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PREVALENCE OF DIARRHOEA DISEASES AMONG CHILDREN UNDER FIVE YEARS IN THE KINTAMPO NORTH MUNICIPALITY

A Dissertation submitted to the department of environmental health and sanitation of the Faculty of Development Studies, Presbyterian University College, Ghana in partial fulfilment of the requirements for the award of Master Degree in Environmental Health and Sanitation.

BY

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SEPTEMBER 2020

DECLARATION

Candidate's Declaration

I hereby declare that this Dissertation is the result of my original research and no part of it has been presented for another degree in this university or elsewhere.

Name:……..…….

Candidate's Signature..... Date……..……..

Supervisor's Declaration

I hereby declare that the preparation and presentation of the Dissertation were supervised in accordance with the guide on supervision of project work laid down by the Presbyterian University College, Ghana.

Name: ……..…….

Supervisor's Signature: …….. Date: ……..……

ABSTRACT

About 22% of childhood deaths in developing countries are attributable to diarrhoea. Diarrhoea rates in Ghana are reported to be high, with cases estimated at 113,786 among children under-five years in 2011. This study analyzed the prevalence and trends of diarrhoea diseases in the Kintampo North Municipality of Ghana. A retrospective analysis of records on diarrhoea data for a five-year period from January 2015 to December 2019 was undertaken. A total of 36521 diarrhoea case reports extracted from District Health Information Management System (DHIMS) II database in an Excel format was exported to Stata version 14 for data cleaning, verification, and analysis. Excel version 2016 was used to plot the actual observed cases by years to assess trends and seasonality. Males had the slightly higher levels of diarrhoea incidence within the 5-year period. Overall, diarrhea incidence in this study fluctuates, with decreasing and increasing trends. There was an annual increase in diarrhoea from 2015 to 2019, except in 2017 where there was a decline in incidence was observed, followed by a sharp increase in 2018. The Kintampo North Municipality reported 31 cases of diarrhea per 1000 population among children <5 years in 2015. The incidence increased to 71 cases per 1000 population in 2016 and subsequently declined to 53 cases per 1000 population in 2017. Diarrhoea cases were found in this study to be high mostly in May and September, within the years which corresponds to the rainy season with slight deviations. Waterborne diseases increase in rainfall and decrease during drought events in harmattan season in Ghana, which confirms our study. Males are slightly more susceptible to diarrhea than females in the Kintampo District, accounting for an incidence rate of 50.9% (18596/36521) per thousand persons compared to female.

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DEDICATION

To my Late Father Nana Jakpa Tiyur and Mother, as well as my Wife and the entire family for all the sacrifices they made for me to become who I am today.

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LIST OF ABREVIATION

CHPS	Community-based Health Planning and services
GHS	Ghana Health Service
DHS	District Health Services
GDHS	Ghana Demographic and Health Survey
SDG	Sustainable Development Goal
SSA	South- Saharan Africa
UNICEF	United Nations International Children's Emergency Fund
WASH	Water Sanitation and Hygiene
WHO	World Health Organisation
GSS	Ghana Statistical Service
MOH	Ministry of Health
DHIMS	District Health Information Management Systems
IDSR	Integrated Disease Surveillance and Response
KNM	Kintampo North Municipality
JMP	Joint Monitoring Programme
EPI	Expanded Programme of Immunization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The World Health Organization (WHO) defines diarrhoea as the passage of three or more watery stools, per day, or more frequently than the usual for an individual (WHO, 2017). The aetiologic agents are bacterial, viral and parasitic organisms and it is more often than not a symptom of gastrointestinal infection. Diarrhoeal disease is transmitted through the faeco-oral route by ingesting contaminated food or drinking contaminated water. It can also be spread from person to person due to poor hygiene and sanitation. Diarrhoea is life-threatening, as it leads to loss of fluid and could cause serious dehydration. Populations at greatest risk are infants who are not exclusively breastfed, the malnourished and adults with compromised immune system (Faruque *et al.*, 2014); WHO, 2017). There are three major syndromes of diarrhoea: acute watery, lingering and bloody. Acute aqueous diarrhoea is the most common type that probably leads to prompt dehydration (Fitzwater, Shet, Santosham, & Kosek, 2019). This form is most deadly in infants, and is usually Rotavirus-associated, enterotoxigenic *Escherichia coli*, or *Vibro. cholerae* (Fitzwater et al., 2019). A less common form of persistent diarrhoea is typically linked to malnutrition, and is related disproportionately to increased risk of death (WHO, 2017). Bloody diarrhoea is often associated with malnutrition, and bowel injury, and secondary sepsis. It is closely related to dysentery (WHO, 2017).

The symptoms of diarrhoea are both short-term and long-term, from extreme dehydration through to malnutrition, which can in effect weaken the immune system of its victims and make them more future-prone to episodes of diarrhoea, and other illnesses (Keusch, 2016). Infants are more susceptible to

malnutrition as the effect of diarrhea (Keush,2016). In fact, a lot of kids dying from diarrhoea would probably survive if they were suitably nourished (Ahs, 2010; Keusch, 2016). Studies showed diarrhoea can also cause long-term physical disabilities such as stagnant growth and declining intellectual evolution (Keusch, 2016). Whether a child survives an episode of diarrhoea or not depends on where they live (WHO, 2017). While diarrhoeal disease occurs throughout the world, 90 percent deaths of diarrhoeal disease in children younger than five years old occur in developing countries (Keusch, 2016; WHO, 2017). Awareness and access to existing lifesaving technologies interventions are frequently limited. Indeed, work does indicate that only about 1/3 of the children infected with diarrhoeal diseases residing in the developing countries do receive the required treatment they need.

Although diarrhoeal diseases affect persons of any age, children under 5 years old are more vulnerable because each episode of diarrhoea causes malnutrition. Malnutrition is coupled with the low immunity children tend to have, and this makes diarrhoeal diseases one of the major causes of childhood morbidity and mortality (WHO, 2017, Siziya, Muula, & Rudatsikira, 2013, Strand, *et al.*, 2012, Baldwin, 2013). For the past 25 years, worldwide death due to diarrhoeal diseases has reduced significantly, but still remains high for sub-Saharan Africa due to unsafe water, poor hygiene, inadequate sanitation, inadequate education on breastfeeding, malnutrition, increased urbanization and its associated overcrowding (Sire *et al*., 2013; Chisti, Pietroni, Smith, Bardhan, & Salam, 2011, Cooke, 2010). Also, sub-Saharan Africa is likely to experience 60% of an estimated 4.4 million deaths due to infectious diseases annually among under 5 years children by 2030 (Liu *et al*., 2015). A report by World

Health Organization, indicates diarrhoea to be the leading cause of mortality among children under-5 years including preterm birth complications, pneumonia and malaria (WHO, 2019). The report further states that an estimated 5.3 million deaths occurred among children under 5 years in 2018 mostly due to preventable causes of death (WHO, 2019).

In Ghana, diarrhoeal diseases take the fourth position—about 9% of all mortality in the under 5 years—and about 84,000 deaths—25% of this being under 5 years nationwide (Black , *et al*., 2010) According to the United Nations Children's Fund and World Health Organization, "the under-five year mortality rate for Ghana is estimated to be 62 deaths per 1000 live births with an annual reduction rate of 2.9"("UNICEF; WHO," 2015). The Water and Sanitation Publication reported that about 5,100 under 5 years old children in Ghana die due to diarrhoeal diseases annually, and the Sustainable Development Goal 3 aims to reduce mortality among under-five children to 25 deaths per 1000 live births by 2030 (WHO, 2016, WSP, 2012). In the last demographic and health survey conducted in Ghana, 12% of children <5years old had diarrhoea in the last two weeks preceding the survey (GSS, GHS, ICF Macro., 2014). From the survey, 17% of children in the Brong Ahafo region had diarrhoea which is higher than the national prevalence of 12% (GSS, GHS, 2014).

In addition to malnourished children, those exposed to unhygienic environment are more prone to diarrhoea and the dehydration caused by diarrhoea in these groups is fatal because water makes up the greater part of bodyweight of children who have high metabolic rates (WHO, 2013). This makes their body consume more water and their kidneys conserve less water compared to older children and adults (WHO, 2013). It causes about 40% of

hospitalizations for diarrhoea in children under five years of age (Zuccotti *et al.*, 2010). Thus as part of the key measures aimed at preventing diarrhoea incidence among children, including exclusive breastfeeding, promotion of personal and food hygiene and hand washing with soap, the rotavirus vaccination was introduced as part of the routine immunization program to help reduce the burden of diarrhoeal diseases (Hallowell, Tate, & Parashar, 2020). The vaccine was noted to have prevented about 28,900 child deaths worldwide in 2016 and also reduced the number of diarrhoea related hospital admissions by 40% between 2008 and 2016 (Troeger *et. al.*, 2018). However, immunization rates are reported to be still low globally with varying efficacy (Hallowell et al., 2020). In countries where child mortality rates are high, the efficacy of the vaccine reduces due to pre-vaccination exposure to such conditions as high prevalence of malaria and malnutrition among others (Clark et al. 2019). Rotavirus was introduced in Ghana by the Ministry of Health (MOH) in 2012. It is given to children at the age of six and ten weeks old to protect them from diarrhoea. The 2014 Ghana Health and Demographic Survey reports that, 89% of children received the two required doses of the rotavirus vaccination. The report however noted a fall in the overall vaccination coverage, particularly of fully immunized children from 79% in 2008 to 77% in 2014 (GDHS, 2014). There is the need for this study to assess the current trend of diarrhoea prevalence among children under five years old in the Kintampo North Municipality.

1.2 Statement of the Problem

In Ghana, diarrhoeal diseases contributes significantly to under five mortality and morbidity (Black , *et al.*, 2010 ;Dapaa, 2017). The Ghana Demographic and Health survey reported that 12% of children under-five had

diarrhoeal episodes prior to the conduct of the survey (GSS, GHS, ICF Macro., 2014). After the Ghana Demographic and Health survey, a 17% prevalence of diarrhoeal disease was reported in the Brong Ahafo region, a situation higher than the national prevalence of 12% (GSS, GHS,2014). Despite interventions and innovations by stakeholders, the under-five mortality attributable to diarrhoea is worrying and calls for a more concerted effort to addressing the issue. Prevalence of diarrhoeal in the under-five in Ghana are mostly from urban and peri-urban areas where access to portable drinking water and sanitary conditions are relatively improved. However, the situation pertaining in Kintampo which is largely rural is scarce and not well documented. Besides prevalence, risk factors may vary from place to place and identifying peculiar modifiable risk factors is crucial in tailoring appropriate interventions.

1.3 Purpose of the Study

The study seeks to find the prevalence and trend of diarrhoea among children in the Kintampo North Municipality using data from the DHIMS II database. The use of the DHIMS II data file for the study is relevant to bringing out how health facility-level data could be used for implementation of strategies for the control of diarrhea based on context data.

