathogens present in diarrhoea for each season could help in determining the local epidemiology of diarrhoea.

1.3.1.3 Presence of Community WASH Interventions

WASH basically serves as a barrier which prevents pathogens causing diseases from entering the human being to cause harm. The presence of improved water, sanitation and hygiene in a community, is an indication of communities having access to improved WASH. This reflects Sustainable Development Goal (SDG) 6 target of increasing access to improved water and hygiene by 2030 (UN SDG, 2018). In several communities, the construction and provision of WASH facilities have contributed to the improvement in WASH practices for the community (WHO, 2019). When WASH structures are provided, community members gain access to them and use them, thus reducing the likelihood of diarrhoea in the population. However, the presence of these structures alone, may not be enough to prevent diarrhoea since its use could be influenced by other factors such as the effectiveness and impact of the WASH intervention which was put in place (WHO, 2019).

1.3.1.4 Household WASH Practices

In addition to improved water quality and improved sanitation facilities at the community level, other interventions such as education on good hygiene practices at the household and individual levels have been found to reduce diarrhoea morbidity (UNICEF, 2021). Poor WASH practices

by individual caregivers are the known major cause of diarrhoea (Sumampouw et al, 2015; Sinharoy *et al.*, 2016). The quality of water households use for cooking and drinking is affected by how the water is stored and used. Poor water storage practices and unhygienic practices during use of water can lead to contamination of portable water thus, causing diarrhoea (Wolf *et al.*, 2018). Hygiene practices such as disposal of waste and sanitation could also influence diarrhoea occurrence. Use of contaminated water and poor hygiene practices can lead to an increase in diarrhoea occurrence. Similarly, failure to adhere to hand washing practices at critical points such as after contact with faeces and before touching food could be a source of contamination leading to diarrhoea (Agustina *et al.*, 2021; Wolf *et al.*, 2018).

1.3.1.5 Health Seeking Characteristics

People's health seeking practices are normally based on their knowledge on health (Cunnama & Honda, 2016; Webair & Bin Ghouth, 2014). A study by Webair on local illness concepts and health seeking behaviours of mothers revealed that mothers health seeking practices for their children with diarrhoea was based on what they knew about the condition (Webair & Bin Ghouth, 2014). This in turn predicts their reaction when a disease occurs. Similarly, in the case of diarrhoea, health seeking behaviour of a caregiver determines the actions they take when a child has diarrhoea. Thus, health seeking practices can reduce mortality associated with diarrhoea. The source of knowledge on health determines what they would do when there is an occurrence of diarrhoea or any other health condition in their household (Diaz *et al.*, 2013; Masangwi *et al.*, 2016). Caregivers who seek care from health facilities are likely to report immediately when diarrhoea occurs in their household. This shows the trust they place in the health system available to them and their confidence in the health workers' ability to treat their children when they are unwell. This has been explained by the positive correlation which has been found to exist when people seeking health care trust the system and become committed to it (Durmuş & Akbolat, 2020). Such people are less likely to experience detrimental

consequences of diarrhoea. Caregivers who visit the health facility regularly tend to take their children for child welfare clinics where they receive full doses of all vaccines including rotavirus vaccine, and are provided with health education. Rotavirus vaccines given to children under 12 months have proven to significantly reduce the burden and severity of diarrhoea (Kolstad & Johansson, 2011). Households which do not seek health in health facilities are more likely to have poor health seeking practices leading them to consequences which might result in worsening of a child's health status such as severe forms of diarrhoea or experience more frequent episodes of diarrhoea (Fissehaye *et al.*, 2018).

1.3.1.6 Nutritional Factors

Nutrition and diarrhoea have a complex linear relationship. Undernourished people are more likely to suffer from diarrhoea due to their reduced immunity and malabsorption (Sinharoy *et al.*, 2016). Similarly, frequent episodes of diarrhoea can lead to poor nutrition due to electrolyte imbalance and loss of appetite. Poor nutritional status therefore makes an individual susceptible to diarrhoea. Therefore, children who are well nourished are likely to be at a lower risk of having diarrhoea than those who are under nourished (Sambo *et al.*, 2022).

1.3.1.7 Child Characteristics (Age, Sex and Schooling Status)

Children under five years old are a vulnerable group at risk of various health issues. This is because their systems are still developing and their immune system is very weak. Child factors such as age and gender have been found to be associated with the incidence of diarrhoea (Hamooya *et al.*, 2019; Kombat *et al.*, 2024; Siziya *et al.*, 2013). Additionally, as children start school and are introduced to new environments and foods sources they are exposed to the likelihood of picking up different pathogen infections including diarrhoeal diseases. In relation to gender, studies on factors associated with diarrhoea have shown that females had lower odds

of diarrhoea compared to their male counterparts (Lakew *et al.*, 2024; Siziya *et al.*, 2013). However, no plausible explanation was provided for this observation

1.3.1.8 Diarrhoea Pathogens (Type and Co-infections)

Diarrhoea has been found to be caused by different pathogens such as bacteria, viruses and parasites (WHO, 2022). Diarrhoea interventions over the past three decades have been found to reduce the occurrence of diarrhoea significantly by preventing the pathogens from being transmitted to children (Troeger *et al.*, 2018). The only specific intervention, which has directly focused on pathogens, is the rotavirus vaccine. The rotavirus vaccine given to children under one year has been proven to reduce the occurrence of diarrhoea especially among children under five years even in resource limited settings (Bernadeta Dadonaite *et al.*, 2019; Melese *et al.*, 2019). Aside rotavirus, other single pathogens and their co-infections can lead to diarrhoea (Kotloff *et al.*, 2013; Potgieter *et al.*, 2023a; Vasco *et al.*, 2014).

1.4 Justification

In spite of interventions to reduce diarrhoea, it persistently remains one of the leading causes of preventable morbidity and mortality among millions of children under five globally (Dairo *et al.*, 2017; WHO, 2014, 2018b; Yaya *et al.*, 2018). In Ghana, diarrhoea forms part of the 10 top causes of morbidity and mortality adding to the high burden of climate sensitive diseases in the country (Ghana Health Service, 2018a). Additionally, Low-Middle-Income-Countries like Ghana are spending about $52-$216 on treatment of every single episode of diarrhoea in a child under five years that is reported at a health facility (Baral *et al.*, 2020). Thus, there is an urgent need to reduce the diarrhoea burden in Ghana.

One way of significantly tackling the diarrhoea burden is to conduct comprehensive assessments, which take into consideration all the major risk factors of diarrhoea. This research seeks to conduct such an assessment and will provide an insight into various causes of diarrhoea

and their interlinkages. An assessment of WASH interventions, drivers and case-control study reveals other risk factors. These would inform the design and implementation of diarrhoea interventions which are more context-specific and effective in reducing diarrhoea as they are intended to do. This way, well-tailored solutions can be proposed for policy adoption in the country.

Additionally, the study will help provide a better understanding of the bottlenecks in WASH intervention implementation in resource limited settings and ways through which they can be resolved. This information will inform the planning and implementation of similar WASH interventions in other places. It will also provide additional information needed to improve the value and impact of these interventions so that their intended goals are achieved. These findings will provide implementers with guidance in moving towards people-centred interventions that yield the desired results of reducing diarrhoea morbidity. Again, with this information, tailored WASH interventions for coastal areas which have been reported to have a high diarrhoea risk in Ghana can be developed, implemented and adequate practices adopted (Ministry of Health Ghana *et al.*, 2016).

Given the rise in emerging diseases due to mutations and variations in pathogens, it is essential to test for pathogens causing diarrhoea in the coastal communities to be able to provide evidence of the effectiveness of the current vaccines against them or the need for new vaccines due to new variants or newer pathogens of public health importance

Finally, conducting an assessment in Anloga District will be helpful because the district has the unique feature of being surrounded by the Volta River and sharing a boundary with the sea to its south, which predisposes the district to periodic coastal flooding. In 2021 and 2022, the district experienced flooding caused by tidal waves which led to the destruction of structures

(JoyOnline, 2021). Given that diarrhoea related disease is known to increase in the aftermath of floods (Kenyi, 2020; Mumuni, 2013), the district is suitable for carrying out this study.

1.5 Research Questions

1. How are the WASH interventions implemented in communities in Anloga District?
2. What are the epidemiological risk factors of diarrhoea among children under five years in Anloga District?
3. What are the diarrhoea pathogens among children under five years reporting with diarrhoea in Anloga District?

1.6 Study Objectives

1.6.1 Main Objective

To assess WASH intervention implementation and related diarrhoeal risk factors among children under five years in Anloga District of the Volta region, Ghana.

1.6.2 Specific Objectives

1. To evaluate the implementation of WASH interventions in the Anloga District
2. To determine household WASH factors associated with diarrhoea among children under five years in Anloga District
3. To assess the nutritional risk factors associated with diarrhoea among children under five years in Anloga District
4. To assess caregivers' health seeking practices associated with diarrhoea among children under five years in Anloga District
5. To determine the aetiological agents of diarrhoea among children under five years in Anloga District

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Epidemiology of Diarrhoea

Diarrhoea is an ancient public health concern that disproportionally affects children under five years (Lim et all, 2004) with about 1.7 billion cases reported annually (World Health Organization, 2024). Microorganisms implicated in diarrhoea include variety of bacterial, viral and parasitic organisms. These organisms can be transmitted through contaminated food or drinking water, or from person to person through the orofecal as a result of poor hygienic practices (Kehinde Peter & Umar, 2018). Even though diarrhoea is preventable and treatable, it remains a persistent disease burden globally with developing countries bearing the greatest brunt of the problem (WHO, 2024).

2.1.1 Global burden of Diarrhoea in Children under Five Years

Generally, diarrhoea affects all age groups with incidence being highest in the first few years of life and increases after age 70 years (Canizalez-Roman *et al.*, 2016; WHO, 2017). This could be a result of their low immunity and developing systems. Diarrhoea remains the leading cause of morbidity and mortality in children (Kehinde Peter & Umar, 2018) and one of the leading causes of deaths globally among the general population (Azage *et al.*, 2017; Webb & Cabada, 2018; WHO, 2017). Each year, more than 1.7 billion cases of diarrhoeal diseases are recorded among children (WHO, 2024; WHO, 2017). In addition to mortality, diarrhoea morbidity can impact on the physical growth, cognitive function and academic performance of children under five years (WHO, 2014; Yaya *et al.*, 2018).

2.1.2 Burden of Diarrhoea among Children under Five in Sub-Saharan Africa

Africa is disproportionally affected by diarrhoea. The highest burden of diarrhoea globally remains in Sub-Saharan Africa and South Asia (Local Burden of Disease Diarrhoea Collaborators, 2020). Whiles globally about 56,000 diarrhoeal disease episodes per 100,000 people per year were recorded in 2021, in Africa, particularly Sub-Saharan African, about 107,000 diarrhoeal disease episodes per 100,000 people per year were recorded (Dattani *et al.*, 2023). Currently in Ghana, diarrhoeal diseases are the eighth leading cause of mortality among children under five years (Dattani *et al.*, 2023), with morbidity increasing from 287,816 cases in 2012 to 1,429,990 in 2017 (Ghana Health Service, 2018b). In 2021 alone Ghana recorded about 86,000 episodes of diarrhoea per 100,000 population (Dattani *et al.*, 2023).

2.1.3 Effect of Seasonality on Diarrhoea

The incidence of diarrhoeal diseases has been found to vary considerably with seasons (Chaurasia *et al.*, 2020; Gong *et al.*, 2018). This seasonality has been driven by climatic variables such as temperature and precipitation (Geremew *et al.*, 2024). Chao and colleagues in their study reveal that this seasonal pattern observed is due to the association of diarrhoea pathogens with weather conditions such as high temperatures and rain. Therefore, the transmission patterns of diarrhoea can be observed by studying diarrhoea seasonality (Chao Id *et al.*, 2019). Specifically, when an increase in temperature and rainfall are recorded, diarrhoea cases among children under five years also increases (Azage *et al.*, 2017). In Nepal, 1°C increase in temperature was found to be linked to a 3.87% increase in risk of diarrhoeal disease [(4.4%; 95% CI: 3.95, 4.85) and 1 cm increase in rainfall (0.28%; 95% CI: 0.15, 0.41)] (Dhimal *et al.*, 2022). Another systematic review by Carlton et al, corroborated this finding. The review, calculated from their pooled estimates established that there was a positive association between the temperature incidence of bacterial diarrhoea in Low-Middle-Income-Countries (Carlton *et al.*, 2016).

In Ghana, diarrhoea cases have shown seasonal variations and monthly fluctuations (Tetteh *et al.*, 2018) with more cases occurring in the rainy seasons than in the dry season (Anyorikeya Maria *et al.*, 2016; Asamoah *et al.*, 2016). Asare's analysis of diarrhoea data and climate variability in Ghana also confirmed a similar pattern of seasonality in monthly diarrhoea cases with the highest number of cases being recorded in the rainy season (Asare *et al.*, 2022). This pattern however seems to be changing across particular locations. Given the seasonality of diarrhoea diseases, Aik in his study recommended the use of climate variability as indicators to identifying diarrhoea increases in tropical areas (Aik *et al.*, 2020)..

2.2 Aetiology of Diarrhoea

Understanding the aetiology of diarrhoea is essential in the bid to reduce its burden. Baker and colleagues in their systematic review estimated that each year, about 1.7 billion diarrhoea episodes were caused by enteric pathogens (Baker *et al.*, 2016). From the literature, aetiology of diarrhoea in children under five has generally been attributed to specific bacteria, parasites and virus. A systematic review on diarrhoea pathogens in sub-Saharan Africa identified rotavirus (29.2%), astrovirus (3.6%), adenovirus *(10.8%)*, norovirus *(6.6%)*; Bacteria - *Escherichia. coli (15.6%), Salmonella (4.5%), Shigella (9.6%), Campylobacter (8.1%)*; Parasites – *Giardia (7.3%), Entamoeba histolytica (1.8%), Trichomonas intestinalis* (3.0%) in children under five with diarrhoea (Oppong *et al.*, 2020).

However, in some cases, no pathogen is isolated. A study in China for example found that 18% of the diarrhoea cases had no pathogens (Li *et al.*, 2016). However, in clinical diarrhoea treatment, these etiological agents are not routinely assessed. Oppong in his review explains that due to the cost and time needed to conduct clinical investigations of diarrhoea, it is usually not considered as an option. Additionally, these clinical investigations usually provide no direct benefit for the treatment of the affected individual due to its long turnaround time before release

of test results (Oppong *et al.*, 2020) since diarrhoea requires immediate interventions to save lives.

2.2.1 Epidemiology of Diarrhoea Aetiology

Aetiology of diarrhoea over the years has been studied, through research and information obtained in interventions to reduce diarrhoea burden. From these researches, some information on the person, place and time of diarrhoea and the aetiology of diarrhoea has been revealed.

2.2.1.1 Aetiology of Diarrhoea by Person

Research has shown that pathogens may even differ by age of the host being infected. In Bangladesh, a longitudinal study found different pathogens causing diarrhoea for different age groups of children (Donowitz *et al.*, 2021). For children under one year, Donowitz et al, identified Rotavirus, Campylobacter, and Shigella while for children at age one, *Shigella*, *Campylobacter*, and heat-stable toxin–producing enterotoxigenic *Escherichia coli* were the main attributable pathogens for diarrhoea in children at two years (Donowitz *et al.*, 2021). Another study on diarrhoea pathogens in China found that viral infections were common in children under five years. (Shen *et al.*, 2016). In India however, Enteroaggresive *Escherichia coli* (EAEC) remained the leading diarrhoea-causing pathogen detected in the second year of life of the child, followed by *C. jejuni/coli* and *Shigella* (Jain *et al.*, 2019).

2.2.1.2 Aetiology of Diarrhoea by Time

Another observation on aetiology of diarrhoea has been seasonality. The pathogen causing diarrhoea generally vary by months of the year. Previous studies have documented variations in monthly patterns of rotavirus and bacteria in different months of the year based on seasonal variations (Chao Id *et al.*, 2019; Xu *et al.*, 2015). To corroborate this, another finding by Shen and colleagues observed that in China more cases were recorded between April and October when the temperatures were warm and during rainy months (Shen *et al.*, 2016).

2.2.1.3 Aetiology of Diarrhoea by Place

Another factor that influenced the aetiology of diarrhoea is place or location. From scientific evidence, it has been established that diarrhoea pathogens differ by location. Esteves Mills & Cumming (2016), in their review, pointed out that the aetiology of diarrhoeal diseases varies by region. In sub-Saharan Africa for example, pathogens that have been found to cause diarrhoea include rotavirus, *E. histolytica*, *Escherichia coli*, adenovirus, astrovirus, norovirus, *Campylobacter*, *Shigella*, *Salmonella* and *Giardia lamblia* (Oppong *et al.*, 2020). Another multi-country study in Africa and Asia found Campylobacter as the commonest pathogen during the first year of life in Brazil, Peru and South Africa (Platts-Mills *et al.*, 2015).

Even within the region, pathogens differ by country and location. In addition to rotavirus, a study in Burkina Faso identified *Giardia spp*, *Entamoeba coli* and *Hymenolepis nana*, adenovirus, *Shigella spp*, and Enteropathogenic *Escherichia coli* (EPEC) as their most prevalent pathogens causing diarrhoea (Lompo *et al.*, 2021). Another study in Kumasi, Ghana found viruses (rotavirus and adenovirus) and bacteria (*Salmonella spp.*, *Shigella spp*.) as pathogens causing diarrhoea (Ashie *et al.*, 2017). From these studies, the diversity of the pathogens even in species confirm the need to identify location specific pathogens for targeted interventions within each geographical area.

2.2.2 Rotavirus as the Main Diarrhoea Causing Pathogen

Throughout the studies on diarrhoea pathogens, rotavirus stands out as the diarrhoea-causing pathogen of significant public health concern still accounting for the highest level of severity and increased risk of hospitalization, especially in low middle-income countries in spite of interventions (Cohen *et al.*, 2022). In West Africa, the most common pathogen causing diarrhoea was rotavirus (Oppong *et al.*, 2020). Again, in India, the most common causes of

diarrhoea were rotavirus followed by *C. jejuni/coli* and *Shigella* (Jain *et al.*, 2019). Further research in Ghana by Lartey and colleagues revealed that even among the rotaviruses, Group A rotavirus have been identified as the most leading cause of acute gastroenteritis among children under five years globally with a similar pattern observed in Ghana (Lartey *et al.*, 2018). This was the basis for the introduction of the rotavirus vaccine globally which has been effective in reducing the global burden of diarrhoea in children under five years (Armah, 2015; Chang *et al.*, 2021; WHO, 2023). After the introduction of rotavirus vaccine, a significant decline in diarrhoea among children under five years has been reported (Nonvignon *et al.*, 2018).

2.2.3 Changing Pattern in Diarrhoea Aetiology

In recent years, new patterns in the aetiology of diarrhoea are emerging. A systematic review on aetiology of diarrhoea in under-fives in sub-Saharan Africa reported a decline in rotavirus cases and attributed it to vaccine effectiveness and changes in the rotavirus strain that might be circulating (Oppong *et al.*, 2020). Another recent study in India among undernourished children with diarrhoea found that less children under five had rotavirus related diarrhoea (15%) and more diarrhoeagenic *E. Coli* (DEC) related diarrhoea (78.5%) (Jain *et al.*, 2019). From this finding, Jain and colleagues concluded that the higher burden of DEC could signify a change in diarrhoea pathogenicity from rotavirus (Jain *et al.*, 2019). An earlier cohort study in a sentinel facility in China also observed this pattern and concluded that the diarrhoea pathogens were changing with time leading to a new pattern (Shen *et al.*, 2016). These findings emphasize the need for surveillance of circulating diarrhoea pathogens particularly rotavirus.

2.2.4 Other Diarrhoea Pathogens

The Global Diarrhoea Surveillance network recently identified Shigella, norovirus and adenovirus 40/41 as other pathogens of high burden in different geographical settings (Cohen

et al., 2022). This point confirms the recommendation made by the European union expert scientific panel on the rotavirus which suggested the need for virological surveillance in countries before and after the introduction of the rotavirus vaccine to be able to monitor circulating strains and also detect other possible diarrhoea pathogens such as adenovirus, norovirus, sapovirus, etc which may be in circulation (ECDC, 2017). Building on to this recommendation, other studies have implicated these pathogens as causes of diarrhoea aside rotavirus (Chang *et al.*, 2021; Mokomane *et al.*, 2018; Potgieter *et al.*, 2023b; Xu-Hui Zhu *et al.*, 2016).

Gradually, technologies for surveillance of diarrhoea aetiology are improving. For instance, metagenomics and bioinformatics are currently being used in diagnosis. This has enhanced diagnosis results, rapid management, treatment, control and prevention of diarrhoea and surveillance of diarrhoea pathogens (Ugboko *et al.*, 2020). With these technologies, various pathogens causing diarrhoea can be fully identified by a simple laboratory test, for example, the TaqMan Array card (TAC), a new PCR technology helps in identification of multiple enteropathogens such as bacteria, virus and parasites at the same time (Lappan *et al.*, 2021). As interventions for rotavirus have demonstrated their efficacy and resulted in less rotavirus related diarrhoea cases, these technologies have become important to in the identification of other pathogens, which may be on the increase. This would help in targeted interventions to save more lives and drastically reduce the burden of diarrhoea. With the Global Paediatric Diarrhoea Surveillance Network's recent findings that rotavirus is still a leading cause of diarrhoea and hospitalization among children under five in low-middle income countries, it is recommended that countries intensify the use of rotavirus vaccine and take steps to improve its efficacy. Additionally, the Network encouraged the prioritization of interventions towards other diarrhoea pathogens such as Shigella, norovirus and enteric group adenoviruses taking into consideration the fact that pathogens vary by location and setting (Cohen *et al.*, 2022).

The literature reviewed aligns with a recommendation from a facility based study in India on aetiology of diarrhoea that suggested studies assessing pathogens and other factors in diverse setting be increased (Jain *et al.*, 2019). Taking such steps would help in the identification of appropriate and targeted strategies to deal with the increasing aetiologies of diarrhoea.

2.3 Risk factors of Diarrhoea

Generally, the risk factors of diarrhoea especially among children have been diverse, covering four main broad aspects documented as unsafe water, contaminated foods, direct contact with causative microorganisms such as bacteria, viruses & protozoan, and unhygienic environment (Kapwata, Mathee, Jacobus Le Roux, *et al.*, 2018; Melese *et al.*, 2019). These factors may be classified under socio-demographic, Water, Sanitation and Hygiene (WASH), nutrition, and pathogens. This review sheds some light on socio-demographic factors, nutritional factors and WASH related factors that influence diarrhoea.

2.3.1 Socio-demographic Characters and Diarrhoea

Socio-demographic characteristics have been found to influence a number of health outcomes including the occurrence of diarrhoea in children under five years. These factors are individual level factors which influence the behaviour and practices of the caregiver, thus resulting in diarrhoea prevention or its occurrence. Several studies have found various socio-demographic characteristics such as caregiver age, educational level, occupation, and socio-economic status to be associated with diarrhoea (Abuzerr *et al.*, 2019; Akuffo *et al.*, 2017; Sumampouw *et al.*, 2019; Thiam *et al.*, 2017; Wasihun *et al.*, 2018). In this review, a few examples are cited.

The level of education of the caregiver has been found to be associated with diarrhoea in children under five years as higher educational level decreases diarrhoea occurrence (Sarker *et al.*, 2016; Walker *et al.*, 2013; Masangwi *et al.*, 2016; Victora *et al.*, 2008). Victora attributes

this to the fact that highly educated mothers are more likely to practice cleanliness that protects their children from diarrhoea (Victora *et al.*, 2008).

Maternal age has also been found to be significantly linked to diarrhoea in children under five years (Walker *et al.*, 2013; Masangwi *et al.*, 2016). A mother being older reduced the likelihood of her child having diarrhoea compared to a younger mother (Abdur Razzaque Sarker *et al.*, 2016). This could be due to the older mother's previous experiences in childcare aiding her in ensuring the child is protected from diarrhoea.

Different studies by Walker and Firkire have all revealed that socioeconomic status of a caregiver also plays a part in diarrhoea occurring in children (Fikire Id *et al.*, 2019; Fischer Walker *et al.*, 2013). Walker's study found that children from lower-income families are more vulnerable to diarrhoea compared to children from higher-income families. This observation is because children from poor homes are less likely to access healthcare, have healthier diet, and maintain clean hygiene compared to children from rich families (Walker *et al.*, 2013).

Some child characteristics have also been found to influence diarrhoea. They are mainly the child's age and sex (Fikire Id *et al.*, 2019). Demisse and colleagues found that in sub-Saharan Africa, children 12 - 23 months have been found to have a 1.5 times higher likelihood of experiencing diarrhoea compared to children 0 -11 months (Demissie *et al.*, 2021). A review in Nepal also found out that children who were less than two years had a higher chance of experiencing longer diarrhoea episodes than those above two years. They attributed this to the fact that children within this age group are normally weaned and thus lose the protective effect of breast milk while exposed to contaminants from food and the environment as they play and crawl around (Demissie *et al.*, 2021; Sundar *et al.*, 2016). .

2.3.2 Water Sanitation and Hygiene and its Relationship with Diarrhoea Transmission

Water Sanitation and Hygiene (WASH) defined as safe drinking water, sanitation and hygiene, remains a prerequisite to health and is one of the basic foundations of health (World Health Organisation, 2024). The WASH concept comprises of the availability of clean wholesome water for use, and the practice of good hygiene to reduce contamination. WASH plays a critical role in the development and survival of children mainly because children under five years are the most affected by water borne diseases (Darvesh *et al.*, 2017). Generally, WASH cuts across different sectors with multiple stakeholders playing different roles to ensure water, sanitation and hygiene needs of a given population are met. WASH interventions therefore normally consist of a blend of water, sanitation or hygiene projects by different sectors. This leads to diverse direct outcomes including health (Esteves Mills & Cumming, 2016).

WASH is dynamic and may yield varied results depending on the context within which it is implemented. The setting, context of the people, type of intervention, the implementers, beneficiaries and many other factors come to play in determining the effectiveness or efficacy of WASH interventions. To be able to appreciate the effectiveness of WASH, context of the setting plays a critical role (Esteves Mills & Cumming, 2016). Assessments for WASH interventions are therefore essential in every single setting to be able to improve its effectiveness and maximise capacity.

The importance of WASH interventions cannot be overlooked. When an environment is unclean, it plays a major role in disease occurrence including diarrhoea. In most cases, children under five years remain the most vulnerable to these situations (Azage et al, 2017; Oksfriani *et al.*, 2015). For example, poor water supply, sanitation and hygiene have been found to be major contributors to diarrhoea diseases among children under five years (WHO, 2014). According to the WHO, about 842 000 diarrhoea deaths among this age group in Low-Middle-Income-Countries are caused by poor WASH (WHO, 2014). Most diarrhoea cases can therefore be

prevented through improving sanitation practices and hygiene such as handwashing for communities (Tetteh *et al.*, 2018). A review in Nepal alludes to the fact that through WASH, diarrhoea prevention and control can be regulated. This is because improved WASH reduces the risk of water and food contamination caused by unhygienic environmental conditions (Sundar *et al.*, 2016). In Ghana, this has been demostrated by a study which assesed the trends of diarrhoea and found a declining trend over the years as WASH was introduced in the Oti region (Tetteh *et al.*, 2018).

In diarrhoea prevention, WASH works by breaking the faecal-oral pathway for transmission of diarrhoea pathogens to humans. This principle serves as the basis of all WASH interventions. Thus, basic sanitation delivery interventions when implemented, are done with the aim of improving and protecting public health (WHO, 2019). As WASH interventions are mainly to shut the faecal-oral pathway of transmitting pathogens, the understanding of these pathogens is essential in planning and implementing interventions. Generally, the major diarrhoea transmission pathway of ingesting contaminated food or water leads to the entry of the pathogens into the body and causing diarrhoea. Research has found that, poor WASH practices increases exposure to faecal pathogens (WHO, 2014). Also, when WASH is improved, it prevents the ingestion of contaminated food and water, and poor hygiene which lead to health outcomes such as diarrhoea and scabies (WHO, 2014). The Global Enteric Multicentre Study (GEMS) held in multi-sites across Africa and Asia also confirmed that when WASH is improved, it could reduce contact with enteric pathogens which cause diarrhoea (Baker *et al.*, 2016).

The details of the contamination, type of pathogen and the ingestion for each setting or context may lead to variation or modification in the known transmission pathways per location. Hence, context and setting in WASH is very important. This is because it could modify known

pathways due to the peculiarities of each setting. This emphasizes the point that the leading diarrhoea transmission pathways in various locations need to be clearly studied to understand what pertains at each specific location (Esteves Mills & Cumming, 2016). Esteves Mills & Cumming give an example in this review of how different water interventions would have different effects on diarrhoea. They demonstrate that though community level water interventions are effective, when compared to household level interventions and specific water interventions like provision of water filters and high-quality water, the later significantly reduces the risk of diarrhoea by about 0.11 than the former. This was mainly because of the possibility of contaminating the water fetched from the community source before it is used (Esteves Mills & Cumming, 2016).

To have effective WASH interventions, the various components of WASH need to be well coordinated and targeted. A review on effectiveness of households and community WASH interventions in Bangladesh buttresses the same point. The review looked at effectiveness of WASH interventions in Bangladesh and their climate resilience. From the review, they found that though the country has some WASH interventions in place, different sectors (such as health, environmental, government, etc) need to come together to be able to improve the effectiveness in the wake of climate change consequences across different locations. The authors therefore conclude on the significance of suitable WASH interventions in meeting the needs of specific geographical locations in the country (WHO, 2015).

Coordinated and targeted WASH interventions would help in dealing with the different interacting pathways through which diarrhoea pathogens spread. There is still a paucity of information on the most appropriate ways to combine approaches whiles taking into consideration the setting and context to derive the best outcomes (Esteves Mills & Cumming, 2016). Lappan, in his study findings, affirmed that these observed gaps could be due to the

interventions to address the numerous pathways connecting the enteropathogens in the environment to human beings (Lappan *et al.*, 2021). Additionally, Esteves Mills & Cumming, in their review pointed out the need to consider integration of other diarrhoeal disease control methods such as WASH with etiological responses including vaccines (Esteves Mills & Cumming, 2016).

In all these discussions, the dynamism of WASH comes to play and the need for consistency in use and practice becomes essential. To be able to derive the full benefit of a WASH intervention leading to a reduction in diarrhoea cases, the WASH practices need to be maintained and continually practiced over time (Darvesh *et al.*, 2017).

2.3.2.1 Community Level Water Sanitation and Hygiene Structures

Provision of safe water and improved sanitation requires physical structures for communities and are intended to meet the needs of the population. When the entire population is not covered, the risk of diarrhoea remains high (Sundar Budhathoki *et al.*, 2016; UNICEF, 2016). This is because the section of the community without access would continue to have diarrhoea and could continue the spread of pathogens once no WASH structures are available to break the transmission. In Nepal for example, parts of the country with inadequate access to water supply and sanitation coverage have a four times higher risk of diarrhoea compared to those in settings which are covered (Sundar Budhathoki *et al.*, 2016).

Another study in Solomon Islands found that even in urban settings, where sanitation was poor and communities had access to poor quality toilets, the prevalence of diarrhoea among children under five was high, with one in two children reported to have had diarrhoea (Gali *et al.*, 2020).

As earlier mentioned, WASH requires continuity in order to obtain sustained results. Therefore, behavioural change or modification is an essential consideration in WASH implementations.

In spite of all the progress in improving sanitation status of populations through WASH related efforts and awareness creation over the years, the burden of diarrhoea still remains high (Gong *et al.*, 2018). Sahiledengle and Agho in their review on WASH, pointed out that due to the behavioural nature of WASH practices, it may not be enough to conclude that a population with improved WASH structures would necessarily have reduced diarrhoeal episodes among children especially in low-income settings. They further add that other household level factors such as place of residence, wealth quintile and type of floor material in the house causing diarrhoea may not be identified when such assertions are made (Sahiledengle & Agho, 2021). For example Mshida and colleagues found out that poor hygienic feeding practices in addition to unimproved water increases the risk of diarrhoea among children (Mshida *et al.*, 2018). Another cross-sectional study in Indonesia found that the habit of washing hands using soap by toddlers or by their mothers, the habit of disposing of garbage in addition to availability of family toilet facilities, influence the occurrence of diarrhoea in children (Agustina *et al.*, 2021). According to Agustina et al (2021), practicing handwashing, using family toilet facilities and having proper garbage disposal practices reduce the risk of contamination with pathogens thereby reducing the risk of diarrhoea. Additionally, a multi-country study found that other practices such as disposal of child's stool and human excreta visible in toilet facilities could increase the risk of diarrhoea in children aside the use of shared toilet facilities (Baker *et al.*, 2016). These situations show that relying solely on the presence of WASH structures to reduce the incidence of diarrhoea may not be adequate.

Even for settings with the structures, some standards such as proper waste disposal, prevention of open defecation, and handwashing with soap are necessary to ensure the structures are not facilitating the spread of diarrhoea pathogens. (Agustina *et al.*, 2021). As a way of addressing this gap, WASH moves hand in hand with education and knowledge provision. People who are not educated on WASH are likely to have little knowledge on the causes of diarrhoea (Mashoto

et al., 2014), this could negatively influence their WASH practices. In some villages in Tanzania, people who had little knowledge on causes of diarrhoea were likely to have poor hand-washing practice. (Mashoto *et al.*, 2014). Similar to this behaviour pattern, Sundar explains how caregivers in Nepal would generally wipe their hands and would only wash them when they see visible signs of dirt on it (Sundar Budhathoki *et al.*, 2016). These practices show their lack of knowledge on how washing hands with soap and water could effectively prevent diarrhoea in their children.

On the contrary, in settings where handwashing is understood and well-practiced, positive results are seen. For instance in Afghanistan, handwashing and use of improved sanitation facilities were found to reduce diarrhoea incidence among infants (Aluisio *et al.*, 2015). Given that water, sanitation, and hygiene (WASH) improvements have the potential to reduce rates of diarrhoeal disease by preventing exposure to infectious pathogens (Mashoto *et al.*, 2014), understanding why existing interventions are not being used or effective is essential in WASH. This is because a little knowledge of behaviour change in WASH can yield significant impact on communities (WHO, 2015)

2.3.3 Nutrition as a Risk Factor of Diarrhoea

Nutrition plays a key role in the child's development and can be affected by food intake and illness particularly infections to the child (Tickell *et al.*, 2020; UNICEF, 2013). Thus, when a child does not receive adequate nutrition, their nutritional status is affected negatively and could lead to malnutrition. Malnutrition results as complex interaction of a combination of factors such as food intake, infections and diseases. The consequences of malnutrition on a child are therefore intense since it leads to growth impairment. This may have lifelong implications even in adult populations and implications on economic development (Rakotonirainy *et al.*, 2018).

Childhood nutrition has been found to be associated with diarrhoea (Ferdous *et al.*, 2013). Further study into this has revealed a unique relationship between malnutrition and diarrhoea. This relationship has been described as bi-directional with malnutrition influencing diarrhoea occurrence and diarrhoea facilitating the occurrence of malnutrition (Scrimshaw *et al.*, 1968). Other researchers like Iskandar and colleagues, in their study on risk of nutritional status and diarrhoea among children under five have described the relationship between diarrhoea and nutrition as a bidirectional relationship which could lead to a vicious cycle in the child (Iskandar *et al.*, 2015).

