FACTORS CONTRIBUTING TO THE PREVALENCE OF CHOLERA DURING 2008 TO 2009 IN VHEMBE DISTRICT OF LIMPOPO PROVINCE, SOUTH AFRICA.

by

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DECLARATION

I, Dieudonne K'angweji Kazaji, declare that the mini-dissertation: "Factors contributing to the prevalence of cholera during 2008 to 2009 in Vhembe District of Limpopo Province, South Africa", hereby submitted to the University of Limpopo, for the degree of Masters of Public Health (MPH) has not previously been submitted by me for a degree at this or any other university; that it is my work in design and execution, and that all material contained herein has been duly acknowledged.

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Dr Kazaji DK Date

DEDICATION

This mini-dissertation is dedicated to all patients and family victims of cholera outbreak which occurred six years ago in the rural communities of the Vhembe district in Limpopo Province.

To my lovely wife, Mrs. Yvonne Kapinga Kazaji, for being the pillar of my strength and courage. Her prayers, enthusiasm, relentless encouragement and the moral support kept me focused.

To my lovely children: Grace Christella Odia, Jesus Arsene Ngueji, and Darrel Yves Junior Kazaji. This mini-dissertation, fruit of my sweat and sacrifices, should serve as a learning curve for you. Always remember that "*success is always the result of hard work*", and that "*a slow movement of a Tiger is not a mistake, but a calculated accuracy*".

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ABSTRACT

Cholera is an acute enteric infection caused by the ingestion of bacterium Vibrio cholerae present in faecally contaminated water or food. Primarily linked to insufficient access to safe water and proper sanitation, its impact can be even more dramatic in areas where basic environmental infrastructures are disrupted or have been destroyed. The aim of the study was to investigate the factors contributing to the prevalence of cholera and the environmental risk factors associated with cholera in the Vhembe district of Limpopo province between 2008 and 2012. The objectives of the study were to identify environmental risk factors for cholera and to determine the number of cholera cases in the Vhembe district.

The study used a quantitative, retrospective and cross-sectional research method. The records of 317 patients who met the study criteria were reviewed using an audit tool. The Statistical Package for Social Sciences (SPSS) version 22 was used to analyze the data. The results revealed that lack of adequate hygiene practices, limited access to safe drinking water, lack of safe food preparation and handling, and inadequate sanitation system are risk factors associated with cholera. The study recommends prevention, control of cholera outbreak and case management.

Keywords: Cholera, outbreak, Vibrio cholerae 01 and 0139, Watery diarrhea (rice-water), Prevalence, Risk factors.

DEFINITION OF CONCEPTS

Cholera

Cholera is a bacterial infection of humans caused by Vibrio cholera (of classical or El Tor biotypes) which characteristically causes severe diarrhea, and death (in those severely affected) from water and electrolytes depletion. Cholera has been called “blue death” due to a patient’s skin turning a bluish-grey color from extreme loss of fluids (McElroy & Patricia, 2009).

Cholera case

Cholera case refers to any patient, irrespective of age, with acute watery diarrhea and severe dehydration (usually with vomiting). Bhunia and Sougata (2009) define a cholera case as the occurrence of acute watery diarrhea (i.e. three or more loose stools per day); with severe dehydration among patients of any age.

Epidemiology

Epidemiology is the study of the distribution and determinants of health-related states or events (including disease) in specified populations, and the application of this study to the control of diseases and other health problems (Last, 1995). It is also defined as the study of the distribution of clinical phenomena in populations.

Outbreak

An outbreak is an explosive event, characterized by a sudden and rapid increase in the number of cases of disease in a population (Gordis, 2004).

Epidemic

An epidemic is the presence or the occurrence in a community or region, of a group of illness of similar nature, clearly in excess of normal expectancy, and derived from a common or from propagated source (Gordis, 2004).

Endemic disease

Endemic disease refers to the constant presence of a disease or infectious agent within a given geographic area or population group; may also refer to the usual presence of a given disease within such area or group (Last, 1995).

Case-fatality rate

A case-fatality rate is the number of people who die of a disease divided by the number of people who have the disease. Given that a person has the disease, what is the likelihood that he or she will die of the disease? Thus, case-fatality is a measure of the severity of the disease (Gordis, 2004).

Prevalence

Prevalence refers to the number of affected persons present in the population at a specific time, divided by the number of persons in the population at that time. It is calculated per 1000 (Gordis, 2004).

Incidence

According to Gordis Incidence refers to the number of new cases of a disease that occur during a specific period of time in a population at risk for developing the disease

(Gordis, 2004).

LIST OF ABBREVIATIONS

CFR	Case fatality rate
DC	District Code
DoH	Department of Health
GIS	Geographic Information System
JOCs	Joint Operation Committees.
MDGs	Millennium Development Goals
NHLS	National Health Laboratory Services
RDP	Reconstruction and Development Programme
V. Cholerae	Vibrio cholerae
VIP L	Ventilated Improved Pit Latrines
WHO	World Health Organization

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CHAPTER I

OVERVIEW OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND

Cholera is an acutely dehydrating, watery disease caused by the bacterium Vibrio cholera. It is often described as a classic water-borne disease because it is commonly associated with contaminated water (David, Bradley, Balakrish & Siddique, 2004). This description oversimplifies the transmission of Vibrio cholerae, because the bacterium can also be transmitted by contaminated food. Frequently contaminated water is mixed with food, allowing either to act as vehicle for transmission, and contaminated water is more common in less developed countries (Shapiro, Otieno & Adcock, 1999).

Lack of access to safe water remains a serious problem in the developing countries (Bhunia & Sougata, 2009); as a result some of the rivers, the main source of water for communities, are commonly contaminated with bacteria that cause disease by producing one or more enterotoxins. Among these, Vibrio cholerae causes the most severe (Sanchez & Holmgren, 2005). According to Van den Bergh, Holloway, Piennar, Koen, Elphinstone, and Woodborne (2008), there have been concerns about the recurrence of epidemics of diseases such as cholera, previously thought to be under control. Many scientific studies have been undertaken to study cholera and factors contributing to its re-occurrence and spread to new areas (Goldstein, 2005).

Cholera occurs in epidemic form when there is rapid urbanization without adequate sanitation and access to clean drinking water. Several cholera outbreaks from various countries such as India, Bangladesh, Indonesia, Peru, Mozambique, Tanzania, have been reported to be associated with contaminated piped water, and poor sanitation (Bhunia & Sougata, 2009). Other risk factors include poor hygiene, overcrowded living conditions and lack of safe food preparation and handling. Unstable political and environmental conditions such as wars, famines, floods that lead to displaced populations and the breakdown of infrastructures are very important risk factors as far as the cholera disease is concerned (Nevondo & Cloete, 2001). Hence, the focus of epidemics/ pandemic has shifted to developing countries, where the above risk factors are common, over the last century (Nevondo & Cloete, 2001).

Cholera has claimed many lives through history and continues to be a global health threat. Cholera cases mainly occur in the developing world (Reidl & Close, 2002). In the early 1980s, death rates are believed to have been greater than 3 million a year, although it is difficult to calculate exact numbers of cases, as many go unreported due to concerns that outbreak may have impact on the tourism of country (Sack, Bradley & Chaignat, 2006). A total of 293, 121 cholera cases and 10, 586 cholera deaths were reported worldwide in 1998, which is almost twice the number of cases as reported in 1997 (WHO, 1999). In 2008, 56 countries notified 190, 130 cholera cases and 5, 143 deaths to the World Health Organization (WHO); however, the actual estimated burden is 3 to 5 million cases worldwide and this caused 100, 000 to 130, 000 deaths a year as of 2010 (WHO, 2010).

Cholera may occur as sudden progressive outbreak after a natural disaster such as a cyclone, flood, and an earthquake. The disruption of the water distribution system and an inadequate hygiene situation or inadequate sanitation system after a natural disaster may cause cholera outbreaks as the disease is transmitted mainly through contaminated water (Watson, Gayer, & Connolly, 2007). Diarrheal diseases constitute a major global public health problem, and affect indigenous populations and travelers. Apart from natural disasters, human migration has also been identified as a cholera risk factor, as it plays a role in introducing disease into new populations (Wilson, 1995). Increases in population density as a result of massive migration, can strain existing sanitation systems, thus putting people at increased risk for many diseases including cholera (Root, 1997; Siddique, Zaman, Baqui, Akram & Mutsuddy, 1992).

Throughout history, populations all over the world have been affected by devastating outbreaks of cholera, and Africa where cholera outbreaks have been reported at an increasing annual rate since 1990, has been described as the new homeland for cholera (Gaffga, Tauxe & Mintz, 2007). In South Africa, the Limpopo outbreak between 2008 and 2009 was probably due to the human migration as cholera risk factor. The epidemic originated from Zimbabwe where 88, 834 cholera cases were reported in March 2009 (Mintz & Guerrant, 2009). This was the country’s worst cholera epidemic in recent memory and as a result, Zimbabwe declared a national emergency in early December 2008.

1.2 RESEARCH PROBLEM

Cholera has been a substantial health burden on the developing world for decades and it is endemic in many parts of Africa and Asia, having recently become more endemic in South and Central America (Zuckerman, Lars, & Alain, 2007). Cholera continues to be a major cause of morbidity and mortality in low income communities. Annual deaths from cholera may have decreased but overall morbidity remains high. Epidemics generally occur in underdeveloped areas with inadequate sanitation, poor hygiene, and limited access to safe water supplies, whereas in some countries, a seasonal relation for cholera epidemics has been observed (Koelle, Roco, Pascual, Yunus & Mostafa, 2005). Enteric infections resulting from these parameters and causing diarrheal disease due to Vibrio cholerae remain a leading global health problem in developing countries (Sanchez & Holmgren, 2005).

Despite all its prevention and control measures, South Africa still experiences cholera as one of its major health problems. However, cholera rapidly spread throughout Zimbabwe's provinces and then into neighboring countries, spreading to districts in Botswana, Mozambique, Zambia, and South Africa. The Musina town of the Vhembe district, as the gateway to South Africa, played host to thousands of Zimbabwean migrants fleeing the crisis that has bedeviled Zimbabwe from 2000, seeking economic opportunities and asylum. The situation was worsened by the outbreak of cholera that started in Zimbabwe but later spread to the Vhembe district claiming many lives. More than 900 suspected cholera cases were reported, and the Vhembe district, which borders Zimbabwe, was declared a disaster area (WHO, 2008). Out of eleven stool samples tested on the 19th November 2008 in Polokwane NHLS five were positive. From this date the Vhembe district was the epicenter of the outbreak. Within a few weeks, the disease spread throughout the Limpopo Province. A total of 4634 cholera cases and 30 deaths were reported in the Limpopo Province in 2009, with a Case Fatality Rate (CFR) of 0.65%. In the Vhembe district, 1, 066 cases with 14 deaths (CFR of 1.31%) were reported, which is approximately 23% of the overall cholera cases (Limpopo, DoH, 2009).

1.3 RESEARCH QUESTIONS

The following research questions guided the study:

- What is the prevalence of cholera infection during 2008 to 2009 in the Vhembe district?
- What are the contributing factors associated with cholera in the Vhembe district as from 2008 to 2012?
- What are the clinical aspects of cholera in the population?

1.4 AIM OF THE STUDY

The aim of the study was to investigate the factors contributing to the prevalence of cholera and the contributing factors associated with cholera in Vhembe district of Limpopo province.

1.5 OBJECTIVES OF THE STUDY

The objectives of the study were:

- To determine the number of cholera cases at the Vhembe district
- To identify the contributing factors for cholera in the Vhembe district
- To identity the clinical aspects associated with cholera.

1.6 OVERVIEW OF RESEARCH METHODOLOGY

A retrospective cross-sectional research using the quantitative approach was used. Records of cholera patients were reviewed to investigate if there is a relationship between environmental risk factors listed in data collection tool and the development of cholera outbreak. Data was collected for two weeks from seven health facilities of the Vhembe district with the assistance of infection control and environmental health officers. An instrument for data collection was used to extract data from the records including patients' medical records, registries of reportable communicable diseases and the Limpopo provincial database; data from provincial office was reviewed for comparison, whether they are in line with data collected from hospitals. Data were analyzed using IBM SPSS version 22. Details of the research methodology are discussed in chapter 3.

1.7 SIGNIFICANCE OF THE STUDY

Outbreaks may cause a high burden of disease and a rapid damage to the curative health services where public health systems have broken down, leading to a considerable public health and economic impact. Specific and rapid identification of interventions would be useful in limiting the spread and case-fatality rate of these outbreaks. An understanding of the socio-environmental risk factors and the pattern of outbreak can inform prevention efforts for this disease and those of similar nature. This will influence policy-makers as cholera is a preventable disease. It may also be used to develop an early warning system for future cholera outbreaks. Such an approach will tackle the morbidity and mortality due to the cholera disease.

Cholera, like other water related diseases, can cost governments billions of rand to eradicate. Absenteeism by the workforce caused by cholera adversely affects industrial output. Cholera outbreaks can adversely affect tourism and affect Tax revenues (productivity losses for business and individual due to illness decrease tax revenues). Cholera outbreaks may also lead to loss of trade. Therefore, a better understanding of the socio-economic, environmental and public health consequences of water supply and sanitation related diseases obtainable through better monitoring surveillance systems may help the public and policy-makers understand the value of microbiologically safe water as well as improved sanitation facilities. Basic hygiene education and sanitation programs can be used to improve human health in developing countries, particularly in rural communities, where resources may be inadequate.

1.8 CONCLUSION

Chapter 1 discussed the overview of the study, research problem, the research questions, aim of the study, overview of research methodology and significance of the study. The next chapter will focus on literature review.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to appraise what other researchers have discerned regarding cholera epidemic and the environmental factors, and to discover shortcomings in similar studies that can be used to draw comparisons with the present study. The researcher sought to present a comprehensive analysis of the relevant literature. Academic books, journal articles, research reports on the topic and web sites were used to compile the literature review. Old and recent literature were used in order to give an historical overview of cholera as the disease is an age old threat to public health which started in the mid 1800's.

This chapter gives an overview of the cholera epidemic elsewhere in the world, the genesis of epidemics and what was done about it. The chapter also sheds light on the studies conducted by other researchers which could be used to understand better the nature of the topic of interest, how it can be investigated, and how to effectively evaluate these documents in relation to the proposed research (Hart, 1998).

2.2 INTERNATIONAL (GLOBAL) PERSPECTIVE

2.2.1 Epidemiology

Enteric infections causing diarrheal disease remain a major concern worldwide. According to Sanchez and Holmgren (2005), it has been estimated that 2 billion to 4 billion episodes of infectious diarrhea occur annually in developing countries, resulting in 3 million to 5 million deaths, with the highest incidence and case-fatality rates in children below the age of five years. Diarrheal disease also constitutes the most common health problem in travelers to developing countries (Sanchez & Holmgren, 2005). Almost half of all cases of diarrhea are due to bacteria that cause disease by producing one or more enterotoxins. Among these, V. cholerae causes the most severe disease. Cholera is thought to be at least as prevalent now as it was 50 years ago, with approximately 100, 000 – 300,000 cases reported annually to WHO in 1995- 2004 (Zuckerman et al, 2007). Populations all over the world have sporadically been affected by devastating outbreaks of cholera.

Cholera is most commonly transmitted through the faecal oral route via contaminated water or food. Cholera transmission has been linked to contaminated drinking water drawn from shallow unprotected wells, rivers or streams, and even bottled water and ice. Seafood has also frequently been a source of cholera, particularly raw or undercooked shellfish (CDC/NCID, 1999). According to Plotkin and Orenstein (1999), the consumption of high-risk food, impure water and poor sanitation, correlate with a low socio-economic status and poverty; thus, economic status plays an important role in cholera transmission (Steffen, Acar, Walker, & Zuckerman, 2003). In endemic areas, the incidence of cholera is highest in children, and decreases with age due to acquired immunity. In non-endemic areas, cholera prevalence is not age-dependent, as a majority of the populations have no immunity to the bacterium (Steffen et al, 2003).