1.4 Research Questions

1. What is the prevalence of diarrhoea diseases by age and sex among children in the Kintampo North Municipality?
2. What is the trend of diarrhoea prevalence from 2015 to 2019 in the Kintampo North Municipality?
3. What are some of the measures needed to prevent diarrhoea

1.5 Research Objectives (Main and Specifics)

1.5.1 Main Objective

To assess the trend of diarrhoeal diseases among children under-five years old in the Kintampo North Municipality from 2015 - 2019

1.5.2 Specific Objectives

1. To describe the prevalence of diarrhoea cases by age and sex
2. To assess the five-year trend of diarrhoea cases in the municipality from 2015 to 2019.
3. To assess the measures needed to prevent diarrhoea

1.6 Significance of the Study

Data of diarrhoea cases are routinely captured on surveillance forms and into the District Health Information Management Systems (DHIMS) software. However, only the aggregate data are mostly reported. Detailed analysis of the data which could help inform decisions on appropriate distribution of resources and monitoring of interventions are often not done. There is therefore limited information on the trend of diarrhoea prevalence at the local level. This study which seeks to find the trend of diarrhoea prevalence among children in the Kintampo North Municipality by using data from the DHIMS 2 database as well as the risk of diarrhoea diseases over a five-year period by certain child characteristics such as age, sex and place of residence. The study will be of immense importance to the community and also help policy makers make inform decisions on appropriate distribution of resources to health facilities and also guide the monitoring of health-related interventions aimed at preventing or reducing the incidence of diarrhoea diseases among children under five. The results will also help in monitoring the progress of diarrhoea cases in the

municipality towards the achievement of the Sustainable Development Goals 3 target 3.2 which seeks to end all preventable child deaths by 2030.

1.7 Delimitation of the Study

The DHIMS II data used for this study does not capture all individual and household level characteristics that could have been used to draw associations with diarrhoea. Thus, the study cannot assess the predictors or association of most background characteristics with diarrhoea in the study area.

1.8 Limitations of the Study

The secondary data was used for the study and this was not a common illness usually managed at home which may increase the prevalence rate or decrease the rate which is *a* limitation. However, there is a potential of biasness of reporting or over reporting the number of diarrhea cases that may arise from data collection. And processing of this data poses a challenge since some facilities may lack well-trained data experts to reduce validity and reliability of data collected as this study uses only passive surveillance system dataset. DHIMS II outpatient monthly morbidity report does not currently cover all individual and household characteristics that can be used to draw associations with diarrhoea and another disease morbidity at the district level. Including more individual level and household background characteristics will help estimate factors that predict the occurrence of diarrhoea based on sociodemographic factors.

1.9 Organization of the Study

The research work is presented in five (5) chapters. Chapter One provides a general background to the study. It analysed the extent of the problem, states the objectives of the research and addresses the significance of the study in

Kintampo North Municipality. Chapter Two examined existing literature relative to the study. Chapter Three described the methodology employed in gathering data from the field. This included observation and a brief description of the study area. Chapter Four analysed the results and Chapter Five summarized the key findings of the study, provided recommendation and conclusion.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviews relevant literature on the prevalence of diarrhoea among children under than five years. It also looks at the socio-demographic characteristics associated with diarrhoea, prevention and management as well as the conceptual framework used for the study.

2.1 Overview of Childhood Diarrhoea

World health organization defines diarrhoea as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual (WHO, 2007). Worldwide, diarrhoeal diseases are reported as the leading cause of mortality among children aged five years and below (UNICEF, 2018). In some parts of the world, they account for higher mortality rates than all other causes combined (Petri *et al.*, 2008; UNICEF, 2018). Childhood diarrhoea affecting children five years old and below accounts for approximately 63% of the global diarrhoea burden (Walker *et al*., 2012; Zhang *et al.*, 2016), and is the second significant cause of infant mortality in developing nations (Platts-Mills *et al.*, 2015; Kotloff, 2017) where poor sanitation and insufficient potable water supply are key factors (Chakravarty *et al.*, 2017; Squire and Ryan, 2017).

In Africa, Asia, and South America, diarrhoea accounts for one in eight deaths among children younger than 5 years per annum (Keddy *et al*., 2016; Kotloff, 2017) and an estimated 16% of child deaths in Nigeria annually (Charyeva *et al.*, 2015). In Ogun State, South-West Nigeria, diarrhoea is one of the three diseases (the others being typhoid fever and cholera) which together

are the second most prevalent water-related disease (Omole *et al.*, 2015). Acute diarrhoea, the passage of stools with abnormal consistency and frequency in a day (e.g. more than three times) which lasts for less than two weeks, is a syndrome that is frequently not subject to differential diagnosis in medical practice (Petri *et al.*, 2008; Zhang *et al.*, 2016). Bacterial diarrhoeal cases are the most prevalent of all diarrhoeal cases around the globe (Zhang *et al.*, 2018). Commonly reported enteric bacterial diarrhoeal diseases and the causative agents are botulism (Clostridium botulinum), Campylobacter gastroenteritis (Campylobacter jejuni), cholera (Vibrio cholerae), Escherichia coli gastroenteritis, Salmonellosis (various Salmonella serovars), Shigellosis (Shigella spp.), and Staphylococcal food poisoning (Staphylococcus aureus enterotoxins) (Humphries and Linscott, 2015; Tarr *et al.*, 2018). Children below five years of age have the most at risk from foodborne pathogens, including Shiga toxin-producing Escherichia coli O157, Campylobacter, Shigella, Yersinia, Salmonella, and Cryptosporidium (Liu *et al.*, 2014a; Kotloff, 2017).

In the past few decades, the awareness in hand washing has tremendously reduced the burden of diarrhoea caused by enteric bacteria and protozoans, yet, it has less impact on diarrhoea caused by viruses (Tagbo *et al.*, 2019). The mouth is the typical portal of entry for gastrointestinal pathogens, which are ingested alongside contaminated food and water (Rodulfo *et al.*, 2012). Also, they are acquired via contact with diarrhoeic animals and their contaminated environments or with the faecal matter of a diarrhoeic person (Humphries & Linscott, 2015; Squire & Ryan, 2017). While in their gastrointestinal habitat, these pathogens, through a variety of pathological mechanisms by which they could be typed, trigger the over secretion of fluid in the lumen of the small

intestine associated with electrolyte imbalance, and eventual diarrhoea (Humphries and Linscott, 2015; Crawford *et al.*, 2017).

In spite of the huge burden of diarrhoea, it is preventable with modern science and public health intervention (Centres for Disease Control and Prevention, 2016a, b). In some cases, diarrhoea may be self-limiting. In severe infections, however, antibiotics may be prescribed to prevent possible death. The resulting risk, however, is antibiotic resistance, which is an important public health threat towards the treatment of diarrhoea (Centres for Disease Control and Prevention, 2013). The continuous surveillance of antimicrobial resistance is an epidemiological strategy at tracking new and emerging resistances to some of the last-line antibiotics. Accurate diagnosis of diarrhoeal pathogens is necessary for surveillance, prevention, and control of diarrhoea (Ranjbar *et al.*, 2014; Tarr *et al.*, 2018). Traditional, phenotypic tests such as Gram staining, bacteriological culture and recording of colonial characteristics, and biochemical tests form the mainstay of laboratory diagnosis in less developed countries (Liu *et al.*, 2014a, b). However, such tests take longer turnaround time to identify slow-growing bacteria, resulting in delayed treatment of patients (Khan & Jahan, 2017; Maciel & Leite, 2018).

In many other cases, the results of these tests, even when considered in concert, are false negatives (Miller *et al*., 2013). Conventional epidemiological typing methods which include biotyping, antibiogram, and serotyping are quite useful in describing temporal epidemiological studies (MacCannell, 2013). However, aetiological agents of approximately 40% of gastroenteritis cases go undetected by these methods, complicating diagnosis and treatment (Finkbeiner *et al.*, 2008; Khan & Jahan, 2017). Molecular approaches have increasingly

brought to light significant viral, parasitic, and bacterial enteric pathogens and also their virulent traits (Zhou *et al*., 2016). Most molecular techniques employ polymerase chain reaction (PCR) to detect deoxyribonucleic acid (DNA) in a sample (Chang *et al.,* 2013). One of the tools in molecular epidemiology is microbial typing. Microbial typing helps to diagnose the aetiology and the route of transmission of infection, identify virulent and resistant strains and evaluate the impact of control measures of infectious diseases (Ranjbar *et al*., 2014).

Next-generation sequencing (NGS), a technique which quickly and extensively sequences a mixed population of DNA or ribonucleic acid (RNA) genomes have enhanced the study of infectious disease epidemiology (Platts-Mills *et al*., 2013). Metagenomics, which is the technique that directly sequences and analyses the total nucleic acids isolated from a sample, without culture, has a promising prospect in the field of infectious disease diagnosis (Decuypere *et al.,* 2016). Globally, researchers are already utilizing metagenomics in the aetiology and antimicrobial resistance surveillance of diarrhoea. Conversely, most of the studies on diarrhoea aetiology in Sub-Saharan Africa has focused more on the prevalence, antimicrobial profile, and risk factors (Godana and Mengistie, 2013; Akingbade *et al.,* 2013; Chiyangi *et al.,* 2017).

2.2 Types of Diarrhoea

2.2.1 Acute Watery Diarrhoea

Acute watery diarrhoea often presents with sudden development of an unusual frequent stooling of mostly fluid. Other signs are vomiting, fever, nausea and abdominal pain (Dipasquale *et al*., 2018). In the gastrointestinal tract, absorption of over 90% of the physiologic net fluid takes place in the proximal small intestine. The pathogenic mechanism that leads to diarrhoea occurs when

enteric pathogens attack the proximal small intestine (Thiagarajah *et al*., 2015). Acute watery diarrhoea is often caused by enterotoxin-secreting bacteria such as enterotoxigenic Escherichia coli (ETEC), and Vibrio cholerae, which cause fluid loss without cellular injury (Willey *et al.*, 2013). Viruses such as rotaviruses and caliciviruses that damage the intestinal epithelium also cause fluid loss. Besides, they have more tendency to cause fever, vomiting and watery stools without blood and mucus (Tagbo *et al*., 2019). Usually, cases of watery diarrhoea run an acute but brief (1–3 days) self-limiting duration.

2.2.2 Dysentery

As defined by World Health Organization, dysentery is bloody diarrhoea, i.e. any diarrhoeal episode in which the loose or watery stools contain visible red blood (UNICEF and WHO, 2009). Dysentery is most often caused by Shigella species (bacillary dysentery) or Entamoeba hystolytica (amoebic dysentery). Dysentery starts with the sudden onset of repeated stooling. However, unlike acute watery diarrhoea, stools are often smaller in quantity and are characterized by blood and pus. Thus, it is also referred to as acute bloody diarrhoea. Dysentery usually presents with fever, tenesmus, abdominal pain, and cramps; vomiting occurs less often (Wang *et al*., 2019). Inflammation of the colon (the part of the large intestine that extends from the cecum to the rectum) due to infection by one of a number of enteric pathogens leads to dysentery. The main cause of dysentery in children is the Shigellae (Tickell *et al.*, 2017). Campylobacter jejuni and enteroinvasive E. coli or salmonellae of many serotypes being relatively less frequent causes. Entamoeba histolytica seldom causes dysentery in young children (Khan and Jahan, 2017: Delfino Vubil *et al.*, 2018). Dysentery usually requires antimicrobial therapy (Williams & Berkley, 2018).

