PRESBYTERIAN UNIVERSITY COLLEGE, GHANA

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DEPARTMENT OF ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

SALMONELLA TYPHI INFECTION AMONG WASTE COLLECTORS IN THE ABLEKUMA NORTH MUNICIPALITY

BY

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DECLARATION

Candidate's Declaration

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

Signature……

Date……

Hannah Anita Obenewa Obeng

(Student)

Supervisor's Declaration

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

Signature……

Date……

DR RICHARD AMFO-OTU

ABSTRACT

Salmonella typhi is the major cause of typhoid fever, a systemic bacterial illness of public health importance. This study examined the risk factors and prevalence of *Salmonella typhi* infection among waste collectors in the Ablekuma North Municipality. A cross-sectional approach and stratified sampling method were employed in this study. Pre-tested questionnaire covering socio-demographic information, level of knowledge on *S. typhi* and personal hygiene practices was administered to each respondent. A total of 60 respondents were recruited and screened against *S. typhi* surface antigen using the Widal slide agglutination test. *S. typhi* prevalence of 31.67% was recorded among the waste collectors. Respondents showed good level of knowledge on typhoid fever as well as good personal hygiene. However, factors such as number of working years, finger biting, irregular hand washing without soap after handling waste, level of monthly income, and lack of personal protective equipment were observed as predisposing factors to typhoid fever disease. Based on the findings of this study, it is recommended that waste recycling companies must provide personal protective clothing and enforce their usage while the Municipal Assembly should educate the workers in the waste management sector on personal hygiene practices and sanitation related diseases in order to minimize the risk of acquiring infectious diseases in their line of duty.

DEDICATION

This work is dedicated to the Almighty God, for his guidance and wisdom, and to my parents, Mr. and Mrs. Obeng-Adu and my Siblings.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Salmonella enterica subspecies enterica serovar Typhi (*Salmonella typhi*) together with Salmonella serovar Paratyphi A are the major cause of typhoid fever (Crump, 2019), a systemic bacterial illness of public health importance (Mogasale *et al*., 2018). It is Gram-negative bacteria that invade the bloodstream and cause typhoid fever (Marks *et al*., 2017). Humans are the reservoir of *Salmonella typhi*; hence the bacteria undergo restricted growth and multiplication outside the human host. It however may survive for considerable periods in the environment (Crump, 2019). If untreated, typhoid fever may result in several complications including intestinal, neuropsychiatric in some patients (Waddington *et al*., 2014). Humans can become chronic carriers and food handling practices among carriers can result in food contamination and leads to *S. typhi* transmission (Mogasale *et al*., 2018). However, irrigation methods that make use of fecal contaminated water pose high risk that could result in maintaining disease endemicity especially in developing countries (Mogasale *et al*., 2018). Salmonella typhi infections remain one of the common causes of bloodstream infections associated with low income communities. The infection shows similar clinical outcome with other fibril illness making it difficult to distinguish from other febrile illnesses and often results in high fatality ratio. The infection occurs only in humans and presents with different degree of clinical outcomes (Bhan *et al*., 2005).

A report in 2000 revealed that, about 21.7 million illnesses and 216,000 deaths due to typhoid fever was recorded (Crump *et al*., 2015). A similar report by The International Vaccine Institute (2010) showed that, 11.9 million typhoid fever illnesses and 129,000 deaths occurred in low- and middle-income countries (Crump *et al*., 2015). Mostly, cases

of typhoid fever in Developed countries are uncommon and often found among immigrants that acquired the infection abroad or imported by emigrant and have an estimated annual incidence of 540 per 100,000 or about 17 million cases worldwide (Crump *et al*., 2015). Most outbreaks of typhoid fever are reported to occur in sub-Saharan Africa and countries in South-east Asia (Muyembe *et al*., 2009; Baddam *et al*., 2012). A medium incidence of *Salmonella* typhi infection is reported to occur in other regions of Asia and Africa, Latin America, the Caribbean, and Oceania at rate of 10 to 100 cases per 100,000 people per year. This data is however reported to be inconclusive and inconsistent as it is based on extrapolation of data across regions and age groups. Recently, a population-based study in Latin America suggests lack of data on typhoid fever with the possibility of reduced incidence over the past 30 years (Crump *et al*., 2015). A similar report in Africa indicates substantial heterogeneity between countries. For example, some Southern and Northern African countries have very low rates (<5 cases per 100,000 person/year) while several countries in Eastern and West Africa have rates of 100 cases per 100,000 (Marks *et al*., 2017).

Salmonella typhi frequently exits its host through feces and shedding in urine (Crump, 2019) during and following both clinical and subclinical acute infection. Shedding may be temporary or chronic. An infected person or convalescent carriers may continue to shed the bacteria for a period between 3–12 months after the onset of acute illness while chronic carriers may continue to shed the bacteria after a period of 12 months (Crump, 2019). Individuals who have chronic infections are known to be a major source of transmission in countries with low incidence of typhoid cases (Crump, 2019). Transmission of the bacteria is being the ingestion of fecal contaminated food and water through the fecal–oral route. There are two major patterns of transmission of *Salmonella Typhi*; short-cycle transmission where contaminated food and water due to fecal shedding

into the immediate environment and propagated through inadequate hygiene and sanitation measures, and long-cycle transmission where human feces and use of raw human faces or sewage for irrigation purposes leads to contamination of broader environment (Crump, 2019). In view of the rout of transmission of typhoid fever, the World Health Organization (WHO) recommends provision of safe water as one of the preventive measures for typhoid fever (Mogasale *et al*., 2018).

The infection is endemic in low and middle-income countries where poor sanitation and lack of access to safe water for domestic purposes remain a serious public health problem. The associated risk factors for the disease include ingestion of food and water contaminated with fecal matter or eating vegetables and salads grown with human waste as fertilizer (Abioye *et al*., 2017). In addition, getting into close contact with relative with recent typhoid fever as well as poor sanitation and poor personal hygiene serve as risk factors for transmission of typhoid fever disease (Abioye *et al*., 2017).

S. typhi is susceptible to acidic environment and must strive to overcome and survive within the highly acidic gastric environment for successful colonization and establishment of infection in the terminal ileum. Thus, one characteristic of salmonella associated enteric fever is the suppression of gastric acid secretion during acute infection. Subsequently, the degree of acid suppression is dependent on the degree of the infection severity and returns to normal after treatment (Tiwari *et al*., 2004). The ability of *salmonella typhi* to tolerate and survive in highly acidic environment serves as a determinant that enable it to migrate into the small intestine to cause infection (Crump *et al*., 2015) and serves as a risk factor to the human host since gastric acid secretion is needed for protection against pathogenic organisms during innate immune responds. *Salmonella typhi* is a gender independent enteric fever, affecting both men and women with high incidence among children and young adult between 5 and 25 years of age

(Crump *et al*., 2015). Ingestion of the bacteria is usually followed by asymptomatic period between 7 to 14 days. Studies have shown that some individuals infected with the bacteria develop subclinical or asymptomatic bacteremia during which fecal shedding can occur prior to progression into the symptomatic stage (Waddington *et al*., 2014). A predominant clinical presentation associated with the asymptomatic stage is fever characterized by rise in body temperature between 39 to 40°C within the first week after infection (Crump *et al*., 2015). The symptomatic stage is characterized by influenza-like symptoms, a dull frontal headache, malaise, anorexia, a dry cough, sore throat, and occasionally epitasis. Constipation is known to be one of the symptoms in early stage of the infection, however many patients experience diarrhea or bloody diarrhea at some point (Crump *et al*., 2015). Other symptoms include diffused and poorly localized abdominal pain, nausea and vomiting as well as rigors are uncommon and this can be a useful feature to distinguish the illness from malaria (Cunha *et al*., 2013). In addition to fever, physical examination may lead to findings such as slightly distended abdomen with a "doughy" consistency and diffuse tenderness. Occasionally moderate soft and tender hepatomegaly and splenomegaly and a relative bradycardia are observed. Records of tachycardia are reported to be more common and the observed bradycardia cannot be attributed entirely to enteric fever (Crump *et al*., 2015). Prolong untreated infection may cause weight loss, weakness, and an altered mental state, and complications such as psychiatric disturbance, pneumonia Gastrointestinal bleeding may occur.

Recent reports indicate that, majority of patients continuously excrete *Salmonella* serovar Typhi or Paratyphi A in their stool or urine for some days after administration of antimicrobial and could continue for a period of three months. About 1 to 4% of patients is reported to excrete the bacteria after 3 months and may not cease shedding. Chronicity of the infection is said to occur among individual who continuously shed the bacteria in

their stool and urine after 1 year. Chronic carriers mostly do not exhibit any form of symptoms although acute typhoid fever could occur occasionally (Crump *et al*., 2015). Individuals who are carries of chronic *Salmonella* serovar Typhi are reported to be at high risk of gallbladder carcinoma (Crump *et al*., 2015).

Several strategic approaches have been outlined for the prevention and control of salmonella typhi infection as well as other enteric fever related diseases. These include identification and treatment of chronic carriers of *Salmonella* serovar Typhi, use of vaccines, and expanding access to safe drinking water which is a component of the Millennium Development Goal 7. In Western Europe and North America for example, a declined in the incidence of enteric fever due to the introduction of treatment of municipal water, pasteurization of dairy products, and exclusion of human feces from food production was reported (Crump *et al*., 2015). A similar result was achieved in Latin America (Crump *et al*., 2004) and in some Asian countries (Nga *et al*., 2012) due to economic transition and water and sanitation improvement. Currently two typhoid vaccines have been developed and are in use in the United States. The Ty21a vaccine; a live attenuated oral vaccine that contains chemically attenuated *Salmonella* serovar Typhi strainTy21a, and the parenteral Vi vaccine for the *Salmonella* serovar Typhi Vi capsular polysaccharide antigen. Several diagnostic methods have been developed for the detection and diagnosis of invasive *Salmonella* infections. These methods are not limited to detection of convalescent and chronic fecal carriage of typhoidal *Salmonella* only, but are widely been used for the estimation of the burden of the disease for public health assessment. Among the widely used methods for the diagnosis of salmonella typhi infection include culture, serological assays or antibody detection, and polymerase chain reaction (PCR). Different tests and biological samples may be required for each situation (Baker *et al*., 2010). Microbial culture remains the gold standard method for diagnosis of

invasive salmonellosis. Culture relies on the isolation of *Salmonella typhi* from sterile clinical samples, usually blood and bone marrow. Culture enables isolation of the bacteria for further analysis including antimicrobial susceptibility testing, epidemiologic typing, and molecular characterization. The optimum detection period by culture method is within the first and second weeks of the illness with still viability after the third week if the infection is not treated. Bone marrow aspirate culture is reported to show high level of sensitivity than blood culture due to the higher level of bacteria in the bone marrow (Crump *et al*., 2015). Studies have shown that bone marrow aspirate culture remains highly sensitive after antimicrobial administration than blood culture (Crump *et al*., 2015). However, bone marrow aspiration is an uncomfortable and specialized procedure, uncommonly performed outside research studies (Crump *et al*., 2015). Antibody detection method such as the Widal test is widely adopted for the diagnosis of invasive salmonellosis. The Widal test measures agglutinating antibodies against Lipopolysaccharide cell membrane antigen (O) and the flagella antigen (H) of *Salmonella* serovar Typhi in the sera of individuals with suspected enteric fever (Crump *et al*., 2015). Although the Widal test is widely adopted because of its simplicity and cost effectiveness, its performance is hampered by inaccuracy, lack of standardization of reagents and inappropriate result interpretation (Lunguya *et al*., 2012). Current data obtained suggests that, the Widal test lacks sensitivity and specificity due to background antibody levels in the general population (Keddy *et al*., 2011) and the cross-reactive nature of the selected antigens. Nucleic acid amplification tests, including conventional PCR and real-time PCR that targets various genes such as Hd flagellin gene *fliC-d,* Vi capsular gene *viaB*, the tyvelose epimerase gene (*tyv), and* the 16sRNA gene are currently been used for the detection of both *Salmonella* serovars Typhi and Paratyphi A mainly in blood (Kumar *et al*., 2012). The sensitivity of PCR is reported to exceed 90%

(Chaudhry *et al*., 2010), although much lower sensitivities is reported depending on the number of bacteria in the blood (Nga *et al.*, 2010).

Antimicrobial management of invasive salmonella typhi is aimed at alleviating clinical symptoms, providing supportive treatment with fluids and nutrition, and to monitor for the development of complications. Antimicrobial interventions help to reduce mortality and complications and shorten the illness as well as eradicate fecal carriage and reduce transmission. Treatment of salmonella enteric fever in endemic areas is often done with a 3 to 4 days regimen based on the observed clinical symptoms. Treatment with antimicrobials is recommended when there is evidence of sepsis or extra intestinal infection or for specific populations at risk of bacteremia and disseminated disease (Gordon *et al*., 2010). The ability of antimicrobials to penetrate the intracellular sites of the infection in the reticuloendothelial system and gallbladder determines its effectiveness. Several antimicrobial drugs including gentamicin and first- and second-generation cephalosporin's such as cefuroxime, Chloramphenicol, Amoxicillin and trimethoprim are been used for the treatment of salmonella related enteric fever. However, the emergence and spread of Multi-Drug Resistance (MDR) strains of *Salmonella* serovars Typhi and Paratyphi A has led to the evaluation of new antimicrobials including extended-spectrum cephalosporin's, fluoroquinolones, and azithromycin. The fluoroquinolones (ciprofloxacin, ofloxacin, fleroxacin and pefloxacin), when administered for 7 to 14 days and evaluated often recorded 100% effectiveness (Crump *et al*., 2015). The emergence of MDR has also led to the use of combine therapy (fluoroquinolones, cephalosporin, and azithromycin) on patients that fail to respond promptly to monotherapy treatment (Crump *et al*., 2008; Meltzer *et al*., 2014). The potential advantages of antimicrobial combinations include broadening of the spectrum of antimicrobial activity, particularly in the face of potential drug-resistant strains,

utilization of any potential synergy between the drugs, and the potential to reduce the emergence of resistant strains during the course of treatment (Mandal *et al*., 2004).