Despite efforts being made by many countries to contain the spread of the disease, cholera has been reported in many countries worldwide (WHO, 2001a). However, officially notified cases do not reflect the overall burden of the disease due to underreporting of cases prompted by political and economic reasons, fear of loss of tourism and trade, as well as poorly functioning surveillance systems (WHO, 2001b). Siddique and co-workers estimated 235, 000 clinical cases of cholera in Bangladesh 1991 (Siddique et al, 1992), yet none were officially reported that year (WHO, 1992). The WHO has estimated that the number of reported cases represent 5-10% of the actual number of cases worldwide (WHO, 2003).

2.2.2 Historical overview of cholera

Recorded evidence of cholera epidemics goes back to 1563 in a medical report from India (Nevondo & Cloete, 2001). Cholera is known to have started in Asia: “Asiatic cholera”, as it was sometimes called, has been endemic in South Asia, especially the Ganges Delta region. It was much feared because it regularly occurred in epidemics with high mortality rates (Bhunia & Sougata, 2009).

In the nineteenth century cholera spread from its apparent ancestral site in the orient to other parts of the world, producing pandemics in Europe (Nevondo & Cloete, 2001). The first pandemic was recorded in 1817 and it showed a spread of the disease outside the Indian subcontinent along trade routes to the west of southern Russia. A second pandemic started in 1826 and reached the major European cities by the early 1830s. In

1831, the pandemic reached the UK and the response was important in that it led to the establishment of local Boards of health and a “Cholera Gazette”, which served as a clearing house for tracking the epidemic (Rosenberg, 1962).

At that time cholera was thought to be spread by the “miasma” (like a fog) coming from the river, but the classic epidemiological study of John Snow in 1854 in London showed that the disease was associated with contaminated drinking water even before any bacteria were known to exist (Snow, Frost & Richardson, 1936). Three more pandemics continuing up to 1925 involved Africa, Australia, Europe, and all the Americas. The causative agent, Vibrio cholerae, was not identified until 1884 in Kolkata (where a cholera temple was built for protection against the disease), during the fifth pandemic (Koch, 1984). Leading causes of earlier pandemics and the way they ended is not known. However, cholera did not persist in any of the new geographical areas that it had invaded but continued as an endemic disease in the Ganges Delta. Due to a large numbers of cases and deaths during the pandemics, the disease was viewed as a major public-health disease requiring governmental intervention. The New York cholera epidemic led to the first Board of Health in the USA in1866 and cholera become the first reportable disease (Duffy, 1971).

The seventh cholera pandemic involved almost the whole world. The pandemic began in Indonesia, rather than the Ganges Delta, and the causative agent was a biotype of V. cholerae serogroup 01 called El Tor (Cvjetanovic & Barua, 1972). It was first isolated in 1905 from Indonesian pilgrims and was found again in 1937 in Sulawesi, Indonesia (Tanamal, 1959). Then in 1960, for unknown reasons, this strain began to spread around the world. It invaded India in 1964, reaching West Africa in 1970 (Cvjetanovic & Barua, 1972), Southern Europe in 1970 (Baine, Mazzotti & Greco, 1974), and reached South America in 1991 (Swerdlow, Mintz & Rodriguez, 1992). The disease spread rapidly in Latin America, causing nearly 400, 000 reported cases and over 4, 000 deaths in 16 countries of the Americas that year (Nevondo & Cloete, 2001). By the end of 1996, cholera had spread to 21 countries in Latin America again, causing over 1 million cases and more than 12, 000 deaths (CDC/NCID, 1999). This epidemic has now subsided. When an epidemic strikes an area where health care is not adequate the results can be disastrous, as demonstrated in a refugee camp in Goma, Zaire (DRCongo) in 1994. An estimated 58, 000- 80, 000 cases and 23, 000 deaths occurred within 1 month (Goma Epidemiology Group, 1995).

The seventh pandemic has still not receded; on the contrary, the disease has now become endemic in many of these places, particularly South Asia (India, Bangladesh) and Africa. Only serogroup 01 was then known to cause epidemic cholera, but in 1992 a newly described non-01 serogroup of V. cholerae, designated 0139 Bengal (WHO, 2000a) was found to cause unusual cholera outbreaks in India and Bangladesh (Cholera working group, 1993). Both serogroups 0139 Bengal and 01 now coexist and continue to cause large outbreaks of cholera in India and Bangladesh. The isolation of the serogroup 0139 has now been reported from 11 countries in South Asia (WHO, 2000b). Although 0139 continues to be detected in South Asia, accounting for 15% of all existing strains (WHO, 2001b), the outbreaks have not yet led to the eighth cholera pandemic as was initially feared.

2.2.3 Socio-environmental factors

As described in the historical overview of this chapter, cholera has been prevalent worldwide since the 19th century. This disease has been prevalent also in Sub-Saharian African countries, including South Africa. Several cholera outbreaks have been reported as related to contaminated piped water and poor sanitation, as noted in cases from different parts of India (Bhunia, Ramakrishnan, Hutin & Gupte, 2006).

A study was conducted by Bhunia and Soughata, (2009) to investigate the outbreak in the Sundarban area of West Bengal in India in an effort to identify the causative agent (and its sensitivity) and source, and to propose control measures. The outbreak is described by time, place, and person. A matched case-control study was then conducted and rectal swabs and water specimens were collected. Among five rectal swabs taken from five probable case patients, two grew V. cholerae 01 El Tor Ogawa. The other three did not grow any pathogen. In this study environmental investigations were also done. Affected areas were visited to assess the water supply system and sanitary situation. Water specimens were collected from piped water and stored drinking water for bacteriological analysis. Based on the distribution of cases and hypothesis-generating interviews among case patients as well as the case-control study pointed to the drinking water supply as the source of outbreak, a hypothesis was formulated that drinking water sources and hygienic practices could be the source of the outbreak. The outbreak of West Bengal was the result of the storm and flood which increases the risk of drinking water contamination by disrupting the water distribution system and the sanitary situation. This situation led to the acute scarcity of safe drinking water and poor sanitation facilities. The unhygienic environmental situation, open-air defecation practice and dense population in temporary shelters increase the risk of cholera outbreaks (Sur, Dutta, Nair & Bhattacharya, 2000).

In summary, the acute severe watery diarrhea outbreak was probably caused by V. cholerae 01 El Tor Ogawa. Epidemiological investigations indicated that this outbreak was waterborne. A number of components suggested that piped water accounted for a number of cases during this outbreak. First, there was an association between consumption of piped water and cholera. Second, the distribution of probable cases over time suggested that the piped water supply partially explained the outbreak. The outbreak was associated with contaminated non-chlorinated piped water intake. Unsafe water handling practices might have played a key role, along with contaminated piped water through breached connections. Third, several studies have reported many waterborne cholera outbreaks caused by contaminated piped water in West Bengal (Sugunan, Ghosh, Roy, Gupte & Sehgal, 2004). Fourth, water specimen analysis supported the hypothesis of contamination. The Millennium Development Goals (MDGs) proposed to decrease by one-half the population without access to safe water and sanitation by 2015 (UNDP, 2010). The MDGs consider piped water as a safe water source. However, through breached connections, waterborne pathogen transmission may occur when the quality of the piped water system is not checked periodically.

The outbreak was investigated to identify the causative agent and source, and to propose control measures. The probable cholera outbreak affected a high-risk cyclonic-devastated population. Transmission of the outbreak presented a unique characteristic: the first part due to the contaminated non-chlorinated piped water intake and the second part mainly by unsafe water handling practices. On the basis of these conclusions, a number of recommendations were planned and these were: “The repair of pipelines which were broke by villagers near their houses for easy access to water, daily chlorination, periodic monitoring of water pipelines, and water quality assurance by testing”. This environmental investigation in sundarban area of West Bengal, led to a conclusion that drinking contaminated water source and lack of hygienic practices were the source of the outbreak. In line with the Sundarban area investigation, the researcher is also interested in the environmental risk factors that may contribute to the Vhembe district cholera outbreak.

In addition, Bhunia and Sougata study (2009) had three limitations: First, the case-control study was conducted in a highly affected area during the outbreak period. This may have decreased the ability to describe in detail the association between the disease and various risk factors; however it is unlike to affect the conclusions. Second, the small sample size of 228 for 1, 076 cases limited the capacity to conduct a meaningful multivariate analysis. Third, it was not possible to obtain laboratory confirmation for more than two cases. Thus, it could not be excluded that the outbreak could have been caused by other microorganisms than V. cholerae.

Endemic cholera was believed to occur only in the estuarine deltas of tropical and semitropical areas such as the Ganges basin. These areas are generally densely populated with sewage facilities near water sources, which are being used for washing, bathing, drinking, and defecating (Glass and Black, 1992). In these settings, human feces containing vibrios contaminate water that if consumed perpetuates the transmission of the organisms. A study was conducted by Mohammad, Emich, Donnay, Yunus, and Sack (2002) in Matlab, a rural area of Bangladesh, 53 km southeast of Dhaka, where cholera is endemic. The study area has poor water and sanitation conditions, and the objective was to identify environmental risk factors for cholera in an endemic area of Bangladesh, using a geographic information system (GIS) approach.

The study data were collected from a longitudinal health and demographic surveillance system, and integrated within a geographic information system database of the research area. Two study periods were chosen because they had different dominant biotypes of the disease: from 1992 to 1996 El Tor was dominant and from 1983 to 1987 classical cholera was dominant. The study found the same three risk factors for the two biotypes of cholera including proximity to surface water, high population density, and poor educational level. The GIS database was used to measure the risk factors and spatial filtering techniques were employed. These robust spatial methods are offered as an example for future epidemiological research efforts that define environmental risk factors for infectious diseases. This study indicates that by identifying a suitable environment for cholera and mapping spatial patterns of the disease, efforts can be taken at appropriate places to prevent cholera. Thus, a major effort to prevent fecal contamination of water is needed in order to reduce cholera incidence in endemic areas.

A comparison of spatial and social clustering of cholera was conducted once again in Matlab, Bangladesh, by Sophia, Mohammad, Yunus and Emich (2010). In order to compare spatial and social clustering of cholera, this study investigated cholera transmission in rural Bangladesh from 1983 to 2003, using a kinship-based social network where household clusters act as nodes and are connected by individual migrations. Social networks were constructed and used to model kinship relationships because they are likely to engage in some form of interaction, either within or outside of the household. The results illustrate that spatial clustering of cholera is much more prevalent in Matlab than clustering socially. This is likely due to socio-environmental risk factors at the neighborhood scale, such as water and sanitation environments and population density.

The main limitation of this study, from a social perspective, is that only kinship connections were measured. However, a comparison of social and spatial clustering suggests that the local environment is of greater importance than social connectivity in cholera transmission. Furthermore, the possibility exists that the observed clustering in space is a result of not only environment, but also social interaction with non-kin. The spatial network may thus, effectively, also capture a social network.

Improved understanding of disease transmission dynamics is critical for public health. Nevertheless, while improvements in sanitation, socio-economic status, and education have helped reduce rates of diarrheal disease in Bangladesh and other countries in the developing world, it remains a priority to identify specific pathways of transmission and thus develop effective intervention methods. This research introduces a way of analyzing if and how social interaction may contribute to cholera occurrence. This study conducted by Sophia et al (2010) in Matlab, shows that cholera always clusters in space and seldom within social networks. Cholera is transmitted mostly through the local environment rather than through person-to-person. Comparing spatial and social network analysis can however help improve understanding of disease transmission.

In a study conducted by Van den Bergh et al (2008) in the coastal city of Beira, Mozambique, the objective was to model the number of confirmed cholera cases in relation to certain environmental parameters, and to investigate the feasibility of predicting future cholera outbreaks. The seasonal behavior of the target variable (cholera cases) was analyzed using singular spectrum analysis followed by spectrum estimation using the maximum entropy method. The seasonal behavior was compared to that of environmental variables (rainfall and temperature). The aim was to establish mathematical relationships between the number of cholera cases and certain environmental factors that may support the survival and population growth of the cholera bacteria, Vibrio Cholerae, in the natural environment and therefore cause cholera outbreaks (Van den Bergh, Holloway, Pienaar, Koen, Elphinstone & Woodborne, 2008).

The study specifically excluded public health or socio-economic aspects of cholera outbreaks. It made use of recorded cholera case data in Beira, Mozambique, and captured local environmental parameters. Two approaches were used, namely signal processing methods (singular spectrum analysis and wavelet analysis) and statistical methods (dynamic regression and negative binomial regression).

The focus in this study was on the model fitting component, and not on the results of the wider investigation into cholera in Beira. The Dynamic Regression Model that uses explanatory variables to model the forecast variable was more appropriate, since the objective of the Beira study was to find environmental factors that may potentially signal the outbreak. It was found to be the preferred forecasting method for this study in Beira. Other statistical modeling techniques, including generalized linear models and ARIMA time series modeling, were investigated for the purpose of developing a cholera cases forecast model fed by environmental variables (Makridakis, Wheelwright, & Hyndman, 1998).

The dynamic regression model yielded the best forecasting results for the cholera cases in Beira, because of its strength to model the relationship between cholera and others variables, while also taking into account the relationships between the variables amongst each other. The advantage of using dynamic regression is the ability to regress the cholera data on the environmental variables and then fit an ARIMA model to account for residual variability (Van der Bergh et al, 2008).

Vibrio cholerae serogroup 01, biotype El Tor has been responsible for endemic and pandemic cholera in Africa and the rest of the world, with the exception of the Indian continent. Vibrio cholerae 0139, which emerged as new epidemic cholera strain in South-east Asia in 1992, has also notably not reported in any investigation or any outbreaks reported from Africa. A survey of Vibrio cholera 01 and 0139 in estuarine waters and sediments of Beira, Mozambique, was conducted by Du Preez, Van der Merwe, Cumbana, and Le Roux (2010).

This study determined whether the estuarine and freshwater environment in Beira, Mozambique, serves as reservoir of Vibrio cholerae 01 and 0139. Ninety-nine samples were collected from estuarine water at 6 sites in Beira, 54 samples were collected from rural areas around Beira. An equivalent number of sediment samples were collected from the same sites as the water samples. In addition, fish scales from 5 ocean fish and one deep sea water sample were also collected. Different methods including culture methods, the direct fluorescent antibody (DFA) method and polymerase chain reaction (PCR), were used to analyze the samples for the presence of V. cholerae 01 and 0139. The findings of the study provided in situ evidence for V. cholerae 01 and 0139 in water and sediments samples and fish scales during the epidemic and inter-epidemic periods of 2005 and 2006 (Du Preez et al, 2010).

It was not surprising that cholera cases were reported during this period as the communities of Beira are poor, and have no sanitation facilities or piped drinking water. The water in this area is turbid and high in nutrients. The impoverished population, living in informal housing erected on the beach, depends largely on fish netted in the estuary. The area is also a swimming area for the local people and visitors. Du Preez et al’s study seems to be relevant to this study because it underlines the importance of sanitation quality, source of water and foods, and the socio-economic status, listed by the researcher as contributory factors for cholera incidence which should be investigated.

Vibrio cholerae spreads rapidly where living conditions are crowded, water sources unprotected and where there is no hygienic disposal of faeces, such as in refugee camps as well as farms and countries that are environmentally underdeveloped (WHO, 2000b). The potential changes in spatial and temporal spread of diseases and ecological and sociological changes associated with predicted climate changes mean that the potential for Vibrio cholerae 01 and 0139 outbreaks cannot be ignored. Importantly, accurate identification of cholera epidemic strains is paramount for the implementation of vaccination programmes in outbreak areas. These methods of protection reduce the risk of cholera to the traveler and minimize the possibility of transmission of cholera to disease-free regions (Paz, 2009).