Though the diarrhoea-malnutrition relationship has not been explicitly outlined (Iskandar *et al.*, 2015), some researchers over the years have provided some understanding into it. In the 1960s, Schrimshaw and colleagues explained that the malnutrition pathway leads to an alteration in the skin and mucous membranes of the affected individual making them predisposed to infections and distorting the protection barrier (Scrimshaw *et al.*, 1968). Patwari concluded that when malnutrition occurs, it could modify the body's defensive responses making the intestinal environment more conducive for the growth of pathogens such as diarrhoea pathogens. Thus making malnourished children prone to enteropathogens causing diarrhoea (Patwari, 1999).

Similarly, when a child has a diarrhoea episode, they are deprived of growth nutrients due to decreased food intake, nutrient malabsorption and increased nutrient requirements for tissues repair and growth. Thus, a child with frequent diarrhoea episodes becomes prone to malnutrition (Brown, 2003; WHO, 2005). This could be the reason why diarrhoea has been found to be a leading cause of malnutrition globally (Azage *et al.*, 2017; WHO, 2017). Together, diarrhoea and malnutrition (specifically undernutrition) contribute significantly to morbidity and mortality among children globally (Sinharoy *et al.*, 2016; Wasihun *et al.*, 2018).

Sadly, the double burden of diarrhoea and undernutrition is greatest in Low-and-Middle-Income-Countries (Gaffey *et al.*, 2013).

Literature reviewed showed evidence of the effect of nutrition on diarrhoea. Brown for example in his symposium on diarrhoea and malnutrition stated that being malnourished increases the severity of diarrhoeal disease in children under five years (Brown, 2003). The same finding was confirmed by Sundar who stated that a malnourished child is more likely to develop persistent diarrhoea and once that begins, the downward spiral continues in the child's growth. (Sundar *et al.*, 2016). Additionally, an Indonesian study found that malnutrition was a risk for length of hospital stay in children. They found that malnourished children were more likely to have longer hospital stays than their counterparts who were well-nourished. (Iskandar *et al.*, 2015). Patwari tries to provide insight to the gastrointestinal system of a malnourished child with diarrhoea. He explains that malnourished children with diarrhoea have decreased turnover of gut epithelial cells, leading to prolonged episodes of infectious diarrhoea and delayed recovery (Patwari, 1999).

Beyond morbidity, malnutrition is among the major risk factors for diarrhoea mortality (Troeger *et al.*, 2018). Children who are undernourished are three times more likely to die from diarrhoea than children with better nutritional status (Tickell *et al.*, 2020). The Global Enteric Multicentre study also found that severely malnourished children have a high likelihood of dying when they experience a moderate-to-severe episode of diarrhoea (Tickell *et al.*, 2020). This finding was confirmed by a facility-based study among children under five in New Delhi, India. Jain established that undernutrition increased the incidence of diarrhoea putting children under five who are malnourished at a higher risk of dying compared to their well-nourished counterparts (Jain *et al.*, 2019).

Delving into the components of nutrition and how they influence diarrhoea, nutritional risk factors for diarrhoea are generally grouped under three domains i.e. anthropometric indicators, infant and child feeding practices and micronutrient status risk factors (Brown, 2003). Focusing on anthropometry, the main anthropometric measures found to be associated with diarrhoea from research are weight for age, weight for height. Earlier studies after Scrimshaw's publication in the 1960s which drew the first relationship between nutrition and diarrhoea (Scrimshaw *et al.,* 1968) added that undernutrition determined by anthropometric status actually increases the risk of diarrhoea incidence (James, 1972; Sepulveda *et al.,* 1988). For example, wasting, that is low weight for height was found to be a significant factor for diarrhoeal duration. Wasted children are more likely to have longer diarrhoea episodes than those who are not wasted. As the duration of diarrhoea prolongs, the nutritional status deteriorates. This further worsens the wasting or weight loss of the child (Patwari, 1999). This point is buttressed by a review which also found that an underweight child becomes more likely to have persistent diarrhoea episodes (Budhathoki *et al.,* 2016).

Evidently, nutrition has been proven to have a significant effect on diarrhoea occurrence, its duration and even diarrhoea related outcomes in children under five years. Therefore, improving nutrition serves as an intervention for reducing diarrhoea occurrence (Troeger *et al.,* 2020). If a child's nutritional status is improved, it could reduce the likelihood of recurrent diarrhoea.

There have been concerns about these relationships and associations of nutrition and diarrhoea established by the studies. A review by Brown points out that some of these researches may have been narrow since some of their conclusions were limited based on their descriptive designs. Given that descriptive studies are not able to draw causal effects due to inability to fully address all confounding factors, causal effects of nutrition on diarrhoea drawn maybe

challenging (Brown, 2003). Based on the evidence from earlier works on diarrhoea and nutrition, anthropometric indicators alone implicated as a contributing factor of diarrhoea without knowledge of other contributing factors may not be an accurate assertion to make. This point necessitates the exploration of other factors that influence the occurrence of diarrhoea in children under five years. Ferdous in his paper on the severity of malnutrition and diarrhoea among children under five years suggests the need to understand the aetiology and other environmental predictors of this relationship through research since they can influence both the nutritional status and diarrhoea in the child (Ferdous *et al.*, 2013).

2.3.4 Health Seeking Practices for Diarrhoea

Health seeking practices describe what individuals do to prevent or treat disease and or maintain health. For children under five years, the caregivers determine their health seeking practices. Seeking health care especially from a health professional is important and can prevent death and other undesirable consequences (Yakum *et al.*, 2017). Health seeking behaviour for diarrhoea in children under five years is very crucial due to the mortality associated with diarrhoeal diseases. In managing diarrhoea, time remains essential to be able to save the lives of the children (Sarker *et al.*, 2016). Delayed action on the part of the caregiver threatens the child's survival (Adedokun & Yaya, 2020). When a caregiver remains indecisive and moves the child between formal health care and traditional treatment methods, the resulting consequences could lead to loss of the child's life (Cunnama & Honda, 2016). Identifying potential risks to health seeking practices is thus very necessary to preserve the child's life. Knowledge of the right actions to be taken during the child's growth or when the disease occurs, could prevent a number of deaths (Fissehaye *et al.*, 2018)

Sarker in his paper on assessment of health care seeking behaviour for childhood diarrhoeal

disease in Bangladesh described health seeking behaviour as a complex process built over time due to multiple influences such as social, economic, demographic, and even health facility factors (Sarker *et al.*, 2016). In trying to understand and improve health seeking practices, both the caregiver and healthcare provider have a role to play (Webair & Bin Ghouth, 2014). Given these complexities, health seeking behaviour cannot be generalised across settings or among a group of individuals. Efforts are required to understand the reasons behind the behaviour pattern in order to make the needed impact by tackling these factors. For example, a study which found a high health seeking behaviour among caregivers also observed that traditional treatments were used by all caregivers since it was ingrained in their social set up and cultural beliefs (Diaz *et al.*, 2013). Webair et al confirm this, in their study on mothers' health seeking behaviour in Yemen. In the study, they also reported how culture influences the health seeking behaviour of caregivers (Webair & Bin Ghouth, 2014).

A number of factors have been identified that influence the seeking of healthcare for children under five with diarrhoea. These cover socio-demographic, cultural, behavioural and health system factors. One major consideration in seeking health for a child is the mother's behaviour, perception, beliefs and culture. The mother or caregiver plays a significant role in seeking timely and appropriate care for a child under five who has diarrhoea and this has been well documented in various studies.

A study in South Africa revealed that mothers' belief of diarrhoea causes influences the choice of treatment. The decision to use a particular treatment is also dependent on the mother's belief system. Some caregivers choice on the type of health they sought for diarrhoea treatment was based on what they believed was the causal agent of diarrhoea (Cunnama & Honda, 2016). Even in cases where caregivers have knowledge on the health condition, their belief system still influences the type of healthcare their children receive (Webair & Bin Ghouth, 2014) In a

study in Gaza, caregivers resorted to traditional treatment instead of taking their children to a healthcare facility when they felt the child's condition was not serious (Abuzerr *et al.*, 2019). On behaviour for seeking healthcare, a study in South Africa found that some mothers assess the child's current condition before making a decision on the immediate source of care they should go for. In making these judgements, the symptoms the child is presenting was reported to influence the decision they made (Cunnama & Honda, 2016). Other studies have also found a similar pattern. In a Cameroonian study, the child's state was also reported to influence the caregiver's decision to seek for care and the type of care sought (Yakum *et al.*, 2017). Others have also documented that when a child is unwell, maternal view on severity of illness influences health seeking behaviour. In this case, caregivers generally seek some form of care for their under-fives based on what they think is needed (Sarker *et al.*, 2016; Webair & Bin Ghouth, 2014). From the analysis of Bangladesh DHS data, caregivers determined what they would do to the sick child and where care should be sought from (Lungu *et al.*, 2020). Therefore, the action taken for a sick child is dependent on the caregiver's perceived severity of the disease. In situations where a mother sees blood in the stool of their child, she is likely to access professional healthcare services for the child since she deems the situation as serious (Fissehaye *et al.*, 2018). In instances where mothers felt they could manage the child's illness, pharmacies and chemical sellers were the mothers' point of call instead of the health facilities (Sarker *et al.*, 2016).

Caregivers consider their experiences with the health facility when making their decisions. Mothers who regularly visited health facilities were the ones who brought their children to the health facility at the first diarrhoea episode. Delay in seeking healthcare was observed in caregivers who did not visit the health facility often (Fikire Id *et al.*, 2019). In a study conducted in Southern Ethiopia, factors such as 'the first point of call when child was unwell', 'respect for health worker', and 'the outcome of a caregiver's previous visit' were associated with

delays to seeking healthcare among caregivers of children under five years with diarrhoea (Fikire Id *et al.*, 2019). Clearly, the mothers' interaction with the health system informs them on whether to return when their child is unwell. In Sierra Leone, 'the outcome of previous visit', 'cost and availability of healthcare services', and 'belief on what works' were identified as reasons why caregivers did not assess health care for their children when they were unwell (Diaz *et al.*, 2013). Generally, a caregiver's confidence in the source of care which works and provides them with the desired results is a major consideration when deciding the kind of healthcare their child should receive when sick. When a caregiver experiences inappropriate treatment at a health facility, it could lead to mistrust in the system and likelihood of not returning to the facility (Webair & Bin Ghouth, 2014). Diaz also reports that caregivers monitor the symptoms of their child for improvement after visiting a treatment site, if there's no improvement further action such as change of healthcare is taken (Diaz *et al.*, 2013). Aside formal health facilities, caregivers consider other sources of healthcare. For example, Adeoti found that in Nigeria, chemical sellers were a common source for treatment when children had diarrhoea. The health facility was only considered when the child presented with additional symptoms they felt were serious (Adeoti & Cavallaro, 2022)

For sociodemographic influences on health seeking, the economic status of the family, the woman's decision-making capacity, and demographics of the caregiver come to play in the healthcare seeking decision making. A survey on health seeking practices in Burundi found that some women are unable to seek healthcare for their children alone due to fear that they had defied the norm of males playing a key role in decisions such as healthcare choices in the sub-region and lack of funds to access healthcare (Ahinkorah *et al.*, 2022). Consequently, where the woman is not financially empowered on her own or does not have the capacity to make decisions on where the child seeks healthcare, the health seeking behaviour of the caregiver is influenced. Another study in Bangladesh for example, found wealth, age and other

markers of deprivation as markers of health care seeking behaviour (Sarker *et al.*, 2016). In Myanmar, people with higher positions in society are likely to seek health for their children compared with those in lower positions (Lwin *et al.*, 2020)

The trend of health seeking practices for children around the globe generally varies from place to place. An assessment of health seeking practices in sub-Saharan Africa showed that a very low proportion (10%) of caregivers sought professional healthcare for their children under-five when they had diarrhoea (Adedokun & Yaya, 2020). In Sierra Leone, Diaz and colleagues found that healthcare was sought for almost nine in ten children under five who suffered from all conditions including diarrhoea (Diaz *et al.*, 2013). While in Bangladesh, about two-thirds of the caregivers with children under five years having diarrhoea sought healthcare (Sarker *et al.*, 2016). In Burundi, healthcare was sought for less than half of children under five years who were ill (Ahinkorah *et al.*, 2022).

Given the complexities of health seeking behaviour among caregivers, it is essential to pay critical attention to identifying the location specific pattern in each setting. This would help avert the negative turn of health care decisions which result in delayed health seeking (Lungu *et al.*, 2020). Intervening in the issue of health seeking practices requires involvement of all stakeholders at the community level. This would ensure that cultural beliefs and practices are considered and all parties work together to help caregivers provide the best care for their children. Addressing the health seeking practices requires a multisectoral approach. Leveraging other community structures outside the health system can help in improving health seeking practices. To solve the issue of health seeking, it is necessary to understand why caregivers do not access the healthcare system available to them (Yakum *et al.*, 2017).

Evidence from literature indicates the intricate and complex factors that influence health seeking practices. In diarrhoea management, taking the right healthcare decisions are crucial to averting complications to the child. Health seeking behaviour can therefore not be generalized across geographic settings. It remains important that location specific identification of health seeking patterns and behaviours be done.

2.4 Diarrhoea Interventions in Ghana

Like other developing countries with limited access to basic water and sanitation infrastructure, diarrhoeal disease transmission in Ghanaian settings has been strongly associated with unsafe water, poor sanitation and hygiene practices (Ghana Statistical Service (GSS) *et al.*, 2014). The main interventions to reduce diarrhoea currently in place are: provision of improved water sources, toilet facilities, handwashing stations and waste disposal sites as well as rotavirus vaccination for children below six months.

2.4.1 WASH Interventions in Ghana

Implementation of WASH interventions has led to reduction in morbidity and mortality related to water borne diseases burden (Webb & Cabada, 2018). In a systematic review of WASH interventions on diarrhoea in children under five years in LMICs, the pooled analysis showed diarrhoea risk reduction in point-of-use water disinfection (pooled RR: 0.69, 95% CI: 0.60–0.79), point-of-use water filtration (pooled risk ratio (RR): 0.47, 95% confidence interval (CI): 0.36–0.62) and hygiene education with soap provision (pooled RR: 0.73, 95% CI: 0.57–0.94). This confirms an earlier assessment by WHO which also found an 11% -16% reduction in diarrhoea in LMICs when water and sanitation sources were improved for populations (WHO, 2014).

In Ghana, the main WASH interventions the country has adopted are the provision of safe water supply to the population. Over the past few decades, provision of water and sanitation

facilities especially in rural parts of the country have been spearheaded by non-governmental organizations (USAID *et al.*, 2017; World Vision, 2024). These interventions have reduced the populations with access to poor quality water, consumption which could lead to waterborne diseases such as diarrhoea.

To increase the efforts in WASH, the local government is supporting the implementation of WASH related needs of each district. This is being done by integration of the WASH needs into the district medium term development plan and implementing them as part of their routine activities. In 2023, Ghana launched the Ghana Water, Sanitation and Hygiene Sector Development Programme (GWASHSDP) 2021-2030 to coordinate the implementation of WASH activities in the country as the country works towards achieving integrated water resources management and sustainable WASH services targeted at the national, regional and global level by 2030 (Ministry of Sanitation and Water Resources, 2021).

WASH in Ghana has been plagued by poor coordination due to the multiple partners involved in the processes and different aspects of WASH implementation. However, the Ministry of sanitation and water resources is currently working to coordinate all the partners so that their goals and activities are in line with that of the country. In spite all these efforts, the country's level on the sanitation ladder for water, sanitation and hygiene are all below 50%. For basic water, only 44% have access, for sanitation, 10% have access to basic sanitation whiles 47% have access to limited sanitation, a step lower down the sanitation ladder, while for hygiene, 42% have access to basic hygiene (Ministry of Sanitation and Water Resources, 2021).

2.4.2 Rotavirus Vaccination in Ghana

In 2012, Ghana officially rolled out the rotavirus vaccine as part of the childhood vaccinations given at 6 and 10 weeks after birth after a well-planned strategy with all local and international stakeholders (Armah, 2015). From 2012, Ghana added RotaTeqÒ (RotaTeq is a registered

trademark of Merck & Co., Inc.) and ROTARIX (a registered trademark of GlaxoSmithKline Biologicals SA, used under license by GlaxoSmithKline Inc.) as prescribed rotavirus vaccines. These are included in the immunization programme of the country with both two dose vaccines given to children at 6 weeks and 10 weeks respectively (Lartey *et al.*, 2018; Nonvignon *et al.*, 2018). In 2020, Ghana switched vaccines from ROTARIX to ROTAVAC, a three dose vaccine given at 6, 10 and 14 weeks respectively (Owusu *et al.*, 2023)

The introduction of the rotavirus vaccine has led to a decline in the cases of diarrhoea cases reported in the country. (Lartey *et al.*, 2018) (Armah, 2015). However, cases of rotavirus-related diarrhoea among under five children continues to be high compared to diarrhoea caused by other pathogens in the country. Lartey *et al.*, in their paper on pre and post implementation of rotavirus vaccination in Ghana recommended continuous surveillance of rotavirus circulating strains in Ghana to serve as a way of monitoring the strains six years post vaccine implementation (Lartey *et al.*, 2018). After the 2018 assessment, assessing the current rotavirus strains and pathogens causing diarrhoea in Ghana after eight years would provide insight about the pathogens in circulation.

Over the years, Ghana has rolled out two main interventions across the country; these are providing improved water and sanitation, and rotavirus vaccination for children. Some of these interventions especially the WASH interventions have been generalised across geographic areas with little consideration for the geographic differences and other factors such as seasonality, behaviour, pathogenicity, epidemiology, etc (Sundar et al, 2016, Apanga 2021, Asfaha 2018) that may be present. Clearly, given that diarrhoea remains an issue of public health concern in Ghana, there is a need to re-evaluate these interventions to identify more effective ways of dealing with the diarrhoea burden in the country

2.5 Inferences from Literature Reviewed

The key highlights of the literature review are the clear demonstration that the causes of diarrhoea are complex and dynamic. Knowledge on the risk factors from literature or other settings alone are not enough to lead to the required reduction in burden when adopted across all geographical areas. The context, population, setting and several other factors need to be considered.

Undeniably, WASH plays a significant role in reducing diarrhoea burden. This literature highlights the contribution of WASH to reducing the diarrhoea burden but also points out the complexities even in the WASH interventions and their interactions with people who are the end users. Therefore, carrying out research activities in different geographical areas on WASH interventions taking into consideration the processes, people and settings is beneficial.

For about fifteen years, rotavirus has been identified as the main pathogen causing diarrhoea globally and in Ghana. However, with current findings, the identification of other diarrhoea pathogens aside the known rotavirus observed, point to the fact that though rotavirus interventions have been effective, it has led to other pathogens taking the centre stage. As a country, assessing the pathogens in circulation is essential.

From the findings of a multicentre study, authors drew the conclusion that pathogen specific interventions for diarrhoea treatment alone may not be able to fully solve the problem of diarrhoea mortality especially in malnourished children (Tickell *et al.*, 2020). The effects of Rotavirus vaccination and WASH interventions using current approaches seem to have plateaued and the country, Ghana could be experiencing a similar situation. Therefore, tackling a single risk factor of diarrhoea in the bid to prevent the impact of diarrhoea may not yield the desired results. Rather, addressing root causes by assessing the different risk factors that influences diarrhoea could be beneficial to achieving the goal of reducing diarrhoea burden.

To conclude this review, the thoughts of Carlton and colleagues are reiterated; the complex transmission pathways and aetiology of diarrhoea points us to multiple exposures such as food, water, direct exposure to faecal matter and other climatic variabilities that cannot be neglected (Carlton *et al.*, 2016). To be able to keep up the progress made and move further, comprehensive assessments, which consider most of these discussed factors and evaluate existing interventions are necessary.

CHAPTER 3

METHODS

This chapter describes the methods used in this study. Details of the study area, study design, sampling procedures, sample size estimation, data collection techniques and tools, data analysis, and ethical considerations are provided in this chapter. Information about the district was obtained from the Anloga District Assembly (Anloga District Assembly, 2022) and the 2021 Population and Housing Census reports published by the Ghana Statistical Service (Ghana Statistical Service, 2021a).

Table 3.1 summarises the main activities conducted and methods of assessment used.

Table 3.1: Designs used in answering the research questions

Research Question	**Method of Assessment**
How are the WASH interventions implemented in communities in Anloga District?	Case study which evaluated the WASH implementation processes in the district
What are the epidemiological risk factors associated with diarrhoea among children under five years in Anloga District?	Case – control study of children under five years
What are the diarrhoea pathogens among children under five years reporting with diarrhoea in Anloga District?	Cross-sectional laboratory analysis of diarrhoea pathogens

3.1 Study Design

The study was done in three phases using multiple study designs and collected data by mixed methods with the convergent parallel approach. Both qualitative and quantitative data were collected simultaneously but analysis was done separately for each study and interpretation drawn from all studies. The detailed methodological approach is documented in Bandoh and colleagues' published protocol (Bandoh, *et al.*, 2024).

The study designs used were a case study design for a process evaluation, and an etiological survey and case-control design for an epidemiological risk factor study. Phase 1 was a process evaluation of WASH interventions implemented in the Anloga District. Phase 2 was a case-control study to determine risk factors of diarrhoea among children under five years in the study district and Phase 3 was a cross-sectional laboratory assessment of diarrhoea pathogens. The study was conducted from October 2022 to December 2023 using both qualitative and quantitative data collection methods.

The process evaluation was a descriptive case study which assessed the steps and activities undertaken when WASH interventions, namely access to basic drinking water services and access to limited sanitation services were implemented in the Anloga District. This described implementation structures, steps, and implementation gaps.

The case – control study assessed the risk factors of diarrhoea in the Anloga District, Volta region among children under five years using quantitative methods. The cross-sectional laboratory assessment identified diarrhoea pathogen in the stool of children presenting with diarrhoea. Stool samples of diarrhoea cases were collected and tested using standard ELISA methods and TAQMAN Array Card RT-PCR Technology. The flow diagram in figure 3.1 describes the workflow pictorially.

Data from all three phases was analysed separately using qualitative methods for phase 1, quantitative analytical methods for phase 2 and descriptive statistics for phase 3. Inferences were made from all three phases to address the objective of the study.

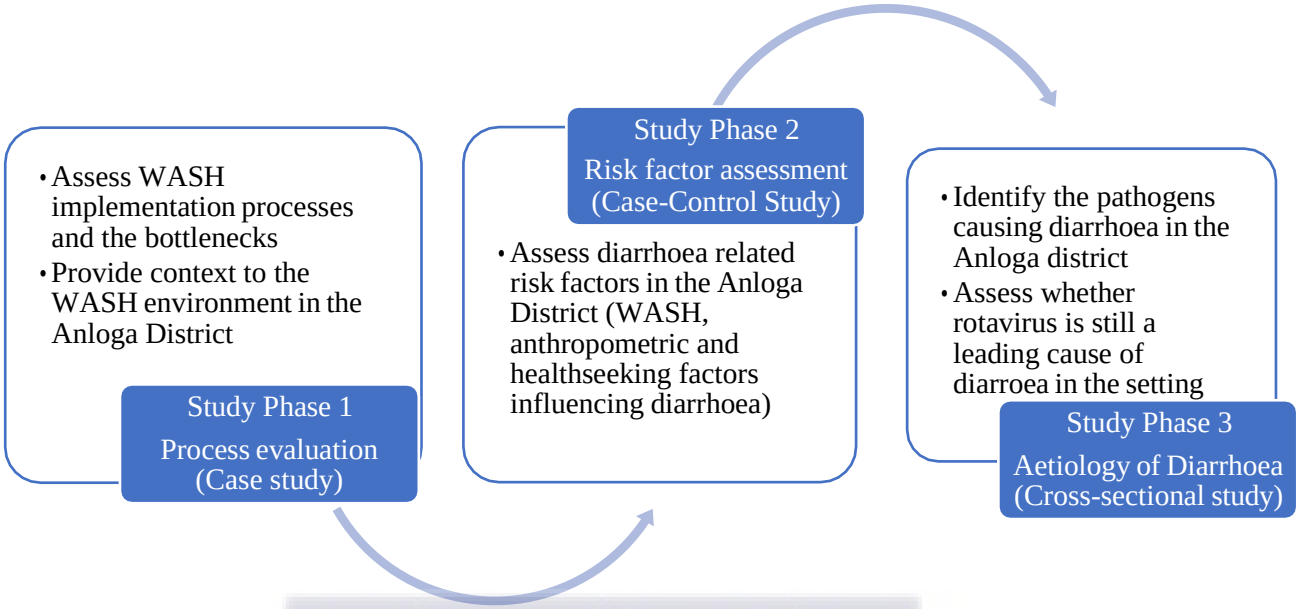


Figure 3.1: Flowchart of WASH implementation process and diarrhoea factors assessment approach, Anloga, 2022

3.2 Description of the Study Area

The study was conducted in Anloga District of the Volta region. Primary data was collected from communities and health facilities in the district.

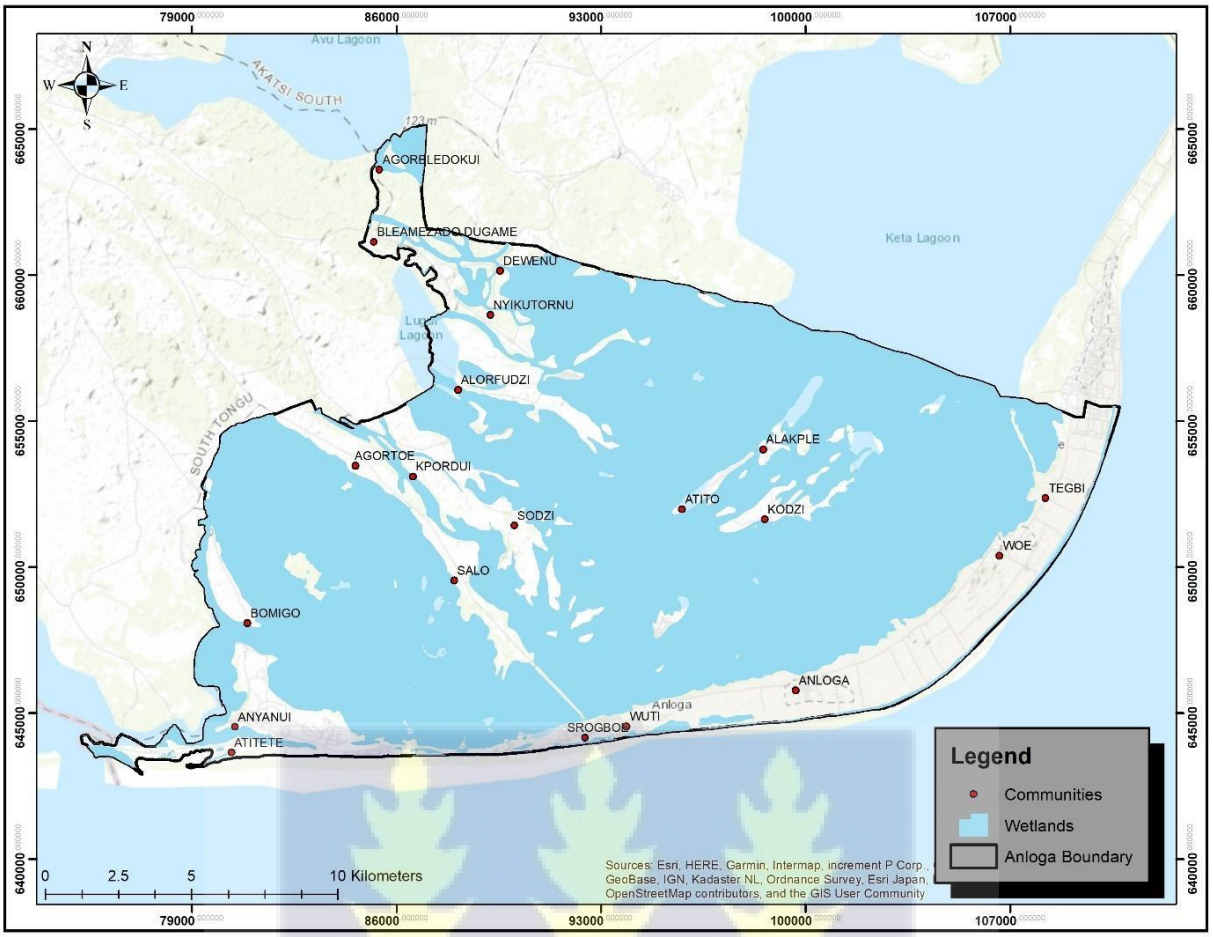


Figure 3.2: Map of Anloga District

Anloga District is one of the 18 districts in the Volta region of Ghana. It is a coastal district carved out of the Keta municipality in 2019. The district has a population of 94,895 (Ghana Statistical Service, 2021b). The district is located east of the Volta estuary, about 160km to the east of Accra, off the Accra-Aflao main road and lies within Longitudes 0.8844° E and Latitude 5.9264° N. It shares common borders with Keta District to the east, South Tongu District to the west, Akatsi South district to the North and the Gulf of Guinea to the south. The total land area for the district is 90,624.9 acres comprising 36,855.4 acres of Lagoon and Volta River, 18,986.4 acres of wetlands and 34,801.1 acres of land (Anloga District Assembly, 2021).

3.2.1 Rainfall

The district falls within the Dry Coastal Equatorial Climate with an annual average rainfall of about 800mm per annum. The district is thus one of the driest along the coast of Ghana. The district experiences a double maximum rainfall pattern. The major rainy season is between March and July while the minor one begins in September and ends in November. Thus, the total amount of rainfall is relatively low.

3.2.2 Water and Sanitation

3.2.2.1 Water Source

The sources of drinking water in the district are river/stream, well, standpipes, dugout and borehole. Pipe borne water forms the major sources of domestic water supply to the people in the district. A number of households (40%) rely on pipe-borne water outside their dwelling. The proportion of urban households with pipe-borne water outside dwelling (50.4%) is almost twice compared to rural households (28.8%). About 9% of households have pipe-borne water inside dwelling. Above 22% of households in the district use public tap or stand pipes with a greater proportion of rural (35.3%) communities relying on the public tap or standpipes and (11.6%) for urban communities. Most households (23.5%) use protected wells for domestic purposes with the urban to rural ratios being (34.9%) and (9.9%) respectively. Over 20% use unprotected wells for domestic activities whiles (17.6%) use pipe-borne water outside dwelling and (16.4%) use public tap or stand pipe for domestic activities. Water collected daily from communal pipes is mainly stored in plastic gallons and other containers for use by the household. Storage containers have designated articles used in fetching water from them for individual use.

3.2.2.2 Sanitation

According to the 2010 Population and Housing Census Report, 43.0% of households in the district have no toilet facilities. More than a quarter of households (29.1%) relied on public toilets (WC, KVIP) in the district. Almost 2% of households in the district use bucket or pan latrine. For solid waste disposal, 48% of households in the district disposed of their solid waste by dumping it in public dumps or open spaces, 18.7% disposed of their waste by burning, while 13.5% buried their solid waste. Households who disposed of their solid waste indiscriminately constitute 8.4 percent. Also, 49.0% of the household population disposed of their liquid waste either by throwing it onto the street/outside or onto their compounds (42.9%). Less than 1 % of the population disposed their wastes through the sewerage system or through a drainage system into a pit (0.6%) and (1.1%) throw into a gutter.

3.2.3 Health Infrastructure and Healthcare Services

The district has four (4) health sub-districts namely Anloga, Tegbi, Anyanui and Shime for effective management of health services. In all, there are six (6) health centres in the district namely Tegbi, Kodzi, Tregui, Galosota, Anloga and Anyanui. There are also four (4) functional CHPS Compounds in the district located at Woe-Dziedzorve, Trekume, Atorkor and Agortoe. In addition, there are three (3) private clinics located at Tegbi, Anyanui and Anloga as well as two (2) maternity homes in Tegbi-Abutia and Anloga, all in the quest for effective health care delivery. These facilities treat diarrhoea. Each month, diarrhoea cases that report to the facilities are entered into DHIMS 2.

Diarrhoea is listed as one of the top ten disease in the district with 2,560 cases reported in 2021 in DHIMS 2. Outbreak of diseases such as cholera is still a major health concern in the district and most of these epidemics are because of poor sanitation and environmental activities.

3.2.4 Socio-demographic Characteristics

The population in the district constitutes 52.9% females with an annual growth rate of 2.5%. More than half (64.5%) of the district's population lives in the urban areas. The population of children under five years old in the district is about 38,000. Most households in the district (67.7%) are engaged in mainly vegetable farming. Anloga District is mainly an agricultural economy, with the majority of the population (35%) engaged as skilled agricultural, forestry and fishery workers. This is followed by craft and related trades workers (25.4%) and services and sales workers accounting for 21.8%. Clerical support workers and technicians and associate professionals recorded the lowest with (1%) and (1.2%) respectively (Anloga District Assembly, 2022).

3.3 Study Variables

3.3.1 Process Evaluation Indicators

Key indicators used to determine the success of the intervention was the district's ability to follow all the laid down steps to plan and implement construction of the required number of improved water sources and improved toilet facilities to their communities (Table 3.2).

Table 3.2: Key Indicators of Success

Indicator	Target to be achieved	Comments
Number of implementation steps followed	10	Processes were termed as implementation steps. Following the implementation steps during the WASH facility construction was assessed to rate the success of the implementation
Number of water sources constructed	106	The implementation steps would lead to construction of water sources (outcome) that would suffice for the entire district giving them a 100% coverage.
Number of toilet facilities built	86	The implementation steps would lead to the construction of toilet facilities (outcome) that would suffice for the entire district giving them a 100% coverage.

Table 3.2 quantifies the logic framework model (Figure 3.3) which governed the WASH implementation in the district. Indicators of success were derived from the processes (number of implementation steps followed) and the outcomes (toilet facilities and water sources needed to ensure the district attains 100% coverage).

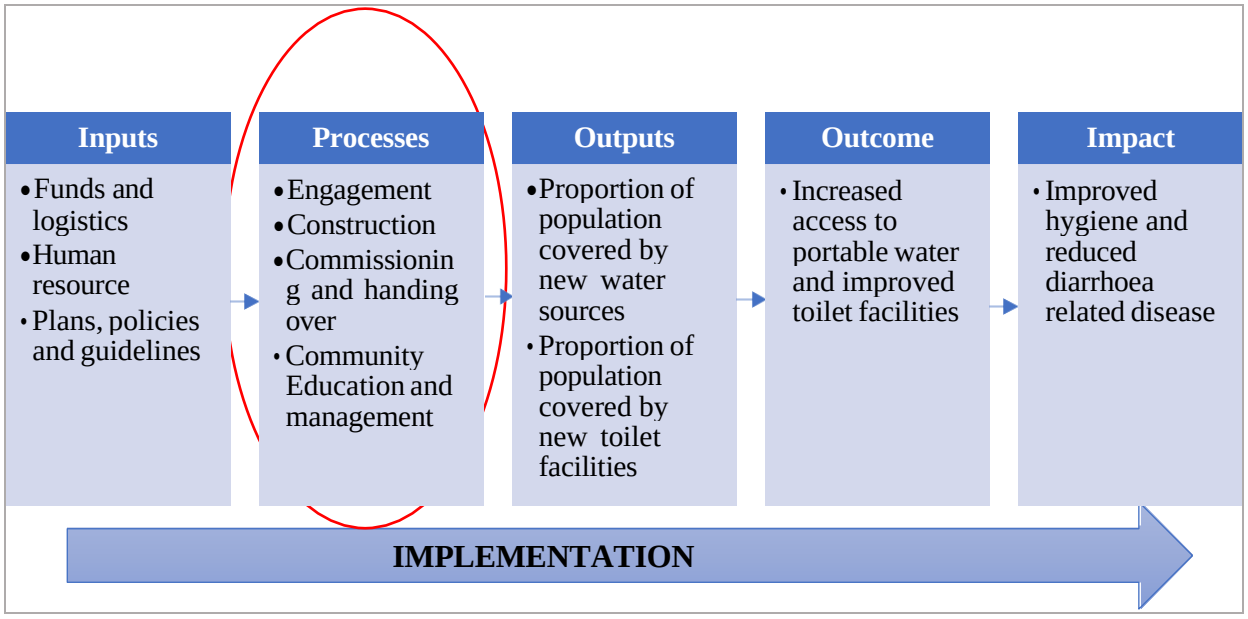


Figure 3.3: Logic model for implementing WASH interventions showing processes undertaking in implementing WASH in Anloga District

The evaluation assessed 2 main WASH cluster indicators: Proportion of households with access to a source of safe drinking- water and proportion of households with access to a functioning toilet (Global WASH Cluster IM Toolkit, 2014). Additionally, the evaluation compared the district's WASH implementation steps to the national sector guidelines for implementation of WASH strategies in Ghana (Ministry of Water Resources, Works and Housing, 2010). The indicators measured by the evaluation are defined in table 3.4 below.