Waste management is a ubiquitous activity comprising individuals or groups collecting, separating, classifying, and selling solid waste as a means of subsistence. The sources where solid waste is collected include residential, commercial, and industrial sectors. The awareness that solid waste poses serious risk to both the environment and human health is well known (Medina, 2005). A study conducted in Canada reported that, workers at the informal waste management sector for example acquired higher job related illness and injuries then those in the formal sector. In view of the high risk associated with the regulated waste management sector in developed countries, majority of researchers have indicated that such risks are at a greater magnitude in the unregulated waste recycling sector especially in developing countries (Lavoie J. & Guertin S. 2001). In developing countries, waste management is a major challenge due to industrialization, urbanization and the increasing human and animal populations. The concomitant effects of these factors include an increased in the demand for food and other life essentials resulting in increased amount of waste which if not properly managed leads to the contamination of air, water and soil and thereby posing serious public health threats. The contributing factors to this malice include indiscipline among citizens, negligence from environmental stakeholders, lack of regulatory bodies, lack of toilet facilities and the poor handling and management of municipal solid waste (MSW). For example, Ogbonna *et al.* (2012) reported that, 20.4kg of solid non-hazardous waste were generated in Port Harcourt by hospitals daily. This waste when dumped along streets and drainages cause flooding, breeding of insects vectors and rodents and subsequent disease spread. Poor waste management has negative impact on public health with municipal waste management

workers, children and waste scavengers being the most vulnerable groups. For example, sharps such us syringes, scalpels and razor blades when disposed at dumping sites put children visiting these sites at risk of injury when they visit the sites to defecate or play as seen in developing countries like Ghana. Municipal waste management workers and waste scavengers are also at risk of injuries caused by these sharp objects. Most of these objects are contaminated and pose serious health risks as they serve as media for the transmission of infectious pathogens like HIV, Hepatitis B and C. A study by Karija *et al* (2013) identified faecal coliform counts of about 15.25 MPN/100ml above the internationally accepted level of 0 MPN/100ml. This observation, according to the group, was due to contamination of drinking water by municipal solid waste. This finding is in conformation with the fact that municipal solid waste in developing countries like Ghana and Nigeria is not segregated and largely contaminated with faecal matters from both humans and animals (Zurbrugg, 2002). Boadi and Markku, (2005) found a high association between food contaminated by flies and the incidence of diarrhea among children under the age of six. Diarrhea due to poor sanitation is known to cause approximately 30,300 among outpatient cases annually (Domfeh, 2009).

1.2 Statement of Problem

Health hazards associated with poor waste management are real and their effects on public health ranging from transmission of endemic Zoonosis to emergence and re-emergence of new Zoonosis arising either from direct or indirect effects of poor waste management cannot be over emphasized. A study in Canada demonstrated that employees in the formal recycling plants reported higher job-related illnesses and injuries more often than other sectors (Lavoie *et al*., 2001). As a result of these inherent risks associated with the regulated waste management sector in high-income countries, there has been discourse with regard to the unregulated recycling and solid waste management

sectors (Lavoie *et al*., 2001). Previous study indicated that, a common practice of collecting household, hospital and industrial wastes in Ghana is the use of tricycles (Medina, 2008). The individuals that operate under the waste management sector in Ghana usually do not use personal protective equipment when collecting refuse from their clients. Their mode of operations does not expose them only to the health risk or hazards associated with waste collection but also their clients through collection and exchange of money. This practice has the potential to serve as a medium for transmission of sanitary related infectious pathogens such as *Salmonella typhi*. However, most of the studies have concentrated on the economic benefits of scavenging, contribution of waste collectors to space savings at the landfills, materials recovered by scavengers, and health and safety practices. Although other some studies have reported on the prevalence of *Salmonella typhi*, there is still knowledge gap with respect to the prevalence of the disease among waste collectors and has affected policy decisions on such practices. This work therefore, contributes to fill the gap by examining the risk factors associated with the mode of operation of the waste management sector and the prevalence of *Salmonella typhi* infection among waste collectors in the Ablekuma North Municipality. In addition, due to the recognition of the critical and synergistic role of water and sanitation improvements in concert with vaccine introduction (Pitzer *et al*., 2014) there is the need to improve our knowledge and understanding of the risk factors associated with *Salmonella typhi* infections in diverse settings.

1.3 Research Questions

1. What is the prevalence of *Salmonella typhi* infections among waste collectors in the Ablekuma North Municipality?
2. What is the knowledge of waste collectors about *Salmonella* typhi infection?
3. What is the attitude of waste collectors towards sanitation and personal hygiene?

1.4 Main Objectives

To assess the prevalence and knowledge of *Salmonella typhi* infections among waste collectors in the Ablekuma North Municipality.

1.5 Specific objectives include:

1. Examine the prevalence of Salmonella typhi infection among waste collectors in the Ablekuma North Municipality
2. to assess the knowledge of waste collectors on waste management and related infectious diseases; and
3. to determine the attitude of waste collectors towards sanitation and personal hygiene.

1.6 Significance of study

This study identified the risk factors associated with waste collectors within the Ablekuma North Municipality in the Greater Accra Region of Ghana. It also provided insight on the knowledge and understanding of waste collectors on *Salmonella typhi* infection (typhoid fever). This study also determined the prevalence of *Salmonella typhi* infection among waste collectors in the Ablekuma North Municipality. This will help the stakeholders (waste management companies) and the municipal assemblies to formulate measures that will help reduce or curb the risk factors associated with the activities of waste pickers within the municipality.

1.7 Limitation

The study intended to compare the sensitivity and specificity of Widal diagnostic method to rapid diagnostic test. However lack of sensitivity of the test kit to correctly detect positive control hindered it continuation for diagnosing *salmonella typhi*. Lack of financial and logistic resources as well as time constrains prevented the extension of the research to other municipal assemblies within the Greater Accra Region.

1.8 Delimitation

The study was limited to waste collectors in the Ablekuma North Municipality. It covered sixty (60) waste collectors. The study focused only on prevalence and knowledge of *salmonella typhi* infection within the study area.

1.9 Organization of Study

The research work is presented in five chapters. Chapter one provides a general over view of waste management practices and the link between sanitation and infections cause by Salmonella typhi. It also addresses the challenges and occupational hazards associated with municipal waste pickers from which the aim and objectives for the study are also derived. Chapter two throws light and gives insight into work done by other researchers on waste management across the globe and portrays the findings relevant to the present study. It also provides comprehensive overview on the Concept of waste management, environmental and health impacts of solid waste picking as well as the causes and level of knowledge of waste pickers on typhoid fever disease. Chapter three focuses on methods and procedures that were used to collect information and data from respondents. It takes into account information on the geographical location of the study area and the target population. Chapter four deals with the outcome of the information gathered from the administration of the questionnaires addressing issues on socio-demography, knowledge of respondent on typhoid infection and personal hygiene. Data obtained is presented in tabular and figurative forms. Chapter five; the findings observations of this research are summarized in this chapter and the short falls or limitations that were encountered.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter throws light and gives insight into work done by other researchers on waste management across the globe and portrays the findings relevant to the present study. It also provides comprehensive overview on *Salmonella typhi* infection the concept of waste management, environmental and health impacts of solid waste picking as well as the causes and level of knowledge of waste pickers on typhoid fever disease.

2.2 Epidemiology of typhoid fever (Salmonellosis)

Salmonella typhi is a common human and animal pathogen that causes a disease referred to as salmonellosis otherwise known as typhoid fever. In humans, this disease takes the form of self-limiting food poisoning (gastroenteritis), with occasional manifestation as systemic infection (enteric fever) that demands timely treatment with antibiotics. Aside the negative impacts of salmonellosis on human, it also leads to quantifiable losses of domestic animals or livestock (Scheidler *et al*., 2001). Typhoid fever remains one of the major causes of mortality and morbidity worldwide with children between the ages of 5-19 being the most affected group especially in endemic areas. At least 10 and 30% of all cases if untreated could be very fatal. However, timely treatment with the appropriate antimicrobial medication reduces the fatality ratio between 1–4%, (Kabwama *et al*., 2015). An outbreak of *S. typhi* in Uganda affected 8092 people and caused 249 intestinal perforations and 47 deaths (Kabwama *et al*., 2015). Recent report indicates that, an estimated 20.6 million new cases of typhoid fever occurs annually worldwide with approximately 223,000 typhoid-related deaths (Kabwama *et al*., 2015). Outbreak of typhoid fever is well documented and largely attributed to poor sanitation, inadequate hygiene practices and unsafe food and drinking water (Kabwama *et al*., 2015). The mode

of transmission of *Salmonella typhi* that causes typhoid fever and other enteric fevers is predominantly from person-to-person through the fecal-oral route without a significant animal reservoir. Individuals who are infected with *Salmonella typhi* but are in the asymptomatic phase of the infection are referred to as human carriers or typhoid Marys and have the potential to spread the infection to persons. Salmonellosis remains a zoonotic disease with enormous animal reservoirs hence contaminated animal food serves as the major mode of transmission. Although dozens of animals harbor this organism, the most common reservoirs include, chickens, turkeys, pigs, and cows. *Salmonella typhi* has the ability to survive in meats and animal products that are not properly cooked or stored under the appropriate conditions hence these products serve as the major sources of transmission of *Salmonella typhi* (Elhag, 2014). Food and water can become contaminated with *S. typhi* when handled by an individual who harbors *S. typhi* and could serve as vehicle for transmission of the bacteria (Cabral, 2010). In both forms of salmonellosis infections (typhoid fever and non-typhoidal salmonellosis), factors of epidemiologic significance including an asymptomatic human carrier state and indiscriminate use of antibiotics serve as a major risk factor for the transmission of the bacteria and increase the risk of antibiotic resistant strains of the bacteria (Arya *et al*., 2017). Approximately 3% of persons infected with *S. typhi* become chronic carriers lasting for many weeks or years. Salmonellosis therefore remains a major public health concern for many reasons not limited to the varied animal reservoirs, the existence of human and animal carrier states, and the lack of government control interventions (Hoelze et al., 2011).

2.3 Structure, Classification, and Antigenic Types of *Salmonella typhi*

Salmonella typhi is gram-negative flagellated anaerobic bacilli with three major antigens namely H or flagellar antigen, O or somatic antigen, and Vi antigen. The bacteria

undergo morphological conformation and exist in two forms called phase 1 and phase 2 in which the H antigen could occur in either phases or both (Kaur & Jain, 2012). On the other hand, the O antigen is present on the outer membranous surface defined by unique sequence of sugar moiety. The Vi antigen overly the O-antigen superficially and it is present in few serovars of the bacteria. An important characteristic of the H antigen is that, it serves as a useful epidemiologic tool that helps to ascertain the source of the infection and the mode of spread (Kaur & Jain, 2012). In no different characteristics from other Gram-negative bacilli, the cell envelope of *Salmonella typhi* is composed of a complex lipopolysaccharide (LPS) structure consisting of three components namely the O-polysaccharide coat, a middle portion (the R core), and an inner lipid A coat (Bhunia, 2018). The LPS of the bacteria functions as an endotoxin and may determine its virulence characteristics. There are many structural significances of the LPS; the repeating sugar units in the outer O-polysaccharide chains plays a vital role that determines the specificity of the O antigen and may help determine the virulence of the organism. This is evident where strains of the bacteria lacking the complete sequence of O-sugar repeat units (rough) are usually less avirulent than strains possessing the complete sequence of the O- sugar units also known as the smooth strains (Bhunia, 2018). In addition, antibodies mounted in response to the common enterobacterial antigen or the R-core, function by offering protection against infection caused by other Gram-negative bacteria that share similar R core property or may minimize their detrimental effects (Nowotny, 2013). Also, the endotoxin produced by the cell wall contributes to the pathogenesis of several of the clinical presentations associated with typhoid fever. For example, the secretion of the endotoxin has been associated with the evocation of fever, activation of serum complement system, kinin and clotting systems, depress myocardial function, and alter lymphocyte function (Levy, 2009). Circulatory endotoxin is also linked in part to

septic shocks associated with systemic typhoid fever infections (Van Amersfoort *et al*., 2003).