One of the shortcomings of the Du Preez study was that it was unable to confirm V. cholerae 01 and 0139 bacteria using molecular techniques. The presence of these bacteria was however confirmed using fluorescent antibodies, a method that has been proven to be very specific for V. cholerae 01 and 0139 (Brayton & Colwell, 1987), and is considered to be a reliable method by a number of researchers working with cholera bacteria in environmental samples (Alam, Sadique, Hasan, Bhuiyan, Nair, Siddique, & Sack, 2006). However this study is notably the first documented record of the presence of V. cholerae 0139 in the coastal water of Africa.

In conclusion, Du Preez et al' study (2010) for the first time provides in situ evidence for V. cholerae 01 and 0139 in the aquatic environment, predominantly as viable but non-culturable cells in water and sediment samples, in African coastal waters. V. cholerae 01 and 0139 was present in both the epidemic and inter-epidemic periods indicating a year-round reservoir, similarly to that reported for studies performed in Bangladesh. Hence, an in depth understanding of V. cholerae ecology can enhance efforts to reduce human exposure to this pathogen and minimize the health risk this poses. Furthermore, Bhunia and Sougata study is more practical based on the recommendations proposed. First, efforts must be made for the early diagnosis of cholera in remote areas, thus the common use of culture should be substituted with the use of rapid kits tests that have been proposed in complex emergencies (Wang, Ansaruzzaman, Vaz, Mondlane, Mes & Seidlein, 2006). This will reduce the waiting time of confirmation tests and also help to avoid the situation whereby the results remain pending for a long period. Rapid detection, epidemiological investigation of diarrhea outbreaks and oral cholera vaccination may be the only way to prevent death and disease (WHO, 2010). Second, safe water must be made easily accessible at different points with less distance in the affected areas. Third, rainwater harvesting followed by chlorination at household level or solar disinfection may be achieved to prevent the type of environmental contaminations that triggered a waterborne outbreak followed by person-to-person transmission during natural disasters (WHO, 2005).

The study conducted by Sophia et al, (2010) compares spatial and social clustering of cholera in rural Bangladesh. Data included a spatially referenced longitudinal demographic database, which consisted of approximately 200, 000 people and laboratory-confirmed cholera cases from 1983 to 2003. Matrices were created of kinship ties between households using a complete network design and distance matrices were also created to model spatial relationships. Moran's / statistics were calculated to measure clustering within both social and spatial matrices. The results indicated that cholera always clusters in space, with transmission mostly occurring through the local environment rather than through person-to-person contact. The only limitation of this study from a social networks perspective was that only kinship connections were measured. Nevertheless, the results illustrated that spatial clustering of cholera is much more prevalent than clustering socially. This is likely due to socio-environmental risk factors at the neighborhood scale, such as water and sanitation environments and population density. Thus, infectious diseases often cluster spatially, but can also cluster socially because they are transmitted within social networks by personal interactions that allow pathogens to spread among individuals (Hanneman, 2001).

With Van den Bergh et al, (2008), the study consist in the application of a methodology that propose the use of spectral methods to inform the development of statistical forecasting models for cholera case data. The spectral analysis is refined by means of a cross-wavelet technique, which is used to compute lead times for co-varying variables, and suggests transformations that enhance co-varying behavior. Several statistical modeling techniques, including generalized linear models, ARIMA time series modeling, and dynamic regression are investigated for the purpose of developing a cholera cases forecast model fed by environmental variables. Dynamic regression was found to be the preferred forecasting method for this data. The objective was to model the number of confirmed cholera cases in relation to certain environmental parameters, and to investigate the feasibility of predicting future cholera outbreaks. The limitation in this study is on the model fitting component, and not on the results of the wider investigation into cholera in Beira.

2.2.4 Seasonality of cholera outbreaks

Cholera has pronounced seasonality. There have been concerns about the recurrence of epidemics of diseases such as cholera, previously thought to be under control (Goldstein, 2005). Many scientific studies have been undertaken to study cholera and factors that may contribute to its re-occurrence and spread to new areas. In Bangladesh, where the disease is endemic, two peaks occur each year that corresponds with the warm seasons before and after the monsoon rains (Siddique et al, 1992). Specifically, linkages between environmental conditions and outbreaks of cholera in Bangladesh have been demonstrated by Huq and Sack (2005), where the Poisson regression model has been used to model cholera case data.

In Peru, epidemics are strictly confirmed to the warm season (Tauxe, Mintz & Quick, 1995). The seasonality seems to be related to the ability of vibrio to grow rapidly in warm environmental temperatures. In this study two seasons are also taken into consideration as risk factors to cholera epidemics. The rainy season (humid) and the dry season are picked by the instrument used by the researcher to collect data in the selected areas. The research intends to demonstrate whether there is a relationship between cholera cases and the period of occurrence.

A study by Gil, Louis, and River (2004) indicated the relationship between cholera incidence and elevated sea surface temperatures and effects of the 1997-1998 El Nino in Peru. Furthermore, Pascual, Rodo, Ellner, Coxwell, and Bouma (2000) investigated the relationship between El Nino Southern Oscillation (ENSO) and the occurrence of cholera.

In 2010, Haiti experienced cholera epidemics as a result of a huge earth quake disaster. 60, 240 cumulative cholera cases including 1, 415 deaths at national level were reported (WHO, 2010b). Laboratory tests on the cholera strain responsible for the outbreak in Haiti, conducted by the US Centre for Diseases Control and Prevention (CDC) in Atlanta, showed that it is most similar to cholera strains found in South Asia.

In endemic areas, annual rates of disease vary widely, probably as a result of environmental and climate changes. Better understanding of the relation to climate would thus allow better planning for epidemics by public-health officials.

2.2.5 Cholera: a new homeland in Africa

Cholera was largely eliminated from industrialized countries through water and sewage treatment over a century ago. Today it remains a significant cause of morbidity and mortality in developing countries, where it is a marker of inadequate drinking water and sanitation infrastructure (Gaffga et al, 2007). In the 1960s, at the beginning of the seventh and current cholera pandemic, cholera had an exclusively Asia focus. In 1970, the pandemic reached sub-Saharan Africa, where it has remained entrenched.

According to Gaffga et al, 2007, Africa where cholera outbreaks have been reported at increasing annual rates since 1990, has been described as the *“new homeland”* for cholera. People in Africa are increasingly affected by cholera outbreaks caused by the V. cholerae 01 and 0139 bacteria. The African region account for over 90% of the cases of cholera reported to the World Health Organization (WHO, 2007). The persistence or control of cholera in Africa will be a key indicator of global efforts to reach the Millennium Development Goals (MDGs) and of the commitments by leaders of the G-8 countries to increase development aid to the region.

African countries where cholera epidemics were reported by WHO are listed in the following table:

Table 2.1: Cholera in Africa, 2000- 2012

Country	Date	Cases	Deaths	CFR
Madagascar	13March 2000	15, 173	860	5.7%
Somalia	21 April 2000	2232	230	10.3%
South Africa	16 April 2001 18 May 2003 10 March 2009	86, 107 2362 12.000	181 3 59	0.21% 0.13% 0.49%
Cote d'Ivoire	21 Sept. 2001 14 July 2002	3152 581	175 19	5.5% 3.3%
Nigeria	26 Nov. 2001	2050	80	4%
Chad	4 Sept. 2001 5 January 2004	3557 131	113 11	3.2% 8%
Tanzania	20 July 2001	109	3	2.8%
Malawi	26 August 2002	23, 135	675	3%
DR Congo	8 June 2003 20 July 2011	13, 452 3896	380 265	2.82% 7%
Mozambique	18 March 2004	15, 237	85	0.56%
Zambia	22 January 2004	1721	70	4.06%
Angola	9 June 2006	46, 758	1893	4,0%
Zimbabwe	30 May 2009	98, 424	4276	4.34%
Sierra Leone	2 October 2012	20, 736	280	1.35%
Cumm. total		**346, 158**	**9, 628**	**2.78%**

Table 2.1 shows that as from the year 2000 to 2012, South Africa had the highest number of cholera cases amounting to 100, 469 with CFR of 2.41% followed by Zimbabwe with a total number of 98, 424 cholera cases, with CFR of 4.34%. The other countries which experienced the higher number of cholera cases were Angola with 46, 758 cases, Malawi 23, 135 cases, Sierra Leone 20, 736 cases, Democratic Republic of Congo 17, 348 cases and Mozambique 15, 237 cholera cases. The highest Case Fatality Rate (CFR) was observed in Somalia with 10.3%, followed by Madagascar with 5.7%, Cote d'Ivoire with 5.2%. Four countries had respectively a CFR of 4%, these include: Zimbabwe, Zambia, Angola and Nigeria. South Africa, despite the higher number of cholera cases, had a lowest CFR of 0.23%, followed by Mozambique with 0.56% and Sierra Leone 1.35%. However, this table shows the potential explosive pattern of cholera outbreaks, extremely virulent and potentially fatal disease for both children and adults.

In 2013, a total of 47 countries from all continents reported 129, 064 cases of cholera to the WHO, of which 43% were reported from Africa and 47% from the Americas where a large outbreak started in Haiti at the end of October 2010 (WHO, 2015a). The trend is that globally, the cases reported from Africa have decreased since 2012 with 43% of cases reported in 2013 against 93% to 98% of total cases worldwide reported from Africa between 2001 and 2009. In contrast to a global trend of decreasing case fatality ratios (CFRs), CFRs have remained stable in Africa at approximately 2%. However, many people still die of the disease, notably in sub-Saharan African, Asia and in Hispaniola, clearly showing that cholera remains a significant public health problem (Mengel, Delrien, Heyerdahl, & Gessner, 2014).

2.3 NATIONAL (SOUTH AFRICA) PERSPECTIVE

2.3.1 Background

Cholera has been prevalent also in sub-saharian African countries including South Africa, as demonstrated above. The WHO has confirmed that cholera had always been endemic but under control in South Africa, although the worst cholera epidemic was seen in the early 1980's, particularly in the rural areas.

South Africa is a water-scare country, and the demand for this resource is growing as the economy expands and the population increases (Momba, Osode & Sibewu, 2006). Despite all its prevention and control measures, South Africa still experiences the cholera epidemics as one of its major health problems; they are predominantly attributed to underdevelopment and lack of adequate facilities in some of the rural and peri-urban areas of the country. In 2001, the government described cholera as a disease of poverty, and it is the poorest who are most at risk, particularly those who live in underdeveloped rural areas and rely on rivers and streams for their drinking water (Nevondo & Cloete, 2001).

The first case of cholera was diagnosed in South Africa in 1973 (Mugero & Hope, 2001). In August 2000, South Africa faced one of its biggest health challenges ever when a cholera epidemic gripped the rural parts of Northern and Southern Kwazulu Natal. The epidemic developed into the most serious epidemic yet experienced in South Africa. It affected the whole country infecting 117, 147 people and killing at least 265 people in eight of the nine provinces. The movement of people from province to province and between southern African countries resulted in the spread of the cholera bacterium to seven of the nine provinces in South Africa.

As of the 27th July 2001, the total number of cases was 106, 224 and the total number of fatalities 228. This is a serious situation considering the size of the South African population, which was approximately 40 million in 2001 (Nevondo & Cloete, 2001).

KwaZulu Natal, Northern Province, Mpumalanga, and Gauteng were the four provinces where the problem of cholera was most severe. The KwaZulu Natal, where the epidemic began, reported the majority of cases (99% of the total number of cases reported nationally) and the highest number of fatalities amounting to 96% of the total number of fatalities (Nevondo & Cloete, 2001).

The Vibrio Cholerae 01 type El tor Ogawa was isolated as the causative organism. In addition to the suffering and loss of lives, the epidemic cost the communities a lot of resources on the treatment of cholera patients, loss of significant productive work time and other social economic costs. Environmental Health officers were deployed in all high-risk areas to educate members of the public about cholera and how to avoid it. Both national and provincial response was also organized through the setting up of coordination structures including: inter-ministerial committees, National Task Forces on cholera, and Joint Operations committees (JOCs) at Provincial, Regional and District levels with technical support from the WHO.

2.3.2 Risk factors for cholera epidemics

As early as 1971, South Africa was considered at risk of cholera. The hot humid summer seaports, overcrowded communities, with low standard of environmental sanitation and scanty, restricted and unprotected water supplies in some areas facilitated the introduction of cholera.

Cholera is an age old scourge that strikes fear in the minds of people all over the world now, as it did in the mid 1800’s when cholera swept through London and Dr John Snow finally proved that the disease was spread through contaminated water. Water in London is now safe but millions of mainly impoverished people across the globe have been affected by cholera since the present pandemic started in the Ganges delta in India in 1961. Nevondo and Cloete (2001) stated that cholera epidemics occur where there is rapid urbanization without proper planning for adequate sanitation and access to clean and safe drinking water. Other risk factors include poor hygiene, overcrowded living conditions and lack of safe food preparation and handling. Unstable political and environmental conditions due to wars, famines and floods leading to massive displacement of the population are very important risk factors to consider as far as the cholera disease is concerned.

Black people constituted the majority of the population that was affected by the cholera outbreak during 2001 due to the fact that they mostly live in places with poor sanitation and poor living conditions. Households with good living conditions and educated members were not affected. Due to the high level of labour immigration practices of male adults, females constitute the biggest proportion of the population in the communities affected, about 60% of reported cases, and age groups 11-20 and 21-30. Therefore the age distribution curve was skewed to the left, younger age groups more represented, typical of endemic scenario, adults having substantial immunity from previous infections (Mugero & Hope, 2001).

An understanding of the simple fact that the bacteria that causes cholera is spread from person to person by contaminated food and water and that urgent but simple rehydration can save many lives, goes a long way to allay irrational fear. Ignorance leads to fear – and sometimes death. Regardless of the intervention, further understanding of cholera biology and epidemiology is essential to identify populations and areas at increased risk and thus ensure the most efficient use of scare resources for the prevention and control of cholera.

2.3.3 Cholera transmission

Cholera transmission is closely linked to inadequate environmental management. Typical at-risk areas include peri-urban slums, where basic infrastructure is not available, as well as camps for internally displaced people or refugees, where minimum requirements of clean water and sanitation are not met. Early propagation of cholera outbreaks depends largely on the extent of individual bacterial shedding, host and organism characteristics, the likelihood of people coming into contact with an infectious dose of V. cholera and the virulence of the implicated strain. Cholera transmission can then be amplified by several factors including contamination of human water- or food sources; climate and extreme weather events; political and economic crises; high population density combined with poor quality informal housing and poor hygiene practices; and spread beyond a local community through human travel and animals, e.g. water birds (Mengel et al, 2014).

The consequences of a disaster – such as disruption of water and sanitation systems, or the displacement of populations to inadequate and overcrowded camps – can increase the risk of cholera transmission should the bacteria be present or introduced. Epidemics have never been arisen from dead bodies. Cholera, therefore, remains a global threat to public health and a key indicator of lack of social development (WHO, 2015b).

2.3.4 Imported cholera cases and risk of travelling

The cholera outbreak of 2008 on the northern border of South Africa is not different: poor governance and the destruction of water and sanitation infrastructure in Zimbabwe forced the population to drink from sewage contaminated water sources. Finally the outbreak spread into South Africa via refugees seeking medical assistance and truck drivers returning from Beit Bridge to as far afield as Durban.

According to Zuckerman et al (2007), most cases of cholera worldwide are unreported and most cases of imported cholera go undetected. Failure to acknowledge a cholera epidemic may hinder governmental response and control efforts in epidemic settings. Epidemic cholera is a disease of great local importance, as evidenced by large, past outbreaks in Haiti and Zimbabwe. However, the burden of cholera in endemic areas, which appears to dwarf the burden in non-endemic areas, is often overlooked. There is a need to be vigilant for imported cases, since there is always a possibility that infected persons could introduce *V. cholera* into informal water supplies. Between the years of 1995 and 2001, the WHO reported 1, 829 cases of cholera in developed countries, the majority of which were imported, However it is believed that this figure reflects less than 10% of the incidence of cholera due to milder cases being unrecognized, as well as significant underreporting (Steffen et al, 2003).