2.2.3 Persistent Diarrhoea

Persistent diarrhoea is acute as well as prolonged (at least 14 days) rather than brief also referred to as chronic diarrhoea (Centres for Disease Control and Prevention, 2016a, b). The case may begin with the passage of frequent watery or bloody stool but last for a long period thus causing loss of weight. It accounts for less than ten percent of all diarrhoea but is responsible for 30 to 50 percent of death caused by diarrhoea (Black, 1993). Persistent diarrhoea has different causes which are either infectious or non-infectious. The infectious causes include intestinal parasites (Cryptosporidium, Cyclospora, E. histolytica, Giardia, Microsporidia), bacteria (Aeromonas, Campylobacter, C. difficile, E. coli, Plesiomonas, Salmonella, Shigella), and viruses (norovirus, rotavirus). While the non-infectious causes include altered immune function, disorders of the pancreas, medications (antibiotics), heritable metabolic disorders (enzyme deficiency), intolerance to some food products (gluten, lactose), intestinal disorders, disorders o the thyroid, and reduced blood flow to the intestines (Centres for Disease Control and Prevention, 2016a, b; Holtman *et al.*, 2016; Spitz *et al*., 2016; El-Chammas *et al.*, 2017).

Major organisms that are responsible for persistent diarrhoea are enteroaggregative E. coli, Shigella, and Cryptosporidium (DuPont, 2016). The pathogenesis of persistent diarrhoea could be multifactorial and fundamentally based on continuous damage to the mucosal linings o the intestines due to several infections with different pathogens (Giannattasio *et al*., 2016). Malnutrition also increases the likelihood of death in children with persistent diarrhoea. Evidence-based studies have established a strong relationship between chronic diarrhoea

and HIV-positive patients in developing countries (Agholi *et al.*, 2013; Gebremedhin *et al*., 2013; Kumurya and Gwarzo, 2013; Rostami *et al.*, 2014).

2.3 Aetiology of Diarrhoeal Diseases

The aetiology of diarrhoea may be infectious or non-infectious. In non-infectious diarrhoea cases, factors such as food intolerances (lactose and gluten), intestinal complications (irritable bowel syndrome, ulcerative colitis, Crohn's disease, and celiac disease), and reactions to drugs (Humphries and Linscott, 2015). Before the late 1960s, less than 20% of enteric infection symptoms could be linked to a specific aetiological agent by any known diagnostic method (Ahmad *et al.*, 2010). Diarrhoeal diseases are caused by several viral, bacterial, and protozoan species (Platts-Mills *et al*., 2015; Zhang *et al.*, 2016). Co-infections by a spectrum of enteric pathogens is the norm in diarrhoeal diseases (Serrano & Millan, 2014; Becker *et al.*, 2015).

Rotaviruses and diarrhoeagenic E. coli (DEC) are the most reported enteropathogens globally, with the DEC being particularly important in resource low countries (Onanuga *et al.*, 2014). Evidence based studies from Sudan (Adam *et al.*, 2018), Burkina Faso (Bonkoungou *et al.*, 2013; Ouedraogo *et al*., 2016), China (Zhang *et al*., 2016), Nigeria (Enitan *et al.*, 2019), and other endemic regions reveals that a significant amount of diarrhoea episodes in children are caused by enteric viruses. Rotaviruses, Noroviruses, Adenoviruses, Bocavirusese and Calciviruses have been implicated in childhood diarrhoea (Aktaş *et al.*, 2019). However, recent reports show rotaviruses as the major cause of fatal cases among children below 5 years old (Gatinu *et al*., 2016; Nnukwu *et al*., 2017; Giri *et al*., 2019). Moreover, group A rotavirus, in particular, is the prominent aetiological agent that is responsible for infantile

gastroenteritis globally, causing an estimated 20% of diarrhoea-related deaths in children below the age of five. Low-income countries and those which have no running RVA vaccination programmes are particularly affected by the rotavirus group A (RVA) diarrhoea (Gatinu *et al*., 2016; Zhang *et al*., 2016; Crawford *et al.*, 2017).

Diarrhoeagenic E. coli (DEC) has been grouped into six pathotypes based on their pathogenic processes and clinical features. These subtypes are enteropathogenic E. coli (EPEC), enterohemorrhagic E. coli (EHEC), enterotoxigenic E. coli (ETEC), enteroinvasive E. coli (EIEC), enteroaggregative E. coli (EAEC), and diffusely adherent E. coli (DAEC). DEC pathotypes have also been further categorised based on their virulence mechanisms (Yu *et al*., 2015; Zhang *et al*., 2016; Thakur *et al.*, 2018). Also, there are important regional variations in the prevalence of the different DEC pathotypes. DEC pathotypes from different locations around the globe are genetically diverse (Yu *et al*., 2018). In outbreak situations, Vibrio cholerae, Escherichia coli and Clostridium difficile have been reported as the causative agents of diarrhoea in Bangkok (Dalsgaard *et al*., 1999), China (Scheutz *et al*., 2011; Escher *et al.*, 2014), Yemen (Camacho *et al*., 2018; Weill *et al.*, 2019), Iran (Tajeddin *et al.*, 2019) and Nigeria (Eko *et al.*, 1994; Lawoyin *et al*., 1999; Usman *et al*., 2005; Elimian *et al.*, 2019). The role of viruses as agents of diarrhoea outbreaks among children cannot be overemphasized. Astroviruses in Bankok (Sirinavin *et al.*, 2006), Noroviruses in China (Rogers *et al*., 2019), and Rotaviruses in India and Botswana (Barman *et al.*, 2006; Erick, 2020) have been implicated in childhood diarrhoea outbreaks.

The parasitic diarrhoeal diseases of public health importance are Amebiasis (Entamoeba histolytica), Cryptosporidiosis (Cryptosporidium spp) and Giardiasis (Giardia lamblia). The two predominant causes that have been reported are Cryptosporidium and Giardia, of which Cryptosporidium is the more medically important across the world (Kotloff *et al*., 2013; Squire and Ryan, 2017; Troeger *et al*., 2017). However, studies from China (Yu *et al.*, 2019), Ghana (Nkrumah and Nguah, 2011), Nigeria (Ighogboja and Ikeh, 1997; Akingbade *et al.*, 2013), Kenya (Mbae *et al*., 2013) and Buzigi and Uganda, 2015 have detected other enteric parasites such as G. duodenalis, E. bieneusi, Schistosoma mansoni and C. cayetanensis among diarrhoeic children, though at very low proportion when compared to bacteria and viruses.

2.4 Risk Factors for Diarrhoea In Children

2.4.1 Duration of Breastfeeding

Breastfeeding has a huge impact on the health status of children. A significant correlation exists between breastfeeding and diarrhoea episodes (Godana & Mengistie, 2013; Siregar *et al.*, 2018). Sub-optimal breastfeeding increases the risk of developing diarrhoea because breast milk can confer proper functioning of the gut immune system in infants, both for a short and long-term duration (Bartick *et al.*, 2017; Ogbo *et al.*, 2018). Also, breast milk decreases a newborn's risk of contracting gut diseases because it is made up of antibodies, immunoglobulin A (IgA), which confer protection against pathogenic bacteria and harmonize the activity of white blood cells (Willey *et al*., 2013; Hennet & Borsig, 2016). In Africa, the rate of breastfeeding in Nigeria is lower than that in Uganda, Ethiopia, and Tanzania (Ogbo *et al.*, 2017). This would mean that there might be a higher risk of infants presenting with diarrhoea in Nigeria than

in the other countries of comparison. Infants should be given breast milk within the first hour after birth and breastfeeding should be exclusively practiced during the first six months before feeding with supplementary foods (WHO, 2002). The initiation of supplementary food before the end of the first six months increases the risk of contamination, especially in the less developed countries where potable water and basic sanitation is lacking (Desmennu *et al.*, 2017).

2.4.2 The Source of Drinking Water

Consumption of contaminated water is a viable means of transmission of diarrhoea-causing pathogens. Contamination may occur at the water source, during storage by unhygienic packaging, or during mealtimes through contact with unwashed hands or exposure (Pires *et al.*, 2015; Wasihun *et al.*, 2018). The availability of potable water may not necessarily be taken for granted in every part of the world; but the challenge of insufficient or outright lack of potable water is worse in less developed countries, thus predisposing their populations to a higher burden of diarrhoeal diseases (Omole *et al*., 2015). Unhygienic handling of drinking water is also an attributable factor for diarrhoea in children (Oloruntoba *et al*., 2014; Chakravarty *et al*., 2017).

2.4.3 Hygiene and Sanitation

Non-adherence of mothers/caregivers to the practice of hand washing predisposes their children/wards to diarrhoea (Chakravarty *et al*., 2017). Infant feeding bottles, which can be easily contaminated with faecal bacteria may, in turn, contaminate milk held in them, and milk encourages bacteria growth if not consumed immediately (Oloruntoba *et al*., 2014; Joshua *et al.*, 2016; Wasihun *et al.*, 2018). Also, unhygienic sewage disposal and the use of crude toilet facilities may predispose children to diarrhoea (Kapwata *et al.*, 2018).

2.4.4 Age

Globally, the prevalence of diarrhoea has been reported to be higher in children than in adults, especially among children below five years (Walker *et al*., 2013; Charyeva *et al*., 2015; Zhang *et al.,* 2016). Diarrhoea incidence among children has been reported to be highest in the age group below 24 months and declines with an increase in age (Walker *et al*., 2012; Akinnibosun and Nwafor, 2015).

2.4.5 The Level of Maternal Educational Level

The impact of the educational level of mothers in the health status of their children is important because it is directly related to their awareness levels. Mothers without formal education are more likely to have children who will suffer diarrhoeal diseases when compared to educated mothers (Desmennu *et al*., 2017). Moreover, because access to formal education is limited in rural areas where more males than females go to school, there is a higher rate of uneducated mothers in such locations thus increasing the risk of children having diarrhoea in rural environments (Jolaiya Tolu *et al.,* 2016). Apart from the factors listed above, vitamin A deficiency (Elalfy *et al.,* 2014; Stevens *et al*., 2015), zinc deficiency (Walker *et al.,* 2013; Troeger *et al.,* 2020), childhood wasting (Mokomane *et al.,* 2018; Troeger *et al*., 2018), low use of ORS (Charyeva *et al.,* 2015), mother's hand washing (Abuzerr *et al*., 2019; Alemayehu *et al*., 2020), childhood stunting (Larsen *et al*., 2017) and low rotavirus vaccine coverage (Troeger *et al*., 2020) have been indicated as risk for childhood diarrhoea in developing countries.

2.5 Approaches to Diarrhoeal Diseases Diagnosis

The polymicrobial nature of diarrhoea aetiology requires the medical microbiologist to harness the differential diagnosis towards establishing the causative agent of the disease (Panchalingam *et al.*, 2012; Humphries and Linscott, 2015). Accurate detection of the etiologic agent is a very important step for diarrhoeal disease surveillance and control activities (Tarr *et al*., 2018).

2.5.1 Conventional Diagnostics

The traditional approach to the diagnosis of infectious diarrhoea includes Gram staining and microscopic examination, plate culture (and records of morphological characteristics), toxin assay, antigen-antibody assay, and biochemical testing (Ahmad *et al.*, 2010). They are still being routinely used in clinical laboratories to detect and identify enteric pathogens (Liu *et al.*, 2011). They have good sensitivity and specificity (Platts-Mills *et al*., 2013), but are quite laborious (Loman *et al.*, 2013), because they must include a battery of methods to detect a spectrum of potential viruses, bacteria, and parasites (Chang *et al.*, 2013). Also, time of identification takes longer, a factor which may threaten the chance of proper antibiotic and supportive therapy and ultimately of survival for a patient in a critical condition.