2.4 Pathogenesis of salmonellosis.

Particular serovars show a strong propensity to produce a particular syndrome (*S typhi*, *S paratyphi*-A, and *S. schottmuelleri* produce enteric fever; S choleraesuis produces septicemia or focal infections; *S typhimurium* and *S. enteritidis* produce gastroenteritis); however, on occasion, any serotype can produce any of the syndromes. In general, more serious infections occur in infants, in adults over the age of 50, and in subjects with debilitating illnesses. Infection with *Salmonella typhi* occurs when food and water contaminated with the bacteria is ingested through the fecal-oral rout. Occasionally, the infection may be transmitted from person-to-person. The extent of pathogenicity of the bacteria is dependent on certain virulent factors including the ability to invade cells, possession of complete lipopolysaccharide coat, intracellular replication capability, and secretion of toxin(s) detrimental to the host (Nash *et al*., 2015). Upon ingestion of contaminated food or water, the bacteria colonize the ileum and colon. This is followed by invasion into the intestinal epithelium where it undergoes binary replication leading to proliferation within the epithelium and also the lymphoid follicles (House *et al*., 2001). This mechanism of invasion of the epithelium employed by species of salmonella is a receptor mediated-interaction where there is an initial binding of the bacteria to specific receptors on the surface of the epithelial cell. The receptor-mediated interaction induces enterocyte membrane to undergo conformational changes or ruffling and stimulates pinocytosis of the organisms (House *et al*., 2001).. Invasion of the epithelium is accompanied by proliferation and dissemination of the bacteria to the mesenteric lymph nodes and throughout the body via the systemic circulation where they are further taken up by the reticuloendothelial cells. The reticuloendothelial cells function as a system that

confines and control further spread of the organism (House *et al*., 2001).. Occasional some serotypes of the bacteria surpass the reticuloendothelial system and infect other organs including, the liver, spleen, gallbladder, bones, and meninges especially when the host's immune system is compromised. However, most serovars are timely eliminated at the extraintestinal sites or are confined to the intestine in the case of gastroenteritis infections (House *et al*., 2001).

2.5 Pathophysiology of salmonellosis

When Salmonella invades the intestinal mucosa, it stimulates the epithelial cells to synthesize and secretes proinflammatory cytokines including IL-1, IL6, IL-8 and TNF to induce acute inflammatory response that could damage the intestine by causing intestinal ulceration (Gewirtz *et al*., 2000). In addition, secretion of the endotoxin inhibits protein synthesis and causes disintegration of the intestinal membranes. The inflammatory reaction induced by the bacteria causes symptoms such as fever, chills, abdominal pain, leukocytosis, and diarrhea (Baran *et al*., 2000). In some cases, polymorphonuclear leukocytes, blood, and mucus may be seen in the stool of individuals having salmonellosis. The occurrence of diarrhea is associated with the secretion of fluid and electrolytes by the small and large intestines in response to the presence of the bacteria. When salmonellosis becomes systemic, it results in enteric fever (Pawlowsk *et al*., 2009).

2.6 Clinical manifestation of typhoid fever

Generally, three clinical forms of salmonellosis are recognized; gastroenteritis, septicemia, and enteric fevers. At the septicemic stage of salmonella infection, which is also recognized as the intermediate stage, the patient does not experience any form of intestinal symptoms and the bacteria cannot be isolated from fecal specimen (Chen et al., 2013). In most cases of salmonellosis, the immune state or resistance level of the host and the virulence of the bacteria determine not only the severity of the infection, but also the

ability of the bacteria to localize in the intestine or disseminates to the blood stream (Martínez & Baquero, 2002). The incubation period for Salmonella gastroenteritis is dependent on the bacterial dose but it is usually between 6 to 48 hours after ingestion of contaminated food or water. In most cases, symptoms such as nausea, vomiting, diarrhea, and abdominal pain are recorded (Kabwama *et al*., 2015). Other common symptoms of salmonellosis include myalgia, headache, fever (38°C to 39°C) and chills. About two-thirds of patients experience abdominal cramps. Fever and diarrhea may persist for a period between 2 to 7 days (Chin, 2000). Enteric fevers present the most severe systemic form of salmonellosis and it is caused by all species of Salmonella. This is usually accompanied by gastroenteritis that resolves prior to occurrence of systemic disease. Without timely antibiotic intervention, enteric fevers are severe and could be highly fatal (Chin, 2000).

2.7 Host Defenses mechanism against *Salmonella typhi* infection

The immune system of the host plays a major role that enables it to resist intestinal colonization and invasion by Salmonella. This includes the maintenance of normal gastric pH < 3.5 which is cytolytic to salmonella (Nair, 2015). This mechanism helps to reduce the number of salmonella ingested into the body. In some cases, especially healthy individuals, this acidic pH of the gastric environment prevents the entry of pathogens into the intestine (Nair, 2015). The normal small intestinal motility facilitates the movement of ingested bacteria quickly and in so doing offer protection to the bowel. In addition, normal intestinal microflora offer further protection by secreting short-chain fatty acids that have cytotoxic effects on salmonella species. Additional protection of the intestine against salmonella is provided by secretary or mucosa antibodies that attack and destroy the bacteria through antibody-antigen interaction (Topping & Clifton, 2001). When these host defense mechanisms are compromised, an individual becomes more susceptible to

salmonellosis. A typical example is evident in AIDS patients where the infection becomes frequent and persistent even when the patient is put on extended antibiotic therapy.

2.8 Diagnosis of typhoid fever

The diagnosis of salmonellosis involves an initial isolation of the bacteria from the required clinical sample. Salmonella species are identified in the laboratory using biochemical and serological tests. Culture and sensitivity test on blood, stool or bone marrow is the gold standard for diagnosis of *S. typhi*. However, the most widely adopted test is the Widal test and the use of rapid diagnostic test kits that involves detection of antibodies against *S. typhi* antigens from human serum with visible agglutination or immunoprecipitation reaction (WHO, 2016). Fecal and blood samples or other species are cultured or plated on selective media such as blood agar, MacConkey media, eosin-methylene blue, bismuth sulfite, Salmonella-Shigella, and brilliant green agars as well as into enrichment broth such as selenite or tetrathionate for identification and confirmation of the isolates. A positive test is recorded when there is bacteria growth on selective media. This is followed by determination of biochemical reactions of isolated colonies on triple sugar iron agar and lysine-iron agar to enable a presumptive identification to be made. Confirmation of the isolate after the presumptive identification is done using polyvalent and specific antisera to analyze the O and H antigens of the bacteria (Roy *et al*., 2002).

2.9 Control of salmonellosis

Complete eradication of salmonellosis is difficult to achieve and hence remains a major problem of public health concern. One of the approaches adopted to control this infection is the treatment of animal products prior to exposure to the public (Tauxe *et al*., 2010). This is because animal products such as poultry and livestock serve as reservoirs and

harbor the bacteria. Hence, treatment of these products will significantly minimize human exposure to salmonella infections. For example, in Denmark, all animal feeds are treated to kill salmonella prior to distribution to the public. This intervention resulted in drastic reduction in the incidence of salmonellosis (Davies *et al.*, 2004). In addition, methods such as changing animal slaughtering practices help to reduce cross-contamination of meet and meet products, providing regular training in hygienic practices for all food-handling personnel, and ensuring that foods are well cooked and refrigerated under the appropriate conditions of temperature and humidity as well as expanding governmental enteric disease surveillance programs play a major role in the control of salmonellosis. Other control strategy is the use of vaccines for typhoidal salmonella infections which is very effective especially among children. However, there is no vaccine for non-typhoidal salmonellosis. Treatment of salmonellosis involves administration of intravenous or oral fluids to replace replacing fluid loss due to diarrhea or vomiting and controlling pain, nausea, and vomiting. Specific therapy consists of antibiotic administration (Manatsathit *et al*, 2002).

2.10 Treatment of Salmonella typhi infection

2.10.1Treatment of severe *Salmonella typhi*

Severe salmonellosis or typhoid fever results in self-limiting gastrointestinal bleeding but in rare cases, blood transfusion is administered to the patients to replace the excessive blood loss. In extreme cases of salmonellosis, treatment is done through surgery, intra-arterial vasopressin, or colonoscopic interventions to halt the hemorrhage (Shaikhani *et al*., 2013). Intestinal perforation caused by the bacteria can be managed by employing methods such as nasogastric suction, administration of fluids to correct hypotension, and prompt surgical intervention. Surgery has proven to be the best approach towards resolving intestinal hemorrhage with survival rate between 70 to 97% (Crump *et al*.,

2015). In contrast, approximately 30% of conservatively managed patients survive. In majority of sevre typhoid infections, closure of perforations is usually adequate but sometimes procedures that bypass damaged parts of the ileum are employed to resolve the condition. Vigorous peritoneal toilet often accompanies closure of intestinal perforations. As such metronidazole and clindamycin are recommended in a combined with ceftriaxone or fluoroquinolone-treated patients. Severe enteric fever cases could lead to altered consciousness and hemodynamic shock resulting in high fatality rate however, studies have shown that administration of high dose of dexamethasone has the potential to substantially curb the mortality rate associated with severe enteric fever. Respondents treated with chloramphenicol, dexamethasone at 3 mg/kg infused intravenously over half an hour, followed by eight doses of 1 mg/kg every 6 h, recorded a case fatality ration of 10% in comparison to 55.6% among controls (Crump *et al*., 2015). On the contrary, a nonrandomized study conducted in Papua New Guinea using lower equivalent doses of hydrocortisone failed to reproduce similar treatment outcome (Crump *et al*., 2015).

2.10.2 Treatment of Chronic Carriage

Use of extended dose of antibiotics therapy is widely adopted for the eradication of chronic carriage. This is contrary to the short duration of administration of antimicrobial therapy required for the treatment of acute infection. The susceptibility of bacterial strain is a determinant factor for the selection of antimicrobial agent for treatment but incertain cases, antimicrobial combinations such as Ampicillin or amoxicillin and probenecid, trimethoprim-sulfamethoxazole, and fluoroquinolones is adopted at a greater success rate (Crump *et al*., 2015). In instances where antimicrobial therapy fails, cholecystectomy or surgery is used at greater risk. However, combinations of surgery and administration of antimicrobials helps to improve treatment outcome among chronic carriage (Crump *et al*., 2015).

2.11 Antimicrobial management

The management of invasive *Salmonella* infections is carried out with the aim of eradicating the infection so as to resolve clinical symptoms. This is usually achieved by administering antimicrobials and supportive treatment with fluids and nutrition, as well as monitoring for the onset of possible complications. When antimicrobial therapy is effective, it helps in decreasing the rate of mortality and complications associated with severe cases of typhoid fever and also shorten the duration of the illness. In addition, effective antimicrobial treatment eradicates fecal carriage and reduces further transmission of the bacteria. In typhoid endemic localities, antimicrobial treatment is administered to patients who have experience symptom of fever for a period of 3 to 4 days (Crump *et al*., 2015). In health adults and children, use of antimicrobial agents for the treatment of nonsevere and nontyphoidal *Salmonella* diarrhea is not encouraged especially when there is sepsis or extraintestinal infection (Crump *et al*., 2015). Due to the intracellular nature of salmonella infection, effective treatment is largely dependent on the penetrability of the antimicrobials to the intracellular sites of infection (Crump *et al*., 2015).

2.11.1 Traditional First-Line Antimicrobials

Traditionally, chloramphenicol was used the first antimicrobial against typhoid fever and proved to be very effective for several years (Crump *et al*., 2015). Mostly Chloramphenicol treatment resulted in alleviation of enteric fever symptoms within 4 to 6 days, and turned possibly fatal cases into treatable ones with reduced fatality rate. However, the daily four times regimen that needs to be taken for at least 2 weeks to reduce the risk of relapse has been proven to have negative effect by making patients highly uncomfortable. (Arjya *et al*., 2011; Phongmany *et al*., 2005). High level of treatment efficacy was also recorded for Amoxicillin and trimethoprim-sulfamethoxazole

regimen with less risk of cytoxicity in comparison with Chloramphenicol (Crump *et al*., 2015). Although Chloramphenicol, amoxicillin, and trimethoprim-sulfamethoxazole were the standard antimicrobial in endemic areas for many years, The emergence of multidrug resistance (MDR) strains of *Salmonella* serovars Typhi and Paratyphi A called for the development and evaluation extended-spectrum antimicrobials including cephalosporins, fluoroquinolones, and azithromycin as alternative treatment option (Crump *et al*., 2015).