Eight years ago, cholera epidemics were reported in the northern part of the country, as a result of a cholera outbreak in Zimbabwe, which has left more than 4, 276 people dead. A number of cholera cases in two of South Africa's provinces were also reported as it emerged that the number of cholera cases in South Africa in 2008 and 2009 were confined largely to the Limpopo and Gauteng provinces. Based on the epidemiological data, Limpopo had the highest case load of cholera with 4, 634 cases, followed by Gauteng with 21 confirmed cases. In other provinces, only isolated suspected cases were reported.

The Limpopo province outbreak which mostly affected Vhembe district, and known as *"imported cholera cases"*, occurred through a massive movement of Zimbabwean citizens during the period of outbreaks. Cholera spread to the Zimbabwean migrant worker community in Limpopo and Mpumalanga provinces of South Africa, and cholera bacteria were detected in the Limpopo River on 3 December 2008 (Independent Online, 2008). Tests have confirmed that the eastern parts of the Limpopo River between South Africa and Zimbabwe have been contaminated with cholera bacteria. Incidentally, the past 100 imported cases of cholera worldwide were reported to the WHO during 2004, and 68 cases during 2005 (WHO, 2004). Nevertheless, national and provincial response was very effective during the outbreak, and Heath Professionals with Environmental Health officers were involved in health education programme.

2.4 CONCLUSION

This chapter reviewed different researches conducted on the cholera epidemic worldwide. It outlined the history and the epidemiology of the disease. The chapter also identified various risk factors for cholera epidemics in areas at risk, enabling the researcher to develop a holistic picture of the possible socio-environmental and climatic factors involved in the emergence of the disease in new regions. The next chapter discusses the research methods which were used in the study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses techniques used in obtaining data during the study. It focuses on the study site, the research design, the study population, sampling techniques, data collection methods and data analysis. The chapter also discusses the reliability and validity of the study, as well as ethical considerations.

3.2 STUDY SITE

The study was carried out in four municipalities of the Vhembe district namely Makhado, Musina, Muthale, and Thulamela. The four municipalities are well served by eight hospitals comprising respectively Elim, Louis Trichardt (Makhado) and Siloam in Makhado, Messina hospital in Musina, Donald Frazer in Mutale, Malamulele, Tshilidzini and Hayani in Thulamela. Hayani hospital was excluded from the study because it is a psychiatric institution.

The Vhembe district is a fairly large and rural district situated at the northern part of South Africa and shares a border with Zimbabwe, where the cholera epidemic started in 2008. Through a massive migration of people the epidemic crossed the border invading firstly the population of Madimbo village and Messina. The outbreak spread from Madimbo village and Musina to the rest of the Vhembe district. As a result, on December 11, 2008, Vhembe was declared as a disaster zone by the Limpopo government due to the spread of cholera across the Zimbabwean border to the district (Independent Online, 2008).

Vhembe district was chosen for this investigation because recurrent V. cholerae outbreaks in Limpopo indicate a ubiquitous and continuous presence of cholera bacteria in the area between 2008 and 2012. The figure 3.1 shows the geographical position of the Vhembe district in the northern part of the Limpopo province where the study was undertaken.

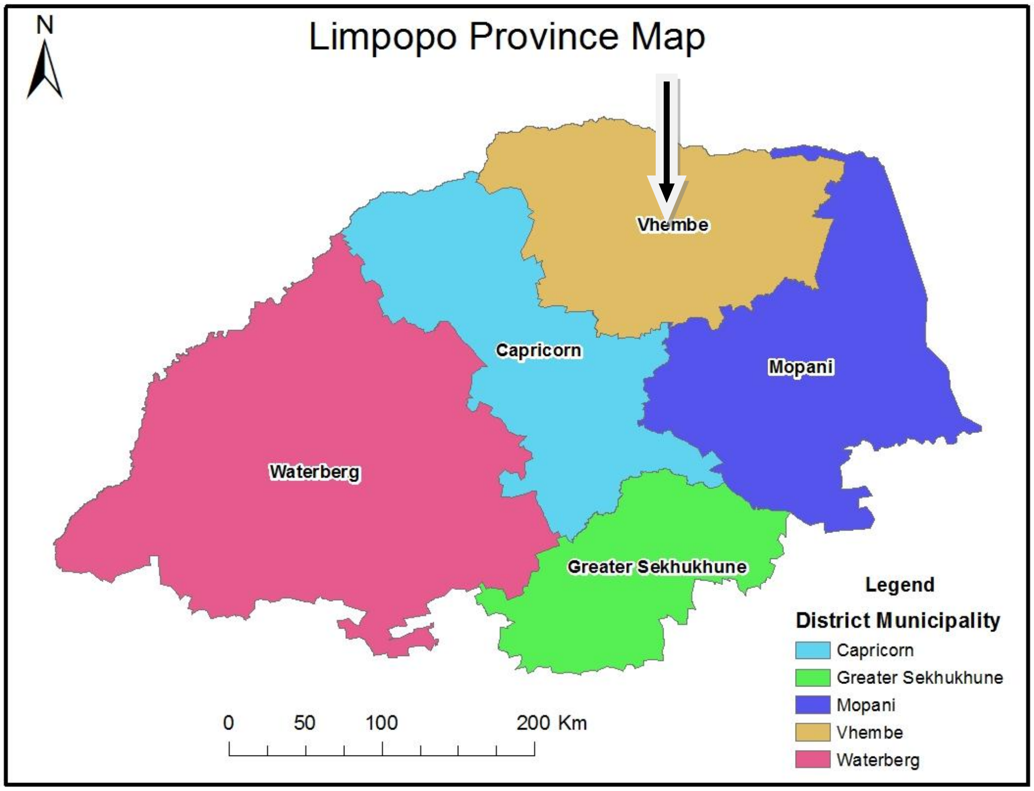

Figure 3.1 Limpopo province map with districts

Fairly large (25, 597 km2) and rural, the Vhembe district is one of the 5 districts of Limpopo province of South Africa. The main geographic feature of the district is the Soutpansberg Mountains. Vhembe is surrounded by:

- The republic of Zimbabwe to the north,
- Mopani district (DC33) to the south-east,
- Capricorn district (DC 35) to the south-west,
- Waterberg district (DC36) to the west.

In addition figure 3.2 represent the health facilities covering the all Vhembe District.

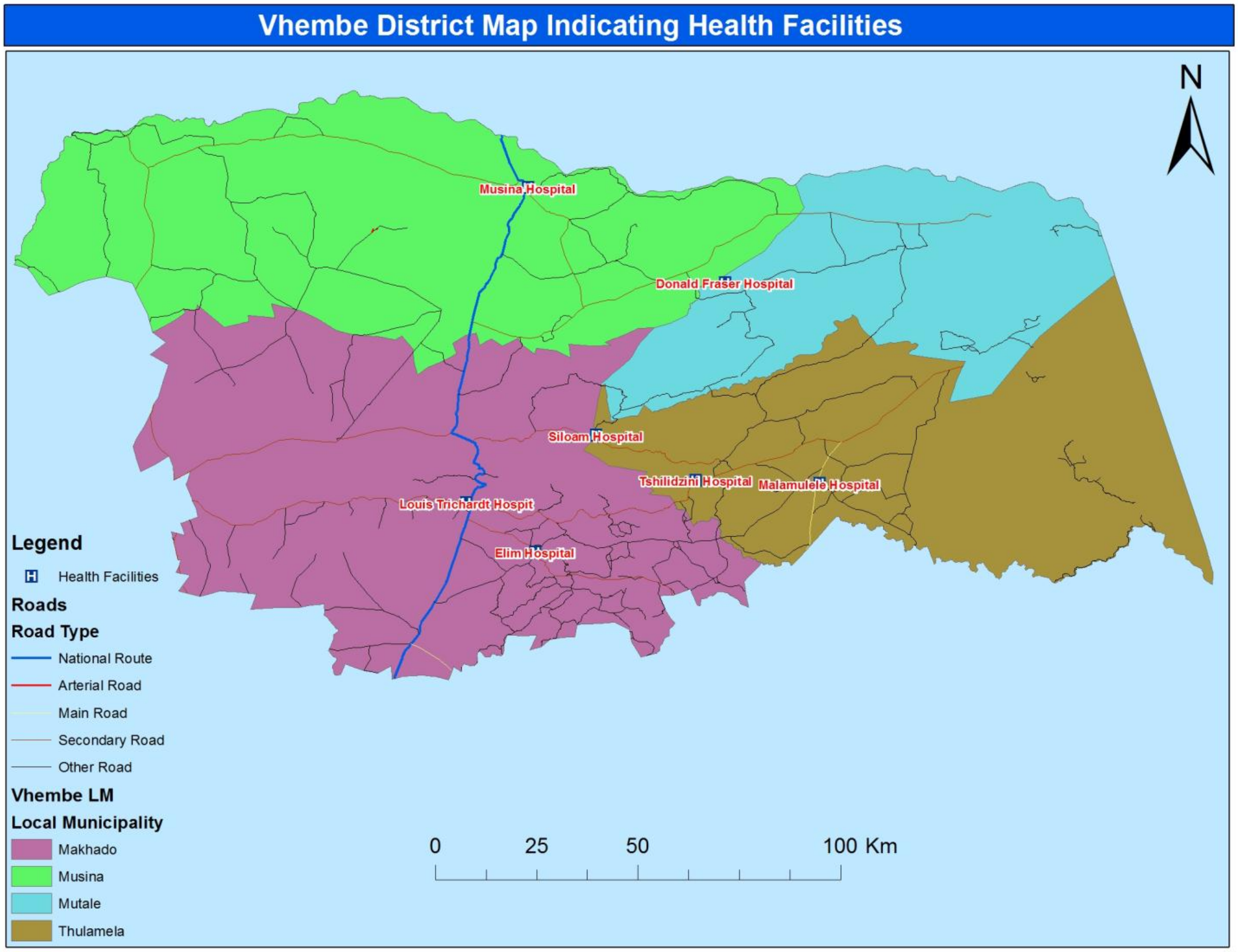

Figure 3.2: Vhembe district map with health facilities

The total population of Vhembe district is estimated at 1, 302, 113; the sub district populations are detailed as following:

Table 3.1: Population per local Municipality

Local municipality	Population	%
Thulamela	625 524	48.04
Makhado	534 531	41.05
Mutale	88 726	6.81
Musina	45 002	3.50
TOTAL	1, 302, 113	100.00

The four municipal areas are reasonably well served with health infrastructure such as Hospitals, Clinics, Community Health Centers, Mobiles clinics, Places of safety and Malaria camps. These medical facilities are however inadequate considering the size of the population.

General problems experienced at health facilities, particularly clinics as cholera is a concern, include: inadequate sanitation facilities, depletion and interruption of water source quality, Regular electrical interruptions, Shortage of essential medicines and equipments, and overcrowding of patients.

The rendering of efficient services is hampered by these factors, and also a shortage of staff and finances. The aforementioned factors posed a serious challenge during the cholera outbreak. It is also important to indicate that there are still communities which use traditional medicines for their ailments (traditional healers involved in the treatment of cholera). Religions, beliefs and customs also play an important role in the use of health services by the local communities.

The water and sanitation conditions of the whole of the Vhembe district, is characterized by most of villages that are served with communal taps from the boreholes. In some areas water is available through municipal taps but only intermittently. Therefore, the provision of water is limited and villages do not meet the RDP’s minimum standard of water provision. Many households do not have sanitation at RDP’s standards, and some households share common municipal latrines and sewage collects in open drains. Another alarming aspect is that communities in rural areas are not well educated on elementary personal hygiene. Thus, there is a high occurrence of water and sanitation related diseases such as Diarrhea, Malaria, Bilharzias, and scabies.

3.3 RESEARCH METHOD

A quantitative method was used because it is systematic and objective in its ways of using numerical data from a selected subgroup of a universe (or population) to generalize the findings to the universe that is being studied (Kobus, 2011). This method was used because the researcher was dealing with quantities or numerical data. It involved the gathering of measurable data and statistical analysis of that data. The researcher sought to prove the research questions. It is a quantitative-descriptive method used by the researcher, which required questionnaires in the form of a tool as a data collection method.

3.4 RESEARCH DESIGN

A research design is a plan according to which one obtains research participants (subjects) from whom data is collected from (Welman, Kruger & Mitchell, 2005). The design describes the intended program of action with the participants, with a view to reaching conclusions about a given research problem.

The purpose of a research design is to provide a logical framework upon which the research project is conducted and enables the researcher to gather evidence that will allow the research question to be addressed. It is a framework for the collection and analysis of data (David & Sutton, 2011). A retrospective cross-sectional study was used to determine the factors that contribute to the prevalence of cholera in Vhembe district.

3.4.1 Cross-sectional study

A cross-sectional design examines the relationship between diseases or other health-related characteristics and variables of interest as they exist in a defined population at one particular time, or over a short period (McMahon & Trichpoulos, 1996). Cross-sectional studies take a snapshot of a population at a single point in time and measure the exposure prevalence in relation to the disease prevalence.

In a cross-sectional design the researcher is concerned with selecting many cases on the basis of variation in identified characteristics, known as variables. An example is selecting individuals (cholera cases) by geographical area. A cross-sectional study is concerned with collecting data on more than one case at a single point in time and often referred to as the “social survey design” (David et al, 2011). The researcher carried out a cross-sectional study for the following three main reasons:

- To describe a population or a subgroup (cholera patients) within the population with respect to an outcome and a set of risk factors.
- To find the prevalence of cholera, for the population or subgroups within the population of Vhembe district at a given time point.

- To investigate the distribution of cholera by factors such as place, type of water sources, sanitation systems, hygienic practices, food sources etc...

3.4.2 Retrospective study

The study involves collecting data about a past event; the outcome has already occurred at the time the study is initiated. This study allows the researcher to formulate ideas about possible associations and investigate the relationships between cholera cases and variables such as age, gender, employment, hygienic practices, although causal statements should not be made. Furthermore, Uwe (2011) defines a retrospective study as a process of defining appropriate groups for comparison, justifying the boundaries of the time to be investigated, checking the research question, and deciding which historical sources and documents should be used (Uwe, 2011).

In this study, administrative databases and medical records about patients who are already known to have suffered from cholera were used. The study is concerned with giving a description of circumstances at the time of the research. The boundaries of time to be investigated were the period of cholera outbreak during 2008 and 2009, which occurred in Vhembe district.

3.5 POPULATION AND SAMPLING

3.5.1 Population

A population refers to the entire set of elements about which the researcher would like to make generalizations (LoBiondo-Wood & Haber, 2010). The target population consisted of all persons living in Vhembe district, that are 2 years or older who presented with the symptoms of sudden watery diarrhea, with or without vomiting.

De Vos (2005) furthermore describes a population as setting boundaries with regard to the elements or participants. This group may be studied for different reasons, such as the risk of getting a disease. In this study, the size of the population was 1, 160, written as N = 1, 160. This number represents the group of individuals or the total number of patients diagnosed with cholera available in the database.

The total population of Vhembe district is 1, 302, 113 with a population size of 550 as given by Morgan & Krejcie (1970). The baseline study population for this research project consisted of all patients of 2 years or older who presented with the symptoms of watery diarrhea (rice-water), dehydration, with or without vomiting, and diagnosed with cholera during the period of cholera outbreak (2008 and 2009) in all health facilities of the Vhembe district. The research period was extended to three more years until 2012 because isolated cases were reported later on after the outbreak at Elim and Louis Trichardt hospitals; this was to make sure that there are no cholera cases unreported in Vhembe district.

3.5.2 Sampling

According to Brink, Van der Walt and Van Rensburg (2012) a sample is a part or fraction of a whole, or a subset of a larger set, selected by the researcher to participate in a research study. A sample thus, consists of selected group of the elements or units of analysis from a defined population. The population "gives" the sample, and then it "takes" conclusions from the results obtained from the sample.