Table 3.3: Measurement of Indicators

Indicator title	Definition	Measurement	Data collection method
Percentage coverage for water sources	The percentage of the population served by the water source constructed	Numerator: total number of water sources constructed Denominator: total number of water sources planned to be constructed	Review of mid-term development plans and district annual reports
Percentage coverage for toilet facilities	The percentage of the population served by the KVIP or water closet constructed	Numerator: total number of KVIP or water closet constructed Denominator: total number of KVIP or WC planned to be constructed	Review of mid-term development plans and district annual reports
Proportion of implementation steps followed by district	Number of standard steps the district followed in their WASH implementations	Numerator: number of steps followed by district Denominator: standard number of steps to be followed during a WASH implementation	Review of national plans and policy documents KII, IDI, FGD, checklist administration

The key components of the process evaluation assessed were the context, reach, dose delivered (target set), dose received (target achieved) and fidelity of the intervention. These were defined according the Linnan and Steckler's approach for conducting process evaluations (Linnan & Steckler, 2002). Definitions used for each component are stated in the table below.

Table 3.4: Definitions of Process Evaluation Components Assessed

Component	Definition
Context	The physical, social and political characteristics of the environment (district, national) that directly or indirectly affected the implementation during the evaluation period
Reach	The proportion of the intended target population who actually benefited from the interventions put in place.
Dose delivered	The number of WASH structures the district intended to provide
Dose received	The number of people who were actually reached by the intervention
Fidelity	How the WASH structures were developed according to the laid down guidelines.

Adapted from: (Al Daccache & Bardus, 2022; Linnan & Steckler, 2002)

The measurement indicators and the component definitions guided the development of all the tools used in collecting the data for the process evaluation. This was done to ensure that the required information was obtained. Information on the components was collected during the interviews and document review process.

3.3.2 Case Control Variables

3.3.2.1 Dependent Variable

Diarrhoea morbidity was the dependent variable

3.3.2.2 Independent Variable

The independent variables were classified under socio-demographic, environmental factors, nutritional factors and health seeking factors. Details are provided in table 3.5 below.

Table 3.5a: Study Variables for Case-Control Study

Variable	***Definition***	***Means of measurement***
Exposure variables		
Environmental factors (WASH practices)		
Hand washing, critical points for hand washing	- Frequency of hand washing after use of the toilet, before cooking and handling food Hand-washing practices at critical times measured using 5 items of hand washing practice (i.e., after defecation, after cleansing the child's defecated buttocks, before cooking, before eating, and before feeding the child) with a 4-point Likert scale (1 = always, 2 = usually, 3 = sometimes, and 4 = never). The responses were coded as 1 for always and usually, 0 for sometimes, and never. I reclassified the study participants as "yes" for those who answered "always" or "usually" for hand washing practice at critical times and "no" for those who responded "sometimes" or "never" for hand washing practice at critical times in order to obtain a binary outcome (Agaro *et al.*, 2022). A composite score was calculated for each person by adding the scores for each question and finding the average. A score above 2 was classified as poor and a score of 2 and below were classified as good.	Structured interview with caregiver
	- Child use of feeding/ water bottle (child fed using a feeding or water bottle) - Household water storage (how households store water. Such as in type of containers and how containers are maintained) - Type of household toilet facility the household members used - Disposal of child's diarrhoeal stool (method used to dispose of a child's stool) - Children use the toilet facility (whether the child uses the household toilet facility) - Season of recruitment (wet or dry season) of the year	Structured interview with caregiver

Table 3.5b: Study Variables for Case-Control Study

Variable	***Definition***	***Means of measurement***
Nutritional status		
Underweight Wasted	- Children under five years weight for their age with reference to the growth standard - Child under five years weight compared to their height with reference to the growth standard	Anthropometric measurements of child
Healthcare seeking practices		
Health seeking practices	- Rotavirus vaccination received fully by child - Primary point of healthcare (main point for accessing care) - Reason for choice of care (main reason for using a type of health service) - Source of health advice (where the caregivers get advice on health issues) - Child dewormed (child given a deworming drug in the past 6months prior to the interview) - Iron supplementation (child given iron supplementation in the past 6months prior to the interview) - Decision on seeking healthcare (person who makes the final decision on whether healthcare should be sought) - Child on health insurance (child enrolled on a health insurance policy) - Child started school (child enrolled and attending school)	Structured interview with caregiver
Socio-demographic Characteristics		
Socio demographic characteristics	Child Characteristics - Age of child (completed age in months) - Sex Caregiver Characteristics - Age of caregiver (completed age in years) - Educational level of caregiver (highest level of education attained) - Primary occupation of caregiver (main income generating work caregiver does) - Religion - Number of people in household - Wealth index	Structured interview with caregiver

3.3.3 : Etiological Study Variables

Outcome variables for the etiological study were: Rotavirus A presence, type of other pathogens present and pathogen co-infection. Whiles exposure variables were age and sex.

3.4 Study Population

The target population for the study were all inhabitants of the Anloga District. This included community members, children under five years and their caregivers, key stakeholders involved in WASH interventions in the district. The study population for process evaluation were community opinion leaders, community members, district assembly staff and all other stakeholders involved in WASH activities. For the case-control study, the study population were caregivers and their children under five years. For the cross-sectional study on diarrhoea aetiology, children who had reported to the health facility with diarrhoea were the study population.

3.5 Sample size and Sampling Technique/ Method

3.5.1 Sample Size

Sample size was calculated separately for all three phases of the study. Below are the details of the sample size calculations done for each phase.

3.5.1.1 Sample Size for Phase 1 (Evaluating how WASH Interventions were Implemented)

For the process evaluation, no sample size was calculated. All stakeholders playing a key role in the implementation process at the district and community level were purposively selected for the evaluation, identified and interviewed. A minimum of 56 people were targeted for the various interviews and discussions that needed to be carried out.

Table 3.6: Population to be sampled for Qualitative interviews in Phase 1

Type of interview	**Estimated number of people to be interviewed**	**Level of interview**
Key informant interview	5 district assembly staff	District level
In-depth interview	5 per community (10 opinion leaders in 2 communities)	Community
Focus group discussion	8 per discussion, 2 discussions per community (16 per community – 40 community members above 18 years of both sex)	Community
Checklist	5 people per WASH structure type (15 per community – 30 household heads around the structures in two communities)	Community
Total	**Minimum of 56 people**	

3.5.1.2 Sample Size for Phase 2 (Determination of Epidemiological Risk Factors of Diarrhoea)

The sample size for the 1:1 case control study was calculated using the following assumptions (Glaziou, 2005) and an exposure of no toilet facility in household among controls in a similar study done in Ethiopia was used for calculation of the sample size (Asfaha *et al.*, 2018). The sample size for a number of exposures were calculated (see Appendix but the exposure chosen gave the most appropriate sample size.

Table 3.7: Assumptions for case control study

Detectable odds ratio	2
Exposure in control (No toilet facility in household)	46.7%
Alpha risk (probability of detecting a false effect)	5%
Power (probability of detecting a real effect)	80%
Control/case ratio	1

$$n\,(case/control\ group) = \frac{(p_0q_0 + p_1q_1)(z_{1-\alpha/2} + z_{1-\beta})^2}{(p_1 - p_0)^2}$$

Where:

Proportion of controls with exposure (p_0) = 0.467

Proportion of controls who do not have the exposure (q_0) = 0.533

Proportion of cases with exposure (p_1) = 0.302

Proportion of cases who do not have the exposure (q_1) = 0.698

Ratio of cases to controls = 1

z_ (1- α/2) = alpha value = 1.96

z_(1-β) = beta value (power) =0.84

$$n\,(case/control\ group) = \frac{(0.538 * 0.462 + 0.302 * 0.698)(1.96 + 0.84)^2}{(0.302 - 0.538)^2}$$

The minimum estimated sample size was 149 cases and 149 controls for the case control study. A non-response rate of 15% was applied to the sample size to improve its statistical power. In total, a minimum of 171 cases and 171 controls were recruited.

3.5.1.3 Sample Size for Phase 3 (Identify Pathogens Causing Diarrhoea)

Using the prevalence of rotavirus in Ghana (WHO Rotavirus Regional Reference Laboratory for West Africa, 2022), and the number of cases to be recruited into the study, Prevalence = 12% cases = 171, a minimum sample of 83 was obtained

A sample size for a finite population was calculated for the cross-sectional study

$$n = \frac{z^2 * pq}{e^2}$$

Where,

alpha value (z) value standard variant = 1.96

Proportion of population with exposure (p) = 0.12

Proportion of population who don't have the exposure (q =1-p) = 0.88

Estimator (acceptable error) (e) = 0.05

Sample size in an infinite population = (n) = 162

$$\frac{n}{1 + \frac{z^2(p * q)}{e^2 * N}}$$

Where,

Sample size in an infinite population = (n) = 162

Value standard (variant alpha value) (z) = 1.96

Proportion of population with exposure (p) = 0.12

Proportion of population who don't have the exposure (q =1-p) = 0.88

Estimator (acceptable error) (e) = 0.05

The total sample size of 83 was obtained, therefore 83 samples were to be tested for Rotavirus A pathogen, the pathogen for the vaccine given to children under five years in Ghana during routine immunization. Furthermore, 40 samples were randomly selected for pathogen diversity using molecular techniques

3.5.2 Case Definitions

The WHO case definition for diarrhoea was adapted for this study. Diarrhoea was defined as the passage of three or more loose or liquid stools per 24-hour period (or more frequent passage

than is normal for the individual (World Health Organisation, 2017). This definition was used because it conformed to the Integrated Disease Surveillance and Response (IDSR) case definition that Ghana is using for identifying diarrhoea cases (Ghana Health Service, 2019)

The IDSR defines Diarrhoea in children less than 5 years of age as:

Suspected case: Passage of 3 or more loose or watery stools in the past 24 hours with or without dehydration and: Some dehydration -- two or more of the following signs: restlessness, irritability; sunken eyes; thirst; skin pinch goes back slowly, or Severe dehydration -- two or more of the following signs: lethargy or unconsciousness; sunken eyes; not able to drink or drinking poorly; skin pinch goes back very slowly.

Confirmed case: Suspected case confirmed with stool culture for a known enteric pathogen.

(IDSR 3rd Edition (Ghana Health Service, 2019).

In this study, a case was defined as a child under five years attending a health facility in Anloga District and confirmed by the health worker in charge of the facility to have met the suspected case definition for diarrhoea. The health facility was used as the site for identifying cases because the Ghana Health facilities operate with the same IDSR case definition for diarrhoea. A control was defined as a child under five years living in the same community as the case who has not reported to any health facility with diarrhoea in the past seven days.

The seven day period was used to reduce recall bias (Schmidt *et al.*, 2011). To reduce misclassification of cases and controls, the probes on number of stools passed, the duration of the diarrhoea episode and treatment given were asked by the healthcare officer attending to the child.

Inclusion criteria

A child under five years in Anloga District with their caregivers willing to participate in the study were included in the study.

Exclusion criteria

A child under five years who has lived in the district for less than 6 months were excluded because they were considered to have different levels of exposure.

3.5.3 Sampling

3.5.3.1 Sampling for Phase 1 (Evaluating how WASH Interventions were Implemented)

Participants for the interviews were purposively sampled with the intent to maximise information on the WASH implementation process in the district. From August to October 2022, district and community entry engagements were held in the study district to identify the WASH implementation stakeholders. Members of the district WASH team were identified as the main implementers of WASH in the district. Departments constituting the WASH team were; the Environmental Health Department, Planning Department, Works Department District Health Directorate and the Department of Social Welfare. The five heads of these departments were interviewed on their involvement in WASH implementation.

One sub-district noted for its high diarrhoea prevalence was purposively selected for the community evaluation. In the sub-district, two communities were purposively selected for the evaluation due to their large size and proximity to both the coastline and Volta River.

At the community level, a total of five (5) opinion leaders were purposively identified and interviewed in each community. Namely: the head of water structures, waste dump sites, sanitation (toilet structures), community leader or chief and the head of the health facility. Similarly, participants for the focus group were household heads living within 5 meters of the most recently constructed WASH facility. Participants for the checklist were also selected from houses closest to the most recently constructed WASH facility in the community. Detailed methods of the sampling is published in a protocol by Bandoh (Bandoh, Kenu, *et al.*, 2024).

3.5.3.2 Sampling and Recruitment for Phase 2 (Determination of Epidemiological Risk Factors of Diarrhoea)

Cases were identified in the health facilities in the three sub-districts with the highest burden of diarrhoea in the district, Anloga, Anyanui and Tegbi sub-districts. The health facilities which served as study sites were Anloga Health Centre, Tegbi Health Centre, Anyanui Health Centre, Atorkor CHPS, Kodzi CHPS and Dzita CHPS Zone. Caregivers with children under five years were approached after the health practitioner had confirmed the child's diarrhoea status. Recruitment was done consecutively in all facilities from November 2022 to December 2023. This approach was adapted based on a similar method used in a diarrhoea study in Ghana (Ashie *et al.*, 2017).

Trained research assistants who were also health workers were stationed at each health facility. After the health workers had confirmed the child's diagnosis as diarrhoea, the research assistants were alerted to engage the mother about the study. Preliminary screening was done with a checklist to confirm that the child under five years met the case definition. The purpose of the study was fully explained to the caregiver and their concerns addressed. An informed consent was administered, and the caregiver made to sign or thumbprint a consent document. The caregiver-child pair were recruited into the study. The interview was done at the health facility. Details on the case's household location were noted down to help in identification of a control.

For each case recruited, a control was also recruited in the same community. In the community, the research assistants first identified the case's household. Using that as a starting point, a control was selected from the first household with a child under five years closest to the case's house. If there was no child under five years in the next house, interviewer moved into the next household. The procedure was repeated until a house with a child under five years was obtained.

When a probable control was identified, the caregiver was asked if the child had been confirmed by the health facility to have diarrhoea in the past 7 days. A child who had not had an episode of diarrhoea confirmed by a health facility in the past seven days was identified as a control. The child health records book was inspected to confirm the information given by the caregiver. The caregiver was taken through the consenting procedure. After agreeing to take part in the study, they were recruited and the interviews conducted. Cases and controls were recruited and interviewed consecutively across all health facilities and communities on a daily basis until the sample size was attained. Due to the transient nature of diarrhoea, names and household identifiers of the children and their caregivers were recorded to keep track of all children whose diarrhoea status may change during the period of the study. To avoid a case becoming a control or a control becoming a case or a case reporting again with diarrhoea later at any point in the study, caregiver-child sets that had previously been recruited were not recruited a second time. This was ensured by confirming the records before recruitment.

3.5.3.2 Sampling for Phase 3 (Determination of the Aetiology of Diarrhoea)

A sub-sample of all caregivers of children who met the case definition and took part in the case control-study were invited to be part of a cross-sectional study to determine the pathogens causing diarrhoea. Stool samples were taken from all caregivers who consented until the required sample size was reached.

Each caregiver took a pea-sized stool from their child and placed it in a sterile container they were given after the interviews. For children with loose stools, mothers were taught to collect 2ml of stool directly from the child. All collected samples were transported to the laboratory to be assessed for stool adequacy and integrity before testing.

Eighty-three samples were tested for Rotavirus A. The samples were selected randomly using STATA version 17. With the stat software, 83 case identity (ID) numbers were generated.

Stool samples from children with the selected IDs were then selected and tested for Rotavirus A. To determine pathogen co-infection and the presence of other pathogens other than Rotavirus A, 50% of the 83 stool samples collected were randomly selected using STATA version 17. These were tested with the TAQMAN Array Card PCR Technology.

3.6 Data Collection Techniques and Tools/Instruments

3.6.1 Data Collection for WASH Implementation Process Evaluation

Figure 3.4: Process evaluation framework for data collection *adopted from **(Moore *et al.*, 2015)**

The framework which guided data collection was adapted and modified from Moore *et al.*, 2015 (Figure 3.4). Data was collected from primary and secondary data sources from August – October 2022. Primary data was obtained from key informant interviews, in-depth interviews, focus group discussions, and a household checklist. Whiles secondary data was obtained from the desk review of mid-term development plans, annual reports, national policy documents on WASH and other relevant WASH programme documents such as the WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene (JMP) methods and reports. The aim of the review was to identify the standard processes and procedures taken in the

implementation of WASH interventions and assess the planned interventions the district was able to implement over the mid-term development plan period.

Key informant interviews (KII) were conducted at the district level. Heads of units involved in WASH activities such as development, implementation and management were engaged individually in KIIs to document their experiences and roles played in WASH interventions that have been implemented in the district. The interviews were held at the district assembly by a trained research assistant using a key informant interview guide.

For the IDIs in the selected communities, opinion leaders namely, the assembly member, the chief, community member in charge of water structures, community member in charge of all sanitation structures were interviewed individually. One on one in-depth face to face interviews were conducted in communities. Questions on their experiences with implemented WASH interventions in their community namely, the role they played, the steps they observed during the process, how they were engaged, management and sustainability of the intervention were asked. Interviews were conducted by two trained research assistants. One conducted the interviews using an IDI guide and the other took notes in addition to recording the interview.

Focus group discussions were held close to the selected WASH structure. Household heads from houses around the most recent WASH structure were randomly selected and gathered at the WASH structure for the discussion. They were then engaged in a focus group discussion to document their experiences with WASH implementation process in their community. A moderator guided the discussions with questions as prompts using an interview guide. Questions covered how they were engaged, the roles they played, how the implementation was managed and the process of handing over to the community.

The checklist was used to guide data collection in five houses located around the WASH structure. One adult, preferably a household head answered questions on the checklist. In total,

fifteen interviews per community, five around the most recent water source, five around the most recent toilet structure and five around the most recent waste dump site. The variables included in the checklist were; Type of WASH structure, individual or organization who led development of the intervention, origin of WASH structure, donors of structure, information given on use of WASH structure.

3.6.1.1 Process Evaluation Instruments (Evaluating how WASH Interventions were Implemented)

Qualitative tools were used mainly in the process evaluation. They included focus group discussion guides, in-depth interview guides and observational checklists. The tools used are described below.

Key Informant Interview Guide

Key informant interview guide for interviews with key stakeholders at the district focused on the implementation steps for WASH interventions in the communities, engagement process, maintenance, and challenges encountered.

In-depth Interview Guide

An in-depth interview guide was used to collect information from community leaders who took part in the implementation of the WASH interventions. The guide covered their role played in the implementation, implementation steps they witnessed, management and maintenance of the intervention.

Focus Group Discussion Guide

A focus group discussion guide on community members' involvement in implementation of WASH structures, its maintenance and ownership, and information sharing during implementation was used in conducting focus group discussions for community members in both communities.

Observational Checklist

Observational checklist assessing household head's knowledge on WASH interventions implemented in the community, community use and maintenance of WASH structure, and education given on the interventions.

Data Extraction Sheet

Two data extraction sheets were used for the evaluation. The first sheet collected information on the WASH interventions the districts implemented, targets for the district, interventions the district was able to implement. The second extraction form collected data on national level policies, guidelines and strategies for implementing WASH interventions at different administrative levels in the country.

3.6.2 Data Collection for Case control study

In the health facility, the data collection team worked with the healthcare provider. Immediately a case was confirmed in the health facility, the caregiver was referred to the interviewer. The interviewer then engaged the caregiver, explained the purpose of the study fully to the caregiver and addressed any concerns.

A structured questionnaire covering when diarrhoea started, its duration (number of days) and the number of stools the child passed, and treatment given was used to interview the caregiver at the health facility by a trained health worker. This was followed by administration of a questionnaire on socio-demographic characteristics of the caregiver, health seeking practices and child drinking water source, water storage practices, sanitation and hygiene practices. The weight and height measurements of the child under five were also taken.

For controls, after the consent process was completed, a questionnaire on socio-demographic characteristics of the caregiver, health seeking practices and child drinking water source, water storage practices, sanitation and hygiene practices was administered. The process for interviewing cases and controls was the same. The weight and height measurements of the

child under five were also taken. Cases and controls were recruited from November 2022 to December 2023.

Anthropometric Measurements

The nutritional indicator assessed in this study was the weight-for-age (underweight), weight-for-height (wasting) and height-for-age (stunting). Anthropometric measurements of the children were therefore taken. Anthropometric measurements of weight (kg) and height (cm) of case and controls were taken by two trained health workers. Measurements were taken twice and recorded to reduce the occurrence of random errors. During measurements, it was ensured that all children were clad in only underwear or light clothing. The measurements of the child were taken using standard anthropometric methods for children under five years (Cashin and Oot 2018; Centres for Disease Control and Prevention 2007; WHO 2008; WHO and The United Nations Children's Fund(UNICEF) 2019).

Procedure for taking weight and height measurement for children under five years

Weight measurement for children below 24 months, was taken with the help of the caregivers. Caregivers were asked to empty their pockets and drop all heavy objects on them. They were then invited to stand bare footed on the scale. The scale was then tarred, the child was handed to the mother on the scale and the weight of the child taken.

For children above 24 months, the child was guided by the caregiver to stand on the scale by themselves with their feet positioned slightly apart. They were then asked to stand still until their weight reading is recorded to the nearest 0.1 kg (kilogram). Weight was taken with digital weighing scale (SECA, Hamburg Germany).

Length: Recumbent length was taken for children below 24 months using the infantometer. The child was gently placed on the infantometer by the caregiver with his/her head against the

headboard. The child's head was held in place by cupping the ears. One trained health worker ensured that the vertical line formed from the ear canal to the lower border of the eye socket of the child perpendicular to the horizontal board (the Frankfort vertical plane) is obtained before the measurement was taken. The other health worker ensured that the child's feet were together, with back, calf and heel flattened on the board. The footboard was gradually pushed to the feet of the child with left hand whiles the right holds the legs together in place. The length was then recorded to the nearest 0.1cm (centimetres).

For children above 24 months, height was taken with a stadiometer. The child was guided by the caregiver to stand on the footboard with their back against the backboard. The trained health worker ensured that the back of their head, shoulder blade, back, buttocks, calf and their heel touched the backboard of the stadiometer. The head of the child was then positioned so that the horizontal line connecting the upper ear opening and lower edge socket of the eyeball run parallel to the baseboard forming the Frankfort horizontal plane. The tummy of the child was gently pushed in to help the child to stand straight and the headboard pressed firmly on the top of the head. The reading was taken and recorded in centimetres.

3.6.2.1 Case Control Studies Tools (Determination of epidemiological Risk Factors of Diarrhoea)

The main tools for the case control study were structured questionnaires. Namely health facility questionnaire for cases, household questionnaire for cases and controls and the anthropometric measurement sheet. The same set of tools were used in collecting data for both case control studies.

Health Facility Questionnaire for Cases

A structured questionnaire on basic demographic and health information was administered at the hospital upon recruitment of the cases into the study. The aim of the tool was to collect

basic information on the case and information to trace the case's home for the household interviews.

Household Questionnaire for Cases and Controls

A structured questionnaire on household demographic characteristics, water source, sanitation facility used, waste disposal and health seeking practices was administered to the caregiver. To reduce interview related bias, a specific set of interviewers (two people) were assigned to recruiting cases in the health facility alone and the other set assigned to conduct household interviews only.

Anthropometric measurement Sheet

A data template, which collected information on child's age, date of birth and the two anthropometric measurements that were taken, was used in documenting the child weight and height measurements.

3.6.3 Sample Collection for Laboratory Analysis

After the quantitative interviews with caregivers of the cases, a stool sample was collected from children of all caregivers who consented. Using plastic applicators attached to the lid of the stool containers, the stool sample was collected into a sterile container at the health facility. Samples were labelled with IDs assigned during the quantitative interviews. The sample was stored immediately in a refrigerator at 2–8 °C. At close of day, samples from all health centres were transported in cold boxes at 2–8 °C to the main site for storage. Before storage, 2 – 3 drops of glycerol were added to each tool sample. The sample was gently swirled to ensure it was enveloped in the glycerol. Samples mixed with glycerol were then frozen to preserve them prior to testing. In addition to the sample, the age and sex of each case, data of sample collection, facility name were also noted down.

3.6.3.1 Laboratory Tools

A form with sample ID and type of pathogens present in stool were used to record results of laboratory tests.

3.6.4 : Laboratory Sample Processing and Testing Procedure

3.6.4.1 : Laboratory Sample Processing

Samples were received in the molecular laboratory of the Electron Microscopy and Histopathology department of the Noguchi Memorial Institute for Medical Research. This laboratory also serves as the WHO Regional Rotavirus Reference Laboratory for Africa. The laboratory supervisor assessed for stool weighing adequacy since two different tests were to be run on them. Samples that were not adequate and were not of the required state (had growth on them) were discarded. Samples that were of the right quantity and had no growth on their surface were transferred into cryotubes and labelled. The rest of the unused sample were stored at -20°C.

3.6.4.2 : Laboratory Testing for Enzyme-linked immunoassay (ELISA)

Samples were processed and tested for rotavirus antigen using the ProSpecT Rotavirus Microplate Assay for Detection of Rotavirus Antigen in Stool Specimens for the E Enzyme-linked immunoassay (ELISA).

For the test, a 10% stool suspension was prepared according to the manufacturer's instructions. The aliquots were prepared using phosphate buffered saline. A peanut size of stool weighing roughly 0.1mg was used to prepare 1ml aliquot. For stools that were liquid, 100µl of stool was used in the preparation. The procedure for testing was followed as prescribed by the manufacturer's instructions (ThermoFisher Scientific, 2012). The ProSpecT test kit was used because of its high sensitivity and specificity (sensitivity 99.2% and specificity 99.2) (ThermoFisher Scientific, 2012).

3.6.4.3 TAQMAN Array Card (TAC) Laboratory Testing Procedure

The TAQMAN Array Card (TAC) test was done following the manufacturer's procedure (ThermoFisher Scientific, 2021). For each sample, 180mg of stool was weighed. Pure total nucleic acid for each sample was obtained using the QIAGEN box for total nucleic acid extraction. The laboratory protocol was followed throughout the extraction process. The TAC test was run in batches of eight since each card takes 8 samples at a go. For each batch, a master mix was prepared and each had an internal and external control. Steps from Bandoh's (2024) protocol and Lappan guided the laboratory analysis (Bandoh *et al.*, 2024; Lappan *et al.*, 2022).

3.6.5 Laboratory Tools

A form with sample ID and type of pathogens present in stool were used to record results of laboratory tests.

3.7 Quality Assurance and Control

3.7.1 Training of Data Collectors

A three-day training was organized for data collectors before all study data was collected. Data collectors were university graduates with at least one year experience in collecting data for public health surveys. During the training, the study concept was well explained to field workers. Training involved community entry processes, ethical considerations, field etiquette, establishing of rapport with community members, engaging opinion leaders, qualitative interview tips, identification and interviewing of cases and contacts. Data collectors were also trained on the various tools for the study, how to administer them with electronic tablets, interviewing techniques, consenting process and taking of anthropometric measurements. For the case-control study, field workers were also trained to treat all caregivers (cases and controls) in the same way to reduce recall bias that might arise during interviews.

3.7.2 Pretesting of Tools

All the study instruments were pre-tested in a coastal community in Accra with characteristics similar to the study community. Target groups such as caregivers of children under five years, and community stakeholders in WASH interventions were interviewed during the pre-testing. For the KIIs, a district assembly official in the community was identified and interviewed. For the IDIs, two community opinion leaders were interviewed, for the FGD, the community representative mobilized household heads for the discussion to be done. About five (5) households were also interviewed with the checklist. Findings from the pre-test were used to improve the understanding of the tools.

3.7.3 Data Quality Checks

Data collected daily was checked for inconsistencies and all errors addressed before the next day's work. Field supervisors ensured that quantitative data collected were uploaded onto the server before the next day's work. Additionally, supervisors randomly repeated interviews to check data quality. Notes taken from qualitative interviews was inspected daily and recordings downloaded and backed up to prevent loss.

3.7.4 Laboratory Quality Control

All lab procedures were conducted in accordance with the laboratory best practices. A quality management system, and biosafety training was undertaken and the post-test passed. Access to the molecular laboratory and a tour the facility was granted. This orientation was done to provide a basic understanding of the biological agents the lab works with and the need for safety. The laboratory tour provided an overview of the laboratory areas, the equipment in the lab and the activities that were carried out there. An overview of the use each of the equipment was also given.

Before the ELISA test, the lab bench was decontaminated by applying 10% hypochlorite on the surface for 5mins and wiping down with 70% ethanol solution. All equipment used in the test procedure such as pipettes and centrifuge were disinfected. The tests were conducted in a glass chamber to prevent any form of contamination of samples.

For the TAQMAN Array Card (TAC) test, pre-decontamination of the bench was done. Pipettes, equipment, heat blocks and the glass hood chamber were disinfected the night before the test procedure was done and decontamination done on the morning of the procedure.

3.8 Data Processing and Analysis

Data collected for each of the three parts of the study was cleaned and analysed separately.

3.8.1 Process Evaluation Data Processing and Analysis

The data generated for the evaluation was triangulated to produce a concise picture of the processes. Information from desk review was extracted into a Microsoft Excel document and used in development of a WASH framework based on the national and desk documents. The framework outlined the required steps to be taken in implementing a WASH intervention at the district level. The district's current practices and steps being used were compared to the framework and coded using the traffic light system adopted from Thorseth and colleagues (Thorseth *et al.*, 2024) to show the extent to which the steps had been complied with. The information on the district level WASH implementation activities was used to generate frequencies and proportions of indicator targets achieved by the district.

All interviews were transcribed verbatim and analysed using model for inductive thematic analyses by Braun and Clarke (Braun & V. Clarke, 2021) This involved: (1) familiarisation with the data; (2) systematic data coding; (3) generating initial themes; (4) developing and

reviewing themes; (5) refining, defining, and naming themes; and (6) writing the report. Coding for analysis was done using NVIVO Version 14.

Findings from the checklist were summarised based on the variables collected, buttressing what the focus group discussions mentioned. Information from the qualitative report in addition to the checklist were used to identify the actual steps in the WASH framework the district followed during their implementation. Reasons for non-compliance with any of the steps was also be obtained from the report. Through the comparison, the gaps, strengths and bottlenecks in the processes the district is using were identified. This helped in identifying the gaps in implementation. The percentage achievement for WASH structures from the documents with their set targets and activities was calculated.

3.8.2 Case Control Study Data Processing and Analysis

Data was downloaded from kobo collect server and exported to Stata software version 17. Missing variables were all identified using check questions and referring to interviewers for details. Data was cleaned by recoding and recategorizing some variables and tested for normality.

The wealth index was calculated using principal component analysis for 11 questions answered on the household's possession of a list of basic items (Metrics for Management, 2019) and categorised into tertiles, (namely: poor, middle and rich) due to the sample size (Homenauth *et al.*, 2017).

For anthropometric indices, Z-scores for weight for age, weight-for-height and height-for age were generated using WHO Anthro package installed in Stata. Z-scores were then recoded as above 2 as normal and below -2. Proportions for each index was then generated for both cases and controls.

For demographic characteristics, health-seeking practices, and household WASH practices, frequencies and percentages were generated for categorical variables whiles continuous data were summarised as mean (SD) or median (IQR). Chi-square and Fischer's exact tests were used to test for association between categorical characteristics and diarrhoea status at 95% confidence interval.

To determine the factors associated with diarrhoea, binary logistic regression models was fitted through the generalized linear model with a logit link. The size of the association was reported in the form of odds ratios with their corresponding 95% confidence intervals. A binary logistic regression model was run for background characteristics, health seeking characteristics and diarrhoea, WASH practices and diarrhoea and nutritional characteristics and diarrhoea. As a sensitivity analysis a least absolute shrinkage and selection operator (LASSO) regression model with a logit link using 10 folds cross-validation method was also done. Statistical significance was determined at 95% confidence intervals (CI) and p-value $p< 0.05$.

In all the models run, background characteristics were adjusted for. Since cases and controls were selected from the same vicinity, clusters were adjusted for to prevent correlation bias. This was done since the background characteristics of the cases and controls in the same vicinity were likely to be the same.

3.8.3 Laboratory Data Processing and Analysis

Each of the test run had controls added to ensure that the results generated were accurate. All lab tests were accepted based on the results from the controls added to the test. Once the control results were accurate, the tests were accepted as a valid test.

For the ELISA, codes of samples that turned out positive were manually recorded in the Laboratory Microsoft Excel sheet first. Those that turned out negative were then recorded.

QuantStudio Realtime PCR software version 1.3 was used for analysis of the TAQMAN Array cards. Cut off points were adjusted for targets pathogens to correct thresholds. Data was then exported to Microsoft Excel 2016 and cleaned by setting each standard cycle threshold (CT) for pathogens and genotypes. Pathogen level detection was set at 35 and genotype level detection set at 40. For pathogens, all CT values below 35 were set as positive, and above 35 set at negative, undetermined values were also set as negative. For genotypes, all CT values below 40 were set were set as positive, and above 40 set at negative, undetermined values were set as negative. CT positives and negatives were converted to binary outcomes (0= negative and 1= positive). Frequencies of pathogen types classified as bacteria, virus and parasites, pathogen co-infections and distribution by age and sex pathogens were generated with Stata Version 17. Results were presented in tables and figures.

3.9 Analysis of Diarrhoea Cases Presenting to Health Facilities in Anloga

Definitions for Diarrhoea cases classification as mild, moderate or severe adopted from the Vesikari Clinical Severity Scoring System using the parameters diarrhoea, vomiting, dehydration and treatment given (Lewis, 2011) (Tables 3.8 and 3.9)

Table 3.8: Parameter and scores for Vesikari Clinical Severity Scoring System

	Score		
Parameter	1	2	3
Diarrhoea Maximum number stools per day	1-3	4-5	6
Diarrhoea duration (days)	1-4	5	6
Vomiting duration (day)	1	2	5
Temperature	37.1 -38.4	38.5-38.9	3
Dehydration	N/A	1-5%	39.0
Treatment	Rehydration	Hospitalisation	N/A

Adopted from (Lewis, 2011)

Table 3.9: Rating Scale for Vesikari Clinical Severity Scoring System Severity

Severity category	Score
Mild	<7
Moderate	7 -10
Severe	11

*Maximum score 20 Adopted from (Lewis, 2011)

Frequencies were generated for the diarrhoea cases. Diarrhoea cases were described by severity and by the main diarrhoea interventions in the district. Descriptive analysis of diarrhoea cases by the diarrhoea interventions the district had in place was conducted. That is the provision of access to basic water services (improved water), access to limited sanitation services (improved sanitation) and rotavirus vaccination. Chi-square and Fischer's exact tests were used to test for association between these categorical characteristics and diarrhoea severity at 95% confidence interval. The analysis compared each intervention to the severity of diarrhoea recorded. Additionally, diarrhoea severity was described by the various types of pathogens present. These were presented in tables and charts.