2.11.2 Fluoroquinolones

When multidrug resistant strains of salmonella emerged, class of antimicrobial called fluoroquinolones (ciprofloxacin, ofloxacin, fleroxacin and pefloxacin) was evaluated for it efficacy against enteric fever. When administered, fluoroquinolones become concentrated intracellularly at the site of the infection (Crump *et al*., 2015). Fluoroquinolones are highly bactericidal *in vitro* (481,486), and proven 100% efficacy when administered against salmonella for duration between 7 to 14 days and shows minimal chance of relapse (Nelwan *et al.*, 2006; Rizvi**,** 2007, Chandey & Multani, 2012; Effa *et al*., 2011). In this respect, fluoroquinolones give rapid clinical response including resolution of fever within 3 to 5 days. Studies conducted in Vietnam have shown that shorter course of fluoroquinolones streatment within 2 to 5 days produced similar clinical outcome for uncomplicated salmonellosis (Vinh *et al*., 2005). Fluoroquinolones were widely used for the treatment of suspected and confirmed cases of enteric fever because they were affordable and easy to administer orally. Following the emergence of Chloramphenicol resistant strains of salmonella, Ciprofloxacin, a class of fluoroquinolones for the treatment of nontyphoidal enteric fever particularly in Africa and recorded a recurrence ratio of 30% compared to Chloramphenicol recurrence ratio of 43% (Gordon *et al*., 2010; Gordon *et al.*, 2008). This observed difference was attributed to the high intracellular penetrability of fluoroquinolones as compared to

Chloramphenicol. Over time, susceptible isolates of salmonella developed resistance to fluoroquinolones especially in endemic areas (Chinh *et al*., 2000; Hassing *et al*., 2013). The cause of the resistance was point mutations in the genes that encode DNAgyrase, which happens to be the target enzyme for the drug (Hassing *et al*., 2013; Chau *et al*., 2007; Aarestrup *et al*., 2003; Parry et al., 2010; Sjölund-Karlsson *et al*., 2014; Booker *et al*., 2005). In view salmonella impaired response to ciprofloxacin and ofloxacin led to the reform by Clinical and Laboratory Standards Institute (CLSI) breakpoint guidelines, that now classifies these mutant species as ciprofloxacin-intermediate strains (Humphries *et al*., 2012). These strains are reported to be very common in Asia and have caused large outbreaks in the region. Records of such strains have been documented in sub-Saharan Africa and South America (García *et al*., 2014). Whole genome analysis of *Salmonella* serovar Typhi reported that, the haplotype H58 has the potential of becoming MDR and to exhibit reduced susceptibility to ciprofloxacin (Holt *et al*., 2008). Reports indicates that the number of *S. typhi* strains with multidrug resistant (ampicillin, trimethoprim-sulfamethoxazole (TMP-SMZ), and Chloramphenicol) has elevated over the last two decades in endemic areas. This has therefore negatively impacted on efforts toward prevention and control of *S. typhi* transmission (Feasey, *et al*., 2015). In Malawe for example, the ratio of multidrug resistance was 6.8% between 1998 and 2010. However, in 2014, the number of reported cases of typhoid fever in Nigeria for example, increased from 14 to 782 with 97% multidrug resistance isolate recorded (Yang *et al*., 2018). It is therefore a necessity for scientists to develop new and effective drugs or vaccines to eliminate the negative effects of any future typhoid fever outbreak. The use of fluoroquinolones for the treatment of strains with reduced susceptibility should be avoided when possible and an alternatives antimicrobial include extended spectrum cephalosporins (e.g., ceftriaxone) be opted instead for the treatment of nonsevere cases of

salmonellosis. In addition, azithromycin or traditional first-line antimicrobials could be used for the treatment if the isolate is susceptible. Where there is no option, the maximum dose of fluoroquinolones should be administered (20 mg/kg/day of ciprofloxacin, for at least 7 days). After the emergence of fluoroquinolones intermediate strains, later-generation of fluoroquinolone such as gatifloxacin was developed and proved to be effective against *Salmonella* infections caused by isolates that showed reduced susceptibility to ciprofloxacin. Administration of a single dose of 10 mg/kg of Gatifloxacin for a period of 7 days resulted in more than 90% cure rate and reduced duration for the clearance of fever among out patients (Joshi *et al*., 2007). DNAgyrase and topoisomerase IV are the enzyme target for Gatifloxacin. Use of fluoroquinolones has raised some level of patient safety including potential damage to weight-bearing joints and cartilage. Human studies showed that, a short course of fluoroquinolones have reversible and reduced effect on growth and joint (Adefurin *et al*., 2011). Fluoroquinolones are also reported to cause damage to tendons in patients over 60 years of age.

2.11.3 Extended-Spectrum Cephalosporins

Following the development of intermediate fluoroquinolones strains led to the formulation of antimicrobials with extended spectrum of action. These class was called the Cephalosporins which include Ceftriaxone, cefotaxime and cefoperazone. Although all these have proven to be effective, the principal cephalosporin evaluated in clinical trial for treatment of typhoid fever is Ceftriaxone (Crump *et al*., 2015). Ceftriaxone exhibit slow bactericidal property against *Salmonella* serovar Typhi *in vitro* with the ability to penetrate and kill intracellular bacteria making it generally safe to use even among children (Ekinci *et al*., 2002). Varied treatment duration for Ceftriaxone against typhoid fever have been reported to range between, 3 to 14 days with a cure rate from 70% to

90% (Crump *et al*., 2015). Treatment with Ceftriaxone results in slow rate of symptom alleviation often between 6 to 8 days 10% occurrence of relapse for treatment duration less than 7 days. Treatment of typhoid fever with Oral extended-spectrum cephalosporins such as cefixime however showed slow treatment response and records of clinical failures and disease relapse occurred (Pandit *et al*., 2007).

2.11.4 Azithromycin

Azithromycin is the antimicrobial of choice for the treatment of uncomplicated enteric fever. It is predominantly prescribed in areas with high prevalent of fluoroquinolones and MDR strains (Frenck *et al*., 2000; Parry *et al*., 2007). Azithromycin has higher potential to penetrate most tissues and possesses 10 to 100 times greater intracellular concentration in macrophages and neutrophils than serum concentrations. Azithromycin is released at a slower rate from intracellular site (Crump *et al*., 2015). and has a long half-life between 2 and 3 days. This property of Azythromycin has enabled it to be administered once-daily with no safety issues about it usage in children. Azithromycin functions as an immunomodulatory element by reversing immunoparalysis often associated with typhoid fever (House *et al*., 2002). A randomized controlled trial have reported that azithromycin has equivalent or superior to therapeutic effect in the management of uncomplicated typhoid fever than chloramphenicol, fluoroquinolones, and extended-spectrum cephalosporins. In addition, azithromycin is known to render prompt abrogation of clinical manifestations as well as decrease disease relapse and convalescent fecal carriage (Crump *et al*., 2015). Doses have varied between 10 and 20 mg/kg/day for between 5 and 7 days, and the optimum dose and duration are yet to be determined. Occasional patients in these studies have demonstrated a slow clearance of bacteremia.

2.11.5 Carbapenems and Tigecycline

Carbapenems are antimicrobials often resorted to when there is combined resistance to all first- and second-line drugs. This class of antimicrobials includes imipenem, meropenem, and ertapenem but and tigecycline is often used as an alternative to carbapenems. However these drugs are expensive making their usage economically not viable (Capoor *et al*., 2009). In many areas of South Asia, the potential to resorting to the traditional antimicrobials including chloramphenicol, ampicillin, and trimethoprim-sulfamethoxazole for the treatment typhoid fever is high since there have been reports of increasing susceptibility proportions of *Salmonella* isolates that had previously been classified as resistant.

2.11.6 Antimicrobial Combinations

Antimicrobial combination for the treatment of typhoid fever is adopted in cases whereby a patient fails to respond timely to mono therapy. Most frequently it involves a combined therapy including fluoroquinolones, cephalosporins, and azithromycin (Meltzer, *et al*., 2014). Combined therapy has advantage over monotherapy in that it has the potential to broadening the spectrum of antimicrobial activity especially when there is suspected case of drug resistant strain. It also ensures complete eradication of the bacteria and reduce the incidence of emergence and re-emergence resistant strains during the course of treatment (Mandal *et al*., 2003).

2.12 Treatment of enteric fever during pregnancy

Treatment of enteric fever during pregnancy is recommended for certain antimicrobials whiles others must be administered with caution. For example, use of ampicillin, amoxicillin, and ceftriaxone during pregnancy is reported to elicit no problem to the pregnant mother and the fetus while fluoroquinolones are recommended occasionally when dealing with pregnant patients infected with MDR *Salmonella* isolates (Crump *et*

al., 2015). There has been no evidence of fetotoxicity with azithromycin administration in animal studies and a limited controlled data in human pregnancy is available (Lin *et al*., 2013). In view of this, the U.S. Food and Drug Administration assigned azithromycin to pregnancy category B, which means that it can only be administered during pregnancy in situations when benefit outweighs risk. Azithromycin has been found in human milk after administration hence it usage by nursing mothers must be done with caution Crump *et al*., 2015).

2.13 Concept of waste management

The waste management sector is broadly defined as the waste recycling activities of waste pickers and other groups such as itinerant waste buyers (IWBs), middlemen and recycling companies involved in the recovery, processing and trading on materials recovered from waste (Wilson *et al*., 2006; Nzeadibe & Iwuoha, 2008; Wilson *et al*., 2009). The methods employed in this sector impose serious health associated risks of varying degree to the individual involved. The recovery and recycling of municipal waste is a major source of income for recognizable number of individuals living in developing countries. In low income countries, the collection and recycling of waste is largely done by the informal sector with little or no support from state owned institutions (Chidi *et al*., 2010). Many cities across the continent of Africa, Asia, and Latin America are faced with waste management challenges including insufficient waste collection and bad disposal practices. Report indicates that less than half of waste generated across Africa and Asia is collected. Improper waste disposal methods such as open dumps, deposited on vacant land and burning on backyards are widely practices (Medina & Martin, 2010). The propounding effects of these habits are the unset of environmentally related problems such as pollution and risks to human health (Medina & Martin, 2010). Though wastes are generated due to human activities, the way by which they are contained, handled,

stored, collected and disposed determines their impacts or risks to public health and the environment. In developing countries, the originating point of the environmental and health impact of waste aside ignorant is the high level of expenditure incurred in waste collection, transport and treatment. The unavailability of support fund to compensate for this huge amount of resources going into waste management compels the authorities involve to cut down expenditure on waste management to develop other sectors of the economy. This phenomenon creates a situation whereby there is ineffective waste collection and poor waste management with a concomitant negative impact on human health and environment (Loboka *et al.*, 2013). In Sub-Saharan Africa, these negative effects become more aggravated and evidenced during summer where extreme temperature speeds up bacteria reaction and bio-degradation. Collivignarelli *et al.* (2004) were of the view that, improper waste management (collection, disposal, recycling or treatment) has the potential to cause severe hazards, such as health risks and environmental pollution. Studies done by Zhu *et al*. (2008) and Sharholy *et al*. (2008) confirm that, improper waste management practices contribute to local episodes of disease, regional water resource pollution and global greenhouse gases. Boadi and Markku (2005) found a high association between food contaminated by flies and the incidence of diarrhea among children under the age of six. Diarrhea due to poor sanitation is known to cause approximately 300 deaths among outpatient cases annually (Domfeh, 2009).

2.14 Environmental impacts of waste management

The environmental impact of the waste management sector comes in varied forms depending on the intended purpose; diversion of considerable amounts of waste from disposal, the volume space saved due to recovery of materials, and the reuse and recycling of secondary raw materials (Ezeah *et al*., 2009b). Work done by Nzeadible and

Iwuoha (2008) reported that, approximately 11% of recyclable materials form a composite part of municipal solid waste in Abuja-Nigeria. Approximately 3% of this volume of waste was known to be scavenged and recycled by the informal waste management sector. Similar work done in the cities of Lagos and Enugu reported that, the amount of major materials recovered by scavengers from the waste stream in both cities was approximately 1168.94 tonnes and 41.075 tonnes respectively (Nzeadibe, 2009).

2.15 Health Impacts of Solid Waste Collection

The health impact associated with waste scavenging and recycling is a matter of public health concern since the individuals involved in this venture are not only in constant touch among themselves but also with the broader public during the course of their daily jobs **(Nguyen *et al.*, 2003).** The inevitably constant interactions between waste scavengers and the public make them a potential pathway for the transmission of various communicable and sanitation-associated diseases to the general public. The mode of operation of scavengers especially in developing countries exposes them to various occupational health and safety risks due to lack of access or ignorant of the used of a personal protective clothing or equipment and unsafe handling of waste materials (Wilson *et al.*, 2006). Cointreau (2006) reported that little study is done on health and injury incidence among workers at the waste management sector. This assertion is by no means different form current situation in Ghana and other developing countries like Nigeria as such investigations are hardly carried out these countries. It is however known that scavengers do suffer from health consequences of their occupation such as frequent fever and malaria from mosquito bites, cuts and bruises, body aches and general weakness (Nzeadibe, 2009). They also live in poor housing conditions where in most cases there is no or limited supply of quality water (Nzeadibe & Iwuoha, 2008**).** A report by da Silva *et al* (2005) indicated that majority of recyclers live in substandard housing

having little or no running water, and at times lacking electricity. In most cases the individuals involved in this activity are not ignorant of the dangers associated with their occupation but due to economic reason are tied to the occupation as a means of livelihood (Cointreau, 2006; Nguyen *et al.*, 2003). The health implications associated with the waste management sector is broadly classified into six subthemes: chemical hazards, infection, ergonomic and musculoskeletal damage, mechanical trauma, emotional wellbeing and vulnerabilities, and environmental contamination.

Salmonella typhi (*S. typhi*) is gram negative bacterium and the causative agent for typhoid fever, a systemic infection that affects humans who remains the only host. The common route of transmission occurs through ingestion of contaminated water or food contaminated with fecal matter. The incubation period is usually between 7 days to 60 days (Heymann, 2014).