Sampling refers to the researcher's process of selecting the sample from a population in order to obtain information regarding a phenomenon in a way that represents the population of interest (Brink et al, 2012). However, due to the large sizes of population, researchers often cannot test every individual in the population because it is too expensive and time consuming. This is the reason why researchers rely on "sampling techniques". The Morgan and Krejcie (1970) sample size calculator gave a recommended sample size of 317 participants.

The study used two sampling methods namely, the stratified sampling and cluster sampling technique.

3.5.2.1 Stratified sampling

In this method of sampling, the population is divided into a number of homogeneous, non-overlapping groups, called "strata". An independent sampling (e.g. simple random or systematic sampling) is then conducted within each stratum. The four municipalities of the Vhembe district constitute each a stratum. Within a stratum the researcher extracted the strata. Seven strata were formed representing the seven hospitals of the Vhembe district. Stratified sampling is thus a probability sampling technique in which the researcher divides the entire population into different subgroups or strata, and then randomly selects the final subjects proportionally from the different strata (Explorable.com. 2009).

In this study, each identified hospital (subgroups) within the population of the Vhembe district is a “strata” represented by A, B, C, D, E, F, and G. A total number of patients’ records of 1, 160, which is the population size (N= 1, 160), from the seven identified hospitals and clinics covering the Vhembe district was used for the study.

The Morgan table was used from this population as noted n= 317 (Morgan & Krejcie, 1970). Equally important is the fact that for each stratum (A B C D E F G), the researcher used a simple random sampling method to determine the number of patients, using the sampling fraction of ½.

The following subgroups (strata) were formed in order to determine the sample size out of 1160 cholera patients: Makhado hospital (stratum A), Musina hospital (stratum B), Donald Frazer hospital (stratum C), Siloam hospital (stratum D), Elim hospital (stratum E), Tshilidzini hospital (stratum F), and Malamulele hospital (stratum G). Simple random sampling was conducted within each stratum and gives the following samples size for each subgroup: Stratum A, n_1 = 105; stratum B, n_2 = 109; stratum C, n_3 = 47; stratum D, n_4 = 22; stratum E, n_5 = 27; stratum F, n_6 = 3, and stratum G, n_7 = 2. The total sample size (n) = 317.

- **Types of stratified sampling**

There are two types of stratified sampling, these include: proportionate stratified random sampling and disproportionate stratified random sampling. In this study the proportionate stratified random sampling was used.

- **Proportionate stratified random sampling**

The sample size of each stratum in this technique is proportionate to the population size of the stratum when viewed against the entire population. This means that each stratum has the same sampling fraction.

For example, with 7 strata of 50, 100, 150, 200, 250, 300, and 350 population sizes respectively, and the researcher chooses a sampling fraction of ½; Then, the researcher must randomly sample 25, 50, 75, 100, 125, 150, and 175 subjects from each stratum respectively.

Table 3.2: Association strata with sample size

Stratum	A	B	C	D	E	F	G
Population Size	50	100	150	200	250	300	350
Sampling Fraction	½	½	½	½	½	½	½
Final Sample Size	25	50	75	100	125	150	175

The same sampling fraction for each stratum was used regardless of the differences in population size of the strata. It is much like assembling a smaller population that is specific to the relative proportions of the subgroups within the population (Explorable.com, 2009).

Following the example in table 3.2, the researcher obtained the final sample size for each stratum by using the sampling fraction technique of ½. The researcher randomly sampled 105, 111, 47, 22, 27, 3 and 2 subjects from each stratum as shown in table 3.3.

Table 3.3: Association population with sample size

Stratum	(A)	(B)	(C)	(D)	(E)	(F)	(G)
Population Size	210	222	94	44	54	6	4
Sampling Fraction	½	½	½	½	½	½	½
Final Sample Size	105	111	47	22	27	3	2

The seven strata are represented as follows: Louis Trichardt hospital (stratum A), Messina hospital (stratum B), Donald Frazer hospital (stratum C), Siloam hospital (stratum D), Elim hospital (stratum E), Tshilidzini hospital (stratum F) and Malamulele (stratum G).

- **Advantages of stratified sampling**

The advantages of stratified sampling include the following:

- Stratified random sampling is used when the researcher seeks to highlight a specific subgroup within the population. This technique was useful in this study because it ensured the presence of the key subgroups within the sample.

- With Stratified sampling, the researcher can representatively sample even the smallest and most inaccessible subgroups in the population. Therefore, this made it possible for the researcher to sample the rare extremes of the given population. In this study, stratum F and G were the smallest subgroups which were representatively sampled using the sample fraction ½.

- With this technique, there is a higher statistical precision compared to simple random sampling as the variability within the subgroups is lower compared to the variations when dealing with the entire population (Explorable.com, 2009).

3.5.2.2 Cluster sampling

Cluster sampling is similar to stratified sampling in the sense that the population is divided into a number of non-overlapping groups. However, these groups are usually much smaller than strata. They are called "clusters", and this method of sampling involves the random selection of a number of clusters from which either all elements or a randomly selected number form the sample (Kobus, 2011).

Cluster sampling can then be defined as a sampling technique used when "natural" but relatively homogeneous groupings are evident in a statistical population. In this technique, the total population is divided into these groups (or clusters) and a simple random sample of the groups is selected. Then the required information is collected from a simple random sample of the elements within each selected group. For cluster sampling to be effective, the clusters that are formed should be heterogeneous as the population. If this can be accomplished, then the few selected clusters will be representative of the population.

Cluster sampling is “area sampling” or “geographical cluster sampling”. Clusters consist of geographical areas. The clusters should be mutually exclusive and collectively exhaustive. Cluster sampling is used to estimate high mortalities in cases such as wars, famines, and natural disasters (Claire, Craig & Ashraf, 2006). In as far as cholera cases are concerned, the Cluster sampling technique enabled the grouping of patients according to their “geographical area” which are Makhado, Musina, Mutale and Thulamela municipalities. Patients’ records were also divided into their respective health facilities.

Four strata were formed by the researcher in relation with the four municipalities: Strata A (Makhado), Strata B (Musina), strata C (Mutale), and strata D (Thulamela). The researcher decided to use 50% of the overall patients in each stratum to determine the number of patients’ records for each cluster. Cluster A (Louis Trichardt hospital) = 210; Cluster B (Messina hospital) = 222; Cluster C (Donald Frazer hospital) = 94; Cluster D (Siloam hospital) = 44; Cluster E (Elim hospital) = 54; Cluster F (Tshilidzini hospital) = 6; Cluster G (Malamulele hospital) = 4. Simple random sampling was conducted within each cluster by using the sampling fraction (½) in order to obtain the final sample size for patients. From four strata which included the four municipalities, seven clusters were formed with regard to health facilities. The following figure represents different clusters with their sample size:

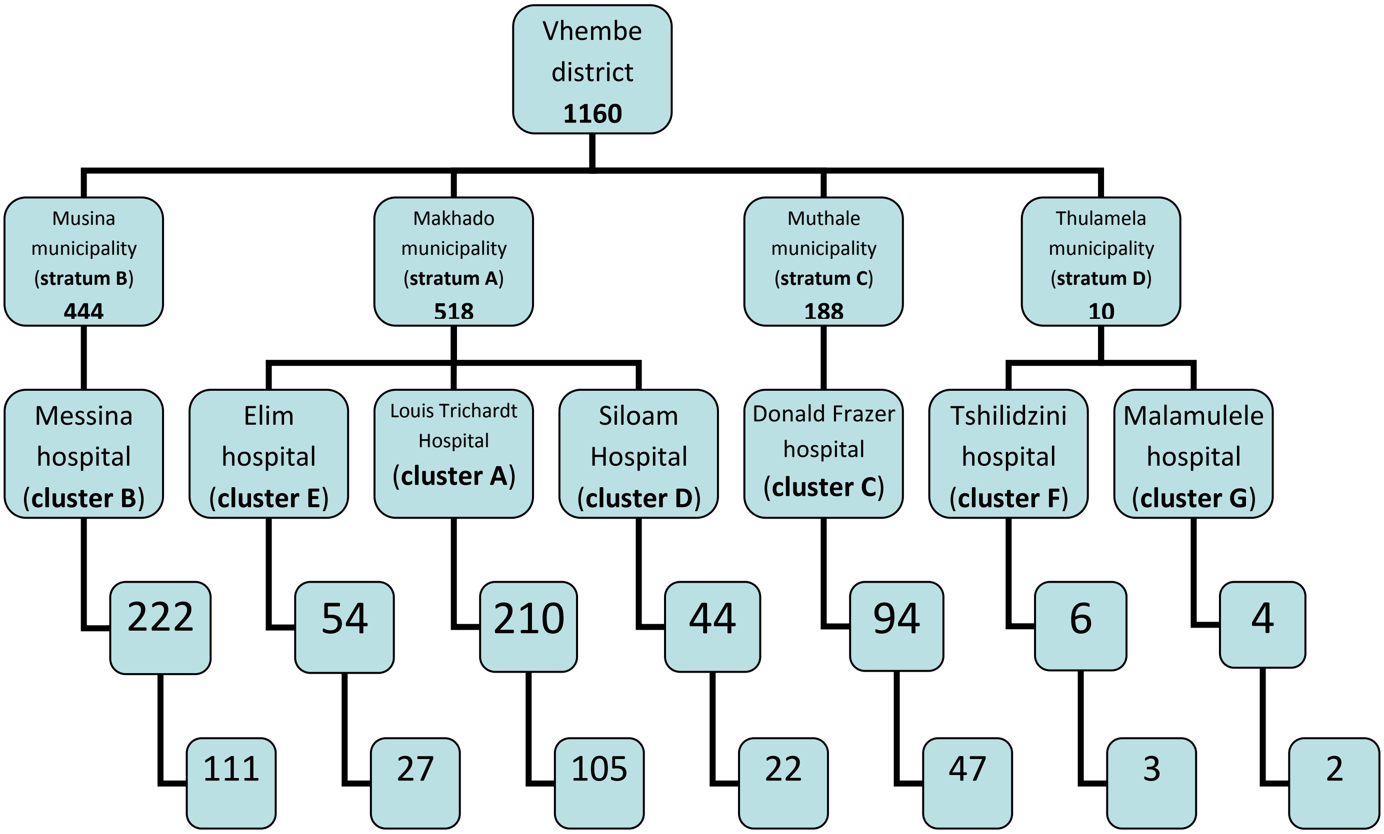

Figure 3.3: Cluster sampling for patients' records

Records of patients who had secretory watery diarrhea were 1827 in the Vhembe district. Out of 1827 records, 1160 were done laboratory tests to confirm the presence of Vibrio cholera in their stools. The laboratory tests results for other patients were still pending at the time of the research as indicated in patients' records. The 1160 patients' records were used as they showed evidence of positive results for cholera. In each cluster, systematic sampling was performed by considering every second patient's record when counting. The final sample size was obtained for each cluster as follows: cluster A (Louis Trichardt) = 105, cluster B (Messina) = 111, cluster C (Donald Frazer) = 47, cluster D (Siloam) = 22, cluster E (Elim) = 27, cluster F (Tshilidzini) = 3, and cluster G (Malamulele) = 2

3.6 INCLUSION AND EXCLUSION CRITERIA

3.6.1 Inclusion criteria

All patients of 2 years or older who presented with the symptoms of watery diarrhea (rice-water), dehydration, with or without vomiting, and diagnosed with cholera during the period of cholera outbreak (2008 and 2009) in all health facilities of the Vhembe district. The records of patients whose stools tested positive for Vibrio cholera were included in the study.

3.6.2 Exclusion criteria

The following patients' records were excluded from the study:

- Those who consulted for other medical reasons
- For children less than 2 years of age as more often they have diarrhea due to other pathogens such as Shigella, Salmonella, Escherischia coli and enteric viruses.
- Non-residents of Vhembe rural community
- Migrant persons including out-migration based on the place of destination.

3.7 DATA COLLECTION

Regardless of the field of study or preference for defining data, accurate data collection is essential for maintaining the integrity of research. A formal data collection process is necessary as it ensures that data gathered are both defined and accurate and that subsequent decisions based on arguments embodied in the findings are valid (Lescroel, Ballard, Gremillet, Authier, and Ainley, 2014).

A self-developed audit tool was used to collect data from patients' medical records, registries of reportable diseases and from database. Data included the following variables: age, gender, location, water sources, sanitation, hygienic practices, employment, ethnicity, size of household, and period of cholera occurrence.

Data was collected from records of patients in the seven hospitals of Vhembe district namely, Donald Frazer, Elim, Louis Trichardt, Malamulele, Messina, Siloam and Tshilidzini.

- **Data collection tool**

An audit tool for cholera outbreak was used by the researcher to collect data from medical records, registries of reportable diseases in each hospital of the Vhembe district and the provincial database. The audit tool was divided into two sections: Section 1 comprised the demographic data and section 2 focused on the clinical picture of cholera. The following parameters were investigated:

- Demographic data: location, type of settlements, nationality, health facility concerned, water and food sources, and type of sanitation;

- Biographic data: age, gender, ethnicity, religions, employment status, hygiene, size of household and period of occurrence and

- Clinical aspects: year of admission, clinical features, cholera confirmation tests, results and outcomes.

- **Data collection procedure**

The researcher used a data collection tool in order to gather relevant information on cholera outbreak**.** Patients' medical records and database were reviewed in Vhembe district health facilities. Data were collected over a period of 4 weeks which include the months of May and June 2014 in the light of the following methods:

Monthly surveillance data for diarrhoea between November 2008 and June 2009 covering the period of V. cholerae outbreak were compiled with the assistance of the infection control and environmental health officers of hospitals. In relation with the period of outbreak, information regarding any changes in the case definition, surveillance and population size was reviewed. A case was defined as the occurrence of acute watery diarrhoea, i.e. three or more loose stools per day, with severe dehydration admitted to healthcare facility among the residents of Vhembe district of 2 years or older between November 2008 and June 2009. Medical records from the selected hospitals were abstracted to collect information regarding the demographic data, biographic data and clinical aspects.

The line list that include information regarding name, age, sex, address and date of onset of acute watery diarrhoea for case patients with severe dehydration admitted to different healthcare facilities was collected using the tools which were specifically designed by the provincial epidemiologist to gather patients information during the outbreak; these collection tools were still available at the selected hospital at the time of this research. The outbreak was described over time, and information was collected using an audit tool.

3.8 DATA ANALYSIS

The analysis of data involves examining it in ways that reveal the relationships, patterns and trends. Data were captured, validated, edited, coded, entered and cleaned before analysis was done. According to Coakes and Steed (2009), the afore-mentioned steps are compulsory before data is analyzed. This study used Statistical Package for Social Sciences (SPSS) as the statistical software for data analysis. IBM SPSS 22 is software for performing statistical procedures in the social sciences field (Coakes & Steed, 2009).

Descriptive statistics were calculated to determine the frequencies and distribution of cholera cases in Vhembe district. Inferential statistics with Chi-square test was calculated to establish the relationship between variables such as settlements and the number of cholera cases, water sources and cholera cases. This statistical method was used as the study required correlation of exposure to risk factors and the development of cholera cases. Cross tabulation was used to determine the distribution of patients' records.

3.9 RELIABILITY AND VALIDITY

There is always a chance that some questions could cause problems, hence questionnaire testing is needed to identify and eliminate such problems (Sudman & Blair, 1998; Sattari, 2007). Reliability and validity are undoubtedly the hallmarks of good measurements and the keys to assessing the trustworthiness of any research study; this gives rise for the need to ensure validity and reliability.

3.9.1 Reliability

Reliability estimates the consistency of the measurement and the degree to which an instrument measures the same way each time it is used under the same conditions with the same subjects. According to Adams, Hafiz, Raeside and White (2007), reliability is a necessary condition for validity but not a sufficient condition on its own. Therefore, reliability is an essential pre-requisite for validity and refers to the consistency or stability of measure. Reliability is determined by a correlation coefficient or reliability coefficient (Last, 2001).

Reliability is concerned with the findings of the research and relates to the credibility of the findings. For a research instrument to be reliable, it has to produce valid results. Schindler and Cooper (2003), state that reliability is a necessary contributor to validity but it is not a sufficient condition for validity. This means that validity also has to be assured when conducting research.