Laboratory diagnosis that is culture-based often produce low yield for enteropathogens and this may hamper antibiotic therapy (Forbes *et al.*, 2017). Although stool microscopy for parasite detection is broadly used, it is, however, insensitive, time-consuming, and requires equipment and training (Panchalingam *et al*., 2012; DuPont, 2016). Moreover, bacteria referred to as ‘viable but not culturable’ (VBNC), as well as, ‘difficult to culture’ (DTC), are

often missed out of the identification process. It has been estimated that only about 1% of bacteria are culturable (Allan, 2014).

2.5.2 Molecular Diagnosis of Diarrhoeal Diseases

Molecular diagnostics, which generally utilize the amplification of DNA or RNA, are increasingly relevant in infectious disease diagnosis. Molecular epidemiology uses the genetic sequence of microorganisms and their hosts to describe the disease patterns as well as gain insight into possible gene function and origin by describing the distribution of genes or gene according to person, place, and time characteristics. Microbial DNA can be detected in all types of samples. The two approaches to molecular detection of microbes are the culture-based and culture independent methods. Culture-dependent molecular methods require that microbes are grown in culture media in the laboratory under optimum growth requirements before DNA is extracted for further molecular processing. On the other hand, culture-independent molecular methods do not require microbes to be cultivated on culture plates for DNA isolation. Rather, DNA is extracted directly from samples (Gosalbes *et al*., 2012; Loman *et al*., 2013).

2.5.3 Polymerase Chain Reaction

Polymerase chain reaction (PCR) is by far the most widely used method for nucleic acid amplification. Among several biomarkers for pathogen detection, nucleic acids are the ultimate. Molecular targets for many enteropathogens are known. Some researchers have utilised multiplex PCR (Liu *et al*., 2011; Onanuga *et al*., 2014), array singleplex PCR (Liu *et al*., 2014a, b; Platts-Mills *et al*., 2013), and quantitative PCR (DuPont, 2016) in diarrhoeal research.

2.5.4 Metagenomics

Metagenomics, which is the culture-independent genomic analysis of microbial communities, has emerged as an influential new research tool in microbiology over the last twenty years (Allan, 2014). There are basically two approaches, the deep amplicon sequencing (DAS) or metagenome shotgun sequencing (MSS) (Miller *et al*., 2013). In diarrhoea diagnosis, the Bacterial DAS strategy typically entails the use of universal primers such as 16S rRNA (Miller *et al*., 2013; Decuypere *et al*., 2016). On the other hand, shotgun sequencing utilizes the process of randomly breaking up DNA sequences into many small pieces and then rearranging them by targeting regions of overlap, thus generating sequencing data that are naturally immune to primer bias (Hao and Chen, 2012). The shotgun approach has a wider coverage in terms of application in microbial community studies.

Other molecular biology techniques deal with the extraction of genomic DNA from an individual organism or cell from a pure isolate, whereas, metagenomics focuses on the direct investigation of total genomic DNA from clinical specimens. Rich phylogenetic information can be harnessed from amplicons of either or both of the two variant regions V3 and/or V6 of 16S ribosomal DNA (rDNA) of the bacteria in samples when pyro-sequenced (Miller *et al*., 2013). Unlike the DAS, shotgun metagenomic sequencing approach can potentially detect all of the microbes present in a sample, despite their kingdom of origin, by sequencing all the nucleic acids extracted from a specimen (Zhou *et al*., 2016). Therefore, its application in the analysis of the diversity and the metabolic potential of microbial communities is indispensable, especially as only a few microorganisms in nature are culturable (Padmanabhan *et al.*, 2013;

Loman *et al*., 2013). Shotgun metagenomics has the potential to detect completely novel genes (Fredricks, 2013). Apart from the detection of enteric pathogens, shotgun metagenomics has other applications in diarrhoea epidemiology. It can be used to investigate the phylogenetic diversity of microbial genes or gene products, antimicrobial resistance genes, and virulence genes (Hu *et al.*, 2013; Allan, 2014; Zhou *et al*., 2016; Braun *et al*., 2017).

Recent reports from around the world suggest the potential of metagenomics as a useful tool in diarrhoea diagnosis (Becker-Dreps *et al*., 2015; Sun *et al*., 2016; Kieser *et al*., 2018; Aiemjoy *et al.*, 2019). Bender and Dien Bard (2018), predict a rising frequency in the application of metagenomic techniques in paediatric medicine. Enteric pathogens, including viruses, bacteria, and protozoans have been identified using different metagenomics methods such as micro-mass sequencing, pyro-sequencing, amplicon sequencing, shotgun sequencing, and whole-genome sequencing. Despite the many advantages of metagenomics in pathogen detection, the major drawback is the enormous data that are often generated which require in-depth bioinformatics software application.

2.5.5 Bioinformatics

A very crucial part of metagenomics technique is the application of bioinformatics tools, especially for data analysis. The application of gene sequencing in epidemiology brings about huge data (Padmanabhan *et al.*, 2013). Bioinformatics is the discipline that focuses on the development of ways to use computer software's to characterise molecular components of living things. In the past few decades, molecular epidemiology focused on strain typing for outbreak and surveillance investigation. The ability to analyse genetic sequences

from microbes has transformed the molecular epidemiology of infectious diseases. Therefore, modern molecular epidemiology relies on new phylogenetic methods that enable the analysis of genetic data to estimate epidemiologic parameters and link epidemic processes to pathogen evolution (Foxman and Goldberg, 2010; Gosalbes *et al*., 2012).

Recent studies reveal the significance of bioinformatics tools in the diagnosis of clinically challenging cases such as asymptomatic clinical presentations (Bodian *et al.*, 2017; Pathak *et al.*, 2019). Besides, there are pieces of evidence showing that bioinformatics is a very reliable epidemiological tool during disease and antimicrobial resistance surveillance (Bessoff *et al*., 2013; Gardner and Hall, 2013; Kaiser *et al*., 2016; Yodmeeklin *et al*., 2017). Also, with bioinformatics applications, scientists are already discovering new drug targets for the treatment of diarrhoeal diseases (Allan, 2014; Ugboko *et al.*, 2019).

2.6 Treatment and Management of Diarrhoeal Diseases

The common treatment options for diarrhoeal diseases are fluid replacement and antimicrobial therapy. Fluid replacement therapy also referred to as oral rehydration therapy (ORT) is especially necessary for young children (Iannotti *et al*., 2015; Bruzzese *et al*., 2018). In Nigeria, cereal-based oral therapies and home-made fluids have proven to be effective in diarrhoea management (Peter and Umar, 2018). In some instances, diarrhoea cases may be self-limiting. However, during severe cases of infection (persistent diarrhoea or dysentery), antimicrobial agents are required (Breurec *et al*., 2016). The first line antimicrobial agents for childhood diarrhoea therapy are co-trimoxazole and metronidazole which could be administered empirically. Others include penicillin, erythromycin, amoxycillin, ampicillin, cefuroxime, ceftriaxone,

tetracycline, chloramphenicol, and ampicillin/cloxacillin, azithromycin, ciprofloxacin, and rifaximin (Udoh and Meremikwu, 2017; Bruzzese *et al.*, 2018). Howteerakul *et al.* (2004), reported co-trimoxazole, norfloxacin, colistin sulfate, and nalidixic acid as the frequently recommended antibiotics for childhood therapy in Thailand. A study in Nigeria showed that metronidazole is the most prescribed antibiotic, followed by co-trimoxazole and gentamycin (Udoh and Meremikwu, 2017). Parenteral treatment with ceftriaxone or ciprofloxacinis recommended for severe diarrhoea cases (Bruzzese *et al.*, 2018). Childhood diarrhoea caused by Shigella is responsible for most cases of mortality in non-bloody diarrhoea (Liu *et al.*, 2016a, b) and morbidity in moderate diarrhoea (Anderson *et al.*, 2019), among children under five years in developing countries. However, the emergence/re-emergence of antibiotic-resistant strains of enteric pathogens is becoming a huge threat (Willey *et al.*, 2013).

Worldwide, there are reports on multidrug-resistant strains of enteropathogens isolated from stools of children under five years (Elsherif *et al.*, 2016). For instance, multidrug resistant Shigella spp has been reported in Ethiopia (Gebreegziabher *et al.*, 2018), Mozambique (Vubil *et al.*, 2018), and Nigeria (Ajayi *et al.*, 2019). Other treatment options include immunotherapy which is an alternative treatment option (Thu *et al.*, 2017; Nagata *et al.*, 2018; Zhao *et al.*, 2019), fortified nutrition such as iron fortification and zinc replacement therapy (Paganini *et al.*, 2016; Van Der Kam *et al.*, 2016; Wessells *et al.*, 2018), lactose-free diet (Iannotti *et al.*, 2015), probiotics, though is limited awareness in Nigeria (Ajanya *et al.*, 2018; Mokomane *et al.*, 2018; Efunshile *et al.*, 2019), and faecal microbiota transplantation which has been used mostly in

Clostridium difficile-associated diarrhoea (Austin *et al*., 2014; Colman & Rubin, 2014; Barnes & Park, 2017).

Oral zinc therapy could help reduce the severity and duration of diarrhoea in children above six months but may not have significant effect in children under six months of age (Lazzerini & Wanzira, 2016). Besides, Zinc absorption during diarrhoea may be reduced and vomiting may be a possible side effect (Ogunlesi *et al*., 2017; Somji *et al*., 2019). In Bangladesh, a combination of ORS, zinc and vitamin A supplementation was very effective at reducing death in children caused by diarrhoea (Billah *et al.*, 2019).

2.7 Prevention and Management of Diarrhoeal Infections

An adequate supply of potable water, sanitation, and vaccination are the main means of preventing diarrhoeal infections (Desmennu *et al.*, 2017).

2.7.1 Improved Water Supply and Sanitation

Acute diarrhoeal diseases can be prevented with a variety of measures focused on limiting the spread of organisms within the community and from person to person. Diarrhoeal diseases spread by the faecal-oral route. Therefore, handwashing is considered a key barrier to the transmission of enteric pathogens (Wolf *et al*., 2018). Studies from the developing world and from the U.S. and Australia childcare settings estimated 42%–47% reduction in the risk of diarrhoeal diseases by hand washing with soap (Bennett *et al.*, 2014). Therefore, effective Hand washing with soap should be practised by parents and caregivers before food preparation, before feeding their children and after leaving the toilet (Oloruntoba *et al*., 2014; Centres for Disease Control and Prevention, 2016a, b).

Globally, over 1 billion people lack access to improved drinking water supplies (Willey *et al.*, 2013) and over 2.4 billion live without adequate

sanitation (Darvesh *et al.,* 2017). Strategies to improve the microbial quality of drinking water can be applied at the source or in the household. Water source strategy includes protected wells, boreholes and public tap stands (Chakravarty *et al*., 2017). Household strategies include improved water storage or approaches for treating water, such as chlorination, solar disinfection, filtration, or combined flocculation and disinfection (Darvesh *et al.,* 2017).

2.7.2 Vaccines

Immunization has reduced the burden of diarrhoea in children. However, there are limited vaccines which protect against few and specific pathogens. There are two enteric infectious agents for which vaccines have been licenced for use at the present time, they include rotavirus and V. cholerae O1 (Preidis *et al.,* 2011).