Due to the direct association of typhoid fever with poor sanitation, public health interventions such as provision of safe water, maintaining good sanitation and waste disposal practices, and proper food handling are needed to prevent the spread of *S. typhi* infection (Yang *et al*., 2018). A common practice associated with developing countries is the dumping of waste within human settlement. The composition of these waste substances might contain dead animals or biological agents that tend to serve as source of food for other domestic animals or birds that feed on refused dump (Karshima, 2016). Usually the cause of dead of such dead animals cannot be ascertained which places serious public health implications including zoonotic transmission and infection (Karshima, 2016). Thus waste scavengers and children that visit the site are at high risk of acquiring zoonotic infection in areas where there is indiscriminate dumping of refuse within human settlement (Hyder *et al*., 2013). A study by Sweeney *et al.* (2011) indicated that, at least 61% of infectious diseases of humans originated from animals. The possible

risk factors include outbreak of disease such as anthrax. Lack of proper waste disposal results in poor sanitation and also creates the optimal conditions for the growth, transmission and spread of diseases such as cholera and typhoid. This implies proper disposal method should be encouraged to reduce the risk imposed on human health due to poor sanitation. Improperly disposed waste substances have adverse pathological outcome on health not only to the waste recyclers but the general population at large. The avoidable risk associated with working in the waste management sector without adequate protective equipment inadvertently exposes these individuals to array of biologically infectious agents or biological by-products from waste when they come into contact with such materials. Infections among recyclers could be caused by biological agents not limited to viruses, fungi, protozoa, and bacteria. One major threat to workers at the waste management sector is infections associated with medical waste and syringes that are improperly disposed at dumping sites without any form of segregation. Hospital waste could at dumping sites directly or indirectly serve as medium for the transmission of various infectious agents Hepatitis B virus and *Clostridium tetanus* bacteria that cause Hepatitis and muscular paralysis respectively. Research conducted in the United States confirmed case of Hepatitis-B and a potential case of HIV thought to have been contracted by recyclers through accidental needle stick (Rendleman & Feldstein, 1997). In Managua, Nicaragua, children involved in waste recycling were known to have decrease in lung function and wheezing due to a higher exposure to particulate matter suspended in the air (Romero *et al*., 2010). A similar result was recorded among individuals working in bottle return stores by Kennedy *et al.* (2004). They found that there was substantial inhalable particulate matter, including fungus and endotoxins (toxic substances released from the cell wall when Gram-negative bacteria are damaged or destroyed). A study in Durango City, Mexico, identified antibodies of *Toxoplasma*

gondii, in serum of blood taken from recycler operating in the city (Alvarado-Esquivel *et al*., 2008). The waste recycling sector is also characterized by diseases such as typhoid fever, tuberculosis, dysentery, poliomyelitis, malaria, and various skin disorders (Medina, 2000). This condition is attributed to increased level of economic hardship and propels waste recyclers toward the consumption of unwholesome recovered food (Furedy, 1992). Consumption of these unwholesome food products cause food poisoning which may result in diarrhoea, parasite infection, and nausea. This is due to the fact that, most of these food products might be contaminated with human and animal excreta containing pathogenic microorganisms with the potential to cause many diseases (Nguyen, 2003; Sarkar, 2003). A study conducted to determine the incidence of acute diarrhoea among waste recyclers reported that, individuals in this sector were 10 times at risk of acquiring acute diarrhoea than the general public (Cointreau, 2006). In addition, examination of stool samples obtained from children in Manila indicated that 98% had parasites, either *Trichuris trichiura*, *Ascaris lumbricoides*, or both (Cointreau, 2006). A study conducted by Yang *et al* (2018) showed that, attitude such as lack of regular hand washing and poor knowledge about prevention as well as consumption of contaminated food served as the major risk factors for typhoid fever in Mahama camp. A study conducted by Laor *et al.* (2017) to assess the level of knowledge, attitude and practice on municipal waste management revealed that, higher number of respondent (73.4%) were knowledgeable of waste management, while 23.7% and 2.9% of respondent had moderate and low levels of knowledge on waste management respectively. Although respondent showed high level of knowledge on waste management, they however recorded the least positive attitude towards practices of proper waste management. Majority of the respondents generally had moderate practices level towards waste management. With reference to respondent's attitude towards municipal waste management, 2.9% positive levels, showed 85.1%

neutral level and 12.0 % negative levels were obtained respectively. In term of practices of proper municipal waste management, result obtained showed that, 23.3% of respondents practiced good waste management while 59.0% and 17.7% had moderate and poor waste management practices respectively. Laor *et a*l (2017) observed that there was statistically significant relationship between practice of respondent and socio-demographic characteristics of the respondent. In addition, Laor *et al* (2017) revealed strong positive association between knowledge and practice of municipal waste management as well as attitude and practice. The results obtained by Laor *et al* (2017) therefore indicate that knowledge and attitude have substantial effect on municipal waste management. This indicates that, respective governments should intensify public education to promote knowledge and also enforce the bylaws governing waste disposal and management. The focus of this work is to determine the prevalence of salmonella typhi and assess the level of knowledge and attitude of waste collectors in the Ablekuma North Municipality that serve as risk factors for the transmission of typhoid fever disease**.** In Ghana, studies on sanitation have been limited to environmental impact of solid waste with scanty or no data on the prevalence of infectious diseases such as Salmonella typhi among waste collectors in the country. A study conducted in Sawaba, Asokore Mampong Municipal Assembly by Suleman *et al*. (2015) to assess the health implication of solid waste on community residence revealed that, residents living closer to open dump sites have been infected with sanitary related diseases such as malaria,, typhoid fever, skin infections among others due to poor waste disposal practices. Suleman *et al*. (2015) further indicated that, the root cause of this problem is due to inadequate sanitary facilities to meet the demands of the people, poor network, in accessibility of some settlement areas, high volume of tones of waste generated due to urbanization and inadequate collection equipment. The aforementioned limitations create an enabling

environment for breading of disease vectors including mosquitoes, flies, cockroaches and mice. Suleman *et al*. (2015) in their quest to assess the awareness of residence on the effect of poor waste disposal and diseases contraction showed that, almost all the respondents in Sawaba community were aware of the health implications of improper refuse disposal. However, Suleman *et al*. (2015) found that 8 of the respondents had had episode of cholera, 105 complained of malaria, whiles 15 and 20 of the respondents indicated they have had typhoid fever and skin infections respectively. However, study has reported on the actual prevalence rate of infectious diseases among waste collectors in Ghana. This study is therefore focused on determining the prevalence of Salmonella typhi among waste collectors to help bridge the knowledge in literature.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Methods and procedures that were used to collected information and data from respondent are highlighted in this chapter. It takes into account information on the geographical location of the study area and the target population. Pre-tested questionnaire was used to collect data on socio-demography, knowledge of respondent on salmonella typhi infection and personal hygiene practices among municipal waste pickers in the Ablekuma North Municipal Assembly.

3.2 Study Area

The Ablekuma North Municipal Assembly within the Greater Accra Region of Ghana is selected for this study. This Assembly lies within the Latitudes 05º 38´ North and Longitude 00º 60´ West and has total land coverage of approximately 13.28 km^2. According to the 2018 census, this assembly is reported to have an estimated population size of 187,000. It shares boundaries with Ga Central Municipal Assembly to the North, Ablekuma West to the South, Okaikoi North to the East and Weija Gbawe to the West. The Ablekuma North Municipal Assembly is made up of seven electoral areas, namely Odorkor, Darkuman West, Darkuman East, Awoshie, Otaten Kwashieman and Sakaman.

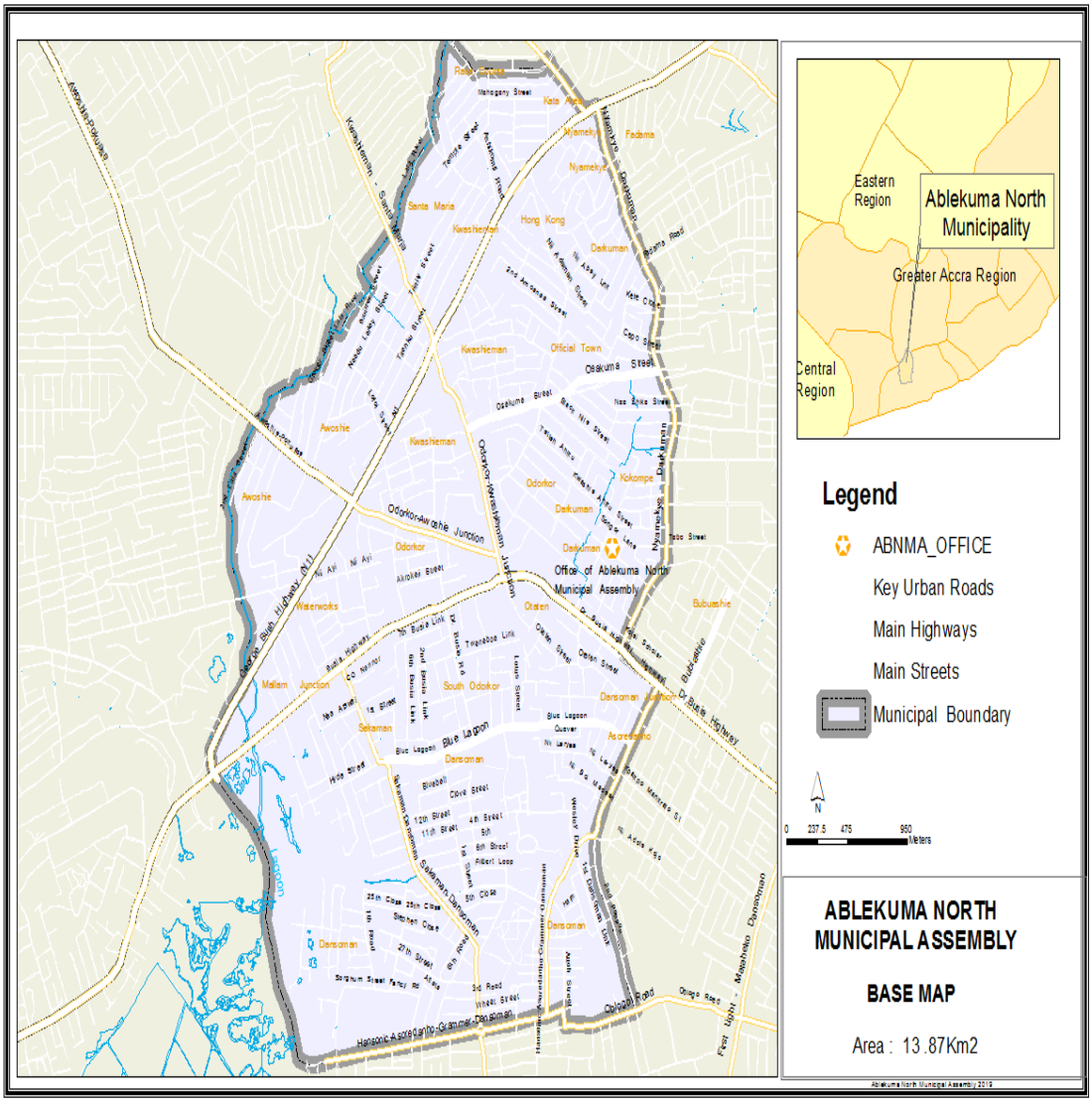

Figure 1: Base Map of Ablekuma North Municipality. Source: ABNMA MPCU

3.3 Study design

This study was conducted using the experimental and cross-sectional approaches involving administration of pre-tested questionnaires for the collection of quantitative and qualitative data as well as laboratory analysis of blood samples from study participant. Individuals involved in waste management within the Ablekuma North Municipality were chosen as study participants. Prior to the commencement of the project, ethical consideration and approval were obtained from the Ghana Health Service and the Public Health Division of Ablekuma North Municipal Assembly respectively. Following ethical clearance, informed concerns were obtained from all study participants before enrolling

them onto the research. All participants were spoken to in the language of best understanding before questionnaires were administered and blood sample taken and tested for salmonella typhi.

3.4 Target Population

Those eligible to participate in the study were waste collectors within the Ablekuma North Municipality. The length of working on solid waste collection system in the municipality was considered and therefore all those who have worked for about a year in the sector qualified to be considered for the study.

3.5 Sample size and Sampling Method

According to the 2018 census, the Ablekuma North Municipality has an approximated population size of 187000 with at least 60 recognized waste collectors in based on data obtained from the office of the Municipal Assembly. There is no record epidemiological record of salmonella typhi in the selected municipality. Sixty (60) waste collectors in the Ablekuma North Municipality were selected for the study using the stratified Sampling technique, and prevalence rate of 4% which was indicated by Nyamusore *et al*. (2018) was used to calculate the sample size.

Sample size = $Z^2 \times (p) \times (1-p)/C^2$

Z = Z-value = 1.96

P = prevalence =0.04

C = confident interval= 0.05

Sample size = $(1.96)^2$ x (0.04) x (1-0.04)/$(0.05)^2$

=59

=~60

3.6 Data Collection Instruments

A well-structured, closed ended pre-tested questionnaire was used to solicit information from the respondents. The questionnaire was sectioned to collect data on socio-demography, knowledge on typhoid fever infection and personal hygiene. The prevalence of the diseases among them was assessed by conducting *Salmonella typhi* blood screening test using the Widal method.