In this study reliability was enhanced by using the supervisor of the study, as well as consulting a statistician to review the audit tool to ensure that all the required variables for the study were listed and well sequenced. The fact that open-ended questionnaires were minimized in the tool also enhanced reliability of the audit tool.

The stability and the similarity of a measurement over time and within a given time period was ensured in this study by pre-testing the audit tool using the records of cholera patients in Vhembe district, and the results remained the same throughout the study. Furthermore, an in-depth literature review was done prior to developing the data audit tool.

3.9.2 Validity

The validity of a research refers to the accuracy of the inferences, interpretations or actions that are made on the basis of quantitative data. In this study, the researcher sought to prove the research questions. Given that this research was interested in the relationship between the independent variables (water sources, sanitation, food sources, and hygienic practices) and the dependent variable (cholera), Pearson’s test was used for correlation.

According to Last (2001), Validity evidence includes content-related evidence, internal structures, and relation to other variables. Validity refers to whether an instrument actually measures what it is supposed to measure given the context in which it is applied. To ensure content validity in this study, the audit tool was given to the supervisor who went through it to check if it covered what the researcher intended to find out. The audit tool was also submitted to a provincial epidemiologist and it was found to be valid. The university statistician was also consulted to evaluate the audit and carry out statistical tests on the validity of the questionnaire comprised in the data collection tool, and the audit tool was found to answer the research questions. The audit tool was also pre-tested before it was used to collect data and a comprehensive literature review was done. In addition, laboratory tests for cholera confirmation which were conducted at the local laboratory enhanced the validity of the study.

3.10 PILOT STUDY

According to Welman, et al, (2005), the pre-testing of a questionnaire involves trying it out on a limited number of subjects who have characteristics similar to those of the target population that the main project is intended to involve. Pre-testing of the audit tool was done for patients' records in different areas of Vhembe district. This was considered essential in order to determine if the audit tool was accurate enough in the collection of the data related to the study. With the assistance of the infection control officer and information and records keeping officer of the selected hospitals, pre-testing the audit tool was done using 30 medical records in April 2015; 10 in Musina, 12 in Makhado, 6 in Muthale, 2 in Thulamela. The 30 records used in the pilot study were excluded from the main study.

The results of the pilot study led to the following corrections:

- Hayani hospital initially selected for the study was excluded because it did not receive any case of cholera. It is exclusively a psychiatric hospital.
- Fountains were used by many patients as source of drinking water. Therefore, the item of fountains was added on the audit tool.

- The employment status was added to the tool as shown the patients' records. Therefore, the level of education was deleted from the audit tool as this was not written in patients' records.

- It was essential to list the sources of drinking water in order to identify which one could be involved in the transmission of cholera, rather than grouping them as safe and unsafe water source.

- Patients' religions were found to be irrelevant to the study; thus Pearson chi-square tests could not be computed to establish any relationship with cholera. Religions are presented as descriptive data. People were infected regardless of their religions because the bacteria V. cholera does not choose whether a person is a Christian, Muslim or not.

3.11 ETHICAL CONSIDERATIONS

It is important that ethical guidelines should be followed when conducting research. Ethics deal with the development of moral standards that can be applied to situations in which there can be actual or potential harm to any individual or a group. They are of particular concern to the researcher because their success is based on public cooperation (Hall & Roberts-Lombard, 2002).

Researchers have some general obligations to people who provide data in research studies and these include the obligation not to harm, force or deceive participants (Hall & Roberts-Lombard, 2002). Ethics were crucial for the successful accomplishment of this research work. Therefore, the following five ethical issues were taken into consideration in order to get approval to conduct the study:

- Ethical clearance was obtained from University of Limpopo Medunsa Campus Research and Ethics Committee (MREC), (Appendix 2).

- Approval to conduct the study in various hospitals of Vhembe district was granted by the Head of the Department of Health, Limpopo Province (Appendix 3).

- Permission to use patients' records and medical database was given by the Hospitals managers.

- The study, even though a retrospective study that used the document reviews methodology, did not mention any of the patients' names. Anonymity was assured by omitting the subjects' identifying particulars such as names and addresses. A coding system was used instead. Age group and gender were added for statistical purposes.
- When reporting data, codes and pseudonyms were utilized in order to ensure confidentiality.

3.12 CONCLUSION

This chapter discussed the research design, the study site, study population and the sampling methods. This chapter highlights the different methods applied in the execution of the study, whereby the research sample was selected through random sampling. Also considered in the chapter were inclusion and the exclusion criteria, the data collection methods, pre-testing of the audit tool, data analysis, reliability, validity and ethical considerations. The next chapter discusses the findings of the study.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The previous chapter discussed how the research was undertaken. The purpose of this chapter is to present and discuss the empirical findings of this research. The discussion of the results is divided into demographic and clinical aspects of the study. Presentation of results is done through the use of tables and figures. This chapter also provides answers to the objectives of the study and the research questions.

4.2 DEMOGRAPHIC RESULTS

4.2.1 Municipalities

Table 4.1: Cholera cases per municipality

Municipalty	frequency	(%)
Makhado	154	48.6
Musina	111	35.0
Mutale	47	14.8
Thulamela	5	1.6
Total	**317**	**100.0**

Table 4.1 shows that Makhado municipality was the most affected area with 48.6% of cholera cases, followed by Musina the entry gate with 35%. A majority of the cases, amounting to 83.6%, were found in the Musina–Makhado municipalities' corridor. Mutale and Thulamela municipalities had respectively 14.8% and 1.6%. Chi-square tests were performed for a possible relationship or association between the local municipalities and the number of cholera cases.

The following table 4.2 includes the four municipalities of the Vhembe district, the number of cholera cases and the chi-square results. The researcher sought to discover if there is an association between municipalities and the occurrence of the outbreak. The fact that these municipalities are rural with poor living conditions could have contributed to outbreak.

Table 4.2: Comparison of cholera cases by municipality

Location (Municipality)	**Cholera cases**	**Pearson chi-square**
Makhado	154	
Musina	111	
Mutale	47	
Thulamela	5	
Total	**317**	**0.005 (p<0.05)**

The results from using the chi-squared test for the 4 municipalities in comparison with the number of cholera cases show p=0.005, which is less than required p-value of 5% (p=0.05). Therefore, this implies that local municipalities in the Vhembe district had an association with the number of cholera cases.

More cases were found in the Musina – Makhado municipalities' corridor, probably due to their geographical position on the N1 road and Musina being the gateway to South Africa. These areas have a high population density, and according to the WHO, overcrowded communities with poor sanitation and unsafe drinking water supplies are most frequently affected by epidemics (WHO, 2015a).

The outbreak of cholera arose from Zimbabwe the neighboring country in the northern part of South Africa. Infected people crossed the border, facilitating the spread of V. cholerae to new areas in the Musina – Makhado municipalities' corridor and the Muthale municipality. The outbreak, from these initial areas, invaded the rest of the Vhembe district. The study found a relationship between these areas with the number of cholera cases probably because of the fact that they are the entry point in Vhembe district of Limpopo province. These rural municipalities have a generally high population density, poor hygienic practices among villagers, and poor sanitation and water condition in the villages and farms. The association between municipalities and cholera cases is likely due to socio-environmental risk factors at the neighborhood scale, such as water and sanitation environments and population density (Sophia et al, 2010).

A majority of people living in these areas are poor and have low socio-economic status. It was established that the consumption of high-risk food, impure water and poor sanitation, correlate with a low socio-economic status and poverty. Thus, one's economic status plays an important role in cholera transmission (Sack et al, 1999).

4.2.2 Health facilities

Vhembe district has seven (7) health facilities (hospitals hospitals and these were selected for the survey. Data collected was organized according to the receiving health facility. Makhado municipality, covered by three health facilities (Elim, Louis Trichardt and Siloam hospital), received more patients (154 cases), followed by Musina municipality (111 cases) which is served by only one health facility (Messina hospital). Mutale municipality, serving as second entry point of Zimbabwean cholera patients received 47 cases at Donald Frazer hospital.

The following table 4.3 indicates the frequencies and percentage of cholera cases per health facility within the municipality.

Table 4.3: Distribution of cholera cases per health facility within municipalities

Health facilities	Location (Municipality)				Total
	Makhado	Musina	Mutale	Thulamela	
Donald Frazer hospital			47		47 (14.8%)
Elim hospital	27				27 (8.5%)
Louis Trichardt hospital	105				105 (33.1%)
Malamulele hospital				2	2 (0.6%)
Messina hospital		111			111 (35.0%)
Siloam hospital	22				22 (6.9%)
Tshilidzini hospital				3	3 (0.9%)
Total	**154**	**111**	**47**	**5**	**317 (100%)**

Messina hospital represented 35% of the recorded cholera cases, followed by Louis Trichardt hospital with 33.1% because of their geographical position at the border for Messina and along N1 road for Louis Trichardt hospital. Donald Frazer hospital accounted for 14.8% of the cases. Tshilidzini and Malamulele hospital had respectively 0.9% and 0.6% of the recorded cases.

The health facilities situated in Musina and Makhado municipalities namely Messina, Elim, Louis Trichardt and Siloam hospitals respectively had more cholera cases. This is probably due to the fact that in these municipalities, there are farms, refugee camps, and increased population density in the villages. In addition, these municipalities experience rapid urbanization, which is significant for the study as noted by Nevondo and Cloete (2001) that, cholera occurs in epidemic form when there is rapid urbanization without adequate sanitation and access to clean drinking water.

4.2.3 Settlements

Most of the cholera cases were found in the villages and farms, with the statistics of 83.6% and 12.9% of cholera cases, respectively. Among the 317 cholera cases, 265 were found in the villages (83.6% confirmed cases), and 41 in the local farms (12.9%). Town and refugee camps had 4 cholera cases each and Tshikota Township, in Louis Trichardt, had 3 cases only. The following figure 4.1 represents the distribution of cholera cases in the different settlements of the Vhembe district.

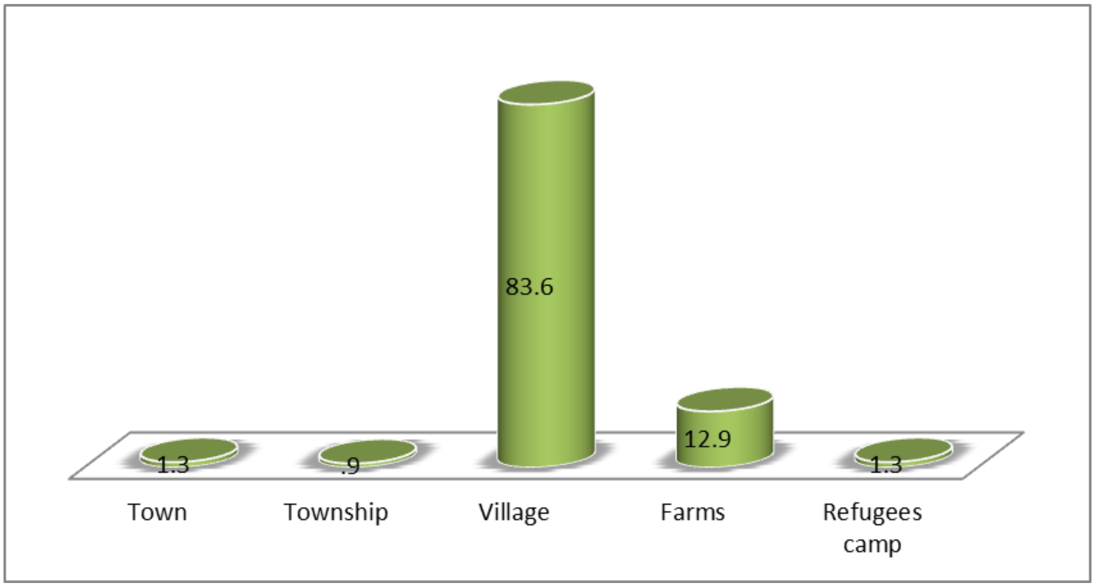

Figure 4.1: Distribution of cholera cases per local settlements

Pearson Chi-squared tests were calculated to establish the relationship/ association between settlements and the number of cholera cases. The table 4.4 indicates the comparison of cholera cases with settlements and the Pearson chi-square test results.

Table 4.4: Comparison of cholera cases by settlements.

Settlements	Cholera cases	Pearson Chi-square
Town	04	
Township	03	
Villages	250	
Farms	41	
Refugee camps	04	
Total	**317**	**0.001 (p<0.05)**

The Chi-square test in table 4.4 shows p=0.001, less than required p-value of 5% (0.05). Therefore, this implies that settlements in the Vhembe rural communities have an association with cholera cases.

According to Sophia, et al (2010), cholera is transmitted mostly through the local environment rather than through person–to–person. There is an increase in population density in the settlements shown in table 4.4 as a result of massive migration from other African countries. Inadequate sanitation systems, lack of access to safe drinking water and poor hygiene are the challenges faced in these settlements.

The acute severe watery diarrhea outbreak which started in the second week of November 2008 was caused by V. cholerae 01 El Tor Ogawa. Vibrio cholerae is a free-living bacterial flora that survives better in saline water (Sanyal, 2000). The massive migration of Zimbabwean citizens in South Africa following a devastative outbreak led to the acute scarcity of safe drinking water and poor sanitation facilities. The unhygienic environmental situation, open-air defecation practice and dense population in temporary shelters increased the risk of cholera outbreak.

The study also demonstrated a possible relationship between cholera cases and the variables “Settlements” and “Health facilities within local municipalities”. With regards to settlements, a majority of the cholera cases were found in the villages at 83.6%, and farms at 12.9% of cholera cases. The association was established with cholera cases because these settings have inadequate sanitation systems, poor hygiene practices, poor food and water handling practices. Supply continuity of water is still a major problem in some of the villages, and people who do not have boreholes sourced it from the available neighbors' boreholes. In the situation where they do not have money to buy water from the few privileged people who have boreholes, they will then rely on the available contaminated water from the surrounding streams.

The Vhembe district is also covered with many farms that lack adequate sanitation and water conditions. The source of water is mainly the surrounding streams, and in some of the farms there is no sanitation system; open-air defecation would be the only option. Refugee camps were found to have less cholera cases (1.3%); this is probably due to the fact that most of the refugees pass the refugee camps when entering South Africa in order to avoid what they call "police harassments". They will be easily mixed with the villagers and also they prefer to settle in farms where they have jobs for their survival.

4.2.4 In-migrations/nationality

The cholera cases were distributed according to the country of origin of the patients. This is because the movement of people between Southern African countries and from province to province was responsible for the spread of the cholera strain to new areas.