2.7.3 Rotavirus Vaccine

Rotavirus vaccination has been very effective in reducing the hospitalization and death rate caused by diarrhoea in Africa. Studies by Das *et al.* (2013), showed commendable reduction in rates of death (74%) and hospitalization (47–57%) caused by rotavirus in childhood diarrhoea. There are two types: a pentavalent rotavirus vaccine recommended for routine use in infants with three doses given at two, three, and six months respectively; and a monovalent rotavirus vaccine recommended as an alternative of two doses given at two and four months (Shah *et al*., 2017; Weldegebriel *et al*., 2018; Mwenda *et al*., 2018). Rotarix and RotaTeq manufactured in Belgium and New Jersey respectively have been effective in the prevention of diarrhoea (Mokomane *et al.,* 2018; Soares-Weiser *et al*., 2019). Rotavac and BRV- PV produced in India have also proved to be promising. BRV-PV, is a heat-stable, live, oral bovine

rotavirus pentavalent vaccine (given at 6, 10, and 14 weeks), which has undergone trial in Niger with a 66.7% efficacy against infantile diarrhoea caused by rotavirus (Isanaka *et al*., 2017; Seck *et al.*, 2017).

2.7.4 The Cholera Vaccine

The two oral cholera vaccines that are available for use and prequalified by the WHO are the oral, whole-cell, killed V. cholerae O1 vaccine supplemented with the B subunit of cholera toxin and the O139 vaccine without supplemented B with names as Dukoral, Shanchol, Euvichol, and mORC-Vax (Riddle *et al.*, 2018; Boeckmann *et al.*, 2019). These vaccines are given in two or three doses depending on age and produce protective efficacy against the moderate and severe disease of between 60% -85%, for up to two to three years after vaccination. They are less effective in children below two years and produce a shorter duration of protection in these individuals (Leung *et al*., 2012). A field trial of the oral cholera vaccine was done in Mozambique, where two doses of Dukoral showed 78% protective efficacy against disease in a cholera outbreak.

2.7.5 New Enteric Vaccines

Recent trends show evidence of novel enteric vaccines. These include ETEC, Shigella, and norovirus vaccines. In the past two decades, research has been ongoing in the area of vaccine development using several methods which include live attenuated, killed whole-cell, and subunit techniques. Some of the new vaccines are in the preclinical and clinical stage of development (Bourgeois *et al.*, 2016; Mani *et al*., 2016; Tennant *et al.*, 2016; Mokomane *et al.*, 2018).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

An overview of this chapter takes a look at the study areas and research methodology and this have been described into detailed. The study area included the Kintampo North Municipalities. The areas to be considered are their locations and maps, vegetation, geology, relief and drainage and climate conditions. The methodology also describes the methods applied during the research period.

3.2 Study Areas

The study was conducted in the Kintampo North Municipality. The municipality is in the newly created Bono East region of Ghana. The Municipal Capital, Kintampo, is located at the Centre of Ghana and serves as a transit point between southern and northern Ghana. The municipality shares boundaries with Central Gonja district to the north and Kintampo South and Pru districts to the south (Figure 2). It covers an area of 5,108km^2. It has an estimated population of 95,480 according to 2010 population and housing census. (http://www.ghanadistricts.com/Home/District/43). Children under-five years are estimated as 14,625, constituting 15.32 (%) percent of the population. There is one Municipal Hospital, four Private Clinics, four Health Centers and 19 functional CHPs compounds. About 73.1% of the district population lives in the rural areas and 64% rely on streams for drinking water (KNM/GHS Annual report, 2016). The area is largely rural and the capital, Kintampo, is semi-urban (Abubakari et al. 2015; Owusu-Agyei et al. 2012). The Mo and the Bono are the major ethnic groups.

About 40.3% of the households in Kintampo do not have toilet facilities in their homes and therefore resort to bush/river/field. For the few households that uses toilet facilities, the commonly used type of toilet facility in the Municipality is public toilet (WC, KVIP, Pit, Pan) representing 7.1 percent. About 21.3 percent of households in the Municipality have bathrooms for exclusive use of members while another 33.0 percent use shared separate bathroom in the same house.

Most households, (about 45.8%), dump their solid waste in a public dump or open space. Another 29.3 percent dispose their solid waste by public dump in a container. House to house waste collection accounts for 2.3 percent. For liquid waste disposal, throwing waste onto the street 39.1% and onto the compound 49.8% are the two most common methods used by households in the Municipality

(http://www.ghanadistricts.com/Home/District/43).

Figure 1: Map of Kintampo North Municipality (Ghana Statistical Service, 2014)

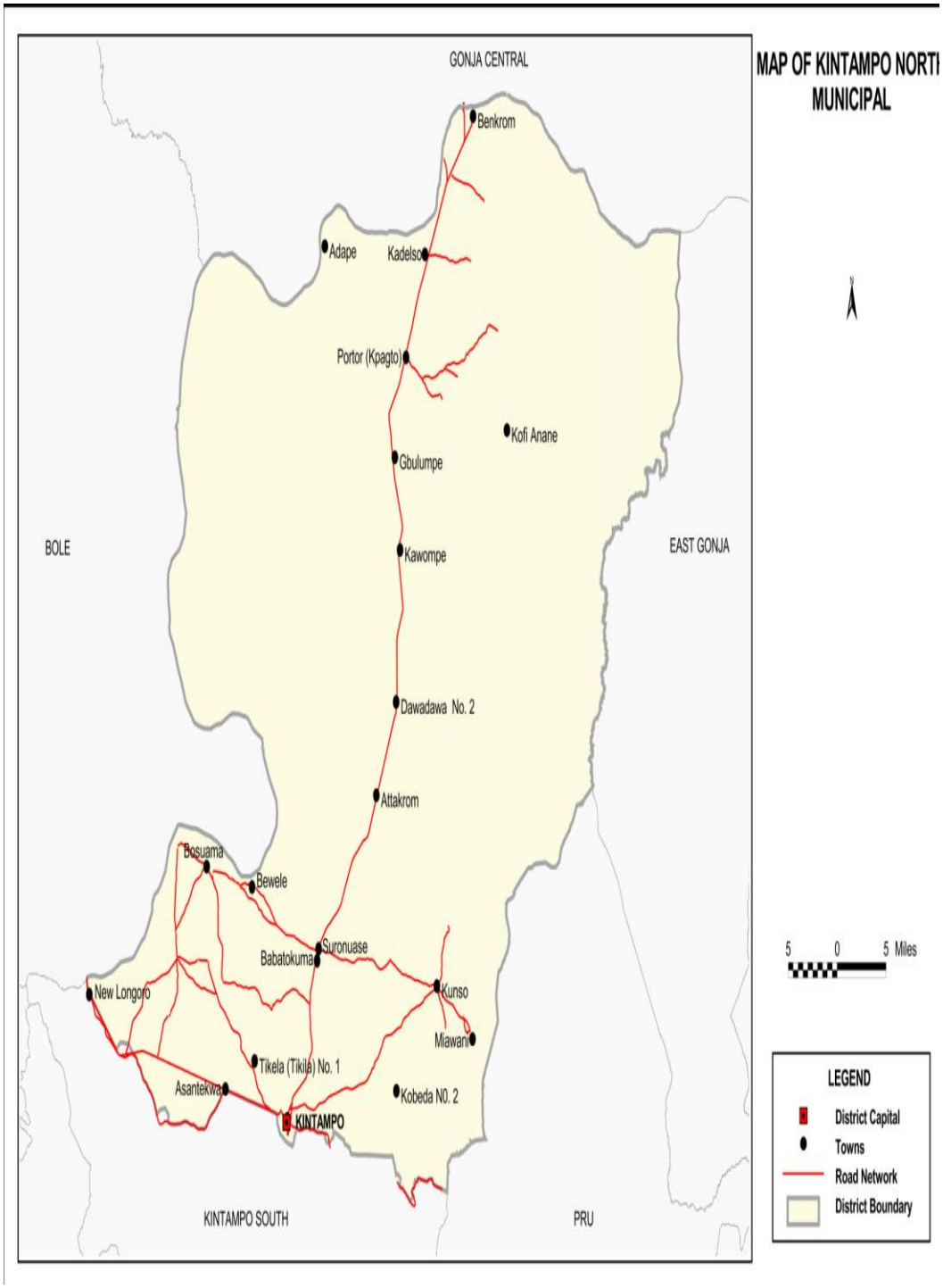


Figure 1:Map of the Kintampo North Municipality

Source: Field Survey (2020)

3.3 Vegetation

The Municipal comes under the Interior Wooded Savannah or Tree Savannah. However, owing to its transitional nature, the area does not totally exhibit typical savannah conditions. Thus, the savannah here is heavily wooded, though most of the trees are not as tall and gigantic as those in the most deciduous forest. It is believed that the transitional zone was once forested and that the savannah conditions currently prevailing have been the result of man's activities. The existence of "fringe forest" found along the banks of major rivers and streams and other areas where the impact of man's activities are minimal.

3.4 Geology

The rocks underlying the Kintampo Municipal form part of the "Voltain formation" which covers about two – fifths (2/5) of the surface area of Ghana and about 80% of the Municipal land surface. Rocks belonging to this formation are mainly sedimentary and exhibit horizontal alignments. Sand stone, shale, mudstone and limestone are the principal examples of these rocks. Oral reports revealed that the Voltain formation was created soon after the Precambrian era when sagging of land occurred resulting in scarp slopes due to different levels of sagging

3.5 Relief and Drainage

The Kintampo Municipal which falls within the Voltain Basin and the Southern Plateau physiographic regions is a plain with rolling and undulating land surface with a general elevation between 60-150m above sea level. The southern Voltain plateau occupying the southern part of the Municipal is characterized by series of escarpments. The Municipal which falls within the

Voltain basin is endowed with a lot of water resources. The major water bodies include the Fra, Urukwain, and the Nyamba rivers. Others are rivers Oyoko, Pumpum and Tanfi. These water bodies flow through the west of the Municipal and join the Black Volta at Buipe. The slopes through which the rivers flow have given rise to water falls. The major ones include the Fular Falls on the Oyoko River and the Kintampo water falls on the Pumpum River. Most of these rivers are intermittent and the large ones like Urukwain and Pumpum fluctuate in volume. This makes them unreliable for irrigation purpose.

In terms of relief and drainage, the vast expanse of flat land especially the Northern part makes it suitable for large scale mechanized farming. Road construction and other activities are also relatively cheap. The vast water resources in the western part of the Municipal could be harnessed for irrigation purposes especially rice cultivation and dry season gardening as well as domestic supply of potable water. Fishing which is already an important activity on the Black Volta can be promoted if measures are put in place to ensure sustainable operations by the fishermen.

3.6 Climate Conditions

The Municipality experiences the Tropical Continental or interior Savannah type of climate, which is a modified form of the tropical continental or the Wet-semi equatorial type of climate. This is due largely to the fact that the Municipal is in the transitional Zone between the two major climatic regions in Ghana. The mean annual rainfall is between 1,400mm-1,800mm and occurs in two seasons; from May to July and from September to October with the minor season (May – July) sometimes being obscured. However, because of the transitional nature of the area, the distinction between the two peaks is often not

so marked. The mean monthly temperature ranging from 30°c in March to 24°c in August with mean annual temperatures between 26.5°c and 27.2°c. These conditions give rise to sunny conditions for most parts of the year. Relative humidity are light varying from 90%-95% in the rainy season to 75% – 80% in the dry season. The climate of the Municipality has the tendency to change and be inclined more to the drier tropical continental conditions or to the wet semi-equatorial conditions.