These analyses were conducted to triangulate the three phases of the study and better understand the diarrhoea situation in the context of the interventions in place.

3.10 Ethical Considerations

The proposal for this study was granted approval by the Ghana Health Service Ethics Review Committee (GHS-ERC 020/07/22) (refer to Appendix 7). Permission was obtained from the regional and district health directorates and the District Assembly. Permission was obtained from the community leaders and health facility in-charges. The purpose of the study was

explained to all participants in detail and their questions answered before enrolment. Participants were assured of confidentiality. Informed consent forms were administered to all study participants prior to participation. Participants signed or thumb printed the informed consent documents before any interview was conducted. Participation in all sections of the study was voluntary and subjects were informed that they could withdraw at any time they wish even after consent had been given and during participating in the study. All information obtained from the study was kept confidential on password protected computers.

Possible Risks and Discomforts

There were no anticipated health risks in responding to questions about diarrhoea and sanitation in this study and also during observational studies. However, there was some discomfort and embarrassment in the conduct of observational studies, where the researcher had to enter the private space of study participants to observe household water sources, and sanitation facilities. To minimize such situations, the research was trained to be culturally sensitive, humane, and polite to study participants. Emphasis was placed on informing study participants on their willingness to withdraw at any time within the study phase.

Benefits

The study benefitted both individuals and the study community. At the individual level, households were expected to become aware and gain knowledge on water, sanitation and hygiene practices on diarrhoea diseases. At the community level, it was anticipated that outcomes of the project would lead to better environmental health and public health benefits.

Cost

There was no cost to study participants in this project. Study participants were reimbursed for any cost incurred to participate in any aspect of the study such as transport. The project made

provisions to refresh participants especially in meetings and engagements that extended for a long period of time.

Compensation:

Study participants were compensated for their time by giving them items such as soap. They were also refreshed depending on the length of time they had to spend in the study.

Confidentiality

Unique codes were used instead of names for interview purposes. Where during the conduct of the research, observations or findings that could be derogatory were made, these were reported generally and were not linked to individuals, communities or any particular institution. Also, the researcher committed to use all data gathered only for the purpose of the research and nothing else. Data collected was stored in a password protected server and made available to the support team only for data analysis purposes.

Study Participation

Participation in this study was voluntary. There was no penalty if anyone decided not to be in the study. If one decided not to be in the study, the person did not lose any benefits otherwise due. Everyone was free to withdraw from this research study at any time. The participant's choice to leave the study did not affect their relationship with any institution.

Outcome of the Study

It is expected that the study will help coastal communities improve both their environmental and public health situations. It is also anticipated that the findings will be used to influence policy- and decision-makers to provide country-specific, evidence-based solutions towards addressing WASH related diarrhoea risks in coastal communities.

Feedback to Participant

As part of the bigger project, this study will use feedback looping strategy of community network platforms. These platforms will contribute to dissemination of research findings using locally sensitive innovative means for research communication. In addition, the study will present its findings at the periodic open fora, which will be organized at least once a year within the community by the mother project.

Funding Information

The study was partly funded by the Danish Government (DANIDA) through the Coastal Community Resilience to Climate Change and Diarrhoea Study being run by the University of Ghana.

Sharing of Participants Information/Data

No participant's personal information was shared at any time of the study and even after the study with any person, group of persons or institutions.

Provision of Information and Consent for Participants

All study participants were informed of the study details including processes and all procedures and consent sought for willingness to participate in the study. Where an individual expressed willingness to participate in the study, a consent form was completed, the details of which were read to the person if illiterate, or given to a literate person to read for him or herself. Those who agreed to participate were made to append their signature or thumbprint as evidence of granted informed consent.

Protection against COVID-19

All data collectors were provided with appropriate personal protective equipment including hand sanitizers, liquid soap, water, tissue and facemasks for themselves and extra facemasks for study respondents where necessary. The team ensured social distancing to reduce contact

exposures. All surfaces close to where researcher and participants met, example tables, doorknobs, etc. were disinfected with 70% alcohol sprays. All data collectors and research participants strictly followed the laid down guidance from the Ghana Health Service Ethics Review Committee.

CHAPTER 4:

RESULTS

4.1 : Phase 1 – Process Evaluation of WASH interventions in Anloga District 2018-2021

Documents reviewed

Document name

Sanitation for All, 2022. Sector Ministers' Meeting. Ghana country overview
CWSA, 2023. Water Safety Framework
GSS, 2022. 2021 PHC, Water and Sanitation
MSWR 2018, Guidelines for Targeting the Poor and Vulnerable for Basic Sanitation Services in Ghana
MSWR 2018, Water, Sanitation and Hygiene in Ghana, WASH Golden Indicators
CWSA Act (Act 564) 1998
WEDC 2005. Briefing Note Ghana , Assessing sanitation policy in Ghana
Act 564, 1998
Aquaya 2020. Ghana Institutional Framework for Water Provision
MWSR, MSWR Medium Term Expenditure Framework MTEF
Theory Of Change UNDAF Companion Guidance
NDPC, 2021. Agenda for Jobs II Creating Prosperity and Equal Opportunity for All 2022-2025.
Anloga District Assembly 2021. MTDP 2022 - 2025
Anloga District Assembly 2020. MTDP 2018 - 2021 (EXTRACT OF KEMA DMTDP, 2018 – 2021)
Anloga District Assembly. Annual reports 2019, 2020, 2021

4.1.1 : Description of Respondents

This part of the study involved 54 participants, of which 40 were engaged in focus group discussion, 10 were engaged in-depth interview and four (4) were key informant interview participants. For the FGD and IDIs, 20 and five (5) participants each were sampled from Anyanui and Atiteti communities respectively. However, only four (4) of five (5) participants for the KII were recruited from the district assembly since the Department of Social Welfare dropped out voluntarily. For the FGD, about six (6) of every 10 sampled participants were females (62.5%, n=25). While in the IDI, eight (8) out of the 10 participants were males and three (3) out of the four (4) KII participants were males. The ages of the interviewers ranged from 20 to 75 years with a median age of 40 years. Majority (47/54) of the respondents were

less than 60 years. About half (25/54) had primary or JHS education. Details of background characteristics of respondents interviewed during WASH process evaluation is presented in Table 4.1

Table 4.1 Background characteristics of respondents interviewed during WASH process evaluation by interview type, Anloga, 2022

	Focus Group Discussion	In-depth Interview	Key Informant Interview	Grand Total
Variable	**n (40)**	**n (10)**	**n (4)**	**n (54)**
Community				
Anyanui	20 (50.0)	5 (50.0)	0 (0.0)	25 (46.3)
Atiteti	20 (50.0)	5 (50.0)	0 (0.0)	25 (46.3)
District assembly	0 (0.0)	0 (0.0)	4 (100.0)	4 (7.4)
Sex				
Female	25 (62.5)	2 (20.0)	1 (25.0)	28 (51.9)
Male	15 (37.5)	8 (80.0)	3 (75.0)	26 (48.1)
Age				
Mean (SD)	**41(±14)**			
<30	11 (27.5)	2 (20.0)	0 (0.0)	13 (24.1)
30-39	10 (25.0)	1 (10.0)	0 (0.0)	11 (20.4)
40-49	9 (22.5)	2 (20.0)	2 (50.0)	13 (24.1)
50-59	6 (15.0)	2 (20.0)	2 (50.0)	10 (18.5)
>=60	4 (10.0)	3 (30.0)	0 (0.0)	7 (13.0)
Educational level				
None	4 (10.0)	0 (0.0)	0 (0.0)	4 (7.41)
Primary/ JHS	20 (50.0)	5 (50.0)	0 (0.0)	25 (46.3)
Secondary	12 (30.0)	0 (0.0)	0 (0.0)	12 (22.2)
Tertiary	4 (10.0)	5 (50.0)	4 (100.0)	13 (24.1)
Marital status				
Single	11 (27.5)	2 (20.0)	0 (0.0)	13 (24.1)
Married	26 (65.0)	4 (40.0)	4 (100.0)	34 (63.0)
Divorced	1 (2.5)	2 (20.0)	0 (0.0)	3 (5.6)
Widow/widower	2 (5.0)	2 (20.0)	0 (0.0)	4 (7.4)
Religion				
Christian	25 (62.5)	7 (70.0)	4 (100.0)	36 (66.7)
Traditionalist	15 (37.5)	3 (30.0)	0 (0.0)	18 (33.3)
Occupation				
Unemployed	1 (2.5)	0 (0.0)	0 (0.0)	1 (1.9)
Formally employed	3 (7.5)	6 (60.0)	4 (100.0)	13 (24.1)
Fisherfolk	4 (10.0)	3 (30.0)	0 (0.0)	7 (13.0)
Farmer	2 (5.0)	0 (0.0)	0 (0.0)	2 (3.7)
Trader	18 (45.0)	0 (0.0)	0 (0.0)	18 (33.3)
Artisan	10(25.0)	0 (0.0)	0 (0.0)	10 (18.5)
Other (specify)	2 (5.0)	1 (10.0)	0 (0.0)	3 (5.5)

4.1.2 : Components of WASH Intervention Assessed

Globally, WASH for countries is tracked by the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP). The tracking is done with 26 indicators under the three main groups: water, sanitation and hygiene. The indicators assess the proportion of the population that uses different types of water sources, sanitation facilities and handwashing facilities (WHO/UNICEF, 2018). The Anloga District focuses on two of the JMP indicators for the population:

a) Provision of basic drinking water services (that is improved water sources not exceeding 30 minutes collection time)
b) Provision of limited sanitation services (that is improved sanitation facilities which are shared)

4.1.3 : Context of Intervention

The Anloga District was carved out of the Keta Municipal by the Legislative Instrument (L.I.) 2372 of 2018 and inaugurated on the 19th of February 2019. Activities of the district assembly are based on regulations of the National Development Planning Commission (NDPC). NDPC is a national agency with the core function of coordinating decentralized development and planning systems in Ghana (National Development Planning Commission (NDPC), 2015). Thus, all water, sanitation and hygiene policies from the various sectors and ministries are collated and used in guiding the WASH implementation in the country. The district implemented interventions adopted to suit their specific needs based on the Medium-Term National Development Policy Framework complied by the National Development Planning Commission (NDPC). For the year 2018 – 2021, a Medium-Term Development Plan was adapted to guide their activities which provide socio-economic infrastructure and services in the district. The activities of the district are funded mainly by District Assembly common

Funds provided by the Government of Ghana and internally generated funds. These activities implemented were guided by extracts of portions pertaining to the district.

After its establishment, the Anloga District continued to implement its activities stated in the Keta Municipality 2018-2021 District Medium-Term Development Plan. Under WASH interventions, the district's goals were to: a) improve access to safe and reliable water supply services for all. b) Enhance access to improved and reliable environmental sanitation service. c) Promote efficient and sustainable wastewater management. These goals were in line with the SDG 6 (Ensure available and sustainable management of water and sanitation for all). However, targets were set for only provision of portable water and toilet facilities in the communities. There was no data available to track other indicators such as handwash facilities in communities and schools or dump waste sites in the district. Data was only available for water sources and toilet facilities constructed in the communities during the period. The district implemented its own WASH interventions as part of its regular activities. The implementation was coordinated by the district assembly.

Implementation of WASH related activities from 2018 – 2021 were done by the district and funded mainly by Government of Ghana funds (such as the District Assemblies Common Fund (DACF), Member of Parliament Common Funds, District Performance Assessment Tool (DACF-RFG), and Central Government direct transfers), and Internally Generated Funds (IGF). Ghana Water Company Limited was the main provider of tapping pipe-borne water to the communities. According to the District Assembly, implementation of WASH activities was indicated to have been done by the district WASH committee made up of the following departments:

1. Department of Planning
2. Department of Works

3. Department of Environment Health and Sanitation
4. Department of Social Welfare
5. District Health Directorate

However, the Department of Social Welfare indicated it had not been part of the implementation of any intervention in recent times.

4.1.4 : Reach of Intervention

The district used the 2010 population and housing Census as the basis for the Projections and targets for the intervention they implemented.

The intended target population for the interventions were 30,600 for water and 87,763 for improved toilets facilities. The reach for the two interventions were 72.5% for water sources and 49% for toilet facilities.

Table 4.2: Intervention Reach for Anloga District WASH interventions Implemented, 2018-2021

Intervention	Intended target population	Target population reached	Intervention Reach
Water sources	30,600	22,000	72.5%
Toilet facilities	87,763	45,000	49.0%

4.1.5 : Dose Delivered

The interventions the district set out to implement were portable water sources (borehole or standpipes) and toilet facilities (KVIP or water closets for households and the community). The district set targets for both water sources and toilet facilities based on the population of the district and the proportion of people who were not served by the existing interventions.

For the water source, the target set by the district is achieved with the standard that one borehole/pipe = 300 people served with water. For water interventions, 106 boreholes/point sources were required to be provided throughout the planned period (2018 -2021) for the district to be able to meet its target.

For the sanitation interventions, the district set the target based on the assumptions below:

- KVIP is the minimum hygienic standard for excreta disposal,
- Minimum number of people per squatting hole is 50
- Twenty squatting holes per KVIP
- Only public KVIP were considered in the calculation and on the assumptions of one KVIP to 1000 population.

The district needed 88 KVIPs (equivalent to 1755 holes/WCs) to meet its set target throughout the planned period (2018 -2021).

4.1.6 : Dose Received

The district assessed the coverage of their targets by using projections from the 2010 population and housing census. As at the end of 2021, there was still a deficit of 32 boreholes unconstructed (Table 4.3). As at the end of 2021, there was still a deficit of 45 KVIPs from the 2018-2021 implementation period to provide adequate sanitation facilities to the people.

Table 4.3: Dose of Intervention delivered and received target in Anloga District, 2018-2021

District WASH Intervention	Dose delivered Target set	Dose received Target achieved	Percentage of set target achieved (%)
Water source structure	106	74	69.8
Toilet facility	88	43	48.9

To achieve the target of improved toilet facilities, the district is currently enforcing the new government policy on every new building having a toilet in its plan before it is approved for construction.

"However, because of the position of the law on construction of public toilets, individuals would therefore be encouraged to build private toilet facilities in their homes which are better managed and catered for."

Extract from the 2022-2025 Mid-term Development Agenda, Anloga

4.1.7 : Fidelity

The Community's Water and Sanitation Agency Sector (CWSA) Guidelines for developing water and sanitation structures in Ghana was adapted as the framework for evaluating WASH implementation steps. The process for implementing interventions was based on the steps below.

Table: 4.4: Framework for Measuring Anloga District 2018-2021 WASH Implementation Steps

Implementation step	Requirement	Step Implementation Status
1. Project management	Presence of a project steering committee made up of required partners	Fully implemented
2. Promotion	Sensitization of communities on eligibility plan	Partially implemented
3. Community development	Carrying out the following activities community entry, sensitization, baseline data collection, hygiene and sanitation promotion, site selection, monitoring and support for construction	Partially implemented
4. Participatory planning	Planning involving District Assembly staff, community groupings, community members each party fully engaged and all planning together	Not implemented
5. Design	Designed according to CWSA design guideline. Equipment specification according to accepted standards. Each structure according to prescribed design	Fully implemented
6. Construction	Done in accordance with specified conditions set	Fully implemented
7. Operation and maintenance	System meets sustainability requirements. Community actively involved or engaged in maintenance Record on operation available	Partially implemented
8. Sanitation	Focus on development of household latrines, Community latrines for schools and clinics. Design according to guidelines and sanitation ladder	Fully implemented
9. Monitoring and Evaluation	Progress monitoring of implementation done. End of project evaluation carried out with stakeholders	Partially implemented
10. Post Project Support	1-year post project support provided	Not implemented

*Adapted from (Community Water and Sanitation Agency, 2010)

4.1.7.1 : Assessment of Implementation Process

Using the CWSA adopted strategies framework, the Anloga District fully implemented five out of the ten steps in building of the WASH structures namely: project management, design, construction, sanitation, monitoring, and evaluation. The district is partially implementing promotion, community development, operation and maintenance. Participatory planning and post project support were not being implemented by the district (Table 4.5)

Table 4.5a: Evidence of Anloga District during 2018- 2021 WASH implementation Steps based on interviews and desk review

Step	Project	Status	Evidence
Step 1:	**Project management**	Fully implemented	The District WASH committee is active. However, some departments do not play an active role. All 4 members interviewed indicated that the assembly implements an action plan, which contains these WASH interventions. Clearly, there are legal grounds for constructing the intervention and everyone is aware of this. *"Yes, we have an implementation plan that we normally follow that is from the planning unit"* (KII 2, Anloga)
Step 2	**Promotion**	Partially implemented	There does not seem to be much communication with the communities on the implementation and new developments. Though some of these new changes affect the way WASH is to be implemented. For example, discontinuation of community KVIPs and encouraging the building of household toilet facilities. *"For some time, the government policy is no longer promoting the construction of capital latrines, so what the government is doing is that it is collaborating with international NGOs like UNICEF to promote ownership of household latrines."* (KII 3, Anloga) The community members however, do not seem to be abreast with these new policies or have not fully understood them. The community members are still expecting the government to provide some services, which are no longer available and are not aware of their expected roles. "*When the white man helped other communities to build their KVIP he just asked them to provide cement but when it got to Anyanui community the story tuned to monetary issues. They wanted us to pay before they can build KVIP for individual homes.* (Anyanui FGD2)
Step 3	**Community Development**	Partially implemented	Generally, the district begins with engaging the community, builds and hands over. Some of the community development steps were fully carried out while basic steps like baseline data collection, community entry were followed. "*So, the planning process starts with data collection when we go to our various communities to identify the problems then together with them, we identify solutions and that informs our plan. So first of all, we engage the community as to what the problems are and together with them, we develop a plan and put budget on it. When we see funding that is when we execute the plan."* (KII 1, Anloga) The steps missed made some communities feel left. *"Yes, he just comes to supervise and go. This is because the people in the assembly, anytime there is such jobs, they bring their own people for it. They did not use anybody in the community. They brought people from Anloga to do it."* (IDI, Anyanui) *"For me I would say the community was not involved, they worked at length before engaging us to come and gather stones as free labour which I did not partake*". (Anyanui FGD 2)

Table 4.5b: Evidence of Anloga District during 2018- 2021 WASH implementation Steps based on interviews and desk review

Step	Project	Status	Evidence
Step 4	**Participatory Planning**	Not implemented	The community members and the district staff interviewed all mentioned that few community members were engaged only during the planning process and others brought on board briefly when implementation was underway. *"We were not engaged from the onset, people started contemplating whether it is NPP who brought it or the community. After completion they leave but the assemblyman is the best person to answer these questions because he was in charge".* (Anyanui FGD 2) "*The community, the only role they played, that was the initial stages, giving us the site, that is the first role they played… they've allocated the site that this is where we put that particular facility*." (KII 2, Anloga) "*Before the KVIP was built the community had a place for it to be placed and the elders have given land out but during the arrival of the KVIP it was placed at its current location and we could not do anything about it. Because we needed it badly, we don't have a choice than to leave it as such*". Anyanui FGD 1
Step 5	**Design**	Fully implemented	Implementations are according to the plan the district uses. The district ensures that they stick to the approved designs. *"There is a committee at the district level which coordinates WASH constructions. Plans are sent to NDPC for approval, communities are supposed to be informed after the approval. Interventions are designed and planned based on the population. Projects are given to contractors based on bidding. Contractor introduced to the community; they agree on assistance they can give him as he undertakes the construction in the community. After completion, it is handed over to the population it was intended for"* (KII 1, Anloga)
Step 6	**Construction**	Implemented	The district constructs based on the agreed design and engages the services of approved contractors going through the laid down procedure. "*Yes, the boys helped in digging the holes for the KVIP but there were contractors originally assigned to the task."* (Anyanui FGD 1) *"……. it comes to the DCE and is incorporated in the action plan and then since we normally operate the action plan… so from there it gets to the works youth department then we have to design the design, that is based on the population, we took both male and females into consideration… then we came out that, okay, they need 8-seater, that is 4 for the boys and then 4 for the girls…"* (KII 2, Anloga)

Table 4.5c: Evidence of Anloga District during 2018- 2021 WASH implementation Steps based on interviews and desk review

Step	Project	Status	Evidence
Step 7	**Operation and maintenance**	Partially implemented	Only specific interventions had operation and maintenance factored into them. Namely water. For the toilet facilities, the process ended with the facility being built. There seems to be no plan for waste management at the community level *"I told you earlier on that am the carpenter that worked on the roof so I have the keys of the toilet with me and I'm the one that opened it for usage. The woman chose one side and the men too chose another*" Anyanui FGD 1 *"Just like they said, we take care of the refuse individually by burying them, for the toilet facility, no one is assigned to taking care of them*." Anyanui FGD 1 For water interventions, there was a sustainable system in place in the various communities. "*Before the pipes were opened for us to start using it, they came to speak to us. We were told how to manage and use the water well. We were told the water will be free in the first month and after the one month, it will be sold to us. We were told to find someone from the community to be in charge of the sale of the water on behalf of the community, keeping records of the bill and making accounts to the community. When the government take their bills, the community will also have their share. That is how we have been doing it. When the bill is paid to the government, the remaining amount is shared between the town and the person in charge of the sales. This helps to bring development to the community*". (Ateteti FGD 2)
Step 8	**Sanitation**	Implemented	The district had started to roll out of the government policy on household toilets. "*For some time, the government policy is no longer promoting the construction of capital latrines, so the government is doing is that it is collaborating with international NGOs like UNICEF to promote ownership of household latrines. There is a reason why the government t is deviating from the construction of community-owned latrines. They are not well taken care of the management of it is always a problem. This is why government has amended its policy which is now ownership of household latrines*". (KII 3, Anloga) *"However, because of the position of the law on construction of public toilets, individuals would therefore be encouraged to build private toilet facilities in their homes which are better managed and catered for."* (Quoting from the 2018-2021 Mid-term Development Plan)
Step 9	**Monitoring evaluation**	Partially implemented	Though there is a committee for monitoring at the district level, there was no evidence that they had carried out any monitoring activity recently. *The committee at the district Assembly level is known as the district inter-coordinating committee on sanitation. The monitoring team, which is made up of the district environmental health department, works department, planning department and an independent member from the community assists during the monitoring process.* (KII 3, Anloga) "*Yes, he just comes to supervise and go. This is because the people in the assembly do that, anytime there is such jobs" (IDI T, Anyanui)*
Step 10	**Post project support**	Not implemented	The community reported that they had not witnessed any monitoring activities after the completion of the WASH structures. Even when they had reached out to the district for support. "*Town council is in charge to monitor sanitation in our homes and the community at large but they fail to do it. Even if someone gives them information about someone people littering the community they won't investigate".*(Anyanui FGD 2)

4.1.7.2 : Findings from Interactions with Households

At the household level, individuals also shared the same views as the focus group discussions. All (30/30) those engaged knew who led the process to bring the WASH structures to their communities. Most (20/30) also knew the source of funding for the structures. Though more than half (17/30) could not tell the origin or why they were brought to them. Less than half (14/30) admitted receiving information on the use of the structures

Aside government provision, some structures had been provided by individuals and non-governmental organisations (NGOs).

4.1.7.3 : Challenges Experienced during WASH Implementation

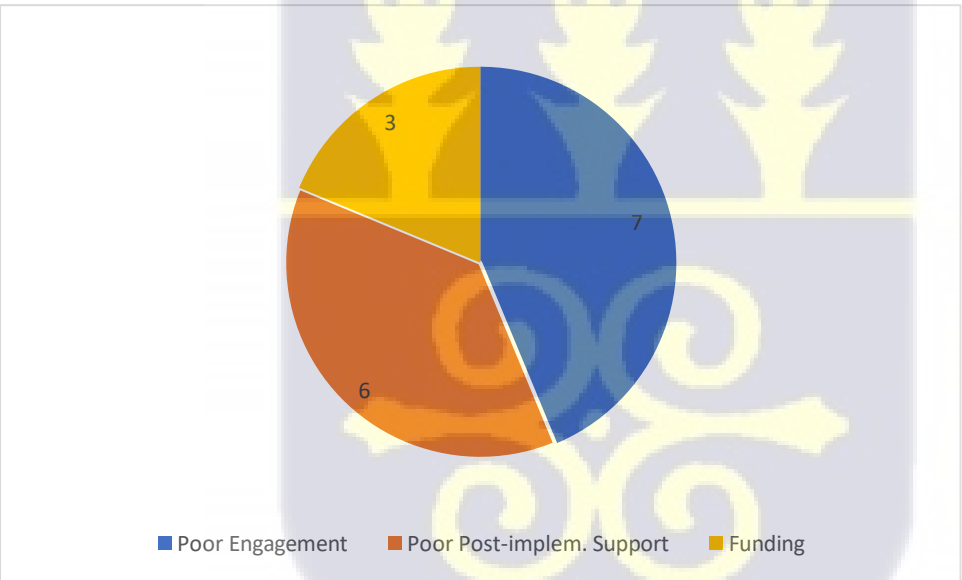


Figure 4.1: WASH implementation challenges identified in Anloga District, 2022

The main challenges identified from interviews were poor engagement with communities during implementation, poor post implementation support for communities and lack of funding.

Table 4.6: Description of Challenges identified in Anloga District during the implementation of WASH interventions from 2018 -2021

Challenges identified	Description of challenge	Source of information
Poor engagement and communication with communities (7 quotes)	Community leaders, opinion leaders and regular community members shared their displeasure about how the engagement and implementation had been handled in their various communities. Some felt they had been used for manual labour and not paid during the construction, others mentioned they were not informed about the construction. There was even an instance where a structure was built for a community and left abandoned since no one handed it over to the community after the project was completed.	- Key informant interviews - In-depth interviews - Focus group Discussions - Checklist
Lack of Post implementation support (6 quote)	The communities visited have WASH structures however, they are unable to take good care of them. Since there is no post-implementation monitoring going, on where one inspects and points out to them how to effectively maintain and manage the structures available to them. This has led to the degradation of a number of WASH structures, putting pressure on the few left in the communities.	- In-depth interviews - Focus group Discussions
Lack of funding (3 quotes)	Currently, all interventions are implemented under the district assembly, therefore once there is a delay in release of funds or unavailability of funds, all projects are put on hold. This was evident in the community interviews as community members recounted how they completed interventions with their own fund. This was confirmed by the district assembly staff who confirmed that a delay in release of government funds resulted in delays in completion of started projects. Due to lack of funding, the district departments are also unable to carry out regular activities of monitoring in the communities, conduct community durbars and complete engagements.	- Key informant interviews - Focus group Discussions - District Annual report

4.2 : Phase 2 – Case-Control Study in Anloga District 2018-2021

4.2.1 : Demographic Characteristics of Caregivers Enrolled in Case-control study, Anloga, 2023

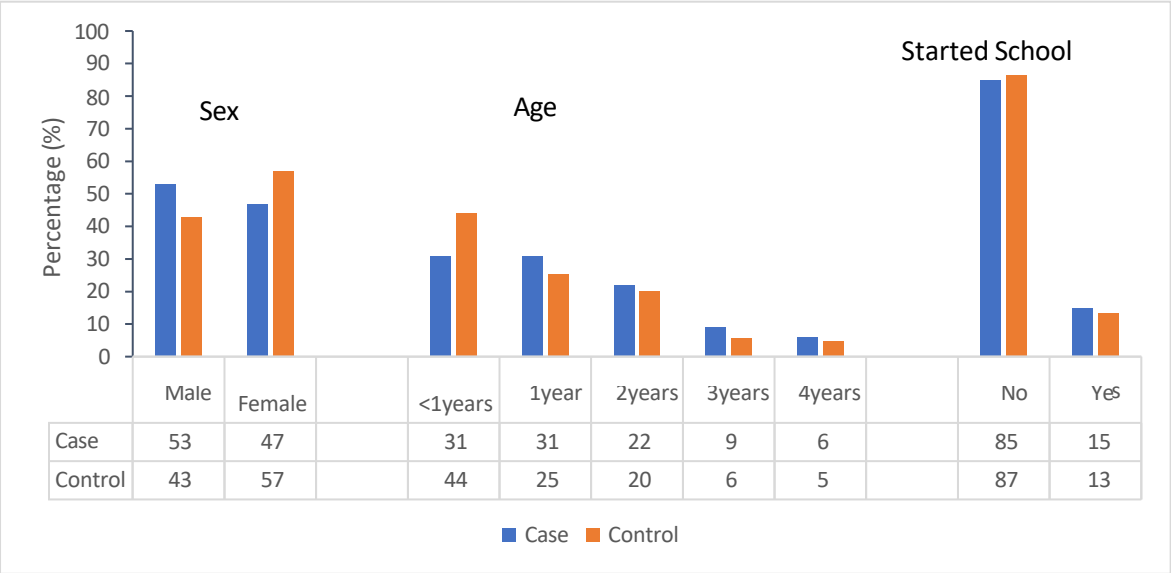
A total of 386 (Case=193 and Control 193) under 5 children were included in the study at ratio 1 case: 1 control. The mean age of caregivers was 29.46 (±7.15) years. Most of the caregivers were between the age group 20-30 years. Caregivers of cases were relatively more educated than the controls (P-value = 0.004). Majority of the caregivers (both case and controls) were traders. Christianity was the dominant religion with a higher percentage of control caregivers being Christians compared to the cases (P<0.05) (Table 4.7). The average household size was 5 (±2) with the largest household having 15 people and the smallest having 2.

Table 4.7: Background characteristics of caregivers interviewed in Anloga District, 2022

Factor	Case n = 193	Control n = 193	Total n = 386	p-value
	n (%)	n (%)	386	
Mean ± SD	29.14 ± 7.36	29.79 ± 6.94	29.46 ± 7.15	0.374
Age of caregiver (in complete years)				**0.017**
<25years	59 (30.57)	33 (17.10)	92 (23.83)	
25-30years	72 (37.31)	93 (48.19)	165 (42.75)	
31-40years	49 (25.39)	52 (26.94)	101 (26.17)	
>40	13 (6.74)	15 (7.77)	28 (7.25)	
Level of education of caregiver**				**0.004**
Primary/less	61 (31.61)	64 (33.16)	125 (32.38)	
Middle/JHS	76 (39.38)	99 (51.30)	175 (45.34)	
SHS/above	56 (29.02)	30 (15.54)	86 (22.28)	
Primary occupation of caregiver*				0.11
Unemployed	29 (15.03)	25 (12.95)	54 (13.99)	
Trader	92 (47.67)	115 (59.59)	207 (53.63)	
Artisans	50 (25.91)	34 (17.62)	84 (21.76)	
Other	22 (11.40)	19 (9.84)	41 (10.62)	
Number of people in household				0.83
1-5	124 (64.25)	126 (65.28)	250 (64.77)	
>5	69 (35.75)	67 (34.72)	136 (35.23)	
Religion				0.23
Christian	155 (80.31)	164 (84.97)	319 (82.64)	
Other religion	38 (19.69)	29 (15.03)	67 (17.36)	
Wealth Index				**0.031**
Poor	53 (27.46)	77 (39.90)	130 (33.68)	
Middle	76 (39.38)	59 (30.57)	135 (34.97)	
Rich	64 (33.16)	57 (29.53)	121 (31.35)	

%: Column Percentage

The age of the children ranged from 0 to 58 months with a median age of 16 (IQR: 7 – 27) months. The median age of the cases was significantly higher than that of the controls (Cases – 19 (IQR: 9 – 28) and Controls – 13 (5 – 25), P-value =0.005). Most of the children were below 1 year (37.5%; 146/386). There were more females (52.1%: 201/386) in the survey than males (47.9%: 185/386). The overall male-to-female ratio was 1:1. Most of the children (87.5%: 331/386) had not started schooling (Figure 4.2).



	Male	Female		<1years	1year	2years	3years	4years		No	Yes
Case	53	47		31	31	22	9	6		85	15
Control	43	57		44	25	20	6	5		87	13

Figure 4.2: Background characteristics of child under five enrolled in the case control study

Table 4.6 shows the effect of background characteristics on the diarrhoea status. From the adjusted binary logistic regression model, socio-economic status, educational level, sex of the child, age of caregiver and wealth index had statistically significant effect on diarrhoea status (P-value <0.05). The odds of diarrhoea among children of caregivers aged 25-30 was 57% lower than children with caregivers less than 25 years (aOR: 0.43, 95% CI: 0.22 – 0.83). Female children had 41% reduced odds of diarrhoea compared to male children (aOR: 0.59, 95%CI: 0.37 – 0.95). Children with care givers who had secondary school and above education had 2.3 times odds of diarrhoea as much as children with care givers who had primary or lower level of formal education (aOR: 2.28, 95%CI: 1.07 – 4.83). While the odds of diarrhoea among children whose care givers had middle level of socio-economic status 2.16 times the odds of children with care giver of poor level of socio-economic status, (aOR: 2.16, 95%CI:1.16 – 3.32) (Table 4.8).

Table 4.8: Background characteristics of caregiver and child associated with diarrhoea among children under five years in Anloga District, 2022

	Generalised Linear Model (GLM)				LASSO Model	
	Unadjusted GLM		Adjusted GLM		LASSO	
Variable	**uOR [95% CI]**	**P-value**	**aOR [95% CI]**	**P-value**	**aOR [95% CI]**	**P-value**
Age of child [in complete years]						
<1years	1		1		1	
1year	1.68[1.00-2.80]	0.048	1.95[1.07-3.58]	0.030	1.76[0.93-3.33]	0.084
2years	1.54[0.90-2.62]	0.116	1.73[0.82-3.67]	0.147	1.70[0.79-3.69]	0.176
3years±	2.09[1.08-4.04]	**0.028**	2.83[1.08-7.38]	0.034	2.68[0.93-7.72]	0.067
Sex						
Male	1		1		1	
Female	0.67[0.44-1.02]	0.061	0.59[0.37-0.95]	**0.031**	0.51[0.32-0.83]	**0.007**
Level of education of caregiver						
Primary/less	1		1		1	
Middle/JHS	0.81[0.52-1.25]	0.333	0.92[0.54-1.58]	0.773	0.81[0.43-1.55]	0.533
SHS/above	1.96[1.13-3.38]	0.016	2.28[1.07-4.83]	**0.032**	2.18[0.92-5.17]	0.078
Age of caregiver [in complete years]						
<25years	1		1		1	
25-30years	0.43[0.26-0.73]	**0.002**	0.43[0.22-0.83]	**0.012**	0.43[0.20-0.93]	**0.032**
31± years	0.52[0.31-0.87]	0.013	0.67[0.37-1.53]	0.044	0.71[0.32-1.59]	0.41
Primary occupation of caregiver						
Unemployed	1		1		1	
Trader	0.69[0.38-1.25]	0.224	1.34[0.57-3.13]	0.505	1.97[0.76-5.07]	0.161
Artisans	1.27[0.68-2.37]	0.458	2.08[0.86-5.03]	0.105	2.57[0.88-7.47]	0.084
Other	1.00[0.43-2.31]	0.997	1.56[0.57-4.25]	0.389	2.14[0.67-6.83]	0.199
Number of people in household						
1 – 5	1		1		1	
>5	1.05[0.69-1.58]	0.828	0.74[0.45-1.23]	0.250	0.65[0.36-1.18]	0.158
Religion						
Christian	1		1		1	
Other religion	1.39[0.84-2.29]	0.201	1.82[0.96-3.49]	0.067	1.56[0.70-3.49]	0.281
Wealth Index						
Poor	1		1		1	
Middle	1.87[1.17-3.00]	**0.009**	2.16[1.16-3.32]	**0.009**	1.94[1.05-3.56]	**0.033**
Rich	1.63[1.01-2.65]	0.047	1.44[0.70-2.53]	0.325	1.23[0.57-2.64]	0.599
Child in school						
No	1		1		1	
Yes	1.14[0.63-2.06]	0.676	0.49[0.21-1.14]	0.097	0.65[0.24-1.78]	0.403

uOR: Unadjusted odds ratio, aOR: Adjusted odds ratio, CI: Confidence interval,

4.2.2 : Household WASH practices of caregivers enrolled in case-control study, Anloga, 2023

Table 4.9 presents the distribution of WASH characteristics of the study participants by their diarrhoea status. More than 90% of cases and controls used an improved water source. More cases (152/193) had access to an improved toilet facility than controls (145/193) ($p<0.001$) but less of the case children used the facility (48/193) than controls (79/193). Over 80% of cases and controls store household water in plastic containers or buckets. Over 70% of cases and controls did not use water bottles or feeding bottles, of these, over 90% wash the bottles daily (Table 4.9). The proportion of cases who used cups with handles for fetching water from their receptacles (71.5%; 138/193) was not significantly higher than controls (70.5%; 147/193) ($p=0.82$). More than 70% of cases and controls used an improved toilet facility. On disposal of child's diarrhoea stool, over 60% of cases and control caregivers mentioned they properly disposed of their child's diarrhoea stools (by allowing the child to use the toilet or disposing the stool in the toilet). More caregivers of cases had good hand washing practices (25.9%; 50/193) compared to controls (19.7%: 38/193). More diarrhoea cases were reported in the wet season (84.72%:327/386).