3.7 Data Collection Method

Questionnaire was administered to each participant to collect quantitative data through researcher assisted method. Following administration of questionnaires, venous whole blood sample was collected from each participant and Widal test was used to screen the samples for the presence of antibodies to *Salmonella typhi* surface antigens ('O' and 'H'). Briefly 4µl of whole blood was drawn from each respondent and transferred into gel separation tube and allowed to stand vertically at room temperature for 5minutes. The tubes containing the blood samples were centrifuge at 3000rpm for 10 minutes to separate the cellular component of the blood from the serum. Micropipette was used to transfer 20 µl of the serum onto a clean racking tile and a drop of the *Salmonella typhi* antisera reagent was added and mixed thoroughly using a clean glass rode. The mixture was then swirled on the surface of the tile and observed for the formation of immunoprecipitation or agglutination reaction. Result was read over a period of one minute and graded based on the Widal Test Grading Principle. Blood samples taken from fifty individuals not involved in waste management activities were used as control.

3.8 Data analysis

Data obtained was analyzed using the Statistical Package for Social Sciences (SPSS) software (version 16). Results were presented in graphical and tabular form. Descriptive data were presented in frequency tables and percentages. A total of 60 waste collectors

in the Ablekuma North Municipality who consented to partake in the research where recruited for the study. Questionnaires covering socio-demographic information, knowledge on *Salmonella typhi* infection and personal hygiene was administered to participants. Participants were screened for typhoid using the Widal Antisera reagent.

CHAPTER FOUR

PRESENTATION OF RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter deals with the outcome of the information gathered from the administration of the questionnaires addressing issues on socio-demography, knowledge of respondent on typhoid infection and personal hygiene. It also describes prevalence and knowledge of waste pickers in the Ablekuma North Municipality in the Greater Accra Region of Ghana on *Salmonella typhi* infection. It addresses personal hygiene practices and risk factors associated with waste pickers in the said municipality.

4.2 RESULTS

4.2.1 Socio-demographic data of respondents

The social-demographic characteristics of respondents were determined and their relationship with typhoid fever was assessed.

Table 1: Socio-demographic Characteristics of respondents

	Frequency(n)	Percent / %
Sex		
Female	35	58.3
Male	25	41.7
Total	60	100.0
Religion		
Christianity	50	83.3
Islam	10	16.7
Total	60	100.0
Ethnicity		
Akan	28	46.7
Ga-Adangbe	20	33.3
Mole-Dabgon	7	11.7
Ewe	4	6.7
Others	1	1.7
Total	60	100.0

Source: Field Survey, 2019

Thirty five (35) of the respondent representing 58.3% were females while 25(41.7%) where males. Fifty of the respondents where Christians by religion and accounted for

83.3% of respondents. A small proportion of respondents belonged to the Islamic religion and formed 16.7% of all respondents. In terms of ethnicity, Akans accounted for 46.7% of respondents while the Ga-Adangbe, Mole-Dagbon and Ewes formed 33.3%, 11.7% and 6.7% respectively. Cumulatively, other ethnic groups constituted 1.7% of respondents (**Table 1**).

4.2.2 Risk factors of typhoid fever infection among waste collectors

Data obtained indicate that, majority of the participants involved in waste management were between the ages of 51-60 accounting for 48 %. A total of 18.3 %, 31.7 %, and 1.7 %were recorded for the age groups between 30-40, 41-50 and 61-70 respectively. Females accounted for majority (58.3%) of the respondents and the rest (41.7%) were males as depicted by Table 2.

Table 2: Distribution of age group and *S. typhi* infection among respondent

Age Groups/years	Female	Male	Total	*S. typhi* positive cases
30-40	4 (6.7%)	7 (11.7%)	11 (18.3%)	5
41-50	12(20.0%)	7 (11.7%)	19 (31.7%)	3
51-60	19(31.7%)	10 16.7%)	29 (48.3%)	10
61-70	0 (0.0%)	1 (1.7%)	1 (1.7%)	1
Total	35(58.3%)	25(41.7)	60(100%)	19

Source: Field Survey, 2019

Table 3: Marital status and sex of respondent

Marital status	Females	Males	Total
Single	2 (3.3%)	9 (15.0%)	11(18.3%)
Married	17 (28.3%)	11 (18.3%)	28 (46.7%)
Divorced	8 (13.3%)	5 (8.3%)	13 (21.7%)
Widow/Widower	8 (13.3%)		8 (13.3%)

Total	**35 (58.3%)**	**25 (41.7%)**	**60 (100%)**

Source: Field Survey, 2019

A total of 9 (15.0%) males and 2(3.3%) females who were single participated in the study while 28 (46.7%) were married individuals. In addition, 13 (21.7%) as well as 8 (13.3%) were divorced and widowed, respectively, as shown on Table 3**.** This indicates that more married women are into waste collection than their counterparts in other forms of relationships. This could be attributed to the extra burden placed on couples in attempt to meet family demands and needs.

Table 4: Association between age and risk of typhoid infection *(p=0.4)*

Age range	**Rate of risk**				**Total**
	No idea	**Very high**	**High**	**Medium**	
30-40	8 (72.7%)	2 (18.2%)	1(9.1%)	0 (0.0%)	11(100.0%)
41-50	9 (47.4%)	5 (26.3%)	3(15.8%)	2 (10.5%)	19 (100.0%)
51-60	9 (31.0%)	13(44.8%)	7(24.1%)	0 (0.0%)	29 (100.0%)
61-70	0 (0.0%)	1(100.0%)	0(0.0%)	0 (0.0%)	1 (100.0%)
Total	**26 (43.3%)**	**21(35.0%)**	**11(18.3%)**	**2 (3.3%)**	**60 (100.0%)**

Source: Field Survey, 2019

Association between age and risk of typhoid fever infection was assessed and the result obtained is presented in Table 4. It is clear that most (43.3%) of the respondents have no idea of possible risk of infection with salmonella *typhi* bacteria from the work they do while a few (3.3%) of them indicated they have medium risk of infection. Even though 32(48.3%) were of the view that their risk of infection could high or very high, those who had no idea represent a significant number who could be susceptible to the infection.

Table 5: Association between sex and risk of typhoid fever infection (p= 0.064)

Sex	**Rate of risk**				**Total**
	No idea	**Very high**	**High**	**Medium**	
Females	12(34.3%)	16(45.7%)	7(20.0%)	0 (0.00%)	35 (100.0%)

Males	14(56.0%)	5 (20.0%)	4 (16.0%)	2 (8.0%)	25 (100.0%)
Total	**26 (43.3)**	**21(35.0%)**	**11(18.3%)**	**2(3.3%)**	**60 (100%)**

Sources: field survey, 2019

Comparatively, more females (45.7%) indicated that the chance of getting typhoid fever infection due to their occupation is very high while majority of men (56%) had no idea or were not aware of the risk of getting typhoid fever in line of their occupation (**Table 5)**. However, no significant association was found between sex and risk of typhoid infection.

With respect to relationship status, majority of respondents in the married group indicated that they were highly at risk of acquiring typhoid fever infection. However, in general, no significant association was found between relationship status and risk of typhoid infection at p=0.908 **(Table 6).** Eleven (11) of the respondents where single out of which 6(54.5%) had no idea of the risk associated with their occupation while 3(27.3%), and 2(18.2%) rated the risk associated with their occupation as Very high and high respectively. Twenty eight(28) of the respondents were married out of which 10(35.7%) had no idea of the risk associated with their occupation while 11(39.3%), 5(17.9%) and 2(7.1%) of respondents in the married group rated risk associated with their occupation as very high, high, and medium respectively. A total of 13 respondents were divorced out of which 7(53.8%) had no idea about the risk associated with their occupation while 4(30.8%) and 2(15.4%) of respondents rated the risk associated with their occupation as very high and high respectively. Eight of the respondents were either Widow/Widower among which 3(37.5%) had no idea about the risk associated with their occupation while 3(37.5%) and 2(25.0%) of respondents rated the risk associated with their occupation as very high and high respectively. Thus, a total of 26(43.3%) of respondents had no idea about the risk associated with their occupation while a total of 21(35.0%), 11(18.3%) and

2(3.3%) of respondents rated risk associated with their occupation as very high, high, and medium respectively(Table 6).

Table 6: Relationship status of respondents and risk of typhoid fever: Crosstabulation

		Rate of risk				Total
		No idea	Very high	High	Medium	
Relationship status	Single	6 (54.5%)	3 (27.3%)	2 (18.2%)	0 (0.0%)	11 (100.0%)
	Married	10 (35.7%)	11 (39.3%)	5 (17.9%)	2 (7.1%)	28 (100.0%)
	Divorced	7 (53.8%)	4 (30.8%)	2 (15.4%)	0 (0.0%)	13 (100.0%)
	Widow/Widower	3 (37.5%)	3 (37.5%)	2 (25.0%)	0 (0.0%)	8 (100.0%)
Total		26 (43.3%)	21 (35.0%)	11 (18.3%)	2 (3.3%)	60 (100.0%)

Source: Field survey, 2019

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Table7: Association between monthly income and risk of getting typhoid fever p=0.007: Crosstabulation

		Rate of risk				Total
		No idea	Very high	High	Medium	
Monthly income(Gh¢)	190 Gh¢	9 (75.0%)	2 (16.7%)	1(8.3%)	0 (0.0%)	12 (100.0%)
	192 Gh¢	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
	200 Gh¢	9 (33.3%)	13 (48.1%)	5 (18.5%)	0 (0.0%)	27(100.0%)
	230 Gh¢	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1(100.0%)
	250 Gh¢	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1(100.0%)
	266 Gh¢	0 (0.0%)	0 (0.0%)	0 (0.0%)	1(100.0%)	1(100.0%)
	270 Gh¢	0 (0.0%)	1(100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)

299 **Gh¢**	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1(100.0%)
300 **Gh¢**	1(11.1%)	4 (44.4%)	3 (33.3%)	1 (11.1%)	9 (100.0%)
350 **Gh¢**	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
400 **Gh¢**	2 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
550 **Gh¢**	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
680 **Gh¢**	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
900 **Gh¢**	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
Total	26 (43.3%)	21 (35.0%)	11 (18.3%)	2 (3.3%)	60 (100.0%)

Source: Field survey, 2019

The relationship between monthly incomes was also assessed as a possible risk factor for the acquisition of typhoid fever infection and the data obtained is presented on **Table 7.**

Table 8: Health insurance status of respondents

Have Health Insurance	**Females**	**Males**	**Total/%**
Yes	33 (55.0%)	14 (23.3%)	47 (78.3%)
No	2 (3.3%)	11(18.3%)	13 (21.7%
Total	**35 (58.3%)**	**25 (41.7%)**	**60 (100%)**

Source: Field survey, 2019

Considering the waste collection work, it is very important for these workers to have active national health insurance cards that they can use to access services whenever they experience any ailment. With reference to health insurance status, majority (78.3%) of the participants had access to health insurance while the rest (21.7%) had no health insurance cover. Females accounted for the most participants with health insurance cover (55.0%) as against about one-fourth (23.3%) of male counterparts as indicated by Table

8. This suggests that the women are more conscious of their health and so are in most cases prepared to take measure to safeguard themselves than men

Table 9: **Association between Number of working years and risk of *S. typhi* infection**

Number of working years	**Number of *S. typhi* reactive cases/%**
< 1 year	1(5.26)
1-10 years	4 (21.05)
>10 years	14 (73.6%)

Source: Field survey, 2019

The number of respondents who work with the government waste management company operating in the Ablekuma North Municipality accounted for 45% while 55% of respondent work for private owned waste management companies.

Majority of the respondent (45%) had over 10 years working experience. Out of the 60 respondents screened, 19 of them reacted to S. typhi surface antigen. Majority (73.6%) of those who reacted positive to *S. typhi* surface antigen had had over 10years working experience in the waste management sector. About 21% of *S. typhi* reactive respondent have worked for 1 to 10 years while 5.26% of respondents had less than a year working experience (Table 9).

4.2.3 Knowledge of respondents about typhoid fever

Knowledge of respondents on typhoid fever and its causes was assessed and the data obtained is presented in **Table 10.** Majority (40/66.7%) of the respondents indicated they have knowledge about typhoid fever and how it is acquired. Respondents cited the following platforms as sources of knowledge and information: family and friends (38.3%), radio/television and newspapers (23.3), others (5.0%) (Table 10).