3.7 Research Design

The study was done using a retrospective and descriptive analysis of diarrhoea cases among children under five years old reported from health facilities in the Kintampo North Municipality from 2015 to 2019 to the district health information system 2 (DHIM 2) platform of the Ghana Health Service. This involved a desk reviewed and data extraction of diarrhoea cases recorded during the five-year period.

3.8 Variables

The outcome variable is the diarrhoea cases defined as a clinician's diagnosis of the passage of three or more watery stools a day in a child <5 years. Other variables collected are the child's age, sex and sub-district of residence.

Table 1: The Demographics Characteristics of the Child

Variable	Definition	Scale of Measurement
Diarrhoea	Passage of watery stool three or more times in a day	Nominal Dichotomous (Yes/No)
Age	Age of child in complete months	Discrete
Sex	Biological sex of child	Nominal Dichotomous (Male/Female)
Sub-district	Sub-district of residence of the child	Nominal
Year/period	Year of reported cases	Discrete

Source: Field Survey (2020)

3.6 Study Population

The study population are all diarrhoeal cases who were recorded at the out-patient department (OPD) in the health facilities in the Kintampo North Municipality from 2015 to 2019. Inclusion criteria; all diarrhoea cases recorded in the facilities during the five-year reference period and exclusion criteria**; p**rovisional or queried diagnosis of diarrhoea during the reference period. Re-attendants or diarrhoea cases who came for review.

3.7 Sampling

3.7.1 Sample size and Sampling Technique

All recorded 36521 diarrhoea cases in the municipality from 2015 to 2019 that have been captured in the District Health Information Management System 2 (DHIMS 2) was used. The DHIMS 2 is a web-based database which is used for collection, storage and analysis of health surveillance data from all

levels of the health system in Ghana. These involved records reviewed of the consulting room registers, monthly Integrated Disease Surveillance and Response (IDSR) summary sheets and extraction of records.

3.8 Data Collection and Data Collection Tool

The data was collected using a self-developed data extraction template. The template was used to capture the number of diarrhoea cases per year. The age, sex and district of residence of the cases was also recorded per each of the years. Diarrhoea case reports were extracted from District Health Information Management System (DHIMS) II database in an Excel format which was then exported to Stata version 14 for data cleaning, verification, and analysis. Excel version 2016 was used to plot the actual observed cases by years to assess trends and seasonality.

3.9 Data Quality Control

Random checks were performed on the records of diarrhoea cases retrieved from the monthly summary sheets for a particular year comparing it the records of the same year as recorded in the Dhims database. The data was double checked and rectified for each of the years.

3.9.1 Data Processing and Analysis

All records were entered in Microsoft Excel. The mean age of the children in months was computed with the standard deviation. The ages of the children were then categorized into two as 0 – 11 months and 12 – 59 months. Frequencies and relative frequencies were computed for the age groups and sex of the children were presented on appropriate tables and charts. The distribution of diarrhoea cases by the sub-district was presented in a choropleth map.

3.9.2 Ethical Consideration

Permission for data use was sought from the Kintampo Municipal Health Directorate of the Ghana Health Service. There was not any direct contact with human subjects whose records are being used for this study. All patient records were de-identified by removing patients, caregiver's names and house numbers. Findings of the study will be disseminated to the authorities of the municipal health directorate in an appropriate forum.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The chapter is organized into two main sections. The results based on research questions are presented in the section including the discussion of the results.

Prevalence of Diarrhoea Cases by Age and Sex

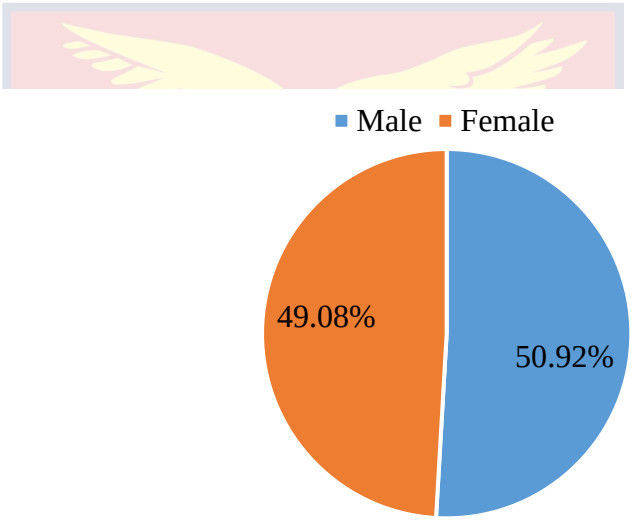


Figure 2:Sex Distribution of Diarrhea Among Children <5 Years in the Kintampo North Municipality, 2015 – 2019

Source: Field Survey (2020)

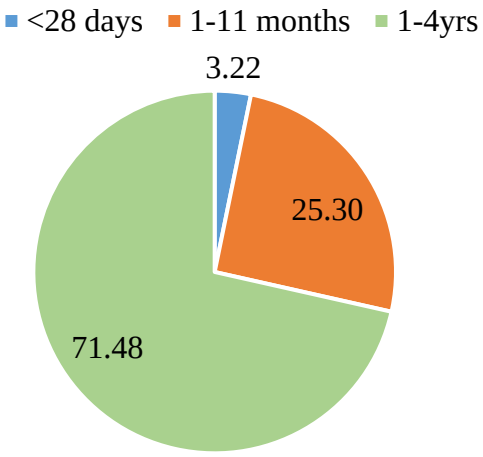


Figure 3: Age Distribution of Diarrhea Among Children Under 5 Years in the Kintampo North Municipality 2015 – 2019

Source: Field Survey (2020)

The above result illustrates the majority of the children were females (50.92%). The males, on the other hand, represented (49.08%), fig 2 The age distribution of diarrhea among children <5 years the Kintampo North Municipality is also shown above in fig. 3 A total of 36521 diarrhoea cases were reported in the Kintampo North Municipality over the five-year period. The median proportion of diarrhea cases was 21.3% (range: 7.72 – 27.98). The males constituted 50.9% (18596/36521) (Figure 3). The majority (71.48%, 26105/36521) of the diarrhea cases were aged 1 – 4 years (Table 2). The incidence of diarrhoea from 2015 to 2019 was high among one to four-year-old children. Childhood diarrhoea of those less than 28 days cases show a continual increasing trend for all years in this study for both males and females. The high incidence of childhood diarrhoea found in this study corroborates district level studies in Ghana (Kwame Adubofour, Kwasi Obiri-Danso, & Charles Quansah, 2013) and other settings in rural Kenya and globally (Kahn *et al*., 2012). Multiple

opportunistic infections for diarrhoea are exacerbated in poor environmental conditions.

These include lack of access to clean water and inadequate personal hygiene (Garn *et al*., 2016). A research conducted by New Hampshire Dept of Health and Human Service identified that diarrhoea can spread especially quickly among babies and young children under five years who are not toilet-trained or who may not wash their hands well after going to the bathroom/toilet. Age and sex were observed to have different outcomes from other studies where sex in not confirmed in this our study. Other studies corroborate 8 Journal of Tropical Medicine the effect of age and sex on diarrhoea outcomes (WHO, 2019). Males are slightly more susceptible to diarrhoea than females in the Kintampo District, accounting for an incidence rate of 50.9% (18596/36521) per thousand persons compared to female. Contrary to this, Bui in 2006 also conducted a research on the most common causes and risk factors for diarrhoea among children less than five years of age admitted to Dong Anh Hospital, Hanoi, Northern Vietnam which found females with high incidence for diarrhoea, (Gupta *et al*., 1994). on risk correlates of diarrhoea in children under 5 years of age in slums of Bankura, West Bengal, identified females to be more affected with diarrhoea (22.89%) than males (21.73%) whereas in the South Indian study females had higher acute diarrhoea (23.8%) than males (21.4%) but it was further reported that the difference was not statistically significance. Females having the highest diarrhoea incidence has many reasons which have been found to differ in many societies with different backgrounds. It has been found that sex difference regarding rate of diarrhoea has many reasons which in turn is far from clear understanding and gender preference is an unlikely

explanation to diarrhoea incidence because the difference has been found in different cultures and in studies with different methodological approaches (Lukeman *et al*., 2014)with an evidence that gender variations in infectious disease like diarrhoea may reflect differences in gender norms (UNICEF & WHO, 2019) wherein some regions, the nutrition of female children is neglected, restricting their access to good health

Trend of Diarrhea Cases in The Kintampo North Municipality

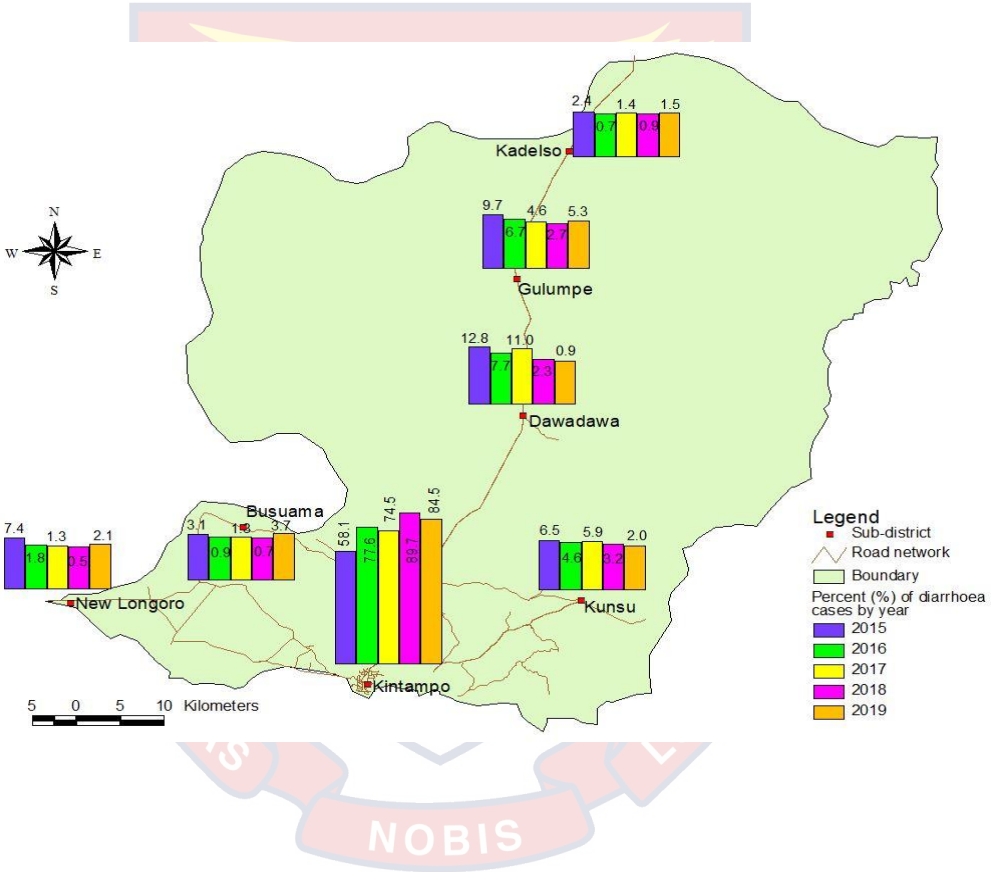


Figure 4: Map Showing the Distribution of Diarrhea Cases in The Kintampo North Municipality

The map shows the distribution of diarrhoea cases in the Kintampo north municipality. The higher cases were reported in the Kintampo sub-districts followed by Dawadawa and Gulumpe as shown (Figure 4).