Table 4.9: Household WASH practices of children under five years in Angola District, 2022

Factor	Case n = 193	Control n = 193	Total n = 386	p-value
N	n (%)	n (%)	386	
Main source of drinking water and for domestic purposes				0.31
Unimproved	3 (1.55)	1 (0.52)	4 (1.04)	
Improved	190 (98.45)	192 (99.48)	382 (98.96)	
Child use of feeding/ water bottle				0.62
No	149 (77.20)	153 (79.27)	302 (78.24)	
Yes	44 (22.80)	40 (20.73)	84 (21.76)	
Frequency of washing bottle with soap and water				0.39
Daily	41 (93.18)	39 (97.50)	80 (95.24)	
Weekly	2 (4.55)	0 (0.00)	2 (2.38)	
Other	1 (2.27)	1 (2.50)	2 (2.38)	
Household water storage				0.89
Plastic container/bucket	160 (82.90)	161 (83.42)	321 (83.16)	
Other method	33 (17.10)	32 (16.58)	65 (16.84)	
Household receptacles for fetching water from the storage				0.82
Using a cup with a handle	138 (71.50)	136 (70.47)	274 (70.98)	
Other method	55 (28.50)	57 (29.53)	112 (29.02)	
Type of toilet facility members of your household use				0.40
Unimproved	41 (21.24)	48 (24.87)	89 (23.06)	
Improved	152 (78.76)	145 (75.13)	297 (76.94)	
Children use of the toilet facility**				**<0.001**
No	145 (75.13)	114 (59.07)	259 (67.10)	
Yes	48 (24.87)	79 (40.93)	127 (32.90)	
Disposal of the child's diarrhoea stools				0.40
Proper	120 (62.18)	128 (66.32)	248 (64.25)	
Improper	73 (37.82)	65 (33.68)	138 (35.75)	
Handwashing Practice				0.15
Good	143 (74.09)	155 (80.31)	298 (77.20)	
Poor	50 (25.91)	38 (19.69)	88 (22.80)	
Season				0.89
Dry Season	30 (15.54)	29 (15.03)	59 (15.28)	
Wet Season	163 (84.46)	164 (84.97)	327 (84.72)	

%: Column Percentage

In investigating the effect of these WASH related factors on diarrhoea status, two different nested models were fitted. Generalised linear regression model and a LASSO with cross-validation model. For the LASSO model all variables (socio-demographic, nutritional and

Health seeking) were controlled for in the model. This was done to ensure there was no interference in the model and to get a true value of the co-efficient.

From the adjusted Genralised Linear Model (GLM) with logit link, children from households where children use the toilet facility was the only factor that was significantly associated with diarrhoea status. Children from households where children use the toilet facility had 61% reduced odds of diarrhoea compared to those from households where children do not use the toilet facility (aOR: 0.39, 95%CI: 0.22 - 0.68).

Table 4.10: Household WASH risk factors of diarrhoea among children under five years, Anloga District, 2022

Variable	Case	Control	Generalised Linear Model (GLM)				LASSO	
	n = 193	n = 193	Unadjusted GLM		Adjusted GLM			
	n (%)	n (%)	uOR [95% CI]	p-value	aOR [95% CI]	p-value	aOR [95% CI]	p-value
Child use of feeding/ water bottle								
No	149 (77.20)	153 (79.27)	1		1		1	
Yes	44 (22.80)	40 (20.73)	1.13 [0.71-1.79]	0.605	1.32 [0.72-2.42]	0.366	1.18 [0.58-2.37]	0.648
Household cooking water storage								
Plastic container/ bucket	160 (82.90)	161 (83.42)	1		1		1	
Other method	33 (17.10)	32 (16.58)	0.66 [0.22-1.92]	0.443	0.61[0.19-1.95]	0.366	0.54 [0.19-1.54]	0.248
Type of toilet facility household uses								
Unimproved	41 (21.24)	48 (24.87)	1		1		1	
Improved	152 (78.76)	145 (75.13)	1.23 [0.81-1.87]	0.34	1.27 [0.69-2.34]	0.441	1.11 [0.56-2.19]	0.765
Disposal of the child's diarrhoea stools								
Proper	120 (62.18)	128 (66.32)	1		1		1	
Improper	73 (37.82)	65 (33.68)	1.02[0.69-1.52]	0.91	1.11[0.61-2.03]	0.723	0.92 [0.46-1.80]	0.798
Children use the toilet facility								
No	145 (75.13)	114 (59.07)						
Yes	48 (24.87)	79 (40.93)	0.48 [0.31-0.73]	**0.001**	0.49 [0.61-2.03]	**0.010**	0.49 [0.25-0.99]	**0.045**
Handwashing Practice								
Poor	143 (74.09)	155 (80.31)	1		1		1	
Good	50 (25.91)	38 (19.69)	1.43 [0.95-2.15]	0.089	1.64[0.99-2.74]	0.053	1.53 [0.86-2.73]	0.145
Season								
Dry Season	30 (15.54)	29 (15.03)	1		1		1	
Wet Season	163 (84.46)	164 (84.97)	0.96 [0.75-1.24]	0.757	0.72[0.35-1.47]	0.370	0.89 [0.35-2.31]	0.819

%: column percentage, uOR: Unadjusted odds ratio, aOR: Adjusted odds ratio, CI: Confidence interval, The variable main source of drinking water and for domestic purposes was taken out of the model because almost all the respondents used water from improved sources hence causing non-convegence in the model. Controlled for Age of child, Sex, Level of education of caregiver, Age of caregiver, Primary occupation of caregiver, Number of people in household, Religion, Child in school, Stunting, Underweight, Wasted, Primary point of call for healthcare, Reason for choice of care, Source of Health advice, Child dewormed (past 6 months), Iron supplementation (past 6 months), Decision on seeking healthcare for sick child, Child on health insurance, Child Rotavirus vaccinated

4.2.3 : Nutritional Risk Factors Associated with Diarrhoea among Children under Five Years in Anloga, 2023

About 34.2% (132/386) of the children were stunted. While 20.0% (77/386) and 19.2% (74/386) of the children were underweight and wasting respectively. The stunting and underweight status of the children varied significantly between the cases and controls (P-value < 0.05). The proportion of cases with stunting was 14.5% more than the proportion of controls with stunting (41.5% vs 26.9%, P-value = 0.003). Similarly, the proportion of cases with underweight status was 17.1% higher than the proportion of controls who were underweight (28.5 vs 11.4, P-value <0.001).

Table 4.11: Anthropometric characteristics of among children under five years, Anloga District, 2023

	Case	Control	Total	P – value
	n (%)	n (%)	n (%)	
Stunting*				0.003
No (>-2 Z-score)	113 (58.55)	141 (73.06)	254 (65.80)	
Yes (<-2 Z-score)	80 (41.45)	52 (26.94)	132 (34.20)	
Underweight**				<0.001
No (>-2 Z-score)	138 (71.50)	171 (88.60)	309 (80.05)	
Yes (<-2 Z-score)	55 (28.50)	22 (11.40)	77 (19.95)	
Wasting				0.796
No (>-2 Z-score)	155 (80.31)	157 (81.35)	312 (80.83)	
Yes (<-2 Z-score)	38 (19.69)	36 (18.65)	74 (19.17)	

More cases were stunted (41.5%, 80/193) compared to controls (26.9%, 52/193). Cases were underweight (55/193) compared to the controls (22/193). Differences seen in stunting and underweight were both significant ($p<0.05$) (table 4.12).

In investigating the effect of these nutritional factors on diarrhoea status, the adjusted glm model showed that underweight status had a significant effect on diarrhoea status. The odds of diarrhoea among Underweight children were 3.5 times that of children who were not underweight (aOR: 3.47, 95%CI:1.67 - 7.21)

Table 4.12: Nutritional risk factors of diarrhoea among children under five years, Anloga District, 2023

Outcome	Case	Control	Generalised Linear Model (GLM)				LASSO Model	
	n = 193	n = 193	Unadjusted GLM		Adjusted GLM			
	n (%)	n (%)	uOR [95% CI]	P-value	aOR [95% CI]	P-value	aOR [95% CI]	P-value
Stunting								
No	113 (58.55)	141 (73.06)	1		1		1	
Yes	80 (41.45)	52 (26.94)	1.92 [1.31-2.82]	**0.001**	1.18 [0.70-2.01]	0.536	1.25 [0.68-2.32]	0.473
Underweight								
No	138 (71.50)	171 (88.60)	1		1		1	
Yes	55 (28.50)	22 (11.40)	3.10 [1.79-5.37]	**0.001**	3.06 [1.36-6.89]	**0.007**	2.77 [1.31-5.87]	**0.008***
Wasted								
No	155 (80.31)	157 (81.35)	1		1		1	
Yes	38 (19.69)	36 (18.65)	1.07 [0.67-1.72]	0.782	0.61 [0.31-1.18]	0.143	0.72 [0.35-1.48]	0.373

*Stunting dropped in LASSO model due to interaction between stunting and underweight variable. Controlled for Age of child, Sex, Level of education of caregiver, Age of caregiver, Primary occupation of caregiver, Number of people in household, Religion, Child in school, Child use of feeding/ water bottle, household cooking water storage cooking, Type of toilet facility household uses, Disposal of the child's diarrhoea stools, Children use the toilet facility, Handwashing Practice, Season, Primary point of call for healthcare, Reason for choice of care, Source of Health advice, Child dewormed (past 6 months), Iron supplementation (past 6 months), Decision on seeking healthcare for sick child, Child on health insurance, Child Rotavirus vaccinated

4.2.4 : Health Seeking Behaviours Associated with Diarrhoea among Children under Five Years in Anloga, 2023

Both cases and controls reported the health facility as their first point of call for health care (176/193). There was no significant difference between the primary point of call for healthcare for cases and controls (p value=1). Majority of respondents (328/386) reported that they chose their primary point of healthcare because it offered better care to their children. More controls (88.01%; 170/193) than cases (81.9%, 158/193) indicated that their choice was because it provided better care (p value>0.002). Most of the caregivers (290/386) reported that their children had not been dewormed. More cases (29%) had been dewormed compared to controls (20%). Differences observed in proportions of cases and control children dewormed was significant (p value = 0.034).

More than 95% of cases and control children had received rotavirus vaccination. More cases (97.4) had received rotavirus vaccination than controls (93.8). There was no difference between the proportion of cases on insurance and that of the controls (p value =0.89).

Decision on whether to seek healthcare for a sick child was taken mainly by the mother (65.9%). the difference observed between cases and controls for this variable was not significant. (p value=0.89). (Table 4.13).

Table 4.13: Caregiver health seeking characteristics risk factors of diarrhoea among children under five years, Anloga District, 2023

Factor	Case	Control	Value	P - value
N	**193**	**193**	**386**	
Primary point of call for healthcare				1.00
Health Facility	176 (91.19)	176 (91.19)	352 (91.19)	
Other	17 (8.81)	17 (8.81)	34 (8.81)	
Reason for choice of care				0.087
Better Treatment	158 (81.87)	170 (88.08)	328 (84.97)	
Proximity/Cost	35 (18.13)	23 (11.92)	58 (15.03)	
Source of Health advice				0.42
Health Professional	157 (81.35)	163 (84.46)	320 (82.90)	
Non-Health Professional	36 (18.65)	30 (15.54)	66 (17.10)	
Child dewormed (past 6 months) *				**0.034**
No	136 (70.47)	154 (79.79)	290 (75.13)	
Yes	57 (29.53)	39 (20.21)	96 (24.87)	
Iron supplementation (past 6 months)				0.82
No	137 (70.98)	139 (72.02)	276 (71.50)	
Yes	56 (29.02)	54 (27.98)	110 (28.50)	
Decision on seeking healthcare for sick child				0.67
Mother	125 (64.77)	129 (66.84)	254 (65.80)	
Other	68 (35.23)	64 (33.16)	132 (34.20)	
Child on health insurance				0.89
No	31 (16.06)	32 (16.58)	63 (16.32)	
Yes	162 (83.94)	161 (83.42)	323 (83.68)	
Child Rotavirus vaccinated				0.66
No	5 (2.59)	12 (6.22)	17 (4.40)	
Yes	188 (97.41)	181 (93.78)	369 (95.60)	

**p<0.05*

The uptake of rotavirus vaccine among cases and controls was above 90%. More cases had been vaccinated (90.9%, 188/193) compared to controls (93.8, 181/193) (Figure 4.3).

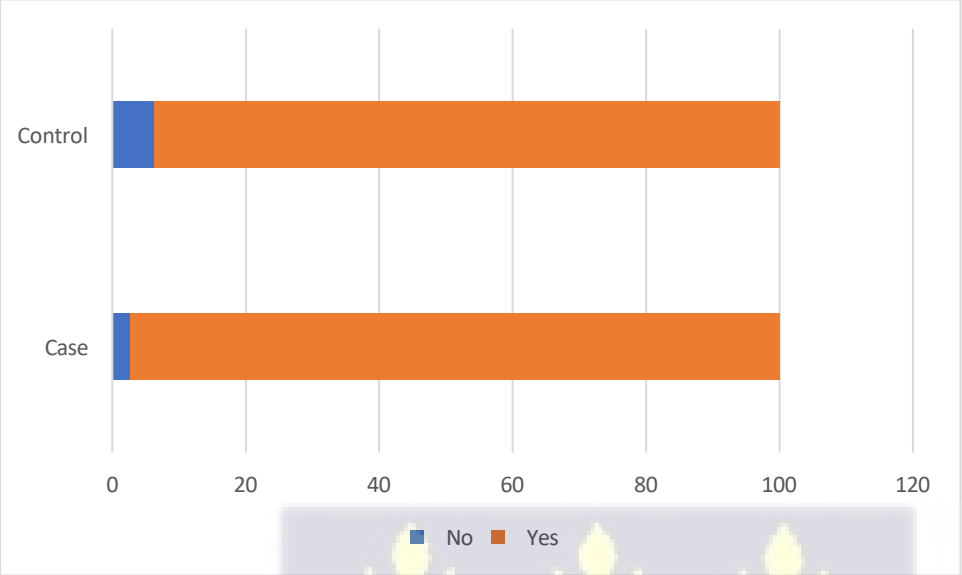


Figure 4.3: Proportion of cases and controls who have received rotavirus vaccine

Caregivers whose primary port of call for healthcare was not a health facility had a 6% reduced odds of diarrhoea compared to those whose first point of call was the health facility. However, the association was not found to be significant p=0.908). Children whose mothers do not take decision on seeking healthcare for child had a 1% higher odds of diarrhoea compared to mothers who took the decision on seeking healthcare for their sick child. However, the association was not found to be significant (p=0.985). Children on health insurance had a 14% reduced odds of diarrhoea compared to those without health insurance. This association was however not significant (p=0.692). Rotavirus vaccination was taken out of the model because almost all the children had received rotavirus vaccination hence there was non-convegence in the model. In investigating the effect of caregivers' health seeking behaviours on diarrhoea status, the adjusted GLM model and the LASSO showed that none of the variables assessed had a signigicant effect on diarrhoea status (Table 4.14).

Table 4.14: Caregiver health seeking risk factors of diarrhoea among children under five years, Anloga District, 2023

Outcome	Case	Control	Generalised Linear Model (GLM)				LASSO Model	
	n = 193	n = 193	Unadjusted GLM		Adjusted GLM			
	n (%)	n (%)	aOR [95% CI]	p-value	OR [95% CI]	p-value	aOR [95% CI]	p-value
Primary point of call for healthcare								
Health Facility	176 (91.19)	176 (91.19)	1		1		1	
Other	17 (8.81)	17 (8.81)	1.00 [0.50-2.00]	0.499	0.80 [0.31-2.05]	0.647	0.94 [0.35-2.57]	0.908
Reason for choice of care								
Better Treatment	158 (81.87)	170 (88.08)	1		1		1	
Proximity/Cost	35 (18.13)	23 (11.92)	1.64 [0.99-2.72]	0.985	1.24 [0.63-2.44]	0.523	0.97 [0.46-2.06]	0.939
Source of Health advice								
Health Professional	157 (81.35)	163 (84.46)	1		1		1	
Non-Health Professional	36 (18.65)	30 (15.54)	1.25 [0.78-1.98]	0.785	1.02 [0.53-1.94]	0.953	0.83 [0.40-1.73]	0.626
Child dewormed (past 6 months)								
No	136 (70.47)	154 (79.79)	1		1		1	
Yes	57 (29.53)	39 (20.21)	1.65 [1.04-2.64]	1.037	2.01 [0.94-4.29]	0.070	1.67 [0.76-3.67]	0.205
Iron supplementation (past 6 months)								
No	137 (70.98)	139 (72.02)	1		1		1	
Yes	56 (29.02)	54 (27.98)	1.05 [0.78-1.42]	0.781	0.61[0.31-1.19]	0.148	0.77 [0.35-1.71]	0.526
Decision on seeking healthcare for sick child								
Mother	125 (64.77)	129 (66.84)	1		1		1	
Other	68 (35.23)	64 (33.16)	1.10 [0.75-1.60]	0.753	0.87 [0.51-1.50]	0.625	1.01 [0.54-1.88]	0.985
Child on health insurance								
No	31 (16.06)	32 (16.58)	1		1		1	
Yes	162 (83.94)	161 (83.42)	1.04 [0.63-1.72]	0.626	1.02 [0.53-1.99]	0.943	0.86 [0.41-1.80]	0.692

Controlled for Age of child, Sex, Level of education of caregiver, Age of caregiver, Primary occupation of caregiver, Number of people in household, Religion, Child enrolled in school, Child use of feeding/ water bottle, household cooking water storage, Type of toilet facility household uses, Disposal of the child's diarrhoea stools, Children use the toilet facility, Handwashing Practice, Season, Stunting, Underweight, Wasted

4.2.5 Description of Diarrhoea Cases which Reported to Health Facilities in Anloga District

The most common symptoms diarrhoea cases presented with were fever (87.1%) and Mucus in stool (78.8%). The least common symptoms were dehydration (14.5%) and blood in stool (14.5%) Figure 4.4.

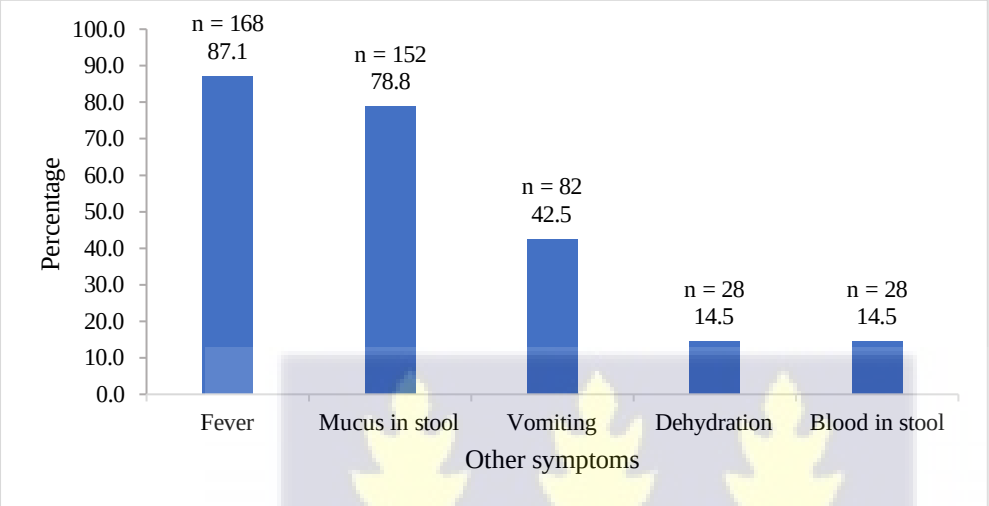


Figure 4.4: Symptoms diarrhoea cases presented with at health facilities in Anloga District

Majority of the cases were of moderate severity (59.1%, 114/193) whiles 7.8% (15/193) were severe (Figure 4.5).

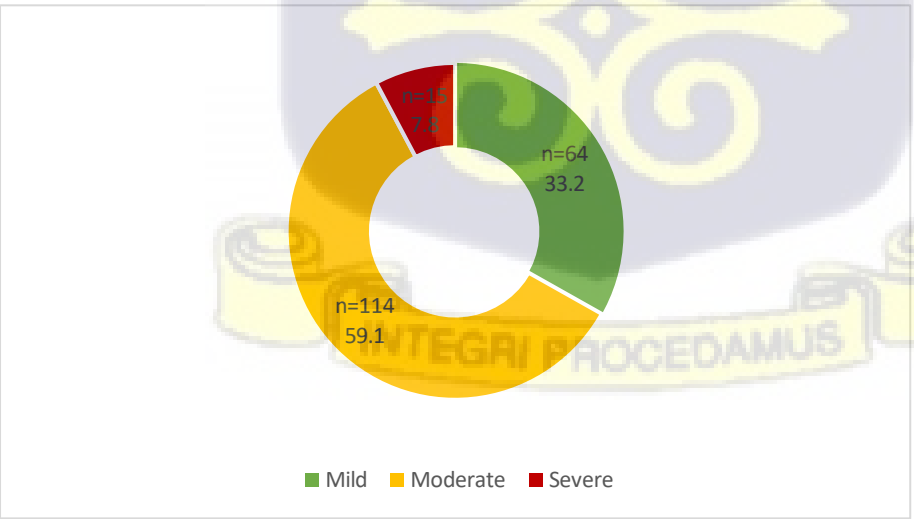


Figure 4.5: Severity of diarrhoea cases identified in Anloga District, 2023

For cases who reported their main source of water as improved, 60% (114/190) had moderate diarrhoea, whiles 7.8% (15/190) had severe diarrhoea. About 59% (90/152) of cases with improved toilet facilities had moderate diarrhoea. There were more severe diarrhoea cases for cases with improved toilet facilities 7.89% (12/152) than those with unimproved toilets 7.32% (3/41). Of the vaccinated children, 50.5% (110/188) had moderate diarrhoea whiles 7.98 (15/188) had severe diarrhoea. Only the difference between water source type was significant ($p<0.05$) (Table 4.15).

Table 4.15: Diarrhoea severity by interventions in Anloga District, 2023

Factor	Severity		
	Mild (n=64)	**Moderate (n=114)**	**Severe (n=15)**
Main source of drinking water and for domestic purpose*			
Unimproved	3 (100)	0 (0)	0 (0)
Improved	61 (32.11)	114(60.00)	15 (7.89)
Type of toilet facility members of your household use			
Unimproved	14 (34.15)	24 (58.54)	3 (7.32)
Improved	50 (32.89)	90 (59.21)	12 (7.89)
Child Rotavirus vaccinated			
Child vaccinated	1 (20)	4 (80)	0 (0)
Child unvaccinated	63 (33.51)	110 (58.51)	15 (7.98)

Row % **p-values obtained significant at p<0.05*

4.3 : Phase 3 – Assessment of Pathogens Causing Diarrhoea in Anloga District 2018 -2021

4.3.1 : Rotavirus A with Enzyme-Linked Immunosorbent Assay (ELISA)

A total of 80 samples were tested for rotavirus A using the ELISA test kit. Out of the 80 samples tested, 2 were positive for rotavirus A antigens (2.5%). All others tested negative (Figure 4.6).

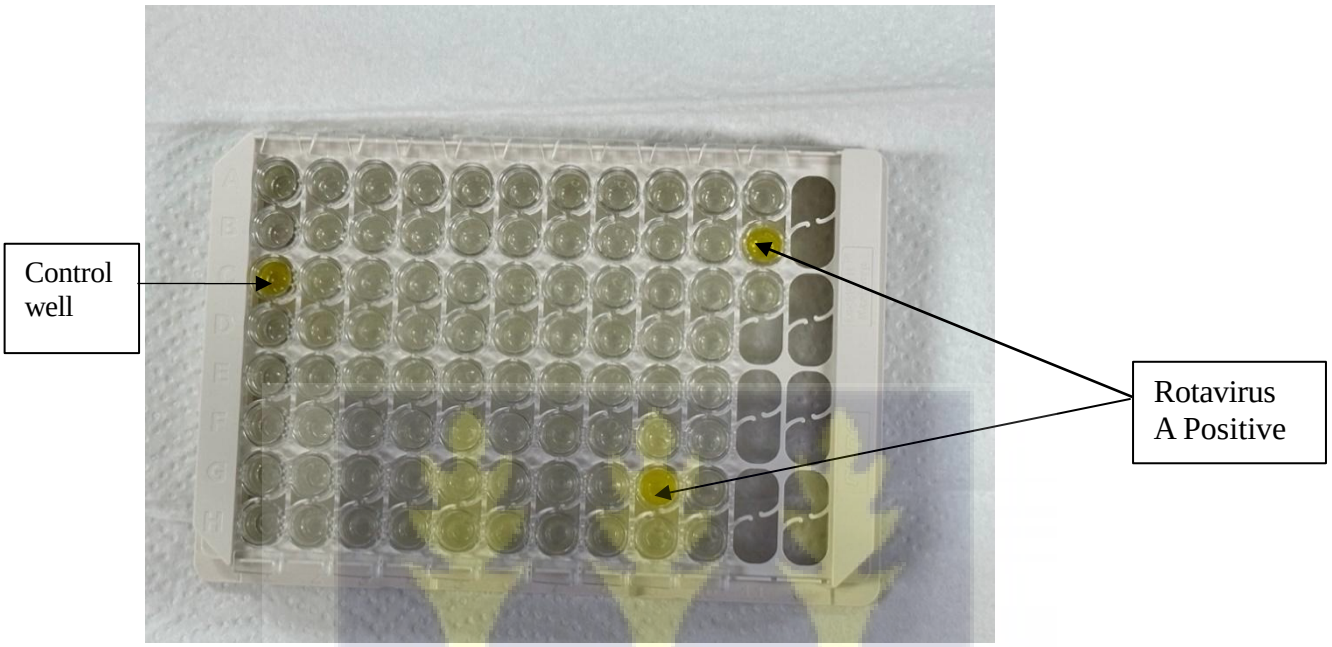


Figure 4.6: ELISA plate showing control well and positive samples

Of the 23 pathogens tested, 15 pathogens were found to be present in the samples. Bacteria was the most prevalent pathogen (46.7%, 7/15) with parasites being the least prevalent (20%, 3/15 9) Figure 4.6

4.3.2 : Diarrhoea Pathogens from TaqMan Array Card (TAC) Test

Pathogen Presence

A total of 38 samples with one blank well and a control sample (made up of the master-mix) were tested with the TAQMAN Array Card. Test was to identify 23 pathogens (ten bacteria, seven virus and six parasites) known to cause diarrhoea among children under five years.

For the bacteria, 7 out of 10 were identified; whiles for the virus, 5 out of 7 were identified and for the parasites, 3 out of 6 were identified.

Prevalence of Pathogen Type

Of the 38 samples tested, bacteria were identified in 86.8% (33/38) of the samples, whiles virus were identified in 68.4% (26/38). About 5% (2/38) of the samples had no pathogen identified in them (Figure 4.7).

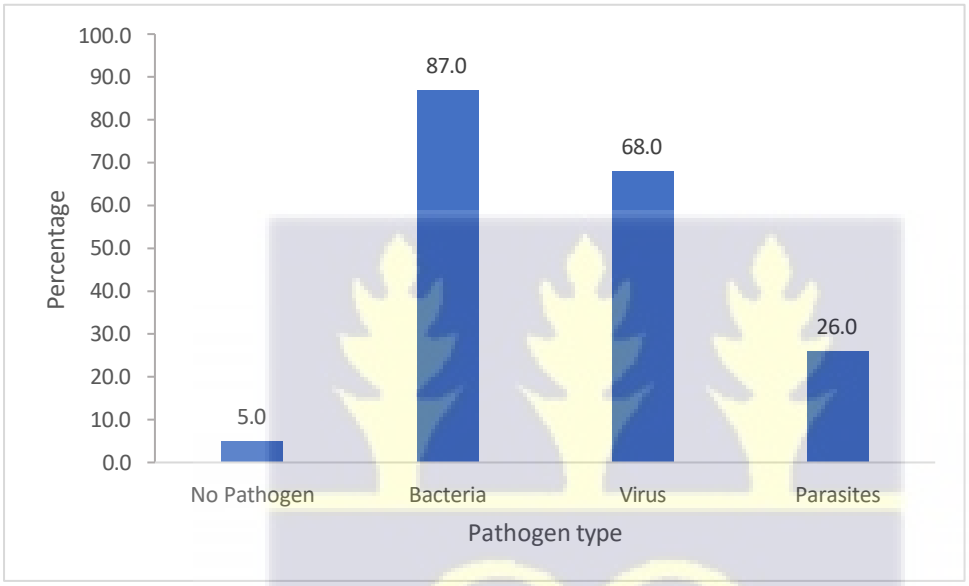


Figure 4.7: Proportion of pathogens identified in samples

Enteroaggregative *Escherichia coli* (EAEC) was the most prevalent pathogen identified in the samples followed by Shigella//Enteroinvasive *Escherichia coli* (EIEC). Adenovirus 40/41, Aeromonas, Cyclospora, *Entamoeba histolytica*, Isospora, RotaTeq, Salmonella, *Vibrio cholerae* were not identified in any of the stool samples tested (Figure 4.8).

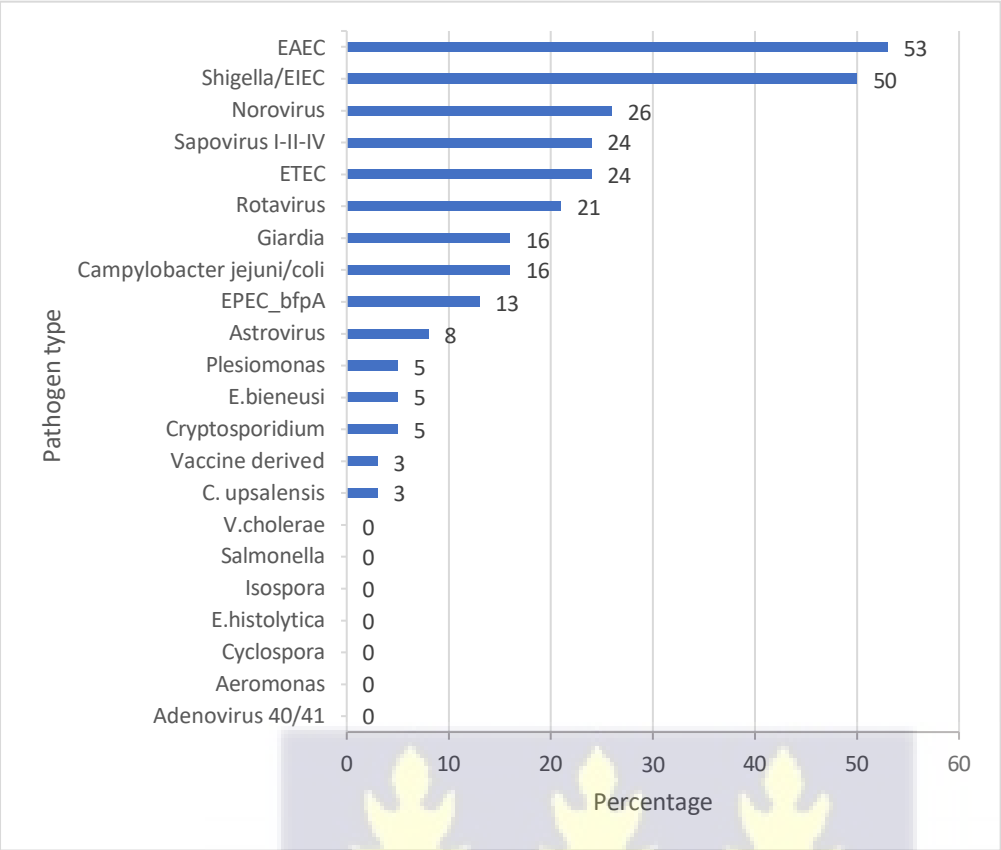


Figure 4.8: Pathogen testing results for samples using TaqMan Array Card

Distribution of Pathogens in Children Under Five Years with Diarrhoea by Sex, Anloga District, 2023

Enteroaggregative *Escherichia coli* (EAEC) was the most prevalent bacteria in the samples tested. It was present in more than half of the samples tested (20/38). Additionally, it was present in about 62% (13/21) males and 41% (7/17) females. *Shigella/* Enteroinvasive *Escherichia coli* was found in 50% (19/38) of the samples tested. *Aeromonas*, *Shigella* and *Vibrio cholerae* were not found in any of the samples. Plesiomanas was present in 9% (2/17) of the males but not found in any female. However, all the differences observed were not found to be significant. The various species of *Escherichia coli* were found more in males than in females (Table 4.15).

Giardia was the most common parasite found. Giardia was present in more females (29.4%, 5/17) than males (4.8, 1/21). There was no significant difference among the viruses found in males and females. *Cyclospora, Entamoeba histolytica* and *Isospora* were not found in either males or females (Table 4.16).

Viruses were found in more females (88.2%, 15/17) than males (76.2%, 16/21). The most prevalent virus was norovirus (26.3%,10/38). Which was found in both males and females. However, it was present in more females (29.4%, 5/17) than males (23.8%, 5/21). Sapovirus I-II-III-IV and rotavirus was present in more than 20% of the samples respectively. More females had rotavirus (29.4%, 5/17) compared to males (14.3%, 3/21). Whiles sapovirus I-II-III-IV was found in more males (33.3%, 7/21) compared to females (11.8%, 2/17). However, all the differences observed were not found to be significant. There was a vaccine strain (Rotarix) observed in one (1) of the 38 samples, precisely in a female. Adenovirus 40/41 was not observed in any of the samples (Table 4.16).