Although cholera infection in the Vhembe district was known to be imported from the affected neighbouring country, South African citizens were the most infected by the virus with 215 cholera cases (68%) reported against 102 cases (32%) for foreign nationalities. Results are indicated in the figure 4.2:

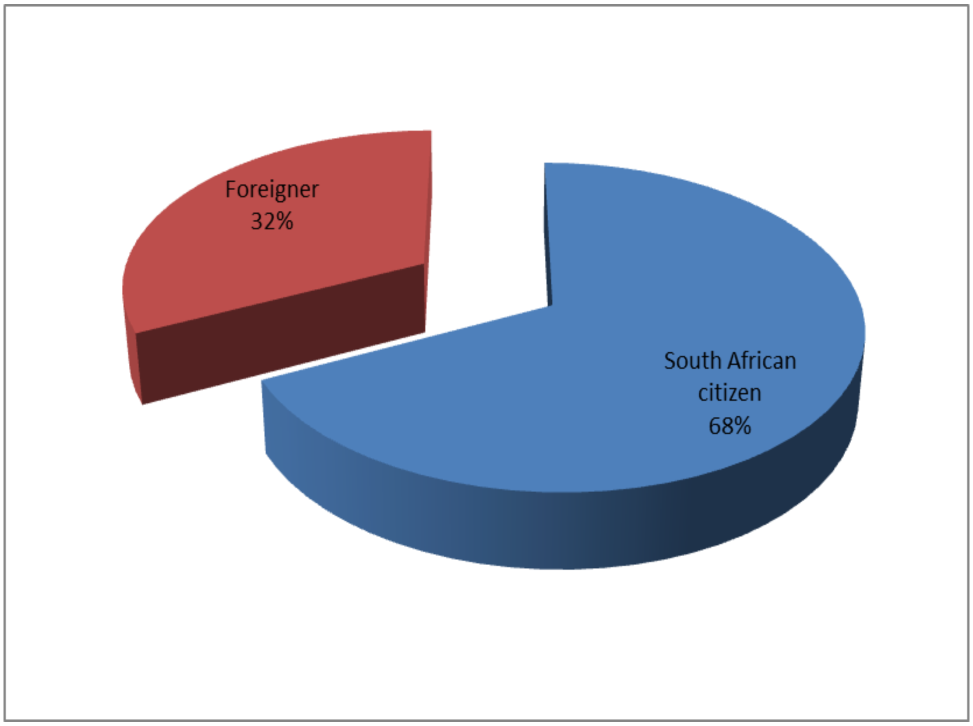

Figure 4.2: Distribution of cholera cases per nationalities

Figure 4.2 shows the distribution of cholera cases among South African citizens (68%) and Foreigners (32%). Pearson Chi-squared test was used to determine if there could have been an association between the variables cholera cases and in-migrations. The results are shown in table 4.5 which includes the South African citizens, foreigners and the result of Chi-square test.

Table 4.5: Comparison cholera cases by In-migrations

In-Migrations	**Cholera cases**	**Pearson chi-square**
South African citizens Foreigners	215 102	
Total	**317**	**0.177 (p<0.05)**

The Chi-square test was calculated in order to establish an association between In-migrations with cholera cases shows p=0.177, greater than required p-value of 5% (0.05). Therefore, this implies that in-migrations in Vhembe district have no impact on/association with cholera cases in this study.

4.2.5 Water sources

The study areas drinking water sources comprises mainly the rivers, streams, dams, boreholes, fountains and tap/piped water. The following figure 4.3 presents the distribution of cholera cases associated with drinking water sources:

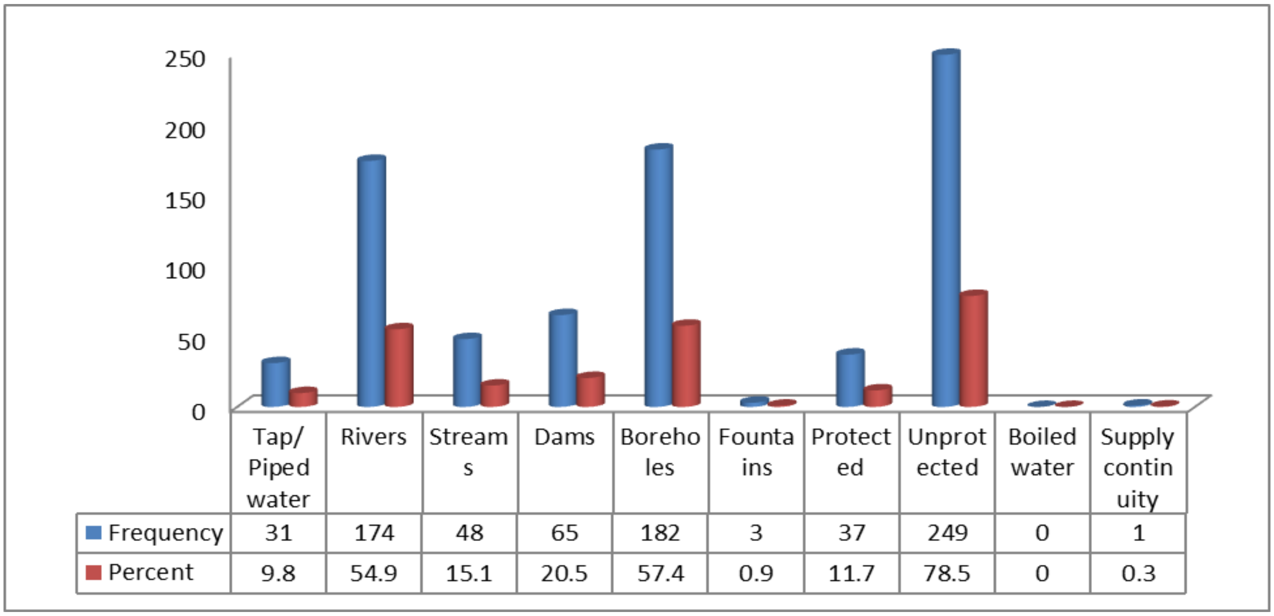

Figure 4.3: Association of water sources with cholera cases

The figure 4.3 indicates that all patients do not boil water for drinking purposes. Most of the people (78.5%) used water from rivers (54.9), and streams (15.1%). Boreholes were found in some villages at 57.4%. Water supply from piped/tap systems represented only 9.8%.

Chi-squared tests were used in the study to demonstrate the relationship between water sources of drinking water and the number of cholera cases. The figure 4.4 represents the distribution of water source divided into unsafe water source at 90%, and safe drinking water source at 10%. In this study, tap/piped water and boreholes are regarded as safe water (protected), whereas water from rivers, streams, dams and fountains are unsafe because they are not protected.

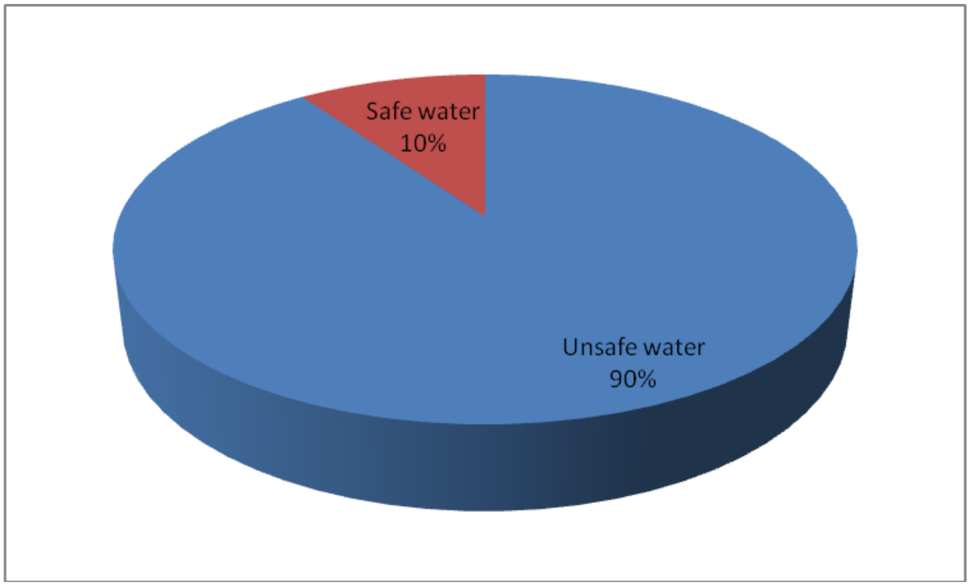

Figure 4.4: Distribution of safe and unsafe water sources

Chi-squared test was used for the water sources in order to establish whether these sources could have the cause of the cholera outbreak. The following table 4.6 includes the water sources, cholera cases and Pearson chi-square results.

Table 4.6: Comparison of cholera cases by water sources

Water sources	Cholera cases	Pearson chi-square
Tap/piped	31	0.163 (p>0.05)
Rivers	174	0.243 (p>0.05)
Streams	48	0.001 (p<0.05)
Dams	65	0.121 (p>0.05)
Boreholes	182	0.058 (p>0.05)
Fountains	3	0.679 (p>0.05)
Total	**503**	

Table 4.6 shows the sources of water shown on the patients' records. The total is 503, more than 317 as 186 records showed more than one source of water. The Chi-square test was calculated and showed that p=0.163, greater than required p-value of 5% (0.05%). Therefore this implies that tap/piped water did not have an impact on/association with cholera cases. The association between water source and cholera was only established with the streams; the p-value of 0.000 is less than required p-value

of 0.05 %. Consequently water from streams had an impact on/association with cholera cases in this study. The other water sources had a p-value greater than p of 5% (>0.05%); this include boreholes, rivers, dams and fountains. Therefore, there was no association with cholera cases.

Though a large number of cholera cases were observed in people who drank water from unsafe sources, people who drank water from safe water sources (tap and boreholes) were also affected by V. cholera bacteria and developed the infection. They could have been infected from other sources; the transmission could have occurred either directly from person – to – person by the fecal-oral route, or indirectly by infected food or water (Dion, 1995). Furthermore, according to Bhunia and Soughata, several cholera outbreaks from various countries have been reportedly associated with contaminated piped water and poor sanitation (Bhunia & Sougata, 2009).

The Chi-square test was computed for the various water sources because it was believed that the common cause of infection at the time of outbreak was drinking water source. Epidemiological investigations indicated that this outbreak was waterborne; people were drinking water from the Limpopo River, Sand stream and Mutale River in Musina, and Nwanedi river in Madimbo. A number of components suggested that unsafe drinking water accounted for a number of cases during the outbreak of cholera. First, there was an association between consumption of water from unsafe sources such as rivers, streams, dams and cholera. Second the distribution of probable cases over time suggested that water from streams and probably boreholes at 50% supply partially explained the outbreak. Unsafe water (streams) and food handling practices might have played key role in this outbreak as demonstrated by the Chi-square test. The cholera outbreak was reported in areas without piped water systems such as villages, farms and townships which are surrounded by streams.

Changes in human behaviour, intermittent piped water supply, and ecology have a key role in the emergence of cholera outbreaks (Codeco, 2001). Unsafe water and food handling in the community led to a number of cholera cases. Stored water was significantly associated with the disease, especially when the stored water was contaminated with faecal coliform and not chlorinated at household level (Gupta et al, 2007).

4.2.6 Sanitation systems

Lack of adequate sanitation systems in most of the areas visited is still a major challenge. According to the WHO, cholera outbreaks can occur sporadically in any part of the world where water supplies, sanitation, food safety and hygiene practices are inadequate (WHO, 2015b). The type of sanitation was indicated in patient's collection forms which were designed at the time of cholera outbreak. The table 4.7 presents the frequency distribution of cholera with the type of sanitation.

Table 4.7: Distribution of cholera cases per sanitation types

Sanitation types	Frequency	%
Presence of sanitation services	2	.6
Absence of toilets	93	29.3
Pit latrine	221	69.7
Others	1	.3
Total	**317**	**100.0**

The majority of patients' records revealed inadequate sanitation systems; 69.7% use Pit latrines and 29.3% do not have toilets at all. A Pearson Chi-squared test was used to establish whether there is a relationship between cholera cases and sanitation. The following table 4.8 includes the types of sanitation, cholera cases and the results for Pearson Chi-square test.

Table 4.8: Comparison of cholera cases by sanitation types.

Sanitation types	**Cholera cases**	**Chi-square**
Presence of sanitation services	02	0.982 (p>0.05)
Absence of toilets	93	
Pit latrines	221	
VIP latrines	01	
Total	**317**	

The results of Chi-square test show that p=0.982, greater than required p value of 5% (0.05%). Therefore, this implies that sanitation in this study did not have an association with the cholera cases. This raises the need to analyze the types of sanitation separately in order to identify which one could have been associated with cholera outbreak. Table 4.9 gives the different chi-square results for the different types of sanitation.

Table 4.9: Comparison of cholera cases by sanitation types.

Sanitation types	**Cholera cases**	**Chi-square**
Presence of sanitation services	02	0.485 (>0.05)
Absence of toilets	93	0.016 (<0.05)
Pit latrines	221	0.094 (>0.05)
VIP latrines	01	0.387 (>0.05)
Total	**317**	

Pit latrines are used in most of the villages; this might have contributed positively in limiting the chain of transmission. The use of chi-square test shows p=0.094, which is greater than required p-value of 5% (0.05%). This implies that Pit latrines did not have an association with cholera cases in this study. At the other hand the absence of toilets was found to have an association with cholera. The p-value of 0.016 is less than required value of 0.05%. Therefore, this implies that the absence of toilets has an impact on/association with cholera cases.

The spread of the bacteria could have occurred also from other sources such as contaminated water or food, or even through direct transmission from person-to–person. Chi-square test has established that the route of contamination of the outbreak was waterborne by drinking contaminated water from the stream, and also by person-to-person transmission, which was evident through inadequate hygiene practices. Whilst there was no evidence to explain the sequence of the outbreak, the environmental assessment suggested possible circumstances. Patients affected during the first phase of the outbreak (15 November to 31st December 2008) excreted the pathogen in the environment. The background of poor sanitary situation and intermittent water supply pattern increases the risk of intake of contaminated water. Moreover, open-air defecation is a common practice in these remote rural areas and represents 29.3% of the population; thus, facilitating rapid transmission.

4.2.7 Food sources

Contaminated food has also been identified as a risk factor for a cholera outbreak. In these areas people get their food from different sources such as small restaurants along the street, shops, street vendors, and from public gatherings such as funerals and weddings as reported at the period of outbreak. A majority of the people cooks their own food, but that does not exclude them for eating food from other sources. The results of the investigation are presented in figure 4.5.

Figure 4.5: Distribution of food sources with cholera cases

The people who cook their food represent 96.2% and 76% rely on food from shops and street vendors. A further 10.7% of the people received food from funerals. These food sources were indicated in patient's form on admission at the hospital. The Pearson chi-squared test was used to establish the relationship between cholera cases and food sources. The results of Chi-square tests, as well as the association of food sources with cholera cases are shown in table 4.10 as follows:

Table 4.10: Comparison of cholera cases by food sources.

Food sources	**Cholera cases**	**Pearson chi-square**
From shops	241	0.017 (<0.05)
From Funeral	34	0.142 (>0.05)
Self-cooked	305	0.401 (>0.05)
Total	**580**	

Table 4.10 shows a total of 580 instead of 317 or less, as 263 patients' records for more than one food sources. The results of Chi-square test show that food from shops had p=0.017, less than required p of 5% (0.05%). Therefore, this implies that food from shops in this study had an impact on/association with the cholera cases. With regard to

food from funerals, the results of Chi-square test show that p=0.142, greater than required p of 5% (0.05%). Therefore this implies that food from funeral in this study did not have an impact on/association with the cholera cases; whereas the use of Chi-square test in order to establish the relationship between self-cooked food and cholera cases shows that p=0.401, greater than required p of 5% (0.05%). Therefore, this implies that self-cooked food did not have an impact on/association with the cholera cases in this study.

It appears to be a paradox because the results have shown that 96.2% of the people cook their own food, yet they were still infected with cholera disease. In this case the source of infection had to be found elsewhere such as contaminated food from other sources such as street sellers and small restaurants, also contaminated drinking water and direct transmission from other infected persons owing to inadequate hygiene practices (Mugero & Hope, 2001).

In addition, poor food handling might have played an important role in the transmission of the bacteria. Contaminated food from funerals and other public catering (10% of cholera cases), shops and street sellers (76% of cholera cases) was significantly associated with the disease. Chi-square test pointed to the food from street sellers, shops and small restaurants as the source of contamination.

4.3 BIOGRAPHIC DATA

4.3.1 Age

Cholera cases in the rural communities of the Vhembe district were distributed according to the age groups. The results indicated that the cases were predominant among people of more than 15 years of age with 88.3% of the cases. For children less than 5 years and between 5–15 years, cholera cases are equally distributed representing 6% for each group. The distribution of cases per age group is shown in the following table:

Table 4.11: Distribution of cholera cases per age group.

Age	Frequency	%
2 - 4 years	19	6.0
5 - 15 years	18	5.7
>15 years	280	88.3
Total	**317**	**100.0**

Chi-square test was calculated with regard to the relationship between the age of patients diagnosed with cholera disease and the disease itself. Table 4.12 shows the association of the age groups with cholera cases and the results of Chi-square test:

Table 4.12: Comparison of cholera cases by age groups.