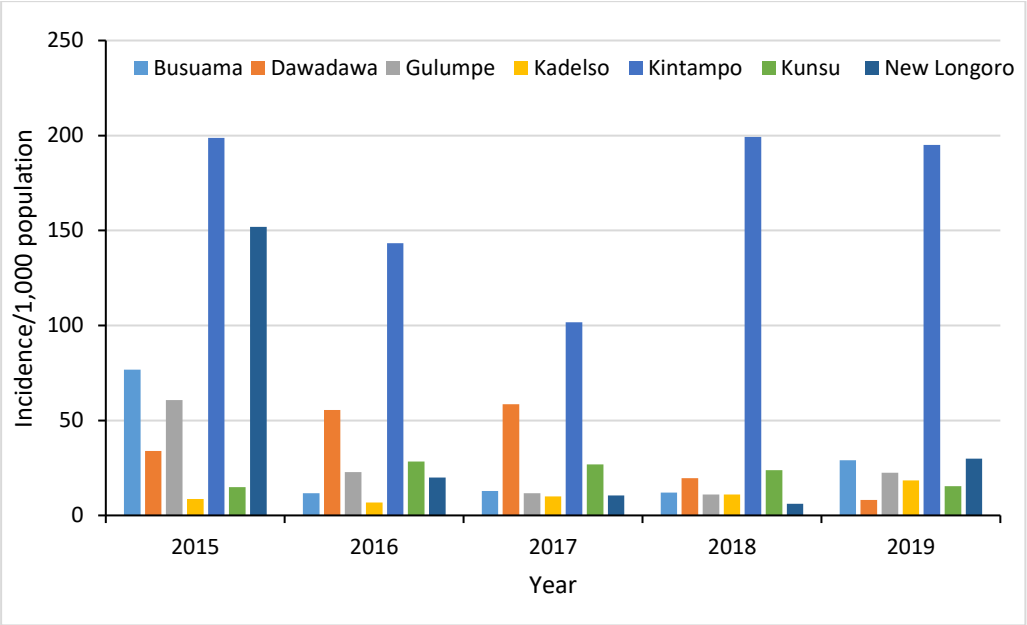
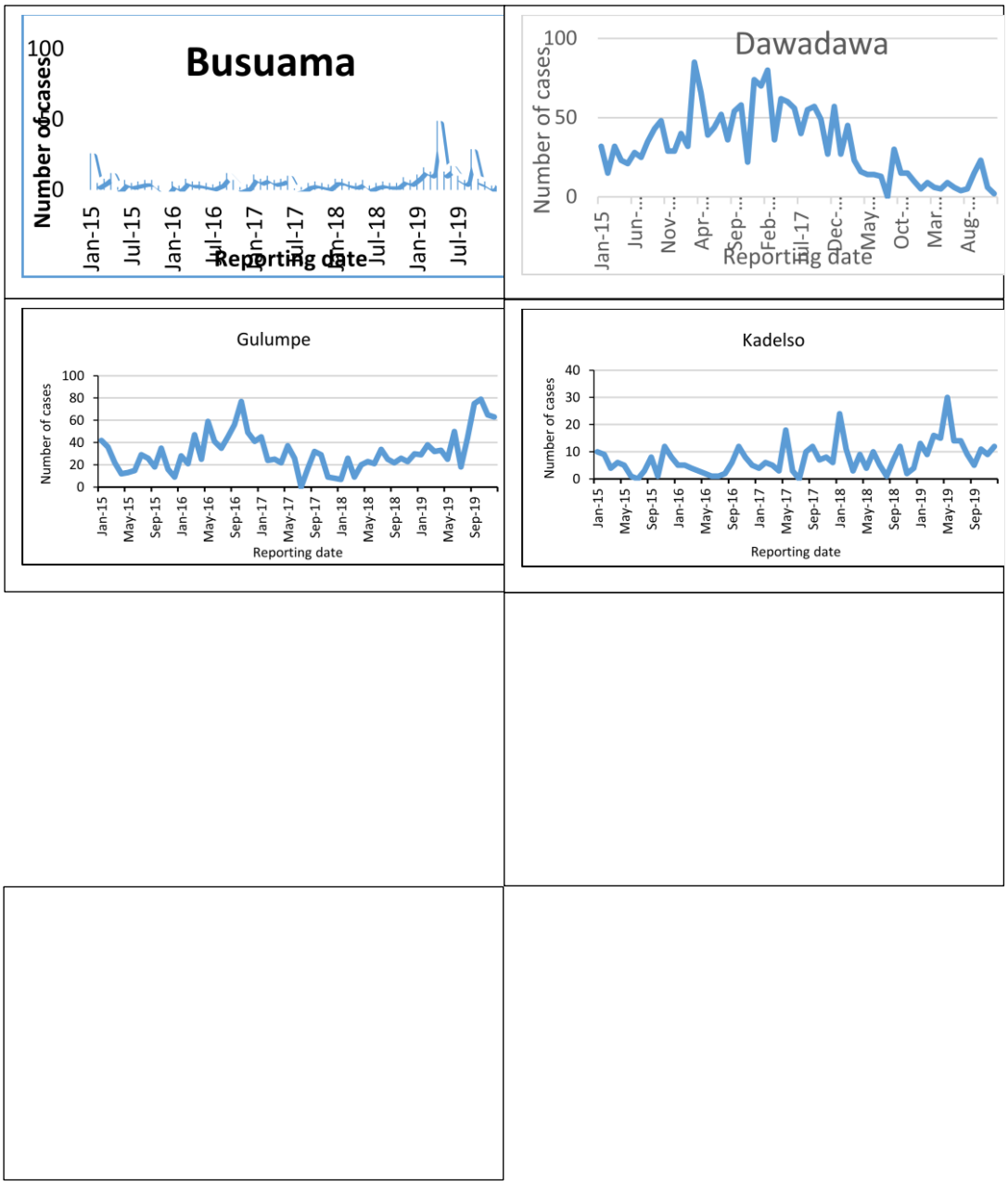


Figure 5: Incidence of Diarrhea Cases Among Children Under-Five Years Old in Kintampo North Municipality, 2015 - 2019

The incidence of diarrhoea cases among children < 5 years varied among the sub-districts over the five-year period (2015 – 2019). The Kintampo North Municipality reported 31 cases of diarrhoea per 1000 population among children <5 years in 2015. The incidence increased to 71 cases per 1000 population in 2016 and subsequently declined to 53 cases per 1000 population in 2017. In the subsequent years, however, diarrhoea incidence increased to 86 cases per 1000 in 2018 and 87 cases per 1000 in 2019. The highest incidence of diarrhoea cases was recorded in the Kintampo sub-district each year over the five-year period (Figure 5). Kadelso sub-district consecutively reported the lowest incidence of diarrhoea cases in 2015 (9 cases/1000 population), 2016 (7 cases/1000 population), and 2017 (10 cases/1000 population). In 2018, New Longoro sub-district reported the lowest incidence of six cases per 1000 population of children <5 years. In 2019, the lowest incidence of diarrhoea (8 cases/1000 population) was reported from Dawadawa sub-district.

Figure 6: Trend of diarrhea cases among children under-five years old per sub-district in Kintampo North Municipality, 2015 – 2019



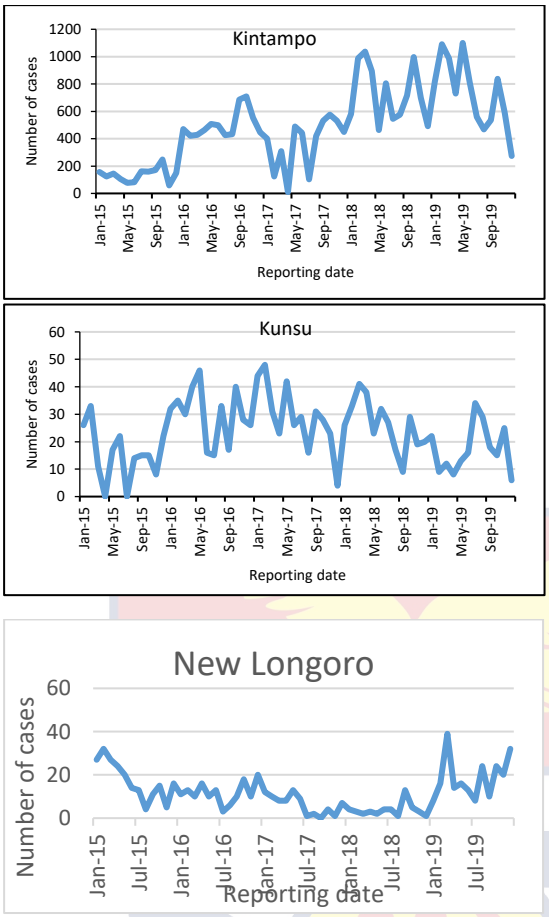


Figure 7: Trend of Diarrhea Cases Among Children Under-Five Years Old Per Sub-District in Kintampo North Municipality, 2015 – 2019

The Busuama sub-district did not report any case of diarrhea in December 2015, only one case was reported in July 2017. However, the sub-districts reported the highest of 49 cases in April, 2019 and 29 cases in September 2019. (Figure 6). The Dawadawa sub-districts reported the highest of 85 cases in March, 2016 and 80 cases in February, 2017. Also, in December, 2017 57 cases were reported in Dawadawa sub-districts. However, low diarrhoea cases were reported in August and December,2019 (Figure 6). The Gulumpe sub-districts reported 59 cases in May, 2016 and in July, 2017 no diarrhoea case was reported, the highest cases of 79 were reported in October,2019 and second highest of 77 cases in October,2016. (Figure 6). The Kadelso sub-districts

reported highest of 30 cases in May, 2019 and 24 cases in January, 2018.In May, 2017 18 cases were also reported. However, in July 2015 and 2017 no diarrhoea cases were reported in the district (Figure 6).

The Kintampo sub-districts reported in October, 2016 the sub-district also reported a significant figure of 710 cases of diarrhoea diseases. However, in April 2017 a remarkable low figure of 10 diarrhoea cases were reported the highest cases 0f 1100 in May, 2019, February, 2019. 1090 cases and 1036 cases in March ,2018 (Figure 6)

The Kunsu sub-districts did not report any diarrhoea cases in April, 2015 and July, 2015 the highest cases of 46 was reported in February, 2016 and 48 cases in February, 2017. (Figure 6). The New Longoro sub-districts reported 32 cases in February, 2015. There was no case of diarrhoea reported in September, 2017 and only 1 case was reported in August, 2018, however 39 cases in March, 2019 (Figure 6).