Table 4.16: Distribution of Pathogens tested for using TAQMAN Array Card by Sex in children under five years, Anloga District, 2023

	Male	Female	Total	p-value*
	n = 21	n = 17	n = 38	
	n (%)	n (%)	n (%)	
Bacteria				
Aeromonas	0 (0.0)	0 (0.0)	0 (0.0)	
Campylobacter upsalensis	1 (4.76)	0 (0.0)	1 (2.63)	0.36
Campylobacter jejuni/coli	3 (14.29)	3 (17.65)	6 (15.79)	0.78
Enteroaggregative *Escherichia coli* (EAEC)	13 (61.90)	7 (41.18)	20 (52.63)	0.20
Enteropathogenic *Escherichia coli* (EPEC) (bfpA)	3 (14.29)	2 (11.76)	5 (13.16)	0.82
Enterotoxigenic *Escherichia coli* (ETEC)	8 (38.10)	1 (5.88)	9 (23.68)	0.020
Plesiomonas	2 (9.52)	0 (0.0)	2 (5.26)	0.19
Salmonella	0 (0.0)	0 (0.0)	0 (0.0)	
Shigella/ Enteroinvasive *Escherichia coli*	10 (47.62)	9 (52.94)	19 (50.0)	0.74
Vibrio cholerae	0 (0.0)	0 (0.0)	0 (0.0)	
Parasite				
Cryptosporidium	1 (4.76)	1 (5.88)	2 (5.26)	0.88
Cyclospora	0 (0.0)	0 (0.0)	0 (0.0)	
Enterocytozoon bieneusi	1 (4.76)	1 (5.88)	2 (5.26)	0.88
Entamoeba histolytica	0 (0.0)	0 (0.0)	0 (0.0)	
Giardia	1 (4.76)	5 (29.41)	6 (15.79)	0.038
Isospora (Cystoisospora)	0 (0.0)	0 (0.0)	0 (0.0)	
Virus				
Adenovirus 40/41	0 (0.0)	0 (0.0)	0 (0.0)	
Astrovirus	1 (4.76)	2 (11.76)	3 (7.89)	0.43
Norovirus	5 (23.81)	5 (29.41)	10 (26.32)	0.70
Vaccine derived *(Rotarix vaccine, RotaTeq vaccine)*	0 (0.0)	1 (5.88)	1 (2.63)	0.26
Rotavirus	3 (14.29)	5 (29.41)	8 (21.05)	0.26
Sapovirus I-II-IV	7 (33.33)	2 (11.76)	9 (23.68)	0.12

*%: Column percentage *p-values obtained from Fischer's Exact test*

For bacteria, *Campylobacter upsalensis* was found only in children under two years. *Campylobacter jejuni/coli* was present in children of both age groups with under twos having the highest proportion (18.18%, 4/22). Enteroaggregative *Escherichia coli* was present in 50% of all age groups, above two years 54.5% (12/22) and below two years (50% (8/16). A higher proportion of children above two years had *Shigella*/ Enteroinvasive *Escherichia coli* (68.8%,

11/16) compared to children under two years (36.4%, 8/22). Enterotoxigenic *Escherichia coli* was present in all age groups but highest among children below two years (27.3%, 6/22). None of the differences in pathogens seen among age groups was significant (p>0.05) (Table 4.17).

For parasites, *Giardia* was the most common parasite found in children of all ages with most being above 2 years (18.8%, 3/16) and least common among under twos (13.6%, 3/22). *Cryptosporidium* and *Enterocytozoon bieneusi* were found in children under two years (4.6%, 1/22) and above 2 years (6.3%, 1/16) respectively. There were no significant differences seen in the parasites by age groups (p>0.05). *Cyclospora*, *Entamoeba histolytica* and *Isospora (Cystoisospora*) were not found among any of the age groups. (Table 4.17).

For virus, astrovirus was found in only children above two years 18.8% (3/16). Norovirus was found in more children under two years (36.4%, 8/22) than those above two years (12.5%, 2/16). The Rotarix vaccine strain was found in one child above two years (1/16). Rotavirus was found in all the age groups. The age group with the highest proportion was children above two years (37.5%, 6/16), and lowest amongst children under two years (9.1%, 2/22). Sapovirus I-II-IV was found in all age groups. More children above two years had sapovirus I-II-IV (31.3%, 5/16) than children below two years (27.3%,6/22). None of the age groups had Adenovirus 40/41. There were no significant differences seen in the parasites by age groups (p>0.05). (Table 4.17).

Table 4:16: Frequency of pathogens tested using TAQMAN Array Card by age in children under five years, Anloga District, 2023

	2 years and below (%)	Above 2 years (%)	p-value*
N	22	16	
	n (%)	n (%)	
Bacteria			
Aeromonas	0 (0.00)	0 (0.00)	
Campylobacter upsalensis	1 (4.55)	0 (0.00)	1.00
Campylobacter jejuni/coli	4 (18.18)	2 (12.50)	1.00
Enteroaggregative *Escherichia coli*	12 (54.55)	8 (50.00)	1.00
Enteropathogenic *Escherichia coli* (bfpA)	3 (13.64)	2 (12.50)	1.00
Enterotoxigenic *Escherichia coli*	6 (27.27)	3 (18.75)	0.71
Plesiomonas	1 (4.55)	1 (6.25)	1.00
Salmonella	0 (0.00)	0 (0.00)	
Shigella/ Enteroinvasive *Escherichia coli*	8 (36.36)	11 (68.75)	0.099
Vibrio cholerae	0 (0.00)	0 (0.00)	
Parasite			
Cryptosporidium	1 (4.55)	1 (6.25)	1.00
Cyclospora	0 (0.00)	0 (0.00)	
Enterocytozoon bieneusi	1 (4.55)	1 (6.25)	1.00
Entamoeba histolytica	0 (0.00)	0 (0.00)	
Giardia	3 (13.64)	3 (18.75)	0.68
Isospora (Cystoisospora)	0 (0.00)	0 (0.00)	
Virus			
Adenovirus 40/41	0 (0.00)	0 (0.00)	
Astrovirus	0 (0.00)	3 (18.75)	0.066
Norovirus	8 (36.36)	2 (12.50)	0.14
Rotarix vaccine	0 (0.00)	1 (6.25)	0.42
RotaTeq vaccine	0 (0.00)	0 (0.00)	
Rotavirus	2 (9.09)	6 (37.50)	0.050
Sapovirus I-II-IV	6 (27.27)	5 (31.25)	1.00

**p-values obtained from Fischer's Exact test*

4.3.2.1 : Diarrhoea Pathogen Co-infections Identified among Children with Diarrhoea in Anloga District 2021 -2022

Of the 38 samples tested, 5% (2/38) had no pathogen, whiles 68% (26/38) had various types of co-infections. Virus-bacteria co-infections were the highest occurring co-infection (42.1%). Almost 20% of the infections were virus-bacteria-parasite co-infections. The least reported co-infection was the virus-parasite co-infection (2.6%) (figure 4.9). A breakdown of co-infections by age and sex is provided in Appendix 6.

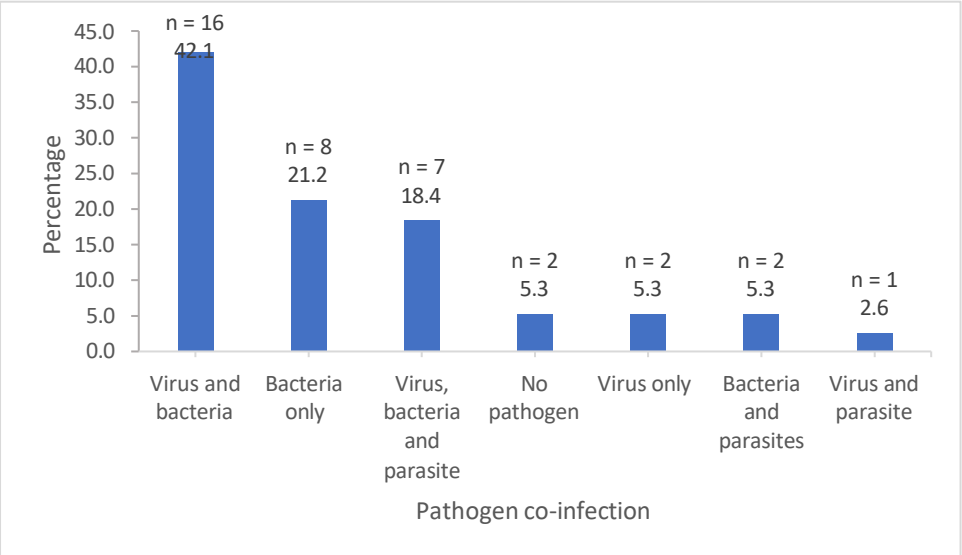


Figure 4.9: Diarrhoea pathogen co-infections among children under five years in Anloga District, 2023

Table 4.18: Diarrhoea severity and pathogen co-infection

Variable	Severity of Diarrhoea		
	Mild	**Moderate**	**Severe**
Number of pathogens*			
None	0 (0)	2 (100)	0 (0)
One or two	4 (30.77)	7 (53.85)	2 (15.38)
Three	3 (33.33)	6 (66.67)	0 (0)
Four more	6(46)	5 (38.46)	2 (15.38)
Pathogen groupings*			
No pathogen	0 (100)	2 100(0)	0 (0)
Bacteria	4 (50)	3 (37.5)	1 (12.5)
Bacteria-parasite	2 (100)	0 (0)	0 (0)
Virus	0 (100)	2 (100)	0 (0)
Virus-parasite	1 (100)	0 (0)	0 (0)
Virus-bacteria	4 (25.00)	10 (62.50)	2 (12.50)
Virus-bacteria-parasite	3 (33.33)	3 (42.90)	1 (16.67)

**p-values obtained from Fischer's Exact test*

An equal proportion of cases with one-two pathogens (15.4, 2/13) and cases with four or more pathogens present (15.4, 2/13) experienced severe diarrhoea respectively. More cases with virus-bacteria combination present in their stool sample had moderate to severe diarrhoea (75%, 12/16) compared to those with bacteria -parasite (0) and virus-parasite (0) co-infections. Cases with virus-bacteria-parasite present in their stool sample had more moderate to severe diarrhoea cases (66.7%, 4/6) than mild cases (33.3%, 2/6) (Table 4.18).

CHAPTER 5

DISCUSSION

5.1 : Introduction

This study set out to evaluate implementation of WASH interventions and assess the risk factors of diarrhoea among children under five years in Anloga District of the Volta region of Ghana using a comprehensive approach covering the community environment, household and individual level factors that influence diarrhoea. The study used a process evaluation to assess the currently WASH implementation approaches in the district. This was followed by a case-control study of children under five years reporting at the health facility with diarrhoea to identify epidemiological risk factors of diarrhoea in the setting. Finally, a laboratory analysis of diarrhoea pathogens was conducted to identify the specific diarrhoea pathogens causing diarrhoea in the district. This section discusses findings from the five main objectives and presents the linkages obtained by this assessment. This section is structured according to the objectives below.

5.2 : Evaluation of the Implementation of WASH Interventions in the Anloga District

The process evaluation assessed whether the WASH interventions in the district are being implemented as planned by the district and challenges faced with the implementation. The evaluation was done considering some key components of a process evaluation proposed by Linnan and Steckler, namely; the reach, dose, and fidelity of the intervention WASH intervention (Linnan & Steckler, 2002). Findings from the intervention and its implications are discussed in the paragraphs below.

5.2.1 : Reach of Intervention and Dose

The district target for their set interventions were not met for both water and sanitation. The district set out to ensure that every one had access to at least basic drinking water services and limited sanitation services. Currently, about three in ten people in the district do not have access to basic water services whiles five in ten do not have access to limited sanitation facilities. Comparing the dose delivered and what was received, there was a deficiency in both the provision of water and toilet facilities. The district was not able to construct the number of WASH facilities to meet the needs of the communities, thus their set target was not met. During the implementation of interventions, programmes were not be able to fully meet their set targets as planned due to new developments or other factors that may have come up on the field. A similar intervention in Tanzania providing water and sanitation facilities for school children was unable to meet their set target and provided only 50% of the intended water supply and less than 50% of the intended drop holes due to budgetary constraints and poor maintenance (Antwi-Agyei *et al.*, 2017). The deficit for toilet facilities was higher than that for water sources. This implies that a higher proportion of the population would not have access to basic sanitation facilities.

According to the SDG, the world is moving towards ensuring that everyone has access to basic drinking water services and basic sanitation by 2030. However, the district according to the country's directive is currently implementing limited sanitation (Ministry of Sanitation and Water Resources, 2021), a step lower than the required global standard. Thus, meeting this lower target implies there would be a high section of the population without appropriate sanitation services. In situations where facilities are not enough, children are normally not considered nor is care given to the type of facility they use since they are not the priority group.

5.2.2 : Fidelity of Implementation

The district implemented WASH interventions according to the nationally accepted standard guidelines for implementation. However, only four in ten of the required steps were fully followed during the process of implementation whiles the rest were partially followed or not followed at all. Steps that were to be carried out at the district level or by engaging district level stakeholders only, such as departments in the assembly were fully followed. The steps fully followed such as formation of a committee at the district level, working with a plan, using the prescribed design and construction process were all well laid out procedures which tied into most of the other activities routinely done at the district and in the offices of the staff. Thus, carrying them out may have been done with ease.

However, steps, which required working directly with the community, were either partially completed or not carried out at all. Steps such as promotion, sensitization and maintenance began from the district offices, but required full engagement at the community level from the start to the end of the WASH implementation process. These required an extra effort of moving into the communities on a regular basis and actively engaging all the community members who were the final beneficiaries. However, that was not the observation. Some projects began silently and others left after completion with no information provided to the community members. These partially implemented steps tie into the finding of the district not being available to provide support to communities after completion of constructions and involving every single stakeholder in planning and implementation until completion of the WASH activity.

Generally, things that are fully under an organisation's control and require less involvement of other parties are normally done with ease since it can be carried out as part of their regular work routine without interference from other parties. However, when it involves other parties

not within their control, people are likely to either skip the task or perform only their part in the face of the least resistance especially when there is no standard laid down procedures assigning specific roles or checks to ensure procedures are duly followed. An earlier evaluation also identified implementers having challenges with engaging and carrying out some of their activities in situations where there were no well laid down structures (Walter, 2013).

The skipping of steps that involved the district could be the reason communication and interaction with community members might have been poor, a challenge identified during this evaluation. As the final beneficiaries of the intervention, communication issues between the district and the community could have an effect on the acceptance of the intervention. Community members and leaders felt information was normally received in piece meal during the implementation. With less involvement of the beneficiaries, acceptance and utilization of interventions are likely to be affected. Gradually the community's faith in the implementers seemed to be getting lost. Building trust in communication during implementation of interventions is a key factor to the success of the intervention. Given that WASH interventions are behavioural, things like these could negatively influence the goal of the intervention, indirectly facilitating the likelihood of diarrhoea occurrence. Actions that lead to poor engagement and breach in communication could have lasting consequences if not identified and handled in the early stages of the programme. In process evaluation on handwashing in primary schools, Chittleborough and colleagues suggested that involving beneficiaries in design of interventions may increase the sense of ownership, improve its use and result in beneficiaries taking better care of the structures after they have been completed (Chittleborough *et al.*, 2012). In this current stage of efforts to reduce diarrhoea, getting all stakeholders to be part of interventions that have been proven to work is essential in achieving the goal of diarrhoea prevention.

Trying to get things done without the beneficiaries reflects using a top-down approach in implementation. A top-down approach in WASH implementation is not likely to provide the desired results in a behaviour change intervention like WASH since the true understanding of the context may be overlooked. Given the dynamic nature of communities, prior experience in implementation may not always be ideal. Spending a bit more time and resources in every implementation site to engage the beneficiaries could help improve the acceptance and outcome of the intervention (Thorseth *et al.*, 2024). In this case, use of the basic water services and limited sanitations services available in the right manner so that diarrhoea can be reduced or prevented.

Community engagement during WASH interventions is not merely a formality that needs to be carried out but rather a process where the implementation team have the opportunity to share ideas with the beneficiaries to find out what would really work in their context. Though it might require compromising on some initial implementation arrangements, programmes should be able to accommodate these changes in order to be successfully implemented.

The skipping of some steps also accounted for one of the pertinent issues identified that is the unclear process of transitioning of some completed WASH structure from the district to the end users. This situation was reported to have occurred with the toilet facilities leading to some with no caretakers. Generally, maintenance of the WASH structures was reported to be poor. According to the community members, some structures had been broken down with no plans of repairs. Additionally, communities complained about the district not being responsive to their calls to support the maintenance. In places where districts had tried to take up the responsibility, due to community members not being part of the implementation process, most community members assumed maintaining the WASH facility was not their responsibility. This issue was better with water structures since the Ghana Water Company had general

oversight of these and occasionally came to the aid of the communities. As a major intervention to prevent diarrhoea and other diseases, beneficiaries seeing maintenance of these WASH facilities as the district's sole responsibility is quite worrying. This is because, for WASH interventions to work and prevent diseases such as diarrhoea, they need to be seen by beneficiaries as part of their lives. In this way, they can use them and be concerned about how they should be maintained since they understand its value to their health and wellbeing.

The district cited limited funding and delay in funding as a major challenge faced during implementation. They explained that activities such as community engagements and supervisions could not be fully implemented since they had no funds. Again, the delay in release of funds from the national level meant they could not meet their set timelines as intended. The issue of funding is common in programme implementations. A process evaluation of a WASH intervention implementation for cholera in Democratic Republic of Congo (DRC) found that delays and shortage of logistics during implementations are likely to reduce the overall effectiveness of the intervention (D'Mello-Guyett *et al.*, 2020). In another process evaluation conducted in Tanzania, delay in government funding and insufficient funds were the major challenge in implementation of WASH interventions (Antwi-Agyei *et al.*, 2017). Similarly in Zimbabwe, the implementation was seen as burdensome due to limited funding available (Thorseth *et al.*, 2024). Once there are no funds, implementers are forced to carry out plans according to their discretion using what is available to them.

Though it is important to ensure that there are funds for the implementation of interventions, post-implementation funds are also critical. This is because they sustain the expected environments created and ensure that the focus of the intervention is still achieved even after its completion through monitoring and support (Antwi-Agyei *et al.*, 2017). These funds play a

critical role in identifying if the community has truly embraced the interventions and are willing to maintain it even if it requires them mobilizing their own resources to do so.

5.2.3 : Explaining Findings Based on the Context of Evaluation

To gain a better understanding of the context of the implementation, the dynamics of the district needs to be taken into consideration. The Anloga District is a newly created district, and is likely to have teething problems as they try to find their footing. A study in Ghana found that newly created districts are faced with struggles such as incomplete institutional setup, weak logistical and financial resource capacity, inadequate human resource in key departments and poor management.(Mensah *et al.*, 2015). These explain what was observed in the study district where staff had been moved from Keta Municipality to set up the Anloga District amidst lack of logistic and financial resources and delays in government funding. However, since the staff are the same people from the old place and the job descriptions in the new site are the same, implementing these interventions should not be too different for them. This is because, the communities already know them and the structures are already in place to get things moving. As an activity in the Mid-term development plan, one factor which could have impacted the WASH implementation is funding. The district is heavily dependent on government funding to implement all planned activities including the WASH activities. This means that carrying out of interventions is fully controlled by availability of funds. Once there are delays or other competing interests, activities are likely to be reprioritized. Additionally, being part of the Mid-term development plan implies that the WASH activities of the district are dictated by the current political agenda. Once the politicians decide, there is nothing much that can be done about it. Though the mid-term development plan has its pros of being a roadmap for the district, its cons cannot be overlooked. Some other documented District Medium-Term Development Plan implementation problems found in district assemblies are: weak institutional structures,

ineffective teamwork, low stakeholder commitment level, inadequate financial and human resource capacity to mention a few (Mensah, 2005). Another study identified over dependency on external funding or central government, low internally generated revenue, political interference, lack of political will, low citizen involvement in planning, and weak institutional capacity as challenges district assemblies also face in Ghana (Appiah, 2016). To be able to implement effective interventions, there is the need to reduce the existing challenges to the barest minimum. Mensah recommended human resource development, an effective monitoring and evaluation system and institutional strengthening as some steps to mitigate these implementation challenges (Mensah, 2005). In the face of this situation, the district currently does not seem to be fully equipped to implement WASH to achieve the desired impact. This is reflected in the lack of data for tracking other essential WASH activities such as construction of toilets for schools, provision of handwashing facilities and waste dumpsites.

WASH structures are made to provide communities with improved water and sanitation facilities. Currently, not all the people in the district have access to basic drinking water and limited sanitation as expected. Also, community participation during implementation, and operation and maintenance processes of these interventions do not seem to be optimal. These could have an influence on acceptance and usage of interventions since these interventions require behaviour change. Diarrhoea prevention has mainly been attributed to breaking the faecal-oral pathway of pathogen entering the human being through the mouth (Tetteh *et al.*, 2018). Thus, if WASH interventions are not properly implemented due to challenges, diarrhoea is likely to persist in such settings especially in places with sub-optimal sanitation coverage. A study in Nepal which assessed the effect of climate factors on diarrhoea diseases found that when sanitation coverage is not optimum, contamination is likely to occur leading to diarrhoea diseases (Nepal Health Research Council, 2016).

For the district, the current WASH implementation processes being used may not be able to help achieve its intended goal of improving water, sanitation and hygiene practices especially at the household and individual levels. Rather for WASH interventions to be effective, constructing structures should move hand in hand with building ownership and leadership in communities. This could improve the understanding of the value of these interventions and promote utilization of the facilities. Unfortunately, since improved WASH is usually measured by the presence and absence of water and sanitation structures in this setting (Ministry of Sanitation and Water Resources, 2021), this issue may remain covered up whiles the main driving factors of diarrhoea leading to the consumption of contaminated food and water continue to increase. This has been best explained by the SHINE trials, randomised efficacy trials which tested improved household-level WASH with and without improved infant and young child feeding (IYCF) on stunting and diarrhoea in Bangladesh, Kenya, and Zimbabwe. Despite high implementation fidelity and uptake of interventions, the children who received the WASH interventions in the trials still experienced very high enteropathogenic exposure and infection, showing that environmental faecal contamination remained pervasive despite these interventions (Pickering *et al.*, 2019). In light of this, their recommendation on WASH sector focused on developing and evaluating interventions that are radically more effective in reducing faecal contamination in the domestic environment than the interventions implemented as the right way to go in order to reduce the spread of diarrhoea pathogens among any given population (Pickering *et al.*, 2019). This recommendation ties into the need for the identification of other risk factors such as individual level and household WASH practices, nutritional, and health seeking practices, which could also influence the occurrence of diarrhoea in the children under five years.

5.3 : Risk Factors of Diarrhoea among Children under Five Years in Anloga District, 2022 - 2023

5.3.1 : Household WASH Factors Associated with Diarrhoea among Children under Five Years in Anloga District

The study found that child access to household toilet facilities reduced their odds of diarrhoea occurrence compared to those who did not use them. Toilets serve as a barrier between the user and contact with faecal matter. Thus, the main aim of the use of hygienic toilets is to ensure that excreta is contained and does not serve as a source of contamination (Global WASH Cluster IM Toolkit, 2014). If toilet facilities are not used, it could lead to open defecation which could serve as a breeding site for flies to transmit diarrhoea pathogens in the community environment (Agustina *et al.*, 2021).

Again, child use of toilet facilities protects children from contaminating themselves. Children under five generally play on the floor and touch surfaces around them even when they are in the process of defecating. Therefore, their hands easily get contaminated with any kind of pathogens present in their environment (Tete Larbi *et al.*, 2021; Wang *et al.*, 2018). Since children in this study are within the stage of mouthing, (Juberg *et al.*, 2001), their contaminated hands and any other objects they find irrespective of its source end up in their mouths often as part of their oral sensory development. This makes it easy for them to ingest diarrhoea causing pathogens which may be found in the environment. In the absence of a toilet facility, children can easily be contaminated by contact their faecal matter containing the diarrhoea causing pathogens. Some of these pathogens could end up being ingested by the child as their hands and other contaminated parts of the body enter their mouths. Thus, a child having access to a toilet facility could reduce the child's contact with faecal matter which is the main source of diarrhoea pathogens.

Though use of improved toilet facilities by households have been found to reduce the risk of diarrhoea in children (Luby *et al.*, 2018; Wolf *et al.*, 2018; Yaya *et al.*, 2018), other studies have argued that shared toilet facilities could serve as a source of contamination as users moving in and out touch surfaces contaminated with diarrhoea pathogens; thus increasing the risk of diarrhoea (Baker *et al.*, 2016; Ramlal *et al.*, 2019). These arguments contributed to the modification to types of sanitation to include basic and limited sanitation services (UNICEF/WHO, 2021). However, in a setting such as Ghana, which is currently working towards achieving access to limited sanitation services, a child not using a toilet facility especially in settings where the only available facilities are shared, is a valid concern that needs attention. This is because the risk of contamination could be higher in the process of the child's toiletry activities. The findings of this study therefore point out the need to consider the best options for a child's use of a toilet facility since it could reduce their risk of diarrhoea compared with those who did not use it.

Handwashing practices among caregivers were good with almost eight in ten reporting they washed their hands before feeding the child, cooking, after using the toilet or after changing the child. This is contrary to findings by Chase and Mishra in Lao where most mothers did not wash their hands (Chase & Mishra, 2021). A key area in hygiene is handwashing especially at critical points because it serves as a primary barrier to transmission of diarrhoea pathogens (Tete Larbi *et al.*, 2021; UNICEF, 2016). Also, a study in Ghana found that a large proportion of caregivers did not wash their hands. However, just like this study, they did not find any association between handwashing and diarrhoea incidence.

For children under five years, a mother's hygiene practices may be enough to prevent the transmission of pathogens to the child only to an extent, the practices done for the child could also influence pathogen transmission. A study in Lao found that caregivers were not aware of

the disease transmission risks associated with exposure to dirt and contaminated environments. Therefore, children in households with poor sanitation practices have a higher risk of exposure to faecal-oral diseases through numerous other routes, not all of which may be obvious (Chase & Mishra, 2021). When the sanitation in the house is poor, the child can be directly affected through contamination and ingestion of diarrhoea pathogens (Agustina *et al.*, 2021). This forms the basis of the concept of Baby WASH, which seeks to reduce children's exposure to contamination and pathogens as they grow with focus on interventions that directly pertain to the child. (Chase & Mishra, 2021). At the centre of the Baby WASH concept, there is the need to tap into the use of caregivers to learn and teach their young children good hygiene practices. Adults are role models children can learn handwashing and other good hygiene practices from at a very early stage in their lives (Zomerplaag & Mooijman, 2005). Capitalising on this role of adults, especially caregivers could significantly improve child health.

A tried and tested way of breaking the faecal-oral pathway of diarrhoea in children under five years is by reducing the transmission of enteropathogens to the children by practicing good hygiene and sanitation practices such as handwashing (Lin *et al.*, 2018). If caregivers are able to diligently wash their hands and that of their children at critical points such as after the caregiver using the toilet, before cooking or feeding the child, and the child is helped to properly use a toilet facility, the chances of the child getting contaminated with entropathogens are likely to be reduced. For example, a study has shown that implementing these proper hygiene and sanitation practices are able to significantly reduce the prevalence of some parasitic infections such as Giardia (Lin *et al.*, 2018).

These interventions of teaching caregivers the need for proper hygiene and sanitation and also supporting them to train their children at a young stage to practice proper hygiene and sanitation are cost effective. Thus, may be less capital intensive to implement. Especially in the study

setting where funding for implementing of WASH interventions was seen to be a major problem. This points to the need to also focus on WASH interventions at the individual level to be able to achieve a meaningful impact.

These risk factors identified by the study therefore highlights the fact that the presence or access to and reports on use of an intervention alone might not be the most accurate way of assessing its effectiveness in the case of reducing diarrhoea incidence. Childcare practices and hygiene behaviour can either interrupt or facilitate the faecal oral transmission of diarrhoea pathogens and facilitate diarrhoea occurrence (Buttenheim, 2008). Rather, focusing on individual WASH behaviour and getting caregivers to involve their young children in good hygiene and sanitation practices could help in reducing diarrhoea occurrence.

5.3.2 : Nutritional Risk Factors Associated with Diarrhoea among Children under Five Years in Anloga District

In the current study, an underweight child had a significantly higher risk of diarrhoea compared to a child who had a normal weight for age. This finding is similar to a study conducted in Egypt which found a child's weight for age to be a significant predictor of diarrhoea in children under five years (Wierzba *et al.*, 2001). When a child has diarrhoea, the child becomes dehydrated and loses appetite, which are factors leading to adverse health outcomes like underweight. Thus the child is likely to become underweight if diarrhoea recurs or persists (Kumar *et al.*, 2019). Generally, undernutrition, classified in sub-forms as stunting, wasting, and underweight influences the incidence of diarrhoea in children. This is because undernutrition makes the child more vulnerable to disease (WHO, 2024).

The relationship between diarrhoea and nutrition has been well researched over the years and a bi-directional association established between diarrhoea and nutrition (Institute of Medicine *et al.*, 1992). Both conditions have been found to influence the incidence of the other (Sambo

et al., 2022). Jain and colleagues have explained that, diarrhoea affects absorption of nutrients by the intestines thus leading to a child being undernourished. Similarly, being undernourished then predisposes the child to diarrhoea diseases (Jain *et al.*, 2019). Therefore, when a child is undernourished, the child has an increased risk of diarrhoea incidence. In confirmation of this earlier finding, studies over the years in Ethiopia (Soboksa *et al.*, 2021), Mozambique (Sambo *et al.*, 2022), and Bangladesh (Ferdous *et al.*, 2013) have found undernutrition to be a predictor of diarrhoea in children under five years. Since undernourished children are likely to have gastrointestinal infections, the severity and incidence of diarrhoea is also likely to increase in them. Thus, they are more susceptible to diarrhoeal diseases compared to their well-nourished age mates (Ferdous *et al.*, 2013).

That notwithstanding, stunting was not found to be significantly linked to diarrhoea in this study. Other studies in children under five have however found stunting to be significantly linked with diarrhoea incidence (Arini *et al.*, 2020; Nasrin *et al.*, 2023; Ramadhana *et al.*, 2023).

5.3.3 : Caregivers' Health Seeking Behaviour Risk Factors Associated with Diarrhoea among Children under Five Years in Anloga District

For health seeking behaviour, there were no observed differences between cases and controls for the variables assessed. Also, the proportions of the variables assessed were similar in both cases and controls. A high proportion of both cases and controls mentioned the health facility as their primary point of call when a household member was sick and receiving health advice from the health workers. This denotes the caregivers trust in the healthcare system in their setting. Durmus, in his study on patient satisfaction explains trust as the patient's belief that the healthcare provider can meet their needs every time, they visit the facility. Thus, they continue to access the facility to get their needs met (Durmuş & Akbolat, 2020). When the caregiver builds trust in the healthcare system, the child's health and wellbeing is likely to

improve constituently. The presence of trusting relationships, or its absence, in the health system is critical to human well-being (Adam & Donelson, 2022)

Though not significant, caregivers whose primary point of call for healthcare was not a health facility had reduced odds of diarrhoea compared to those whose first point of call was the health facility. This could be because caregivers taking their children to other places may not always be able to idenitfy what is wrong with the child and may not show up at those places if they do not think the child's condition is serious. Thus, they would not get an approriate diagnosis. Additionallly, if the place the caregiver visits is not able to tell from the child's symptoms what the condition is, there could be a misdiagonsis leading to lower reporting of diarrhoea.

Children whose mothers do not take decisions on seeking healthcare for the child had higher odds of diarrhoea compared to mothers who took the decision on seeking healthcare for their sick child. When the mother is the primary caregiver, they are able to recognize when the child is unwell and make a decision on where the child should be taken (Pierce *et al.*, 2016). This prevents delay in seeking healthcare and increases the chances of the child getting prompt care. In this study, most of the primary caregivers were the mothers of the children, which could explain the results obtained. However, the association was not found to be significant.

In both cases and controls, eight in ten children, were on health insurance. Children on health insurance had a 14% reduced odds of diarrhoea compared to those without health insurance. Though this association was not significant, research has shown that children with insurance are more likely to receive care on time than those who are not insured (Aziz *et al.*, 2022).

5.3.4 Explaining the Diarrhoea Risk Factors in the District's Context

An in-depth assessment of diarrhoea cases in the study showed that roughly seven in ten children presented with moderate-severe diarrhoea. Based on the evidence from the process

evaluation and case-control study there was higher proportion of the cases with access to basic water services and a lower proportion with access to limited sanitation services. This could explain the severity of diarrhoea presentation as transmission is mainly faecal-oral. Thus, more moderate-severe diarrhoea cases were observed since coverage for limited sanitation services were sub-optimal. This shows that if WASH is not fully implemented, its advantage may not be completely achieved.

WASH interventions provide a barrier preventing the diarrhoea pathogens from getting into the human body (Darvesh *et al.*, 2017; WHO, 2015), hence once this barrier is porous or weak, the children under five years are clearly exposed to ingestion of these pathogens. In cases where these pathogens are ingested, vaccinations are the next way to prevent the children from coming down with diarrhoea. A very high proportion of the children had received the rotavirus vaccination, yet roughly four in ten had moderate to severe diarrhoea. This shows the need to know the pathogens that may be causing these diarrhoea cases.

From the epidemiological risk factor assessments done, it is clear that even in settings like this when households have access to improved water sources and improved sanitation facilities, other individual and community practice factors can also influence the occurrence of diarrhoea. This brings up the importance of considering the existing risk factors of the population in planning the kind of WASH interventions that would be effective in prevention of diarrhoea pathogens from infecting the child under five years.

5.4 : Assessment of Pathogen Causing Diarrhoea among Children under Five Years in Anloga District, 2022 -2023

In this study, in addition to rotavirus, the common pathogens of public health importance identified were *Escherichia coli*, *Shigella*, Norovirus, Adenovirus, and *Campylobacter spp*., *Cryptosporidium*, *Giardia spp*. These have been found according to the WHO to be the part of the major causes of diarrhoea morbidity and mortality among children under five years globally (WHO, 2024).

5.4.1 : Rotavirus A among Diarrhoea Cases in Anloga District, 2022 -2023

In this study, the proportion of rotavirus A cases was low. About two out of ten diarrhoea cases had rotavirus A. This could be explained by the high rate of rotavirus vaccination observed in the children who were part of the study. This finding confirms several studies in children under five which found that rotavirus vaccination reduced the incidence of diarrhoea in children under five years (Armah, 2015; Jenney *et al.*, 2021; Mokomane *et al.*, 2018; WHO, 2023; WHO, 2018a).

Globally, the rotavirus vaccination has reduced the incidence of severe rotavirus related morbidity and mortality in children under five years in various settings (WHO, 2018a). Thus, it has been recommended as a vaccine to be included in all national immunization programmes especially sub-Saharan Africa and south Asia which have high rates of child mortality (WHO, 2018a). In Ghana, Rotateq and Rotarix vaccines are the rotavirus vaccines given to children during the first six months of life. These two vaccines have been found to have a very high efficacy for over two years after receiving the vaccine (Bergman *et al.*, 2021).

The discrepancy in prevalence of rotavirus between the ELISA test 5% and the TaqMan Array Card (TAC) test (21%) was quite wide. This implies that aside rotavirus A determined by ELISA, there could be some other strains of rotavirus in circulation in the district aside

rotavirus A that the children are being vaccinated against. Some of these can only be identified by continuous surveillance and genotyping. Rotavirus genotyping has been recommended as a way of determining circulating strains in vaccinated populations (Ghapoutsa *et al.*, 2021). Given that almost all the children were vaccinated, the prevalence of rotavirus infection is significant. A similar study in a highly vaccinated population in Kenya also found the prevalence of rotavirus to be 14.5% after testing with the ProSpecT Rotavirus Microplate Assay kit (Muendo *et al.*, 2018).

Contrary to other studies where rotavirus was identified only in the first year of life (Platts-Mills *et al.*, 2015), rotaviruses were seen in all age groups. Rotavirus is reported to have been found in vaccinated children under five populations in some African countries. A study in Cameroun which used three laboratory methods (ELISA, GGP and PCR) found about 35% of the samples of hospitalized diarrhoea cases in children under five years were rotavirus positive (Ghapoutsa *et al.*, 2021). Another study in Kenya among a population of acute gastroenteritis children under five years with a high vaccination rate which used the ELISA test found 14.5% of the children to be positive for rotavirus (Muendo *et al.*, 2018). This finding confirms a systematic review which found out that rotavirus still remains a common cause of gastroenteritis among children under five years in Africa (Oppong *et al.*, 2020). In spite of these findings, rotavirus prevalence has generally been seen to have decreased in sites where rotavirus vaccination had just been introduced (Platts-Mills *et al.*, 2015).