Table 10: Knowledge and sources of information about typhoid fever

Information about typhoid	Source of information				Total
	No idea	Friend/ Family	Radio/TV/ News paper	Other	
Yes	0 (0.0%)	23 (**57.5%**)	14 (**35.0%**)	3 (**7.5%**)	40 (100.0)
No	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0)
Total	20 (33.3%)	23 (38.3%)	14 (23.3%)	3 (5.0%)	60 (100.0%)

Source: Field Survey, 2019

Table 11: Knowledge of respondents on signs and symptoms of typhoid fever

Have typhoid and not show signs and symptoms?	Frequency	Percent
Yes	8	13.3
No	37	61.7
No idea	15	25.0
Total	**60**	**100.0**

Source: Field Survey, 2019

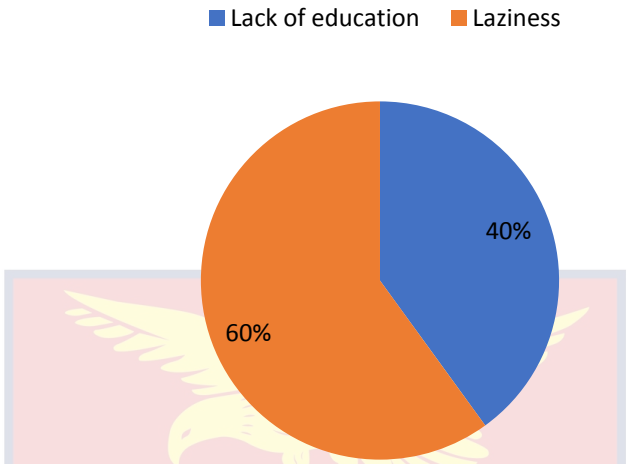
About 20/33.3% had no knowledge on typhoid fever. With respect to symptoms of the infection, 13.3% of respondent indicated that, it is possible for one to have typhoid and not show symptoms while 61.7% indicated that, it is not possible to get typhoid infection without showing symptoms. Also, 25% of the respondents had no knowledge about the signs and symptoms of typhoid (**Table 11**).

4.2.4 Knowledge and attitude of respondents towards personal hygiene

Respondents' behavioral characteristics and knowledge of personal hygiene were assessed with the aim of determining if they serve as risk factors for typhoid fever disease**.** Thirty four waste collectors representing 60% of respondents indicated that, laziness serves as a barrier to good personal hygiene while 24(40%) of respondents cited lack of education as barrier to good personal hygiene**(Figure 2).** Neither lack of water

supply, religious believes, nor was lack of time cited as a barrier to poor personal hygiene.

Figure 2: Participants' response to cause of poor personal hygiene



Source: field survey, 2019

Table 12: Participants' rating of the risk of getting typhoid infection

Rate of risk of getting typhoid infection	Frequency	Percent
No idea	26	43.3
Very high	21	35.0
High	11	18.3
Medium	2	3.3
Total	60	100.0

Source: Field Survey, 2-019

With respect to the rate of risk of typhoid infection, majority (43.3%) of respondents showed lack of awareness of the risk associated with their occupation while 35% and 18.3% indicated very high and high level of risk in association with their occupation **(Table 12).**

4.2.5 Respondents attitude and personal hygiene practices

Respondents were assessed on personal hygiene practices due to the association of typhoid fever with poor sanitation and it was found that majority (96.7%) of the respondents indicated that, they wash their hands before eating (see Table 13).

Table 13: Attitude of respondent toward personal hygiene

Personal Hygiene Parameters	Frequency(n)	Percent /%
Wash hands before taking meal		
Yes	58	96.7
Sometimes	2	3.3
Always use soap for hand washing		
Yes	51	85.0
Sometimes	9	15.0
Wash hands upon return from work		
Yes	60	100
Wash hands after handling waste		
Yes	60	100
How often do you trim finger nails		
Regular	54	90.0
Sometimes	5	8.3
None/No	1	1.7
What is the frequency of trimming finger nails		
Once a week	1	1.7
Once a month	6	10.0
When the nails grow long	5	8.3
Do you bite your finger nails		
Yes	8	13.3
Sometimes	8	13.3
No	44	73.3
Do you have work cloth separately		
Yes	46	76.7
No	14	23.3
Do you wear washed working coat/attire daily		
Yes	39	65.0
Sometimes	15	25.0
No	6	10.0

Source: Field Survey, 2019

A few (3.3%) of the respondents indicated that they sometimes do not wash their hands before eating. Among those who always wash hands before eating, 85% of them do so with soap, whiles 15% of them sometimes do not use soap during hand washing before meal. However, all (100%) respondents indicated that they do wash their hands after handling waste and after return from work.

Data accumulated shows that, most participants (90%) trim their finger nails on regular bases, whiles others (8.3%) indicated they do so sometimes but not on regular bases. Strangely, 1.7% of participants indicated they rarely trim their finger nails. Those who trim their nails do so as and when it grown long and this represented 80% of the respondents. Others trim their nails once a month or once a week representing 10% and 1.7% respectively. Some participants (13.3%) also indicated finger biting practice as a way of trimming their finger nails. Majority (60%) of respondents also indicated that, laziness is a risk factor towards poor personal hygiene and could contribute to increased risk of typhoid infection (Figure 2). In assessing the respondent adherence to personal protective equipment, majority (76.7%) of them indicated they have separate working cloth and shoes. On the contrary, 23.3% of respondents indicated they do not have working cloth and shoes to carry out their work.

Table 14: **Participants awareness of the types of personal protective equipment (PPEs)**

Type of PPE	Frequency	Percent
Gloves	40	66.7 %
Goggles	1	1.7%
Nose Mask	1	1.7%
Overall working coat	5	8.3%
All PPEs present	13	21.7%
Total	60	100%

Source: Field Survey, 2019

In addition, the knowledge and use of other personal protective equipment was assessed and the result obtained presented in **Table 14**. About 40(66.7%) of respondents had

knowledge about the use of gloves for personal protection against infections. The number of respondents who had Knowledge about other Personal Protective Equipments including goggles, nose mask and overall working coast were 1(1.7%), 1(1.7%) and 5(8.3%) respectively. About 13(21.7%) of respondents had knowledge about all the personal protective equipment **(Table 14).**

Table 15: Participants awareness of the risk of getting typhoid infection (AbNM)

At risk of typhoid infection	Frequency	Percent
No idea	15	25.0%
Yes	34	56.7%
No	11	%18.3
Total	60	100%

Source: Field Survey, 2019

Respondent where further assessed if they are at risk of getting typhoid infection due to their occupation and the results obtained is presented on **Table 15**. Fifteen (15) respondents representing 25.0% indicated that they had no idea of any risk factor associated with their occupation while 34(56.7%) said they are aware of the risk involved in their occupation. Eleven (18.3%) of respondents indicated that they are not at any risk at all with respect to their occupation (**Table 15).**

Table 16: **Respondent's opinion on factors that serve as barrier against good personal hygiene practice**

Factors	Frequency	Percent %
Lack of education	24	40.0%
Laziness	36	60.0%
Lack of time	0	0.0%
Inadequate water supply	0	0.0%
Total	60	100%

Source: Field Survey, 2019

On the account of perception or opinion on the barriers against maintenance of good personal hygiene, 60% of respondent cited laziness as the major cause of poor personal hygiene while 40% indicated lack of education as the cause of poor personal hygiene (**Table 16)**.

Table 17: Determination of prevalence of *S.typhi* among waste pickers in the AbNM

Total Respondents	**Females**	**Males**	***S.typhi* positive male**	***S. typhi* positive female**	**Total S.typhi positive cases**	**Total prevalence of S.typhi /%**
60	35	25	7	12	19	31.7%

Source: Field Survey, 2019

A total of 60 participants involved in waste management or waste picking in the **AbNM** were recruited for the study. Out of the 60 participants, 19 of them tested positive to *Salmonella typhi*. Thus, prevalence of typhoid fever among waste pickers in **AbNM** was 31.7%. Out of the 60 participants, 25 were males and 35 were females. Among the 19 positive *S. typhi* recorded cases, 12 were females and 7 were males representing 63.2% and 36.8% respectively. Laboratory data obtained is presented in Table 17.

4.3 DISCUSSION

From the socio-demographic data of respondents, the ages of respondent were between 35 and 62 but the majority of them fell between the range of 41-50 and 51-60 as depicted on **Table 2.** The mean age of participant within the range of 30-60 was found to be 49. This data supports the report by Kibiru (2016) that indicated that incidence of typhoid fever was high (73.1%) among the age groups between 38-47 in Maina Slum in Nyahururu Municipality, Kenya. Our data indicate the incidence of typhoid fever was common among the age groups between 41- 60. This according to Kibiru (2016) could be due to low immunity associated with aging. This result suggests that age could be a predisposing factor of typhoid fever among waste pickers in **AbNM**. In addition, majority of respondents within the age group 51-60 were highly at risk of typhoid infection as depicted on **Table 2**. In general, there was however no significant difference between age group and risk of typhoid infection. The findings of this work further indicate that, married people were more at risk of typhoid infection in comparison with individuals of different relationship status as depicted on **Table 3**. This could be due to work load that is imposed on married people especially women who according to Shah *et al* (2012) are care-givers in African societies and are known to be at increased risk of infection from infectious diseases.

In terms of ethnicity, majority of the respondents were Akans (46.7%) while Gas constituted 33.3%. Mole-dagbon and Ewes formed 11.7% and 6.7% respectively. Other ethnic groups together formed 1.7% of respondents. Although Accra is a heterogeneous society, it is predominantly occupied by Akans and Gas due o the migration of people from Akan speaking communities into the capital city due to close proximity. With respect to the number of working years, 14 out of 19 individuals who had typhoid infection had work for over 10 years **(Table 9).** This could be due to increased exposure

to infectious waste materials in time course of duty. Thus, duration of work in the waste management sector could serve as risk factor towards acquisition of typhoid fever. In addition, more cases of typhoid fever infection were recorded among females (12 cases) than males (7 cases). This confirms the finding of Nyamusore *et al.* (2018) where 53.4% of cases of typhoid fever were recorded among females as against 46.6% male. Findings of this **study** suggest that majority of females knew that they were at high risk of acquiring typhoid infection than their male counterparts. However, there was no observed significant association between sex and risk of typhoid fever infection **(Table 5).** This could be due to the fact that females are more involved in house chores such as cleaning as compared to males and might have increased their exposure and risk of getting typhoid infection. According to Uttah *et al* (2013) and Neil *et al* (2012) females are more at risk of typhoid infection as compared to males which is consistent with the findings of this study.

In this study, most respondent earned less than GhC300.00 per month with some receiving as low as GhC190.00 per month. Majority of the respondents earning less than GhC300.00 were found to be at risk of typhoid infection as depicted by **Table 7.** Thus, majority of the respondents are earning far below the stipulated minimum wage (GhC10.65/day) by the Government of Ghana as of the time the data was taken. This could create high level poverty among the waste pickers in the **AbNM**. A review by Gutberlet *et el* (2012) reported that many recyclers are poor and live under precarious housing conditions, often without reliable water or sewage access. A similar finding by Da Sylver *et al.* (2004) revealed that majority of recyclers lived in substandard housing, having little or no running water and at times were lacking electricity. These factors have high propensity to predispose individuals to infectious diseases and could have accounted

for the high prevalence of typhoid infection recorded among the waste collectors in this study.

In this study, the prevalence of *Salmonella typhi* infection among waste collectors in the **AbNM** obtained was 31.7 % (**Table 17**). This data is consistent with the data obtained by Kabwama *et al* (2017) on prevalence of *Salmonella typhi* infection among individuals who consumed contaminated food and water in Kampala, Uganda where a total prevalence of 29% was recorded. This further emphasizes the strong association that has been established between poor environmental sanitation and *Salmonella typhi* infection as a result of poor waste management. Similar work done by Deksissa & Gebremedhin (2019) reported a high *Salmonella typhi* prevalence of 52.6% using Widal test on 372 patients at Ambo hospital. A total of 50 individuals who are not involved in waste collection were used as control and were tested for the present of *Salmonella typhi*. Three (3) individuals among the non-waste collectors tested positive given a prevalence of 6.0%. Thus, the prevalence of typhoid fever among non-waste collectors was far below the obtained prevalence among the municipal waste collectors. The high prevalence recorded among waste collectors as against low prevalence among non-waste collectors could be due to the high rate of exposure of waste collectors to contaminated or infectious waste materials in time course of duty. Data accumulated in this work indicates that, about 3.3% of respondent sometimes do not wash their hands before meals whiles 15% of respondent indicated that sometimes they wash their hands without using soap (**Table 13**). Lack of consistency in the use of soap for hand washing prior to meal could be a contributing risk factor towards the high prevalence of *S. typhi* infection recorded among waste collectors in the **AbNM**. This finding is parallel to the report by Nyamusore *et al* (2018) that indicated that respondents who did wash hands sometimes after using the latrine were twice as likely to develop typhoid fever compared with those who do it

regularly. This is because *S. typhi* infection is associated with ingestion of contaminated food or water. This finding supports the findings of Nyamusore *et al* (2018) who reported that inconsistent hand washing after visiting the latrine was a major risk factor associated with the outbreak of *Salmonella typhi* infection that occur in the Burundi refugee camp. About 66.7% of respondent in this study had access to the used of gloves to carry out their duty. Thus, about 33.3% of respondent had no access to gloves which could increase the chance of exposure to infectious or biological agents associated with poor waste management or poor sanitation (**Table 14**). This finding suggests that, absence of gloves and other Personal Protective Equipment could increase the risk of acquiring typhoid fever among waste collectors in the said municipality.