Table 4.2: Distribution of diarrhea cases by sex, age, and sub-district in the Kintampo North Municipality, 2015 - 2019

Variable	2015		2016		2017		2018		2019		Total
Sex	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	
Male	1517	8.16	3744	20.13	2892	15.55	5045	27.13	5398	29.03	18596

Table 4.2 Continued

Variable	2015		2016		2017		2018		2019		Total
Sex	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	
Female	1301	7.26	4048	22.58	2994	16.70	4761	26.56	4821	26.90	17925
Sub-total	2818	7.72	7792	21.34	5886	16.12	9806	26.85	10219	27.98	36521
Age group											
<28 days	22	1.87	29	2.47	14	12.0	48	40.85	503	42.81	1175
1-11 months	768	8.31	2085	22.56	1430	15.47	2248	24.31	2677	28.97	9241
1-4yrs	2028	7.77	5678	21.75	4343	16.63	7045	26.98	7039	26.96	26105
Sub-total	2818	7.72	7792	21.34	5886	16.12	9806	26.85	10219	27.98	36521
Sub-district											
Busuama	88	17.96	69	14.08	77	15.71	74	15.10	182	37.14	490

Table 4.2 Continued

Variable	2015		2016		2017		2018		2019		Total
Sex	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	
Dawad	3627	18.67	602	31.22	649	33.62	22.2	11.56	95	4.93	1928
Sex	3	14.46	524	27.75	4	14.51	6	14.09	551	29.18	1888
Kadelso	67	14.82	54	11.95	82	18.14	92	20.35	157	34.73	452
Kintampo	1639	5.53	604	20.38	4384	14.78	8793	29.64	8803	29.68	29664
Kunsu	183	13.01	358	25.44	345	24.52	314	22.32	207	14.71	1407
New Longoro	208	30.06	140	20.23	75	10.84	45	6.50	224	32.37	692
Sub-total	2818	7.72	779	21.34	5886	16.12	9806	26.85	1021	27.98	36521

Source: Field Survey (2020)

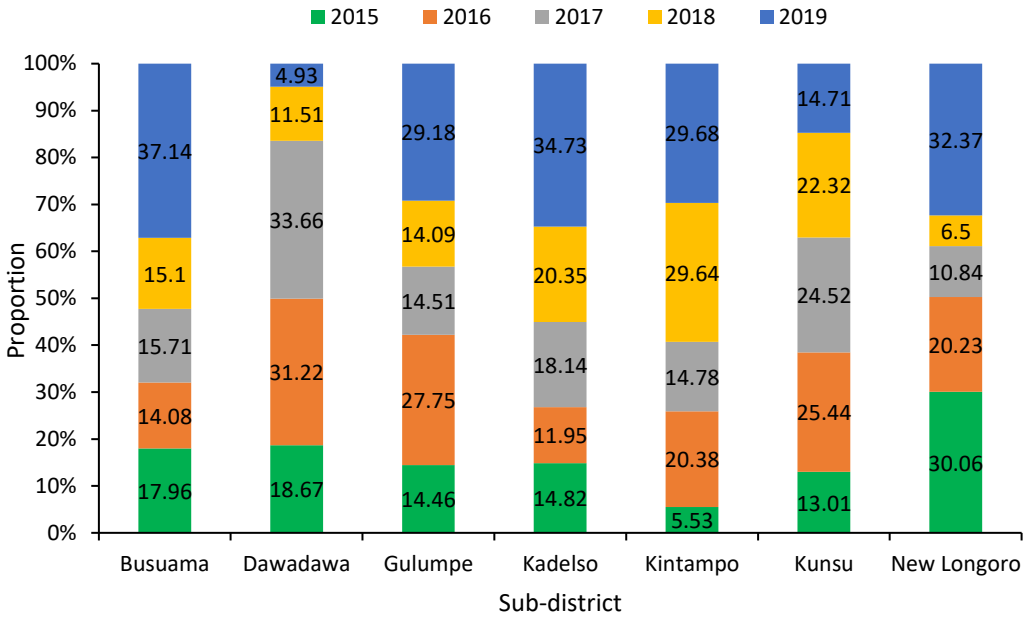


Figure 8: Proportion of Diarrhea Cases by Year Per Sub-District in The Kintampo North Municipality, 2015 – 2019

Source: Field Survey (2020)

The highest proportion of diarrhoea cases were reported in Busuama (37.14%, 182/490), followed by Kadelso with a reported case of (34.73%, 154/452. However, Gulumpe and Kintampo reported similar figures of (29.18%, 551/1888) and (29.68%, 8803/29664). New Longoro also reported (32.37%, 224/692) in the sub-districts in 2019. On the other hand, in Dawadawa sub-district the least proportion of diarrhea cases (4.93%, 95/1928) was reported in 2019 (Figure 8). In the Figure 8 above the age distribution of diarrhea among children <5 years is highest in age group of 1-4 years representing 71.48 %. The second highest group were children between the age group of 1-11 months (25.30%). However, the diarrhea distribution was lowest among children age group <28 days 3.22%. Trend analysis.

This study also examined trends for reported diarrhea morbidities at facility levels in the Kintampo Municipality of the Bono East Region in Ghana using DHIMS II database system. Overall, diarrhoea incidence in this study fluctuates, with decreasing and increasing trends. There was an annual increase in diarrhoea from 2015 to 2019, except in 2017 where there was a decline in incidence was observed, followed by a sharp increase in 2018. The Kintampo North Municipality reported 31 cases of diarrhoea per 1000 population among children less than 5 years in 2015. The incidence increased to 71 cases per 1000 population in 2016 and subsequently declined to 53 cases per 1000 population in 2017. In the subsequent years, however, diarrhoea incidence increased to 86 cases per 1000 in 2018 and 87 cases per 1000 in 2019. The highest incidence of diarrhoea cases was recorded in the Kintampo sub-district each year over the five-year period (Figure 8). Kadelso sub-district consecutively reported the lowest incidence of diarrhoea cases in 2015 (9 cases/1000 population), 2016 (7 cases/1000 population), and 2017 (10 cases/1000 population). In 2018, New Longoro sub-district reported the lowest incidence of six cases per 1000 population of children <5 years. In 2019, the lowest incidence of diarrhoea (8 cases/1000 population) was reported from Dawadawa sub-district. The high incidence of case in Kintampo municipality may be due to the presence of available health facility in the Kintampo Municipality where most of the other communities may refer cases for management.

Other studies have evidenced these decreasing and increasing diarrhoea trends (Mensah & Sabater, 2019). Seasonal variations in diarrhoea outcome were observed without any specific patterns within period of study. Seasonal variations for diarrhoea have been reported in Ghana. Diarrhoea cases were also

found in this study to be high mostly in May and September, within the years which corresponds to the rainy season with slight deviations. This confirms with Anyorikeya *et al.* (Merga & Alemayehu, 2015) that found the rainy season (May - August) as the period with a high incidence of diarrhea (Wardlaw et al., 2010). However, this differs with other projects which may be as a result of regional patterns with a different culture and different environmental conditions. Waterborne diseases increase in rainfall and decrease during drought events (harmattan season in Ghana) which confirms our study. Studies suggested that future climate change could aggravate a number of current health problems including diarrhoea where changes in temperature due to global climate change can increase diarrhoea disease incidence (Cooke, 2010). Diarrhoea disease burden in Ghana is overwhelming especially among under-five children where current report estimated that over 300,000 children under-five died from diarrhoea diseases which are linked to limited access to safe water, sanitation, and hygiene but only 15% of Ghanaians have access to improved sanitation (CDC, 2015). Diarrhoea disease has no discrimination in attacking an individual and anyone can catch infectious diarrhoea. Our research revealed that children under five years alone accounted for more than half (53.87%) of the burden of diarrhoea disease within the period under study in the Kintampo district. Currently in Ghana, there exist donor support and funding agencies that have been put in place to support improve water and sanitation and also child health through health and nutrition, water and sanitation, education, food security, etc. (Kwame Adubofour *et al.*, 2013).

UNICEF Ghana in collaboration with Ghana Education Service, Red Cross/Red Crescent Climate Centre, Engagement Lab at Emerson College, right

to Play, and Ghana Red Cross in their innovative ideas have introduced a programme called *Handwashing with Ananse* which is an educational game to teach children why, how, and when to wash their hands with water and soap. It is a three-chapter story and game experience centered around Ghanaian legends character who is known as *Ananse* who stole all the knowledge about handwashing and hid it in his pockets where children have to play through three scenarios with a tricky move to *Ananse* to win the handwashing knowledge back from him. These interventions hope to reduce diarrhoea cases in Ghana among the children under five years.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter consists of summary of the finds, conclusions and recommendations. The primary objective for this research was to assess the trend of diarrhoeal diseases among children under-five years old in the Kintampo North Municipality from 2015 - 2019

5.2 Summary of findings

This study analyzed the proportions and trends of diarrhoea diseases in the Kintampo North Municipality of Ghana. A retrospective analysis of records on diarrhoea data for a five years' period (January 2015 to December 2019) was undertaken. Diarrhoea case reports were extracted from District Health Information Management System (DHIMS) II database in an Excel format which was then exported to Stata version 14 for data cleaning, verification, and analysis. Excel version 2016 was used to plot the actual observed cases by years to assess trends and seasonality.

Objective 1: To Describe The Prevalence of Diarrhoea Cases By Age And Sex

From the analysis, it can be observed that Males had the slightly higher levels of diarrhoea incidence within the 5-year period. Overall, diarrhea incidence in this study fluctuates, with decreasing and increasing trends.

Objective 2: To Assess The Five-Year Trend of Diarrhoea Cases In The Municipality From 2015 To 2019

The survey describes that there was an annual increase in diarrhoea from 2015 to 2019, except in 2017 where there was a decline in incidence, followed

by a sharp increase in 2018. A total of 36521 diarrhoea cases were reported in the Kintampo North Municipality over the five-year period. The males constituted 50.9% (18596/36521). The median proportion of diarrhea cases was 21.3% (range: 7.72 – 27.98). The 2015 recorded the least proportion of the diarrhoea cases while 2019 recorded the highest proportion of 28.0% (10219/36521). The majority (71.48%, 26105/36521) of the diarrhoea cases were aged 1 – 4 years

5.3 Conclusions

4. What is the prevalence of diarrhoea diseases by age and sex among children in the Kintampo North Municipality?
5. What is the trend of diarrhoea prevalence from 2015 to 2019 in the Kintampo North Municipality?

Evidence from our research shows that the trend of diarrhoea increased annually and with age. There was an annual increase in diarrhoea from 2015 to 2019, except in 2017 where there was a decline in incidence, followed by a sharp increase in 2018. A total of 36521 diarrhoea cases were reported in the Kintampo North Municipality over the five-year period. Gender was not a contributing factor to diarrhoea cases amongst over the period of analysis. Also, the older the child the chances of diarrhea infections. Seasonal variations of diarrhoea were analyzed and the most peaked prevalence was in the rainy season. However, the findings from this study did not clearly show seasonal variations of diarrhoea. These findings corroborate national and global evidence of the epidemiology of diarrhoea. Successful implementation of an integrated plan toward achieving a district decline target for diarrhoea requires commitment from health care providers and stakeholders to work hand in hand. Improving water, sanitation,

and hygiene practices at household levels is key for reducing the incidence and trends of reported diarrhoea cases in the Municipality

5.4 Recommendations

The DHIMS II data should incorporate more information to enrich the data and makes it very useful during secondary analyses. The decline in 2017 needs to be investigated further for any possible interventions in order to reduce the burden of diarrhea in the municipality. Further studies should be designed in Municipality to assess district and household behaviour change practices needed to promote and reduce the incidence of diarrhoea-related disease conditions in the District.

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APPENDIX 1

Data extraction sheet for diarrheal diseases

Year	Sex		Age group			Sub-district							
	M	F	<28 days	1 – 11 months	12 – 59 months	Busuama	Kunsu	Kintampo	Dawadawa	New Longoro	Etc	Etc	Etc
2015													
2016													
2017													
2018													
2019													