All these earlier researches report that the rotavirus vaccine prevents rotavirus A diarrhoea. Thus, if the diarrhoea is not caused by rotavirus A, it can still occur even in vaccinated children. The high rotavirus vaccination rate among the cases could therefore imply that the diarrhoea being reported might not be caused by rotavirus A alone but by other diarrhoea pathogens

present in the setting. This clearly points out that aside rotavirus diarrhoea, there are other pathogens causing diarrhoea in the setting which might be of public health relevance.

5.4.2 : Other Diarrhoea Pathogens among Diarrhoea Cases in Anloga District, 2022 -2023

Bacteria Pathogens Identified:

In agreement with other studies (Moharana *et al.*, 2019; Platts-Mills *et al.*, 2015; Potgieter *et al.*, 2023b), Diarrhoeagenic *Escherichia Coli* (DEC) pathogens were the most common bacteria isolates identified in the study. DEC have been found as a major etiological agent of public health important especially in developing countries where it causes childhood diarrhoea (Moharana *et al.*, 2019). These pathogens are mainly transmitted through contact with human faeces. The most prevalent DEC was Enteroaggregative *Escherichia coli* (EAEC). It was identified in one of every two samples tested. In a study in Guinea Bissau EAEC was also found as the commonest bacteria pathogen to be detected among children under five years with diarrhoea (Mero *et al.*, 2021). However, in children above five years, it is not considered an important pathogen associated with diarrhoea according to a study in China (Zhang *et al.*, 2016). EAEC was found mostly in children below two years in this study. It has also been found elsewhere to be more common in children under one year (Mero *et al.*, 2021).

The study found that one in two samples tested was positive for *Shigella/EIEC*. *Shigella/EIEC* has been found to be associated with moderate and severe diarrhoea in children under five years (Lompo *et al.*, 2021; Mero *et al.*, 2021; Platts-Mills *et al.*, 2015). This could be because children infected with *Shigella* have a poor immune response which may cause them to lose appetite leading to malnourishment (Ferdous *et al.*, 2013). In the study also, *Shigella/EIEC* was identified mainly in children above two years. The finding is similar to findings from Mero's study among children under five years in Bissau which recorded a higher proportion of *Shigella/EIEC* in children above one year (Mero *et al.*, 2021). The study findings are however

contrary to the findings of a multisite study in South America, Africa, and Asia which found *Shigella* to be associated with diarrhoea in the first year of life (Platts-Mills *et al.*, 2015).

Other Viruses Identified:

The study detected five viruses, of which two (rotavirus and norovirus) are considered as important diarrhoeagenic viruses (Najafi *et al.*, 2013). One in four of the samples tested was positive for norovirus. Noroviruses are foodborne pathogens usually transmitted through contaminated water and food (Zhang *et al.*, 2016). They have been associated with a high burden of diarrhoea and found to be a significant cause of diarrhoea gastroenteritis, (a type of diarrhoea disease) in African children (Mans *et al.*, 2016; Potgieter *et al.*, 2023b). A study in China also found norovirus as the second most common pathogen causing diarrhoea outbreaks in children under five years (China) (Zhang *et al.*, 2016). In this study, norovirus infection was highest in children under two years. This is similar to another study that found that norovirus has been found to be associated with diarrhoea during the first and second years of life (Platts-Mills *et al.*, 2015).

The prevalence of sapovirus detected by the study was relatively lower than the other pathogens detected. This finding is similar to a study in South Africa which also detected a low rate of sapovirus (Potgieter *et al.*, 2023b). Generally, low rates of saporvirus have been reported in low middle-income countries. A systematic review reported a prevalence of 6.19% (Magwalivha *et al.*, 2018). Sapoviruses are enteric pathogens that are known to cause acute gastroenteritis in both humans and animals (Magwalivha *et al.*, 2018).

The study did not find adenovirus and astrovirus in any of the samples tested. This corroborates the findings of a systematic review on gastroenteritis pathogens among children under five

years in Africa which reported that adenovirus and astrovirus were the least identified pathogens in the region (Oppong *et al.*, 2020).

Parasite Infection

The most common parasite identified was Giardia. It was also found to be the most common in studies in Guinea Bissau (Mero *et al.*, 2021) and Burkina Faso (Lompo *et al.*, 2021). Giardia has been documented as a common parasite in systematic review in Africa and a cause of gastroenteritis in LMICs with poor sanitation (Oppong *et al.*, 2020). It was found in children of all age groups but mainly in those above two years old. Mero and colleagues also found Giardia to be common in older children above one year (Mero *et al.*, 2021).

Generally, Giardia spreads easily, it is best controlled by good personal hygiene practices of both the mother and child. In a clinical trial on WASH interventions in Dhaka, Bangladesh, three in ten children who received WASH interventions were still infected with Giardia (Lin *et al.*, 2018). This shows the need for individual level interventions to be able to control it. However, giardia has been found to be self-limiting (Garzón *et al.*, 2018), thus it ends up resolving itself even without treatment. It has however been found to have a mild effect on growth faltering specifically stunting in children less than 24 months in Sao Tome. This they explained, could be due to mechanisms such as microbial driven nutrient deficiencies, gut dysfunction and many more (Garzón *et al.*, 2018).

5.4.3 Diarrhoea Pathogen Co-infections

The rate of co-infection among the tested samples was high. In this study, roughly eight in ten tested samples had multiple enteric pathogen combinations with at least two co-infections. Potgieter reported a multiple diarrhoea pathogen co-infect rate among children under five with diarrhoea of almost 60% in South Africa (Potgieter *et al.*, 2023b). Whiles Ghapousta reported 63% co-infection rate in hospitalized diarrhoea cases in Cameroun (Ghapoutsa *et al.*, 2021).

Co-infection with two or more enteric pathogens during the early childhood is known to be a common phenomenon especially in developing countries and have been reported in several studies in Cameroun, South Africa, and other LMICs (Ghapoutsa *et al.*, 2021; Platts-Mills *et al.*, 2015; Potgieter *et al.*, 2023b; Vasco *et al.*, 2014; Zhang *et al.*, 2016). The co-infection of diarrhoea pathogens in developing countries has generally been attributed to poor hygiene and sanitation conditions within their environments (Belina *et al.*, 2023; Potgieter *et al.*, 2023b). The most predominant co-infection combination identified in this study was Virus-bacteria. This was also seen in a study in South Africa where about 50% of the children under five years who were tested had virus-bacteria co-infections (Potgieter *et al.*, 2023b). Almost five in ten of the samples tested had co-infection of bacteria-parasite-virus combination in their sample. The rate of bacteria-virus-parasite combination co-infection was low in another study in South Africa which detected a similar combination in less than 10% of the children under five tested (Potgieter *et al.*, 2023b).

Though co-infections of diarrhoea pathogens are known to be common among children under five years in developing countries, it poses various challenges. Some of these include: Increased severity of diarrhoea in children due to the synergistic effect of the different pathogens present (Ghapoutsa *et al.*, 2021). In the study, when the diarrhoea severity was described by pathogen type and co-infection, all combinations with bacteria had a higher severity than viruses and parasites. In this setting where the rotavirus vaccination coverage is high, severity of diarrhoea by rotavirus is likely to be mild as seen in the study. However, given that there are no vaccines for bacteria nor parasite vaccines, diarrhoea related to these could be severe. In the light of the severity, understanding the etiological role of each pathogen becomes essential since it is difficult to accurately link diarrhoea cases to specific pathogens without further investigations (Zhang *et al.*, 2016). This complexity could impact treatment effectiveness of diarrhoea (Potgieter *et al.*, 2023b). Clearly, the presence of different diarrhoea

pathogens in the samples demonstrated by the co-infections seen in this study adds on to the glitches in using a single pathogen intervention to tackle the diarrhoea menace as is being currently done (Platts-Mills *et al.*, 2015). Though the rotavirus vaccine intervention has solved a part of the diarrhoea problem, there still remains work to be done to further reduce the diarrhoea burden in children under five years. There is the need to focus on vaccines for other diarrhoea pathogens as they increase.

5.5 Implication of Findings

Summarising the findings from the three assessments, the district's WASH intervention is not achieving its aim of reducing diarrhoea burden and its severity. The process evaluation showed the district meeting half of the set target leaving quite a number of the population without access to limited sanitation services, a level which is actually at the bottom of the sanitation ladder. This could explain the higher proportion of moderate to severe diarrhoea cases seen in cases without access to improved toilet facilities. The district's WASH interventions may currently not amount to much in spite of the high improved water coverage. This is because if WASH as a package, is not implemented in full, its full benefit would not be derived. Incomplete implementation of WASH package is ineffective.

This shows that provision of WASH facilities to communities alone, is not enough to ensure they are fully used for the intended purpose. The process of implementation of these WASH interventions plays a key role in achieving the intended goal to prevent diarrhoea. Community engagement before, during and after the intervention are essential to final use and ownership of the WASH interventions. The findings from this study also raise concerns about the current approaches used in the assessment of water and sanitation activities. WASH practices assessed as present or absent may not be a true reflection of steps taken to prevent diarrhoea. Even if the WASH interventions are implemented fully but the other risk factors such as individual and

community practices and the type of diarrhoea pathogens present are not taken into consideration during the process of implementation, these risk factors and other pathogens could still facilitate the occurrence of diarrhoea. Continued involvement of the community during the implementation process to address the other risk factors such as personal and cultural factors in the population and knowledge on the types of pathogens causing diarrhoea could help in reducing the diarrhoea burden.

Additionally, children play an important role in breaking the faecal-oral pathway of diarrhoea though they are mostly not considered in designing WASH interventions. It is necessary to assess the possibility of reviewing existing WASH interventions so that they can also focus on children under five and how they are exposed to diarrhoea pathogens. This could help in reducing their risk of infections and improving their health.

Finally, there seems to be a paradigm shift in the known aetiology of diarrhoea among children under five years. Clearly, the pathogens of concern seem to have shifted to bacteria because the rotavirus vaccine is effective in reducing rotavirus associated diarrhoea. DEC and norovirus prevalence seems to be higher than that of rotavirus. Therefore, relying solely on rotavirus vaccination without considering effectively tailored WASH interventions which are well implemented and used by the population would expose our inability to deal with the emerging diarrhoea pathogens since there are currently no vaccines for them. It calls for a new approach to be adapted since there are no bacteria vaccines for prevention of diarrhoea yet.

5.6 : Strengths and Limitations of the Study

5.6.1 Strengths

Firstly, the study is probably the first of its kind to assess the causes of diarrhoea, taking into consideration the process of implementing a diarrhoea intervention (WASH), epidemiological

risk factors and aetiology in single research. Secondly, the laboratory assessment done used gold standards for determination of diarrhoea pathogens. Finally, the study shows interactions and gaps in the diarrhoea pathway which can be leveraged in a limited resource setting in dealing with diarrhoea.

5.6.2 Limitations of the Study

Some limitations of the study include the following: Since the evaluation was set up after the intervention had been carried out, the data available at the district level did not cover entirely all that was required for the evaluation. To reduce this bias, multiple data sources were used to obtain the best quality of data for the evaluation. Also, this study used a case-control design making it difficult to establish the order of exposure and outcome in the study. Additionally, with the cross-sectional study design used, only a snapshot of existing pathogens in the setting at a given time were observed. However, this is important information which revealed the existence of other pathogens present in the setting aside rotavirus.

Finally, the sample size for the laboratory analysis was small making it difficult to identify significant differences. However, given the gold standard laboratory methods used, the study provides a snapshot of the pathogens which are present in the setting.

These notwithstanding, the study findings serve as a good starting point for future research into the kind of WASH interventions required and the necessary processes to be used when implementing them. It also creates awareness of the need to evaluate interventions in place for preventing diarrhoea so that appropriate modifications can be made when necessary.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study evaluated the process of implementing WASH interventions, identified risk factors of diarrhoea and also determined the pathogens causing diarrhoea in Anloga District of the Volta region. The study found that the district has well laid out processes for implementation of WASH interventions. The structures in place in the district for implementation encompasses various stakeholders to enhance participation and ownership of the intervention. However, not all of these processes and structures seem to be fully adhered to. Targets set over the period were not fully met. Some major challenges identified were poor engagement, no post-implementation support and limited funding. The findings signify that current WASH implementation processes being used or intervention coverage could be contributing to poor community acceptance - affecting usage and desired outcome.

The study also found that non-use of household toilet by the child and a child being underweight were the risk factors associated with diarrhoea occurrence in the children under five years. The risk factors identified reflect poor use of WASH practices by or for children, thus pathogen transmission could continue to increase in diarrhoea cases. No health seeking practice was found to be associated with diarrhoea.

Finally, among the studied population, the leading pathogen for diarrhoea in the district was not rotavirus A which has been the dominant pathogen over the years but rather Diarrhoeagenic E. Coli strains (DEC), precisely EAEC and norovirus. Additionally, the rate of pathogen co-infection was very high with bacteria related co-infections having high diarrhoea severity. There seems to be a paradigm shift in the known aetiology of diarrhoea among children under five years. Given that currently there are no vaccines for these pathogens, measures such as

WASH interventions to prevent the pathogens from being ingested by the children would be beneficial.

6.2 Recommendations

Based on the findings, the following are recommended:

1. The District Assembly should improve stakeholder engagement and participation during implementation of WASH and follow the right steps to get everyone involved to increase ownership and use. It must also consider revisiting the approach to implementation of WASH in the communities

2. The District Assembly should review their Monitoring and Evaluation (M&E) indicators for WASH to be able to capture the community-sensitive indicators such as functionality of structures and post-implementation support, and assign budgets to get these activities carried out as part of routine activities.

3. The Ministry of Sanitation and Water Resources needs to revisit the WASH interventions currently being implemented so in order to extend interventions to target all age groups including children under five years.

4. The Ghana Health Service needs to conduct periodic diarrhoea pathogen surveillance through collaborations with research institutions such as Noguchi Memorial Institute for Medical Research (NMIMR) so that the circulating pathogens can be identified.

5. Ghana Health Service staff in the facilities should educate mothers on diarrhoea transmission pathways and their role in preventing pathogens from getting to their children by practicing and teaching their babies good hygiene practices.

6. Since there are no vaccines for these identified pathogens, and the diarrhoea cases reported are severe due to the high co-infections, the District Health Directorate and Environmental Health Officers should focus on implementing strategies, which aid the breaking of diarrhoea pathogen transmission. Such strategies should include more frequent household inspections with focus on water, sanitation and hygiene practices at the various levels (district, community and individual) with emphasis on the individual level to be able to control diarrhoea in the study district.

6.3 Contribution to Knowledge

This study adds the following to existing scientific knowledge

1. The positive effect of incomplete WASH interventions is minimal irrespective of how long they are implemented and their coverage.

2. In areas with high rotavirus vaccination coverage, diarrhoea in children under five years is caused by E. coli and norovirus and the severity of diarrhoea is due to presence of pathogen of bacteria origin either causing it alone or co-infection.

Publications from this Work with References

1. Bandoh DA, Dwomoh D, Yirenya-Tawiah D, Kenu E, Dzodzomenyo M. Prevalence and correlates of diarrhoea among children under five in selected coastal communities in Ghana. J Health Popul Nutr 43, 95 (2024). https://doi.org/10.1186/s41043-024-00582-8
2. Bandoh DA, Kenu E, Dwomoh D, Afari EA, Dzodzomenyo M. A study to evaluate WASH interventions and risk factors of diarrhoea among children under five years, Anloga district, Ghana: A research protocol. PLoS One. 2024 May 24;19(5):e0302754. Doi: 10.1371/journal.pone.0302754. PMID: 38787902; PMCID: PMC11125463.
3. Bandoh DA, Kenu E, Afari EA, Dwomoh D, Yirenya-Tawiah D, Dzodzomenyo M Assessing the implementation of WASH interventions in a coastal district with high diarrhoea burden, Ghana, 2022 (6400). 2023 ASTMH Annual Meeting Abstract Book. ASTMH 2023: 109; 4.

APPENDICES

Appendix 1: Data Collection Tools for Process evaluation

Interview Guide for Key Implementing Officers at District Assembly

Overview

1. What are some of the interventions the district has in place to reduce water, hygiene and sanitation problems?
    - List as many as you are aware of
    - Of these, list which ones you were part of
    - You can ask for the implementation plan (i.e., document - name & evidence)

Management and implementation

2. What process was used in bringing this particular intervention (pipe borne water extension, waste disposal site, toilet in school and communities).
3. Let's talk in detail about one of these interventions you were part of. Can you walk me through the entire process, for implementing this intervention?
4. Describe each of the steps taken to implement the intervention.

Engagement process

5. For each stage, which stakeholders were involved?
    - What roles did each of the stakeholders you mentioned play in the intervention? (Let respondent list every stakeholder's role)
6. Describe how each stage was carried out.
    - Which people were involved?
    - What did each of them do?
7. For each stage what was needed?
    - How did you get what was needed to implement the activity?
    - Were there enough resources from the beginning to do it well?
    - Was it well managed? How?
8. How did you decide which intervention a community need?
    - Who makes that decision?
9. Did you consult the community during the decisions?
    - What role do they play?
10. During the implementation, did the community have any role to play?
    - What did they do?
    - Which community members are involved?

Sustainability

11. Were there any problems encountered during the implementation?
    - What were they?
    - How were the challenges resolved/ managed?
    - Who were the people who helped in resolving the problem?
12. What could have been done differently

If training and education have not been mentioned in the interviews up to this point, ask the following questions

13. Are there any training activities carried out before/during the implementation process? Describe the training process in detail.
    - Who and who were trained?
    - Who did the training?
    - Where is it done?
    - What tools/materials are used for the training?
14. Is education part of the implementation process?
    - At what point? Who gives this education?

- Who are the target group for the education?
- Were the users educated to access or use the intervention?

Interview Guide for other officers at the district assembly (Other WASH Committee Members)

Overview

1. Can you tell me a bit about your role you play in the district?
2. What are some of the interventions the district has in place to reduce water, hygiene and sanitation problems?
    - List as many as you know off

Engagement

3. Of these, list which one you were part of?
4. Can you walk me through the entire process, for implementing this intervention?
    - Ask for the implementation plan if available.
5. For each step, which stakeholders were involved?
    - What roles did each of the stakeholders you mentioned play in the intervention?
6. What role did you play in this activity being implemented?
7. Were community members involved at any point?
    - How were they involved?
    - What were the steps taken?
    - At what stage were they involved…beginning, half-way, etc.?

Management

8. Were there any problems encountered during the implementation?
    - What were they?
    - Were there enough resources from the beginning to do it well?
    - Was it well managed?
9. How were the challenges resolved/ managed?
    - Who were the people who helped in resolving the problem?

If education have not been mentioned in the interviews up to this point, ask the following questions

10. Was education given as part of the implementation process?
    - At what point? Who gives this education?
    - Who are the target group for the education?
    - Were the users educated to access or use the intervention.
    - How was it done?

11. What could have been done differently
12. Is there any other thing you would like us to know before we end our conversation?

Community Level Interviews (Key Community Members, Assembly Members)

1. What role do you play in the community?
2. Have you been involved in water, sanitation and hygiene issues in the community?
    - What have you been doing?

Management and implementation

1. Can you walk me through the various stages of the implementation you saw?
    - For each stage you mentioned, how did it start?
    - Who and who were involved?
    - What did they do?
    - How did they do it?

Engagement

3. Have you witnessed any water, hygiene or sanitation project being implemented in your community? i.e.: water, community/ household KVIP, school KVIP, waste site?
    - Which one were you involved in?
    - what was your involvement about?
    - When was it done?
    - How was it done?
4. Did you play any role?
    - What did you do?
    - Were any other community members involved?
    - What did they do?
5. Were you or other members of the community consulted during planning and implementation?
6. When the implementation was going on, were you or any community people consulted?
    - How was this done, who did it?
    - What did they tell you?
7. Who decided where the intervention should be located?
    - Who have a say in that decision?

Management

8. Who supervised the implementation?
9. Do you have any idea how it was funded?

Sustainability

10. Were you or any community members given any education on this intervention being implemented? What was the education about? Who gave it? How was it done?
11. What do you think can be done to improve the implementation?
12. Is there any other thing you would like us to know before we end our conversation?

Community Focus Group Discussion

Overview

1. We are going to talk about water, sanitation and hygiene in this community.
2. Who is responsible for water, sanitation and hygiene in this community?
    - When you have issues who do you go to for solutions?

Engagement

3. Which of water, sanitation or hygiene invention have you seen them implement here?
    - Tell us all of them?
    - When was it done?
4. What did you observe?
    - Who led the implementation?
    - How was it done?
    - Did they involve any of the community members?
    - What did they ask you to do?
5. Describe the stages, activities involved in the implementation you saw
6. Did you witness them bring pipe borne water/ bore hole/ well to this community?
    - What did you observe? Who led the implementation? Did they involve any of the community members? What did they ask you to do?
7. Did you witness them implement Open Defecation free intervention in your community?
    - What did you observe?
    - Who led the implementation?
    - Did they involve any of the community members?
    - What did they ask you to do?
8. Did you witness them build KVIPs for the school in your community?
    - What did you observe? Who led the implementation?
    - Did they involve any of the community members?
    - What did they ask you to do?
9. Have you witnessed the creation of a waste dump site in this community?
    - How was it done?
    - When was that?
    - What were the steps taken?
    - Location site?

Management

10. Who supervised the implementation?
11. Do you have any idea how it was funded?

Sustainability

12. Were you or any community members given any education on this intervention being implemented?
    - What was the education about?
    - Who gave it?
    - How was it done?
13. What do you think can be done to improve the implementation?
14. What are your thoughts on how the implementations you have seen so far are done? Do they have anything in common? What can be done to improve it?
15. Is there any other thing you would like us to know before we end our conversation?
16. What do you think can be done to improve the implementation?

Checklist for WASH Structures 3-5 households around (surrounding the newest WASH structures)

No.	Question	Response:
1	Take GPS coordinates of newest WASH structures in the community Structure type:	a)…… b: ……. ……..……
2	For each, confirm from the community if it is being used If no why?	a) Yes b) No ……..
3	Find out if they know how it came into being and the donors who brought it	Who: How it came: ……. Donors:……..
4	Find out if they were given any information on how to use it. How was this information given?	…….. …….. ……..
5	Do they have any comments on how it was implemented?	…….. …….. ……..

Data Extraction Sheet for Desk Review at National and District Level

Type of document	Year of document	Level (National/ District)	Author	Information extracted	Relevance of information	Comments

Appendix 2: Data Collection Tools for Case Control study

TOOLS FOR CASE CONTROL STUDY

Health Facility Questionnaire for Cases Only

1. Recruitment date: …….	2. Interviewer name: ……..
3. Caregiver ID: ……..	4. Caregiver Phone number: ……..
5. Facility name: ……..	6. Community caregiver lives in:
7. Land mark close to case house ……..…….	8. Age of child (months)
9. Sex of child: M……..… F ……..	10. Date of birth of the child (DD/MM/ YYYY) ……/……/……
11. Date of onset of diarrhoea start (DD/MM/ YYYY) ……/……/……	12. Date diarrhoea was reported (DD/MM/ YYYY) ……/……/……
13. What was the first thing you did (if nothing, skip questions 13&15) …….	14. Was any treatment given before coming? Y 1 N 0 (skip next question)
15. What treatment was the child given …….	16. How many times has the child vomited in the past 24hrs? ……..
17. Does the child have any of these clinical symptoms? 18. vomiting Y N 19. dehydration Y N 20. fever Y N 21. blood in stool Y N 22. mucus in stool Y N	23. How many times has the child passed stool in the past 24hrs? ……
24. Has stool sample been taken? Y 1 N 0 (skip 25)	25. Date sample was taken (DD/MM/ YYYY) ……/……/……
26. When do you intend to take the sample (sample must be taken before medication)	27. Was sample taken after treatment? Y 1 N 0

Comments: …….

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Questionnaire For Case and Control Study Subjects

Interviewer ID: ……..	Caregiver's ID:
Child age: …….	Date of interview: (dd/mm/yy) ____/ _____/ _____
Index child's sex: M 1 F 2	Child's date of birth: (dd/mm/yy) ____/ _____/ _____
Where do you live?	Is child a case or control

Demographics				
No	Questions	Coding Categories	Skip to	Codes
A. Household Characteristics				
A1	Who is the head of the household?	Mother… ..... 1 Father.....2 Grandparent ..... 3 Other (specify).....77		HHH
A2	Primary occupation of head of household	Unemployed… .....0 Formally employed..... 1 Fisherfolks… ..... 2 Farmer… .....3 Trader… .....4 Artisan… .....5 Other (specify)..... 77		POHHH
A3	Educational level of household head	No formal education ….0 Primary… ..... 1 Middle/JHS…. .....2 SHS/commercial… .....3 Tertiary… .....4 Other (specify).....77		
A4	How many people currently live in the household	---- -----		PCLHH
A5	How many are (years)	Under 5..... 1 5 - 14 ……..2 15 – 24 ……..…..3 55 - 64 ……..…4 65 and above …..….5		ASHH
A6	Religion	Christian ..... 1 Moslem.....2 Traditionalist.....3 None .....0 Other (specify).....77		
A7	Relationship between caregiver and child	Mother ..... 1 Father.....2 Grandparent… ..... 3 Sibling… .....4 Other (specify)		

A8	Age of caregiver (in complete years)	----- -----		ACCA
A9	Highest level of education of caregiver	No formal education ….0 Primary… ..... 1 Middle/JHS…. .....2 SHS/commercial… .....3 Tertiary… ..... 4 Other (specify).....77		LEDU
A8	Primary occupation of caregiver	Unemployed… .....0 Fishmonger…. .....1 Farmer… .....2 Trader… ..... 3 Artisan… ..... 4 Other (specify).....77		POCG
A9	**Equity Tool** a. Does this household have: a radio?	Yes.....1 No 0		ET
	b. a television	Yes.....1 No 0		
	c. a computer/tablet computer	Yes.....1 No 0		
	d. a refrigerator	Yes.....1 No 0		
	e. a cabinet/cupboard	Yes.....1 No 0		
	f. Does any member of this household own a wristwatch?	Yes.....1 No 0		
	g. Does any member of this household have a bank account	Yes.....1 No 0		
	h. What is the main source of drinking water for members of your household	Sachet Water….....1 Other source of drinking water 0		
	i. What kind of toilet facility do members of your household usually use	Flush to manhole/septic tank (not shared)……1 Other toilet facility ……0		
	j. What type of fuel does your household mainly use for cooking	Wood ..... 1 LPG .....0 Other source fuel ……2		
	k. What is the main material of the floor of your dwelling	Cement .....1 Other material..... 0		
B. Health-Seeking Practices (Request for child U-5s weighing card)				

B1	Has your child's immunization being completed (for their age)	Appropriately vaccinated1 Partially vaccinated……2 Never vaccinated……3		CICA
B2	Has the child taken Rota vaccine	Yes.....1 No..... 0		
B3	When your child is sick where is s/he taken to (primary point of call)	Government hospital …..1 Gov Health centre.....2 Gov. CHPS ..... 3 Private facility .....4 Self-care.....5 OTCMS ..... 6 Herbalist ……. 7 Prayer camp…..... 8 Other (specify)..... 77		CIWT
B4	Why do you take them there?	……..…		
B5	Where do you get health advice from?	Government hospital …..1 Gov Health centre.....2 Gov. CHPS ..... 3 Private facility .....4 Self-care.....5 OTCMS ..... 6 Herbalist .....7 Prayer camp…..... 8 Friend/family ..... 9 Other (specify).....77		WGHE
B6	In the past 6 months has your child been given any medicine for intestinal worms?	Yes.....1 No..... 0		MFIW
B7	In the past 6 months has your child been given iron supplement?	Yes.....1 No..... 0		
B8	When your child is sick, who decide whether the you should seek care or not	Mother…..... 1 Father.....2 Grandparent ..... 3 Other (specify).....77		
B9	What is the basis for the decision	…….		
B10	Who decides where the child should be taken to when s/he is sick	Mother…..... 1 Father.....2 Grandparent ..... 3 Other (specify).....77		
B11	What is the basis for the decision	……		

B12	Is your child on health insurance	Yes.....1 No..... 0		
B13	Has your child started schooling?	Yes.....1 No..... 0		

D. Dietary Diversity						
How often do you give your child the following foods in the past 7 days? (yes/ no/ don't know)						codes
Food item	Daily	1 – 2	3-5	Never	24hrs	
A. Foods made form cereals, roots tubers and plantain foods?						A
B. Vitamin A rich (dark Green Leafy Vegetables (Kontomire, Aleefu, Cassava Leaves)? Ripe Mangoes, Pawpaw?						B
C. Any Other Fruits or Vegetables (Banana, pear, Tomatoes, Orange?						C
D. Any Meat Such as Beef, Pork, Lamb, Goat, Chicken or Duck?						D
E. Fresh or Dried Fish or Shellfish (Prawns, Lobsters...)?						E
F. Eggs?						F
G. Any Foods Made from Beans, Peas, Lentils or Nuts?						G
H. Milk Cheese, Yogurt or Other Milk Products?						H
I. Any Oil, Fats or Butter, Or Foods Made with Any of This?						I
J. Any Sugary Foods or drinks As Chocolate, toffee, Pastries, Biscuits, drinks, ice cream?						J

E. Household Water, Hygiene and Sanitation Practices	
Household sanitation checklist (observe and answer)	

E1	What is the main source of water used by members of your household for cooking?	**Piped water** piped into dwelling..... 11 piped to yard / plot ..... 12 piped to neighbour..... 13 public tap / standpipe ..... 14 Tube well / borehole ..... 21 **Dug well** protected well..... 31 unprotected well..... 32 **Spring** protected spring..... 41 unprotected spring..... 42 Rainwater..... 51 Tanker-truck..... 61 Surface water (river, dam, lake, pond, stream, canal, irrigation channel)..... 81 **Packaged water** bottled water..... 91 sachet water..... 92 Other (specify) ……...…….. 77	WDCF
E2	Where is the water source located	In own dwelling.....1 In own yard/plot ..... 2 Elsewhere 3	
E3	Do you or any other member of this household do anything to the water to make it safer to drink?	Yes.....1 No ..... 0 (skip qE4)	CWS
E4	What do you usually do to make the water safer to drink? (Check all that apply)	Boil ..... 1 Add bleach / chlorine..... 2 Strain it through a cloth ..... 3 Use water filter (ceramic, sand, composite, etc.) . ..... 4 Solar disinfection ..... 5 Let it stand and settle ..... 6 Other (specify).....77 Dk 9	CWSB
E5	Does your child use a feeding/ water bottle	Yes.....1 No 0	
E6	How often is it washed with soap and water	Daily ..... 1 Weekly.....2 Other 3	
E7	How does your household store water for cooking?	Plastic container/bucket .....1 Pot/earthenware vessel.....2 Metal container ..... 3 Bottle/sachet.....4 (skip E8) Other (specify) ..... 77 Don't know 9	

E8	How often is the storage receptacle washed?	Weekly….....1 Monthly .....2 Yearly .....3 Never .....4 Don't know.....9	
E9	What does the household use to fetch water from the storage receptacles	Using a cup with a handle.....1 Using a bowl..... 2 Others (specify)..... 77	
E10	What kind of toilet facility do members of your household usually use? Can you show it to me?	**Flush / pour flush** flush to piped sewer system ..... 11 flush to septic tank..... 12 flush to pit latrine ..... 13 flush to open drain..... 14 flush to dk where..... 18 **Pit latrine** ventilated improved pit latrine ..... 21 pit latrine with slab..... 22 pit latrine without slab /open pit.....23 Composting toilet..... 31 Bucket..... 41 Hanging toilet / hanging latrine ..... 51 No facility / bush / field ..... 95 Other (specify)..... 77	TOTF
E11	Where is this toilet facility located?	In own dwelling..... 1 In own yard / plot..... 2 Elsewhere 3	
E12	Do you share this facility only with others	Yes, other households only..... 1 Yes, public.....2 No ……0 (skip E13)	
E13	How many households use this toilet facility?	Less than 10 households ..... 1 More than 10 households.....2 Don't know.....77	
E14	Do your children use the toilet facility	Yes..... 1 (skip qE13) No 0	
E15	If no, where do they defecate	……..	
E16	What is done to dispose of the diarrhoea stools of your child?	Child used toilet or latrine ..1 Put/rinsed into toilet ….2 Put/rinsed into drain or ditch 3 Thrown into garbage .....4 Buried ..... 5 Left in the open.....6 Other (specify).....99	DDS

E17	Can you please show me where members of your household most often wash their hands?	**Observed** Fixed facility observed (sink / tap) in dwelling.....1 in yard /plot.....2 Mobile object observed (bucket / jug / kettle).....3 **Not observed** No handwashing place in dwelling / yard / plot.....4 No permission to see.....5 Other reason (specify)6	
E18	How often do you wash your hands with soap and water? a) after defecation or using a latrine b) after cleansing the child's defecated buttock, c) before cooking, d) before eating, and before feeding the child	Always=1 usually 2 = sometimes 3 never 4	

Comments: ……

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……..

F. Anthropometry

Interviewer ID: ……..	Caregiver's ID:
	Date : (dd/mm/yy) ____/ _____/ _____
child's sex: M 1 F 2	Child's date of birth: (dd/mm/yy) ____/ _____/ _____
Child age: ……..	Child's weight 2 (kilograms) ……..
Child's length/ height 1 (cm) ……	Child's length/ height 2 (cm) ……

Comments: ……

……..

……..

Appendix 3: Data Collection Tools for Aetiology of Diarrhoea study

Laboratory Sample collection

Interviewer ID: ……..	Caregiver's ID:
Facility name: ……	Facility type: ……
Child age: …….	Date of Sample collection: (dd/mm/yy) ____/ _____/ _____
child's sex: M 1 F 2	Child's date of birth: (dd/mm/yy) _ __/ ____/ _____
Was child given any treatment before the sample was taken? Yes / No	Date sample was sent for storage (dd/mm/yy) ____/ _____/ _____

Comments: ……

……..

……..

……..

Laboratory Results Form

Sample ID	ELISA Status (+/-)	Types of Pathogens Found

Comments: ……

……..

……..

……..