On knowledge of respondents about *Salmonella typhi* infection (typhoid fever), majority of the respondent (66.67%) are aware of and had knowledge on how typhoid fever is caused as well as the signs and symptoms it presents during the infection. About one–third (33.3%) had no knowledge about the cause and mode of transmission of typhoid fever as well as its signs and symptoms. The respondent cited family and friends (38.3%), radio/television and newspapers (23.3), others (5.0%) as sources of acquisition of knowledge about typhoid infection (**Table 10**). Almost a third part (33.3%) of the respondents had no knowledge about the source of information on typhoid fever. Comparatively, a proportion of respondent might have heard and become aware of typhoid fever from their family and friends due to the extended family system that is widely practiced in Ghana and the close proximity and contact between friends and family members that might have had previous experience or might have contracted the typhoid infection. The high level of prevalence of typhoid fever recorded in this study is consistent with data recorded on lack of knowledge of respondent about typhoid infection (Issa *et al*., 2015). Thus, the data suggest a position between lack of knowledge and

acquisition of typhoid infection. This is because; the 33.3% of respondent who had no knowledge on typhoid fever could have served as a risk factor that resulted in the high prevalence of 31.63% recorded among the waste pickers. The association of increased risk with poor awareness of typhoid fever is not surprising, as lack of awareness is reported elsewhere to be associated with poor compliance with typhoid prevention and control practices (Issa *et al*., 2015). With respect to symptoms of typhoid infection, 13.3% of participant indicated that is possible for one to have typhoid and not show symptoms, while 61.7% indicated that it is not possible to get typhoid infection without showing symptoms. This data is consistent with data accumulated for participants responds to knowledge of typhoid fever where about 66.67% of participants had knowledge on typhoid fever. Thus, individuals who had knowledge about typhoid fever also knew that the infection present with signs and symptoms. A few respondents (25%) had no knowledge about the signs and symptoms of typhoid. These results indicate that lack of education could serve as a risk factor for the acquisition of typhoid fever. This finding is consistent with report by Nyamusore *et al*. (2018) that indicated poor awareness of typhoid fever as risk factor for typhoid infection.

With respect to attitudes of respondents towards personal hygiene, they demonstrated high level of good attitude towards maintenance of good personal hygiene. About 96.7% of respondent indicated that, they wash their hands before meal on regular basis, whiles 3.3% sparingly wash their hands sometimes before taking meal. Most respondents (85%) indicated that, they wash hands with soup all the time while 15% applied soap during hand washing on irregular bases or sometimes. The inconsistent habit of hand washing with soap exhibited by some respondents could expose and increase the risk of being infected with typhoid fever. This finding is also consistent with the report by Nyamusore *et al* (2018) that revealed inconsistency in hand washing after visiting the latrine and

ingestion of contaminated foods as risk factor for the transmission of typhoid fever disease. Birhanie *et al* (2014) reported significant association between hand washing habit and typhoid fever infection which is consistent with the findings of this work. In addition, the finding of this work is supported by studies conducted in Indonesia, Vietnam and India, where poor hand washing practices, with no use of soap, were risk factors for typhoid fever transmission (Vollaard *et al*., 2004; Tran *et al*., 2005).

Some attitude of respondent identified in this study that could increase the risk of typhoid fever transmission is the biting of finger nails as means of trimming it down. This could lead to ingestion or inoculation of biological agents into the mouth if the hand is contaminated thereby increasing the risk of acquiring diseases such as typhoid fever. This risk factor could be escalated due to the close contact waste collectors have with contaminated materials. The use of separate working cloths was also identified as some of the practices adopted to encourage good personal hygiene. However, 23.3% as against 76.7% had no separate working cloth which could increase the risk of getting contaminated with infectious agents such as *Salmonella typhi* found to be associated with poor sanitation practices.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The findings and observations of this research are summarized in this chapter and the short falls that were encountered have been stated as recommendation to enable further work to be done.

5.2 Summary

A total of 60 respondents involved in waste management within the Ablekuma North Municipality were screened for *Salmonella typhi* infection using the Widal slide agglutination test. Out of the 60 respondents, infection was found to be very common between the age group 40-60. Nineteen 19 positive cases of *Salmonella typhi* infection were recorded given a prevalence of 31.67%. The incidence of typhoid fever was higher among females (12 cases) than males (7 cases). There was no significant different between age group and risk of typhoid infection. Data obtained suggests that age could be a predisposing factor towards acquisition of typhoid infection. Married individuals were found to be at risk of typhoid infection in comparison with individuals in other forms of relationship. In addition, majority of individuals earning less than GhC300.0 were found to be highly at risk of typhoid infection. Thus, marital status and level of income among waste pickers within the Ablekuma North Municipality could serve as risk factors for typhoid fever disease.

Majority (66.67%) of respondent were aware of typhoid fever and how it is transmitted as well as the symptoms it presents. Thus, in general, respondents had fair knowledge about typhoid fever. Respondents demonstrated high level of good attitude towards maintenance of personal hygiene and hand washing practices before meal and after

handling waste. Irregular trimming and biting of finger nails were identified as risk factors of typhoid fever.

5.3 Conclusion

The prevalence of typhoid fever infection among waste collectors within the Ablekuma North Municipality was 31.7%, which can be described as moderately high. Respondents demonstrated good knowledge about typhoid fever infection as well as its signs and symptoms. Age, sex, number of working years and level of monthly income were found to be associated with typhoid fever infection among the waste collectors in the Ablekuma North Municipality. Respondent showed good knowledge and understanding of personal hygiene but however did not practice personal hygiene practices on regular basis and could predispose them to typhoid fever and other infectious diseases.

5.4 Recommendations

From the findings of the study and conclusions drawn, it is recommended that, waste recycling companies should provide personal protective clothing and enforce their usage by all staff. In addition, the waste management and recycling companies should provide education on personal hygiene practices and sanitation related disease to their workers in order to minimize the risk acquiring sanitation related infection and diseases. Mandated state regulatory bodies for the waste management sector should review the salary structure in the waste management sector and if possible increase the workers' salary.

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APPENDIX

1.0 Consent Form

Hello, my name is ……, from, Presbyterian University College, Ghana. Faculty Of Development Studies and Department Of Environmental And Natural Resources, carrying out a research on "**Prevalence and Knowledge of Salmonella Infections among Waste Collectors in the Ablekuma North Municipal Assembly"**

The aim is to determine the risk factors associated with the mode of operation of the informal waste management sector and the prevalence of *Salmonella typhi* infection among individuals involved in this sector within the Ablekuma North Municipal Assembly.

All the information gathered will be strictly confidential and used for research purposes only. In case of any concerns about the study, feel free to contact **Dr. Richard Amfo-Otu** at Presbyterian University College Ghana, Department Of Environmental And Natural Resources **E-mail Address:** richard.amfo-otu@presbyuniversity.edu.gh **Telephone No:** 0243331041.

I therefore ask for your participation in this study for filling this questionnaire, thanks.

I have been dully be informed about the risks and benefits of participating in this study and therefore, **Agree or Disagree** to participate in the study. My human right is not abuse and my identity is protected throughout the study. My name will not be used in any document to relate the the results to my personal health conditions.

I however, consent that information from this study can be published in an academic journal without reference to my personal identity.

(Name) …… ……..(Signature/thumbprint) …….Date……

1.1 Questionnaire

This questionnaire is part of a purely academic research, designed by a student at Presbyterian University College Ghana. Please complete the following questions to reflect your opinions as accurately as possible and to answer factual questions to the best of your knowledge. The time spent on the instrument should be about 30 minutes. Thank for your anticipated participation. Your help is very much appreciated

IMPORTANT NOTICE: ***information provided through this survey is confidential and anonymous.***

SECTION A: DEMOGRAPHIC DATA

1. Age of respondent ……
2. Sex Female [ ] Male [ ]
3. Religion: Christianity [ ] Islam [ ] Traditional [ ] Others (Please Specify) ……
4. Ethnicity: Akan [ ] Ga- Adangbe [ ] Mole-Dabgon [ ] Ewe [ ] Others [ ]
5. Marital Status: Single [ ] Married [ ] Divorced /Separated [ ] Widow/widower [ ]
6. Do you have any form of health insurance? Yes [ ] No[ ]
7. If yes, what kind of insurance are you on? NHIS [ ] Private Insurance Scheme [ ]
8. Location of Residence …….
9. What is the name of your waste management Company?.....
10. What category of waste Management Company are you in? Government [ ] Private [ ]
11. How long has the Company been in operation?.....
12. How long have you worked as a waste collector?.....
13. Monthly income ……. (GH¢)

SECTION B: KNOWLEDGE ABOUT SALMONELLA INFECTIONS

14. Have you ever heard or learnt of typhoid infection Yes [ ] No [ ]
15. If yes, how did you hear about typhoid infection?

The internet [ ] Friend/Family [ ] Radio/TV/newspaper [ ] Other [ ] Please specify……..

16. How does a person get typhoid infection?

……

……

17. What symptoms of typhoid infection do you know?

……

……

18. Do you think it's possible for someone to have typhoid infection and not show signs and symptoms? Yes [ ] No [ ]
19. Is there a notification system to alert the company of suspected cases of typhoid or other emerging diseases at your workplace? Yes [ ] No [ ]
20. Do you think you are at risk with typhoid infection? Yes [ ] No [ ]
21. If yes how will you rate your risk? Very high [ ] High [ ] Medium [ ] Very low [ ] Low [ ]
22. Which PPE do you know? Tick all that applies Gloves [ ] Goggles [ ] Nose mask [] Overall [ ] Boots[ ] Helmet [ ]
23. Do you use PPE? Yes [ ] No [ ]
24. If no Why?.....

SECTION C: PERSONAL HYGIENE

25. Do you wash hands before eating? Yes [ ] Sometimes [ ] No [ ]
26. Do you use soap to wash hands always? Yes [ ] Sometimes [ ] No [ ]
27. Do you wash your hands when you return from work? Yes [ ] Sometimes [ ] No [ ]
28. Do you wash your hands after handling waste? Yes [ ] Sometimes [ ] No [ ]
29. How often do you cut your figure nails? Regularly [ ] Sometimes [ ] None/NO [ ]
30. If regular what is the frequency? Once week [ ] Once a month [ ] When the nails grow long [ ]
31. Do you bite your fingernails? Yes [ ] Sometimes [ ] No[ ]
32. Do you have worker cloth separately from the ones you bring to work?
33. How often do you wash your working gear?
34. Do you take your bath daily? Yes [ ] Sometimes [ ] No[ ]
35. If yes, how often do you take your bath?.....
36. Do you wear washed attire daily? Yes [ ] Sometimes [ ] No[ ]
37. In your opinion what are the barriers to personal hygiene? ***Please tick all that apply***

Lack of education [ ] Inadequate water supply [ ] Lack of time [ ] Religious beliefs [ ] Laziness [ ] Others (please specify)…….

THANK YOU

1.2 Ethical clearance

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

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

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
GPS Address: GA-050-3303
Tel: +233-302-681109
Fax + 233-302-685424
Mob + 233- 050-3539896
Email: ethics.research@ghsmail.org

MyRef. GHS/RDD/ERC/Admin/App/19/668
Your Ref. No.

5th December, 2019

Hannah Anita Obenewa Obeng
C/o EV Obeng-Adu
P. O. Box 3726
NIB - Accra

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

GHS-ERC Number	**GHS-ERC031/10/19**
Project Title	Salmonella Typhi Infection among Waste Collectors in the Ablekuma North Municipality
Approval Date	5th December, 2019
Expiry Date	4th December, 2020
GHS-ERC Decision	**Approved**

This approval requires the following from the Principal Investigator

- Submission of 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 verbally and seven 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 research findings.

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 implementation.

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

SIGNED.....
Dr. Cynthia Bannerman
(GHS-ERC Chairperson)

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

1.3 List of abbreviations

WHO	**Wold Health Organization**
PCR	**Polymerase Chain Reaction**
MDR	**Multi-Drug Resistant**
ABNMA	**Ablekuma North Municipal Assembly**
SPSS	**Statistical Package for Social Sciences**
IWB	**Itinerant Waste Buyer**
µl	**Microliter**
PPE	**Personal Protective Equipment**
AbNM	**Ablekuma North Municipality**
%	**Percentage**

PRESBYTERIAN UNIVERSITY COLLEGE, GHANA

FACULTY OF DEVELOPMENT STUDIES

Name of Department: Environmental and Natural Resources Management

Programme of study: Environmental Health and Sanitation

Topic: *Salmonella Typhi* Infection Among Waste Collectors in the Ablekuma North Municipality.

Name of Student: Hannah Anita Obenewa Obeng

Student's ID: 18030016

RESPONSE MEMO

SECTIONS/CHAPTER IN DISSERTATION	EXAMINER'S COMMENTS	STUDENT'S RESPONSE TO COMMENTS
Abstract	• It is ok	
Chapter One	• Nothing about waste collection is found in the background	Review about waste collection has been included in the background on **page 8**
Chapter Two	• No theoretical framework was followed or used. • Literature review is good but there was no section for Ghana in particular.	Section on literature review with respect to Ghana has been included and highlighted on **Page 34**
Chapter Three	• Rewrite the research design. It is mixed up. • Sampling explanation is weak.	Research design has been rewritten and sampling procedure has been further elaborated on **page 36** and **page 37** respectively.
Chapter Four	• Some results were related to literature which was good.	
Chapter Five	• It has to be reviewed	Chapter five has been reviewed and rewritten according to the directives of the reviewer. **Page 59**

Reference	• References in general are good as well as the in-text citations.	

Declaration by Candidate:

I declare that I have attended to and incorporated the comments made by the examiner in the dissertation.

Name of Student: ……

Signature: …… Date: ……

Approved by:

Name of supervisor: ……..

Signature: …… Date: ……