Appendix 4: Determination of appropriate sample size for case control study

Table A4.1: Exposures in case control and corresponding sample sizes

Exposure	Prevalence of exposure in controls (%)	Sample size per group	Reference
Hand washing at critical points	74.1%	210	(Asfaha *et al.*, 2018)
Child stool disposal	46.2%	131	(Asfaha *et al.*, 2018)
Drinking pipe water	35%	132	(Issahaku *et al.*, 2020)
Type of toilet facility used	46.7%	131	(Asfaha *et al.*, 2018)
Household water source	23.8%	153	(Adamu *et al.*, 2022)
Seeking care from Health professional	49%	133	(Ghana Statistical Service (GSS) & ICF, 2022)
Vaccination status	26.7%	145	(Bandoh, Dwomoh, *et al.*, 2024)

Appendix 5: Water quality indicators for some communities in Anloga District

Table A4.2: Bacteriological drinking water quality assessment by C2R-CD project

Pathogen	Community	
	Anyanui	Atiteti
Total coliform counts (cfu/100ml)	0-2611	0-4
Escherichia coli (cfu/100ml)	0-8	0-3

Appendix 6: Types of co-infections and distribution by age, sex and pathogen type and number of pathogens per infection

Table A4.3: Frequency of pathogen co-infections by sex in children under five years, Anloga District, 2023

Factor	Male (%)	Female (%)	Total (%)	p-value
N	n = 21	n = 17	n = 38	
	n (%)	n (%)	n (%)	
				0.33
No pathogen	1 (4.76)	1 (5.88)	2 (5.26)	
Bacteria only	6 (28.57)	2 (11.76)	8 (21.05)	
Virus only	1 (4.76)	1 (5.88)	2 (5.26)	
Bacteria and parasites	0 (0.00)	2 (11.76)	2 (5.26)	
Virus and parasite	1 (4.76)	0 (0.00)	1 (2.63)	
Virus and bacteria	10 (47.62)	6 (35.29)	16 (42.11)	
Virus, bacteria and parasite	2 (9.52)	5 (29.41)	7 (18.42)	

Table A4.4: Frequency of pathogens co-infections by age in children under five years, Anloga District, 2023

Factor	Below 2 years (%)	Above 2 years (%)	Total (%)	p-value
N	22	16	38	
	n =	n =	n =	
Type of pathogen present				0.92
No pathogen	1 (4.55)	1 (6.25)	2 (5.26)	
Bacteria	5 (22.73)	3 (18.75)	8 (21.05)	
Virus	1 (4.55)	1 (6.25)	2 (5.26)	
Bacteria and parasites	2 (9.09)	0 (0.00)	2 (5.26)	
Virus and parasite	1 (4.55)	0 (0.00)	1 (2.63)	
Virus and bacteria,	9 (40.91)	7 (43.75)	16 (42.11)	
Virus, bacteria and parasite	3 (13.64)	4 (25.00)	7 (18.42)	

Table A4.5: Description of pathogen coinfections by sex and age in children under five years, Anloga District, 2021-2023

Factor	Number of pathogens in sample				Total	p-value
	None	One to Two	Three	Four or more		
N	2	13	9	14	38	
Sex						0.85
Male	1 (4.76)	7 (33.33)	4 (19.05)	9 (42.86)	21 (55.26)	
Female	1 (5.88)	6 (35.29)	5 (29.41)	5 (29.41)	17 (44.73)	
Age						0.79
2years or less	1 (4.55)	9 (40.91)	5 (22.73)	7 (31.82)	22 (57.89)	
Above 2years	1 (6.25)	4 (25.00)	4 (25.00)	7 (43.75)	16 (42.11)	

Appendix 7: Informed Consent forms

PARTICIPANT INFORMATION SHEET

Case-Control Study above 18 years

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

Good morning / Afternoon my name is.....I work for the University of Ghana School of Public Health (UGSPH) based in Accra, Ghana. Together with Institute of Environmental Studies (IESS), we are conducting a research project to assess what causes diarrhoea as part of a bigger study to understand diarrhoea in coastal areas of Ghana. The main aim of the project is to assess water, sanitation and hygiene practices, food pattern and health practices in the community change over the year and how this affects diarrhoea disease occurrence.

Background and Purpose of Research

Diarrhoea is a leading cause of sickness and death especially among children under five years. Water, sanitation and hygiene (WASH) greatly influences the occurrence of diarrhoea. The changing weather conditions are increasing affecting WASH practices. This is leading to the increase in WASH related diseases such as diarrhoea. Understanding what is causing diarrhoea diseases in coastal communities in Ghana over the different seasons of the year can help reduce the disease. To achieve this, the researchers will collect information on the household environment and practices at different times of the year. The study will be done in selected coastal communities in Anloga district, Volta region.

Nature of Research

This study would be a case-control study with caregivers and children under five years in Anloga district. Caregivers bringing their children under five years with diarrhoea to the health facility would be interviewed. We would also take a stool sample from the child for a laboratory test to find out what germ is causing the diarrhoea. We would also come to the house to talk to you and observe some of your WASH practices. To understand your community better, we would talk to other women in your neighbourhood whose children do not have diarrhoea and ask them the same questions in the household. The information you give would help in providing practical solutions to health issues in coastal areas.

Participant involvement

You have been selected to participate in this survey because you are a caregiver with a child under five years in this community. We would visit you, and ask you questions about your household. The questions will be on your sanitation practices, the water you drink and what you do when the household members especially the child under five years is sick, if anyone has gotten diarrhoea in the past month, what you eat. We would also take the weight and height measurement of you and the child under five years. The survey will be conducted from July 2022 to June 2023. The interview would last for about 25 minutes.

Possible Risks and discomforts

There are minimal risks in responding to questions about diarrhoea and sanitation in this study. We do not anticipate any physical, economic or legal risks, but do expect some level of discomfort and perhaps stress, given the questions in survey tool that explores sanitation and diarrhoea. However, you may experience some discomfort, uneasiness or embarrassment in providing a stool sample if your child has diarrhoea and responding to some of the questions about your thoughts and feelings about the questions. Thus, at any time, you can choose not to answer any questions or stop the study at any time.

Benefits:

There are no immediate and direct benefits of participating in the study however the study will lead to improving evidence-based solutions towards addressing weather-related diseases in coastal communities.

Cost

There will be no cost incurred in this study.

Compensation:

After the interview, participants will be given a bar of soap worth GH¢5 to compensate for their time spent.

Confidentiality:

Unique codes instead of names will be used will be for interview purposes and for samples. Your responses will not be shared with anyone else outside the research team. Data collected will be kept private. Any information from you will have a number on it instead of your name. You can refuse to answer any specific question or stop the interview at any time. If you chose not to answer a question, stop the interview or even not take part at all in the study it will not affect your organization facilities today or in the future. Samples collected would be discarded after results are disseminated.

Voluntary Participation and Right to Leave the Research

Your participation in this study is your choice and voluntary. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with any institution.

Outcome and Feedback

The findings will be used as influence policy- and decision-makers to provide country-specific, evidence-based solutions towards addressing climate related health risks in coastal communities.

Feedback to participant

Findings of the study would also be disseminated through the University of Ghana. Publication of data would also be used as a mode of dissemination of information.

Funding information

Study is funded by the University of Ghana, through Danish Government (DANIDA).

Sharing of participants Information/Data

Data generated from this study will be owned by the University of Ghana School.

Provision of Information and Consent for participants

A copy of the Information sheet and Consent form will be given to you after it has been signed or thumb-printed to keep.

Approval:

Approval for this study was obtained from the Ghana Health Services Ethical Review Committee (**Approval Number:** _____

Contact for additional information

If you have questions about this activity, concerns or complaints about this research study, please contact Delia Bandoh on +233 024 235 6585, or deliabandoh@st.ug.edu.gh or Prof Dzodzomenyo +233 020 837 6845 or mdzozomenyo@uh.edu.gh.

Your right as a participant

This research has been reviewed and approved by the Ghana Health Service Ethics Review Committee (GHS-ERC). If you have any questions about your rights as a research participant, you can contact the **GHS-ERC administrator, Nana Abena Apatu** between the hours of 8am – 5pm through the telephone number +233503539896, or email address ethics.research@ghsmail.org.

CONSENT FORM

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

PARTICIPANTS' STATEMENT

I acknowledge that I have read or have had the purpose and contents of the Participants' Information Sheet read and all questions have been satisfactorily explained to me in a language I understand (Twi [ ] Ewe [ ] ..... [ ]). I fully understand the contents and any potential implications as well as my right to change my mind (i.e., withdraw from the research) even after I have signed this form. I voluntarily agree to be part of this research.

Name of Participant.....

Participants' Signature .....OR Thumb Print..... Date .....

INTERPRETERS' STATEMENT

I interpreted the purpose and contents of the Participants' Information Sheet to the afore named participant to the best of my ability in the (Twi [ ] Ewe[ ] .....[ ]) language to her/her proper understanding. All questions, appropriate clarifications sort by the participant and answers were also duly interpreted to his/her satisfaction.

Name of Interpreter..... Signature of Interpreter.....

Date ..... Contact Details .....

STATEMENT OF WITNESS

I was present when the purpose and contents of the Participant Information Sheet was read and explained satisfactorily to the participant in the language he/she understood (Twi [ ] Ewe ..... [ ]). I confirm that he/she was given the opportunity to ask questions/seek clarifications and same were duly answered to his/her satisfaction before voluntarily agreeing to be part of the research.

Name:..... Signature.....

OR Thumb Print ..... Date:.....

INVESTIGATOR STATEMENT AND SIGNATURE

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed.

Researcher's name..... Signature .....

Date.....

PARTICIPANT INFORMATION SHEET

Parental Consent Case-Control Study

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

Good morning / Afternoon my name is.....I work for the University of Ghana School of Public Health (UGSPH) based in Accra, Ghana. Together with Institute of Environmental Studies (IESS), we are conducting a research project to assess what causes diarrhoea as part of a bigger study to understand diarrhoea in coastal areas of Ghana. The main aim of the project is to assess water, sanitation and hygiene practices, food pattern and health practices in the community change over the year and how this affects diarrhoea disease occurrence.

Background and Purpose of Research

Diarrhoea is a leading cause of sickness and death especially among children under five years. Water, sanitation and hygiene (WASH) greatly influences the occurrence of diarrhoea. The changing weather conditions are increasing affecting WASH practices. This is leading to the increase in WASH related diseases such as diarrhoea. Understanding what is causing diarrhoea diseases in coastal communities in Ghana over the different seasons of the year can help reduce the disease. To achieve this, the researchers will collect information on the household environment and practices at different times of the year. The study will be done in selected coastal communities in Anloga district, Volta region.

Nature of Research

This study would be a case-control study with caregivers and children under five years in Anloga district. Caregivers bringing their children under five years with diarrhoea to the health facility would be interviewed. We would also take a stool sample from the child for a laboratory test to find out what germ is causing the diarrhoea. We would also come to the house to talk to you and observe some of your WASH practices. To understand your community better, we would talk to other women in your neighbourhood whose children do not have diarrhoea and ask them the same questions in the household. The information you give would help in providing practical solutions to health issues in coastal areas.

Participant involvement

Your child under 18years has been selected to participate in this survey because she is caregiver with a child under five years in this community. We would visit her, and ask her questions about her household. The questions will be on her sanitation practices, the water she drinks and what she does when the household members especially the child under five years is sick, if anyone has gotten diarrhoea in the past month, what you eat. We would also take the weight and height measurement of she and the child under five years. The survey will be conducted from July 2022 to June 2023. The interview would last for about 25 minutes.

Possible Risks and discomforts

There are minimal risks in responding to questions about diarrhoea and sanitation in this study. We do not anticipate any physical, economic or legal risks, but do expect some level of discomfort and perhaps stress, given the questions in survey tool that explores sanitation and diarrhoea. However, she may experience some discomfort, uneasiness or embarrassment in providing a stool sample if your child has diarrhoea and responding to some of the questions about her thoughts and feelings about the questions. Thus, at any time, she can choose not to answer any questions or stop the study at any time.

Benefits:

There are no immediate and direct benefits of participating in the study however the study will lead to improving evidence-based solutions towards addressing weather-related diseases in coastal communities.

Cost

There will be no cost incurred in this study.

Compensation:

After the interview, participants will be given a bar of soap worth GH¢5 to compensate for their time spent.

Confidentiality:

Unique codes instead of names will be used will be for interview purposes and samples collected. Your responses will not be shared with anyone else outside the research team. Data collected will be kept private. Any information from you will have a number on it instead of your name. You can refuse to answer any specific question or stop the interview at any time. If you chose not to answer a question, stop the interview or even not take part at all in the study it will not affect your organization facilities today or in the future. Samples collected would be discarded after results are disseminated.

Voluntary Participation and Right to Leave the Research

Your child's participation in this study is your choice and voluntary. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to let her withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with any institution.

Outcome and Feedback

The findings will be used as influence policy- and decision-makers to provide country-specific, evidence-based solutions towards addressing climate related health risks in coastal communities.

Feedback to participant

Findings of the study would also be disseminated through the University of Ghana. Publication of data would also be used as a mode of dissemination of information.

Funding information

Study is funded by the University of Ghana, through Danish Government (DANIDA).

Sharing of participants Information/Data

Data generated from this study will be owned by the University of Ghana School.

Provision of Information and Consent for participants

A copy of the Information sheet and Consent form will be given to you after it has been signed or thumb-printed to keep.

Approval:

Approval for this study was obtained from the Ghana Health Services Ethical Review Committee (**Approval Number:** _____

Contact for additional information

If you have questions about this activity, concerns or complaints about this research study, please contact Delia Bandoh on +233 024 235 6585, or deliabandoh@st.ug.edu.gh or Prof Dzodzomenyo +233 020 837 6845 or mdzozomenyo@uh.edu.gh.

Your right as a participant

This research has been reviewed and approved by the Ghana Health Service Ethics Review Committee (GHS-ERC). If you have any questions about your rights as a research participant, you can contact the **GHS-ERC administrator, Nana Abena Apatu** between the hours of 8am – 5pm through the telephone number +233503539896, or email address ethics.research@ghsmail.org.

PARENTAL CONSENT FORM

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

PARTICIPANTS' STATEMENT

I acknowledge that I have read or have had the purpose and contents of the Participants' Information Sheet read and all questions have been satisfactorily explained to me in a language I understand (Twi [ ] Ewe [ ] ..... [ ]). I fully understand the contents and any potential implications as well as my right to change my mind (i.e., withdraw from the research) even after I have signed this form. I voluntarily agree for my child to be part of this research.

Name of Participant.....

Participants' Signature .....OR Thumb Print..... Date .....

INTERPRETERS' STATEMENT

I interpreted the purpose and contents of the Participants' Information Sheet to the afore named participant to the best of my ability in the (Twi [ ] Ewe[ ] .....[ ]) language to her/her proper understanding. All questions, appropriate clarifications sort by the participant and answers were also duly interpreted to his/her satisfaction.

Name of Interpreter..... Signature of Interpreter.....

Date ..... Contact Details .....

STATEMENT OF WITNESS

I was present when the purpose and contents of the Participant Information Sheet was read and explained satisfactorily to the participant in the language he/she understood (Twi [ ] Ewe ..... [ ]). I confirm that he/she was given the opportunity to ask questions/seek clarifications and same were duly answered to his/her satisfaction before voluntarily agreeing to be part of the research.

Name:..... Signature.....

OR Thumb Print ..... Date:.....

INVESTIGATOR STATEMENT AND SIGNATURE

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed.

Researcher's name..... Signature .....

Date.....

PARTICIPANT INFORMATION SHEET

Assent Form Case-Control Study (under 18years)

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

Good morning / Afternoon my name is.....I work for the University of Ghana School of Public Health (UGSPH) based in Accra, Ghana. Together with Institute of Environmental Studies (IESS), we are conducting a research project to assess what causes diarrhoea as part of a bigger study to understand diarrhoea in coastal areas of Ghana. The main aim of the project is to assess water, sanitation and hygiene practices, food pattern and health practices in the community change over the year and how this affects diarrhoea disease occurrence.

Background and Purpose of Research

Diarrhoea is a leading cause of sickness and death especially among children under five years. Water, sanitation and hygiene (WASH) greatly influences the occurrence of diarrhoea. The changing weather conditions are increasing affecting WASH practices. This is leading to the increase in WASH related diseases such as diarrhoea. Understanding what is causing diarrhoea diseases in coastal communities in Ghana over the different seasons of the year can help reduce the disease. To achieve this, the researchers will collect information on the household environment and practices at different times of the year. The study will be done in selected coastal communities in Anloga district, Volta region.

Nature of Research

This study would be a case-control study with caregivers and children under five years in Anloga district. Caregivers bringing their children under five years with diarrhoea to the health facility would be interviewed. We would also take a stool sample from the child for a laboratory test to find out what germ is causing the diarrhoea. We would also come to the house to talk to you and observe some of your WASH practices. To understand your community better, we would talk to other women in your neighbourhood whose children do not have diarrhoea and ask them the same questions in the household. The information you give would help in providing practical solutions to health issues in coastal areas.

Participant involvement

You have been selected to participate in this survey because you are a caregiver with a child under five years in this community. We would visit you, and ask you questions about your household. The questions will be on your sanitation practices, the water you drink and what you do when the household members especially the child under five years is sick, if anyone has gotten diarrhoea in the past month, what you eat. We would also take the weight and height measurement of you and the child under five years. The survey will be conducted from July 2022 to June 2023. The interview would last for about 25 minutes.

Possible Risks and discomforts

There are minimal risks in responding to questions about diarrhoea and sanitation in this study. We do not anticipate any physical, economic or legal risks, but do expect some level of discomfort and perhaps stress, given the questions in survey tool that explores sanitation and diarrhoea. However, you may experience some discomfort, uneasiness or embarrassment in providing a stool sample if your child has diarrhoea and responding to some of the questions about your thoughts and feelings about the questions. Thus, at any time, you can choose not to answer any questions or stop the study at any time.

Benefits:

There are no immediate and direct benefits of participating in the study however the study will lead to improving evidence-based solutions towards addressing weather-related diseases in coastal communities.

Cost
There will be no cost incurred in this study.
Compensation:
After the interview, participants will be given a bar of soap worth GH¢5 to compensate for their time spent.
Confidentiality:
Unique codes instead of names will be used will be for interview purposes and for samples collected. Your responses will not be shared with anyone else outside the research team. Data collected will be kept private. Any information from you will have a number on it instead of your name. You can refuse to answer any specific question or stop the interview at any time. If you chose not to answer a question, stop the interview or even not take part at all in the study it will not affect your organization facilities today or in the future. Samples collected would be discarded after results are disseminated.
Voluntary Participation and Right to Leave the Research
Your participation in this study is your choice and voluntary. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with any institution.
Outcome and Feedback
The findings will be used as influence policy- and decision-makers to provide country-specific, evidence-based solutions towards addressing climate related health risks in coastal communities.
Feedback to participant
Findings of the study would also be disseminated through the University of Ghana. Publication of data would also be used as a mode of dissemination of information.
Funding information
Study is funded by the University of Ghana, through Danish Government (DANIDA).
Sharing of participants Information/Data
Data generated from this study will be owned by the University of Ghana School.
Provision of Information and Consent for participants
A copy of the Information sheet and Consent form will be given to you after it has been signed or thumb-printed to keep.
Approval:
Approval for this study was obtained from the Ghana Health Services Ethical Review Committee (**Approval Number:** _____
Contact for additional information
If you have questions about this activity, concerns or complaints about this research study, please contact Delia Bandoh on +233 024 235 6585, or deliabandoh@st.ug.edu.gh or Prof Dzodzomenyo +233 020 837 6845 or mdzozomenyo@uh.edu.gh.

Your right as a participant
This research has been reviewed and approved by the Ghana Health Service Ethics Review Committee (GHS-ERC). If you have any questions about your rights as a research participant, you can contact the **GHS-ERC administrator, Nana Abena Apatu** between the hours of 8am – 5pm through the telephone number +233503539896, or email address ethics.research@ghsmail.org.

ASSENT FORM

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

PARTICIPANTS' STATEMENT

I acknowledge that I have read or have had the purpose and contents of the Participants' Information Sheet read and all questions have been satisfactorily explained to me in a language I understand (Twi [ ] Ewe [ ] ..... [ ]). I fully understand the contents and any potential implications as well as my right to change my mind (i.e., withdraw from the research) even after I have signed this form. I voluntarily agree to be part of this research.

Name of Participant.....

Participants' Signature .....OR Thumb Print..... Date .....

INTERPRETERS' STATEMENT

I interpreted the purpose and contents of the Participants' Information Sheet to the afore named participant to the best of my ability in the (Twi [ ] Ewe[ ] .....[ ]) language to her/her proper understanding. All questions, appropriate clarifications sort by the participant and answers were also duly interpreted to his/her satisfaction.

Name of Interpreter..... Signature of Interpreter.....

Date ..... Contact Details .....

STATEMENT OF WITNESS

I was present when the purpose and contents of the Participant Information Sheet was read and explained satisfactorily to the participant in the language he/she understood (Twi [ ] Ewe ..... [ ]). I confirm that he/she was given the opportunity to ask questions/seek clarifications and same were duly answered to his/her satisfaction before voluntarily agreeing to be part of the research.

Name:..... Signature.....

OR Thumb Print ..... Date:.....

INVESTIGATOR STATEMENT AND SIGNATURE

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed.

Researcher's name..... Signature .....

Date.....

PARTICIPANT INFORMATION SHEET

Consent for Process Evaluation of WASH

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

Good morning / Afternoon my name is.....I work for the University of Ghana School of Public Health (UGSPH) based in Accra, Ghana. Together with Institute of Environmental Studies (IESS), we are conducting a research project to assess what causes diarrhoea as part of a bigger study to understand diarrhoea in coastal areas of Ghana. The main aim of the project is to assess water, sanitation and hygiene practices, food pattern and health practices in the community change over the year and how this affects diarrhoea disease occurrence.

Background and Purpose of Research

Diarrhoea is a leading cause of sickness and death especially among children under five years. Water, sanitation and hygiene (WASH) greatly influences the occurrence of diarrhoea. The changing weather conditions are increasing affecting WASH practices. This is leading to the increase in WASH related diseases such as diarrhoea. Understanding what is causing diarrhoea diseases in coastal communities in Ghana over the different seasons of the year can help reduce the disease. To achieve this, the researchers will collect information on the household environment and practices at different times of the year. The study will be done in selected coastal communities in Anloga district, Volta region.

Nature of Research

This will an interview (focus group discussion, key informant interview, in-depth) in Anloga district. You and other stakeholders of WASH interventions in the district and community will be engaged on how WASH interventions were implemented in the community and the community practices. The information you give would help in finding out why diarrhoea cases in your communities are still high and what can be done to reduce them.

Participant involvement

You have been selected to participate in this survey because you are a stakeholder in WASH in the district. We would invite you to take part in an interview on how WASH interventions are implemented in this district and how these interventions are used by the community. The interview would last for about 30 minutes. Interviews will be recorded with your permission.

Possible Risks and discomforts

There are minimal risks in responding to questions about WASH interventions in this study. We do not anticipate any physical, economic or legal risks, but do expect some level of discomfort and perhaps stress, given the questions in survey tool that explores sanitation and diarrhoea. However, you may experience some discomfort, uneasiness or embarrassment in responding to some of the questions about your thoughts and feelings about the questions. Thus, at any time, you can choose not to answer any questions or stop the study at any time.

Benefits:

There are no immediate and direct benefits of participating in the study however the study will lead to improving evidence-based solutions towards addressing climate related health risks in coastal communities.

Cost

There will be no cost incurred in this study. However, any participant who would have to move from their home to meet a research assistant will be reimbursed for the cost of their transportation.

Compensation:

You will begiven a snack to compensate for their time spent during the interaction.

Confidentiality:

Unique codes instead of names will be used will be for interview purposes. Your responses will not be shared with anyone else outside the research team. Data collected will be kept private. Any information from you will have a number on it instead of your name. You can refuse to answer any specific question or stop the interview at any time. If you chose not to answer a question, stop the interview or even not take part at all in the study it will not affect your organization facilities today or in the future.

Voluntary Participation and Right to Leave the Research
Your participation in this study is your choice and voluntary. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with any institution.

Outcome and Feedback
The findings will be used as influence policy- and decision-makers to provide country-specific, evidence-based solutions towards addressing climate related health risks in coastal communities.

Feedback to participant
Findings of the study would also be disseminated through the University of Ghana. Publication of data would also be used as a mode of dissemination of information.

Funding information
Study is funded by the University of Ghana, through Danish Government (DANIDA).

Sharing of participants Information/Data
Data generated from this study will be owned by the University of Ghana School.

Provision of Information and Consent for participants
A copy of the Information sheet and Consent form will be given to you after it has been signed or thumb-printed to keep.

Approval:
Approval for this study was obtained from the Ghana Health Services Ethical Review Committee (**Approval Number:** _____

Contact for additional information
If you have questions about this activity, concerns or complaints about this research study, please contact Delia Bandoh on +233 024 235 6585, or deliabandoh@st.ug.edu.gh or Prof Dzodzomenyo +233 020 837 6845 or mdzozomenyo@uh.edu.gh on Dr. Dzidzo Yirenya-Tawiah on +233 0244 624657 or dzidzoy@staff.ug.edu.gh.

Your right as a participant
This research has been reviewed and approved by the Ghana Health Service Ethics Review Committee (GHS-ERC). If you have any questions about your rights as a research participant, you can contact the **GHS-ERC administrator, Nana Abena Apatu** between the hours of 8am – 5pm through the telephone number +233503539896, or email address ethics.research@ghsmail.org.

CONSENT FORM

Evaluation Of WASH Interventions and Risk Factors of High Prevalent Diarrhoea Among Children Under Five Years In, Anloga District, Volta Region, Ghana

PARTICIPANTS' STATEMENT

I acknowledge that I have read or have had the purpose and contents of the Participants' Information Sheet read and all questions have been satisfactorily explained to me in a language I understand (Twi [ ] Ewe [ ] ..... [ ]). I fully understand the contents and any potential implications as well as my right to change my mind (i.e., withdraw from the research) even after I have signed this form. I voluntarily agree to be part of this research.

Name of Participant.....

Participants' Signature .....OR Thumb Print..... Date .....

INTERPRETERS' STATEMENT

I interpreted the purpose and contents of the Participants' Information Sheet to the afore named participant to the best of my ability in the (Twi [ ] Ewe[ ]. .....[ ]) language to her/her proper understanding. All questions, appropriate clarifications sort by the participant and answers were also duly interpreted to his/her satisfaction.

Name of Interpreter..... Signature of Interpreter.....

Date ..... Contact Details .....

STATEMENT OF WITNESS

I was present when the purpose and contents of the Participant Information Sheet was read and explained satisfactorily to the participant in the language he/she understood (Twi [ ] Ewe ..... [ ]). I confirm that he/she was given the opportunity to ask questions/seek clarifications and same were duly answered to his/her satisfaction before voluntarily agreeing to be part of the research.

Name:..... Signature.....

OR Thumb Print ..... Date:.....

INVESTIGATOR STATEMENT AND SIGNATURE

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed.

Researcher's name..... Signature .....

Date.....

Appendix 7: Ethical Approval Letter

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted

Research & Development D
Ghana Health Service
P. O. Box MB 190
Accra
Digital Address: GA-050-3
Mob: +233-50-3539896
Tel: +233-302-681109
Email: ethics.research@ghs

My Ref. GHS/RDD/ERC/Admin/App 22/432
Your Ref. No.

19th September, 2022

Delia Akosua Bandoh
Department of Epidemiology and Disease Control
University of Ghana School of Public Health
P. O Box LG 13, Legon, Accra

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implet your Study Protocol.

GHS-ERC Number	**GHS-ERC: 020/07/22**
Study Title	Evaluation of Wash Interventions and Risk Factors of High Prevalent Di among Children Under Five Years in, Anloga District, Volta Region, Gh
Approval Date	19th September, 2022
Expiry Date	18th September, 2023
GHS-ERC Decision	**Approved**

This approval requires the following from the Principal Investigator

- Submission of a yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verb days in writing.
- Submission of a final report after completion of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the rese

You are kindly advised to adhere to the national guidelines or protocols on the prevention of

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after

Kindly quote the protocol identification number in all future correspondence in relation to this ap

SIGNED.....
Mr. Kofi Wellington
(GHS ERC Vice Chairperson)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

Appendix 8: Publications and Conference Presentations Generated from Thesis

Bandoh *et al.*
Journal of Health, Population and Nutrition (2024) 43:95
https://doi.org/10.1186/s41043-024-00582-8

Journal of Health, Population and Nutrition

RESEARCH Open Access

Prevalence and correlates of diarrhoea among children under five in selected coastal communities in Ghana

Delia Akosua Bandoh[1], Duah Dwomoh[1], Dzidzo Yirenya-Tawiah[2], Ernest Kenu[1] and Mawuli Dzodzomenyo[1*]

Abstract

Introduction Diarrhoea is a preventable disease affecting children under five years disproportionately. Globally, thousands of children die from diarrhoea related diseases each year, most deaths occuring in sub-Saharan Africa where Ghana is located. Coastal communities bear the greatest brunt due to poor sanitary conditions. We assess the prevalence of diarrhoea in selected coastal communities along the eastern coast of Ghana.

Methods We conducted a cross-sectional study in Mumford, Opetekwei, Anyako, Anyauni and Ateteti communities in the Central, Greater Accra and Volta region respectively. We interviewed households with children under five years on the occurrence of diarrhoea and health seeking practices. We also used a checklist to assess the sanitary conditions of the household. Frequencies and proportions were generated. We determined significant differences using modified Poisson regression models at $p < 0.05$. Results were presented in tables and text.

Results The prevalence ratio of diarrhoea was 36% (95% CI 33–40%). Most cases were from Anyako community. All interviewed households in Mumford and Opetekwei used improved water sources whiles 94% in Atetetio used improved water sources. Children who were fully vaccinated had 32% lower prevalence of diarrhoea compared to those who were not (aPR: 0.68, 95% CI 0.55–0.84).

Conclusion Diarrhoea prevalence was high inspite of the reported use of improved water sources and sanitation facilities by majority of households in the communities. Fully vaccinated children had a relatively lower prevalence of diarrhoea compared to children who were not fully vaccinated. We recommend in-depth analysis of the use of water and sanitation facilities in these settings to understand the reasons for the observed diarrhoea prevalence.

Keywords Diarrhoea, Coastal community, WASH, Health seeking behaviour

Introduction

Diarrhea is a climate sensitive disease disproportionately affects children under five years and remains one of their second leading cause of deaths globally [1, 2]. In 2019, almost 1.7 billion children under five years developed diarrhoea with 525,000 deaths [3]. The greatest burden of the diarrhoea menace was borne by low and middle income countries (LMICs) where improved water, sanitation and hygiene remain a consistent problem. In Ghana, diarrhoea forms part of the ten top causes of children under five years in-patient morbidity [4] with an estimated prevalence of about 13% among children under five years as at 2022 [5].

Unfortunately, the relative risk of diarrhoea is projected to increase by about 8–11% by the next decade due the adverse impact of climate change [6]. This puts countries like Ghana located in sub- Saharan Africa

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IP|LO,SQNE

STUD\' PROTOCOL

A study to evaluate WASH interventions and risk factors of diarrhoea among children under five years, An|loga district, Ghana: A research protocol

Delia Akoeue Bendnl7 , E'rn@S/1Kenu, Dueh Dwomoh, E'dwin.Andrew Atari, Mawu:li Dzodzomenyo

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Abstract

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UNIVERSITY OF GHANA

C2R-CD

2023 ASTMH ANNUAL MEETING

Assessing the implementation of WASH interventions in a coastal district with high diarrhoea burden, Ghana, 2022

Poster ID: 6400

Delia Akosua Benewah Bandoh[1], Ernest Kenu[1], Edwin Andrew Afari[1], Kwadwo Duah Dwomoh[1], Dzidzo Yirenya-Tawiah[2], Mawuli Dzodzomenyo[1]

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Introduction

- WASH interventions have significantly reduced diarrhoeal diseases globally
- Marginal declines recorded in some coastal settlements in Ghana
- Need to identify implementation challenges to improve WASH implementation approaches

Objective

We assessed the WASH implementation process in Anloga, a coastal district in Ghana

Methods

- We conducted a process evaluation of WASH interventions in Anloga, a coastal district in Ghana

- Evaluation covered planning, community entry, engagement, sensitization, education

- Socio-ecological model used to assess processes for implementing WASH interventions

Results

Level	Findings
Societal	• All district staff (4/4) mentioned that community leaders were the main people engaged throughout the implementation • Interventions were implemented only when the district had funds
Community	• Community leaders (7/10) said implementation engagements were with some selected leaders • Community leaders (8/10) reported that the community's main contribution in implementation of WASH was provision of labour
Relationship	• Community members reported being only engaged for labour during construction activities
Individual	• Individuals (18/30) had no knowledge of the source and implementation process of WASH structures around their households

Conclusion

We identified gaps in the information flow to the various levels, and lack of extensive engagement during the WASH interventions implemented in the district

Recommendations

- District adapts an all-inclusive approach to ensure community ownership and appropriate use of WASH interventions
- Periodic supervision by the district with short educational talks would remind community members of relevance of WASH interventions

Acknowledgement

- UGSPH
- C2R-CD Project
- Anloga DA
- GFELTP

Contact deliabandoh@st.ug.edu.gh

Scan for copy of poster

2024 ASTMH ANNUAL MEETING POSTER NUMBER: 8099

Pathogens Causing Diarrhoea In Children Under Five Years Among A Vaccinated Population In Coastal Ghana

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Background

- Diarrhoea by rotavirus is a leading cause of morbidity and mortality in children under five (U5s)[1]
- Introduction of rotavirus vaccine has led to significant global decline in diarrhoea burden (ie: hospitalization)[2]
- Yet diarrhoea remains a public health concern - morbidity and mortality still persists in U5s[3]
- In Ghana

Rotavirus A vaccine introduced in Ghana — 2012

2022

What pathogens could we be dealing with now????? — 2023

Vaccination cover above 94%, diarrhoea persists(13% in U5s)[4]

- **Objective:** Identify possible pathogens causing diarrhea in under-fives in a high prevalent coastal district in Ghana eleven years post introduction of rotavirus vaccine

Methods

- Cross-sectional study in Anloga district, Volta region, Ghana

Case: U-5 with diarrhoea in Anloga Health facility from Nov 2022- Aug 2023

Caregiver Interviews - Immunization status, WASH practices, and socio-demographic characteristics

Stool samples of detained cases collected (38)

Extracted total nucleic acid from stool

PCR (TaqMan Array cards)

- Which identifies 23 pathogens (10 bacteria, 6 parasites, 7 viruses)

Results

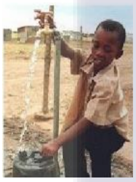
Median age: 21.5(IQR:30) months

Male: 55.3%(21/38)

Rotavirus vaccine received: 97.4%(37/38)

Child not using toilet: 89% (30/38)

Good handwashing practices (71%,27/38)



Access to improved water (97.4%, 37/38)

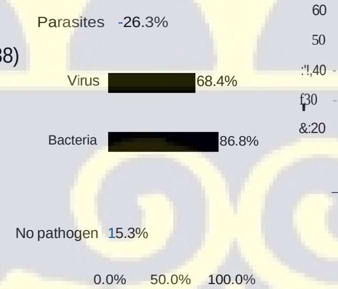


Fig 1: Proportion of pathogens identified In samples

Of the 38 samples tested, 5%(2/38) had no pathogen, whiles 68%(26/38) had various types of co-infections

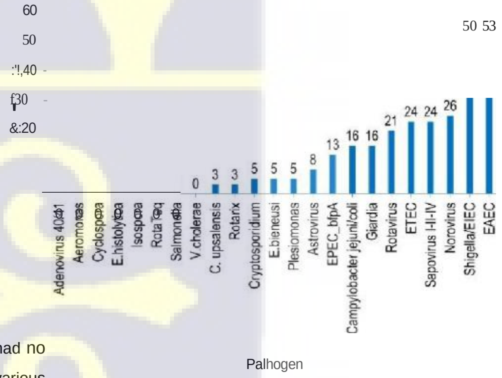


Fig 2: Proportion of specific: microorganisms identified in samples

Conclusion

- Rotavirus not the main diarrhoea pathogen in Anloga, rather EAEC, Shigella/EIEC, Norovirus, Sapovirus and ETEC

Major diarrhoea pathogens detected: Bacteria (EAEC, Shigella/EIEC, ETEC, Campylobacter Jejuni, EPEC), Virus (Norovirus, Sapovirus and Rotavirus)

Children were fully vaccinated, WASH practices were sub-optimal

Recommendations

- Intensify education on effective use of WASH practices to break contact with pathogens - GHS, DA, EHD

Consideration of other diarrhoea vaccines - GHS, Research institutes, Academia

- WHO Rotavirus Ref Lab - NMIMR
- C2R-CD ProJect - UGSPH

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