Age groups	**Cholera cases**	**Chi-square**
2 - 4 years	19	0.687
5 – 15 years	18	
> 15 years	280	
Total	**317**	**0.687 (>0.05%)**

The results of Chi-square test shows that p=0.687, greater than required p of 5% (0.05). Therefore, this implies that age groups did not have an impact on/association with the cholera cases. People were infected through contaminated food and water, and also through direct contact with an infected person, regardless of their age. According to Steffen, et al (2003), the incidence of cholera in endemic areas is highest in children, and decreases with age due to acquired immunity. In non-endemic areas, cholera prevalence is not age–dependent, as the majority of the populations have no immunity to the bacterium. Therefore, the association of age groups with cholera cases could not be established in this study because the Vhembe district is a non-endemic area.

4.3.2 Gender

In this study cholera cases seem to be equally distributed among male and female patients, thus gender does not have an impact on/association with the cholera outbreak. The distribution of cholera cases per gender is represented in figure 4.6:

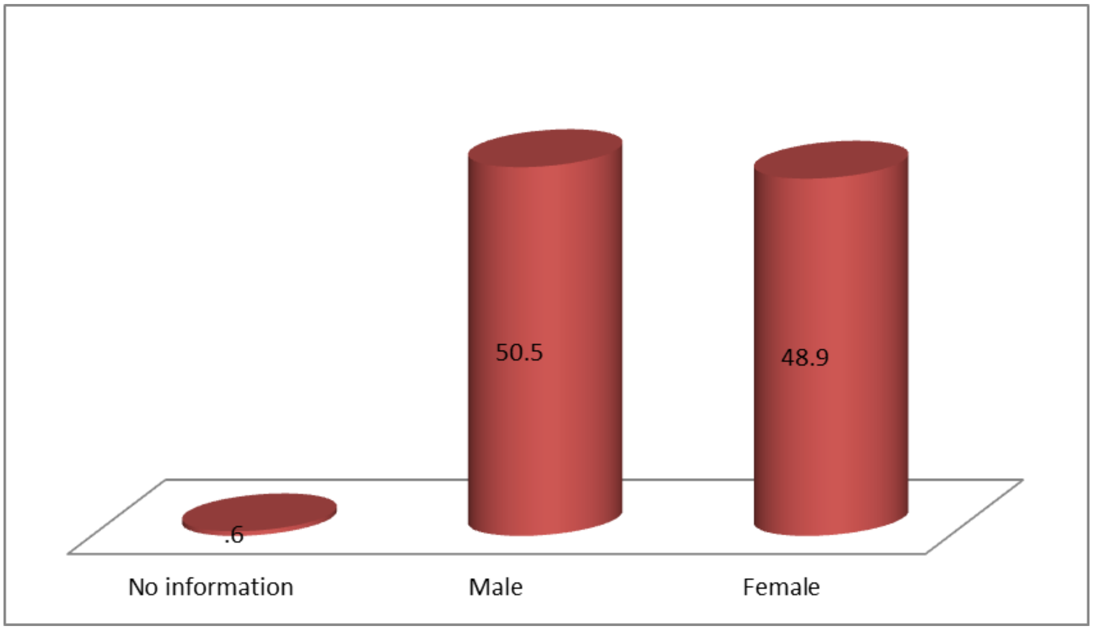

Figure 4.6: Distribution of cholera cases per gender

Figure 4.6 shows that the male and female patients were infected at equal proportion, with slight increase of 1.6% for male. Cholera cases were respectively 50.5% for male and 48.9% for female, with a minimal difference between the two genders. The researcher could not get information for 0.6% with regard to gender with cholera cases.

Chi-square test was calculated in order to establish the relationship between the gender and number of cholera cases. The following table 4.13 represents the association of gender with cholera cases and the results of the chi-squared tests.

Table 4.13: Comparison cholera cases by gender

Gender	Cholera cases	Chi-square
No information	02	0.237
Male	160	
Female	155	
Total	**317**	**0.237 (>0.05%)**

The results show a Chi-square test p-value=0.237, greater than 5% (0.05). Therefore, gender does not have association with cholera cases in this study. People are infected regardless of gender, which explains the apparent equal distribution of cholera cases in this study (50.5% for male and 48.9% for female).

In addition, the age distribution of patients differed substantially in these epidemics of V. cholerae 01 in these locations where most of the patients were adults. There was also not much difference between male and female patients as shown in table 4.13. The following table 4.14 includes age groups and gender with cholera cases.

Table 4.14: Age and gender distribution of patients with cholera

Age (years)	No of patients (% in each age/gender category)	
	Vhembe district (n = 317)	
	Male	Female
2- 4 years	09 (2.83%)	11 (3.47%)
5-15 years	12 (3.78%)	06 (1.89%)
>15 years	139 (43.8%)	138 (43.5%)
Total	**160 (50.5%)**	**155 (48.9%)**

4.3.3 Ethnicity

This study also shows that ethnicity plays an important role in the transmission of cholera. In this study, a majority of the patients were Black people, mostly living in places with poor sanitation conditions and inadequate hygienic practices. The results are represented in the following table:

Table 4.15: Distribution of cholera cases per ethnicity

Ethnicity	Frequency	%
Black	314	99.1
White	2	.6
Indian or Asian	1	.3
Total	**317**	**100.0**

The majority of the people affected by cholera infection during the outbreak were blacks, representing 99.1%. Whites and Indians (Asians) represented 0.6% and 0.3 % of cholera cases respectively.

4.3.4 Religions

In this study cholera cases were classified with regard to the religions of the participants. This is because religion, customs and beliefs remain a major challenge in the Vhembe district as far as cholera is concerned. Some people still rely on traditional healers for their ailments, for instance; thus, these parameters could facilitate the transmission of cholera and also could have an impact in the reporting systems. A number of cases could remain unreported. The following table 4.16 represents the number of cholera cases per religion:

Table 4.16: Distribution of cholera cases per religions

Religions	Frequency	%
Christian	284	89.6
Muslim	14	4.4
Other	19	6.0
Total	**317**	**100.0**

In this table, the majority of patients were Christians with 89.6%; other religions represented 10.4%, respectively Muslim with 4.4% and other 6.0% .

Religions, customs and beliefs are still a big challenge in the Vhembe district in particular and in South Africa in general. People consult traditional healers when they are sick rather than going to hospitals. This has a negative impact on the number of cases that get reported. The study demonstrated that there was no relationship between the variable “religions” and the number of cholera cases. The nature of religions has no relationship with cholera cases. Everybody, regardless of his religion, should follow the principles of good hygiene, and stay away from contaminated drinking water sources and food to avoid or prevent cholera infection.

4.3.5 Employment status

The employment status which determines the socio-economic status of the patient was also investigated as a risk factor associated with the occurrence of cholera infection. Patients were classified in 4 groups as indicated in the following table 4.17 which represents the frequency distribution of cholera in relation to the employment status.

Table 4.17: Distribution of cholera cases per employment status

Employment status	Frequency	%
Unemployed	201	63.4
Employed	74	23.3
Self-employed	9	2.8
Student	33	10.4
Total	**317**	**100.0**

Table 4.17 shows that 63.4% of the population did not have jobs; 26% were employed and students represented only 10.4% of the overall cholera cases.

Chi-square test was used to demonstrate that there could be a relationship between employement status and cholera. The results of Chi-square test obtained from this aspect of the study are shown in table 4.18 which also include the association of employment status and cholera cases.

Table 4.18: Comparison of cholera cases by employment status

Employment status	Cholera cases	Chi-square
Unemployed	201	0.811
Employed	74	
Sel-employed	9	
Student	33	
Total	**317**	**0.811 (>0.05%)**

The results of the Chi-square test shows p=0.811, greater than required p-value of 5% (0.05). Therefore, this implies that employment does not have an impact on/association with the cholera cases. People were infected with cholera irrespective of whether they were employed or not. V. cholerae does not choose the socio-economic status of a person and transmission could occurred at any time, in any place through contaminated food and water, or from person–to–person. The majority of the population are the poor black people (99.1%) and without a job. Those employed were working either as domestic workers or as farmers, or just self-employed. This might have contributed in the transmission of the disease because of the low level of education and poor hygienic practices. The study demonstrated that “employment” as a variable does not have an association with cholera cases. Males and females were infected at equal proportion; thus gender did not have impact in cholera cases.

4.3.6 Hygienic practices

Generally, there are poor hygiene practices in the rural communities of the Vhembe district as shown by the results. Most of the people are not aware of the principles of hand washing before eating, before cooking and after the use of toilets. In addition, those aware of the importance of hand washing do not wash their hands regularly, due to the fact that water is not always available. Lack of hygiene refers to patients who did not have the chance to bath or wash their hands 2 or 3 days before the onset of symptoms; whereas poor hygiene refers to the situation where hand washing before eating and after use of toilets is not done regularly. The following table 4.19 represents the frequency distribution of hygienic practices with cholera cases.

Table 4.19: Distribution of hygienic practices

Hygiene practices	Frequency	%
Lack of hygiene	262	82.6
Hand washing before eating	5	1.6
Hand washing after use of toilets	1	.3
Poor hygiene	49	15.5
Total	**317**	**100.0**

Table 4.19 shows that 82.6% of the population applies the principles of hygienic practices, and 15.5% represents poor and inadequate hygiene. Hand washing before eating, cooking and after the use of toilets remains a challenge in the rural communities, only 0.3% is washing the hands. Chi-squared tests were performed to determine the association between hygienic practices and cholera disease, and the following table 4.20 includes the association of hygienic practices with cholera cases and the results from Chi-square test.

Table 4.20: Comparison of cholera cases by hygienic practices

Hygienic practices	**Cholera cases**	**Chi-square**
Lack of hygiene	262	0.001
Hand washing before eating	05	
Hand washing after use of toilets	01	
Poor hygiene	49	
Total	**317**	**0.001 (<0.05%)**

The Chi-square test shows p=.001, less than required p of 5% (0.05). Therefore, this implies that hygienic practices have an impact on/association with cholera cases. Personal, family and community hygiene practices are important factors which play key role in the spread of cholera infection to other people. This mode of transmission is called “direct transmission” because it occurred from person-to-person. The results in the Vhembe district indicated that 15.5% of the people have poor hygienic practices, 82.5% do not practice the principles of good hygiene at all.

4.3.7 Size of household

The size of households was investigated as it plays a role in cholera transmission. In underdeveloped rural communities, households are usually overcrowded and have a low standard of environmental sanitation as well as poor hygiene. Population density, scanty, restricted and unprotected water supplies, poor and inadequate sanitation situation, and absence of hygienic practices in these areas could facilitate the introduction of cholera (Mugero & Hope, 2001). Figure 4.7 provides the distribution of members per household.

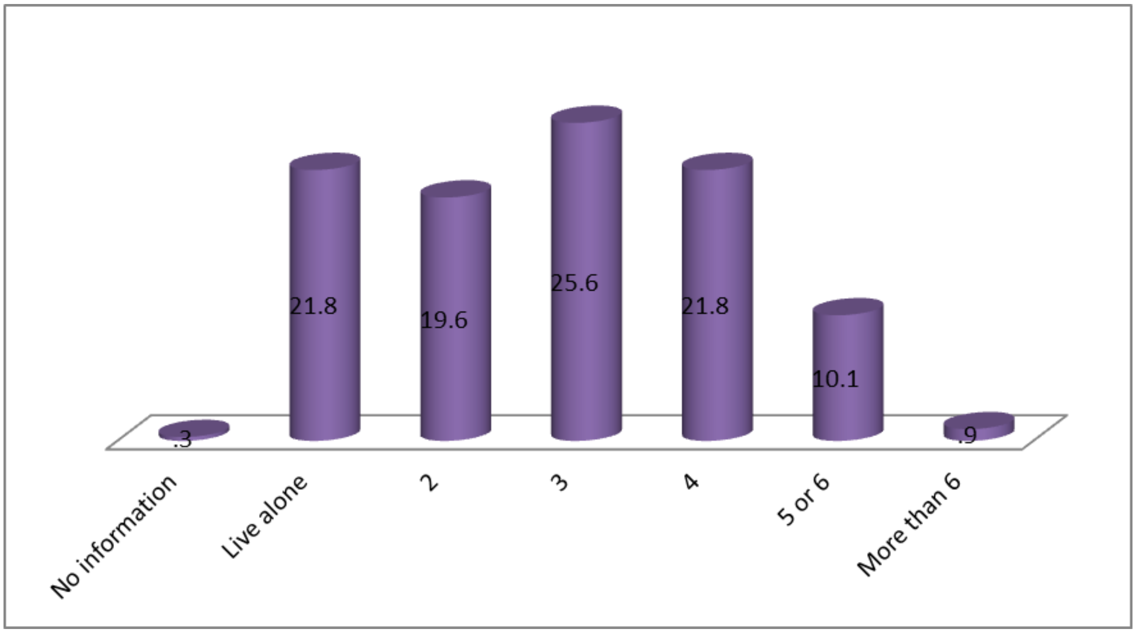

Figure 4.7: Distribution of members per household

The most predominant household size is between 2 and 4 members per household representing 67% of the population; 21.8% living alone and 10% having 5 to 6 members.

Chi-square test were done to establish the relationship between the size of household and the number of cholera cases; the results of this test are given in table 4.21 includes the association of the size of household with cholera cases and Chi-square results.

Table 4.21: Comparison of cholera cases by the size of household

Size of household	Cholera cases	Chi-square	Mean
No information	1	0.796	2.81
Live alone	69		
2	62		
3	81		
4	69		
5 or 6	32		
More than 6	3		
Total	**317**	**0.796 (>0.05%)**	**2.81**

The results of the Chi-square test show that p-value =0.796, greater than required p of 5% (0.05). Therefore, this implies that the size of a household did not have an association with the cholera cases in this study. The people who leave alone represented 21.8% of the cholera cases, which is more than the size of 2 or more members, according to the results. Thus, there is no relationship between the two variables. Household size might contribute to the transmission of infection from one person to another, but could not establish the relationship with cholera cases in this study. This is likely due to socio-environmental risk factors at the neighborhood scale, such as water and sanitation environments and population density. Cholera is mostly transmitted through the local environment rather than through person-to-person. The results illustrated that spatial clustering of cholera was much prevalent in Vhembe that clustering socially.

In addition, villages are overcrowded with no RDP housing standards. Increased densities in the population and poor education levels have been found as the risk factors for the two biotypes of cholera (Mohammad et al, 2002).

4.3.8 Period of occurrence

The annual rates of disease in cholera endemic areas vary widely, probably as a result of environmental and climate changes (Van den Bergh et al, 2008). The seasonality of cholera outbreaks in relation to climate changes would allow better planning for epidemics by public-health officials. Cholera cases in this study were distributed according to the “rainy season” (hot and humid) and the “dry season” (winter). The results are indicated in table 4.22 as follows:

Table 4.22: Distribution of cholera cases per season

Seasons	Frequency	%
Rainy season (humid)	314	99.1
Dry season (winter)	3	.9
Total	**317**	**100.0**

Most of the cholera cases (99%) were observed in the rainy season (hot and humid), and only 1% of the cases was found in the dry season (winter).

The Chi-square test was calculated to establish the association between the rainy and dry season with cholera cases. The results obtained are illustrated in the following table 4.23 presenting also the association of period of occurrence with cholera cases.

Table 4.23: Comparison of cholera cases by season types

Seasons	Cholera cases	Chi-square
Rainy season	314	0.679
Dry season (winter)	03	
Total	**317**	**0.679 (>0.05%)**

The results of the Chi-square test shows that p=0.679, greater than required p-value of 5% (0.05). Therefore, this implies that the Period of occurrence (rainy and dry) does not have an impact on the cholera cases in this study.

The cholera outbreak in the Vhembe district lasted for a significant period of six months from November 2008 to the beginning of May in 2009 with more cases in rainy season (314 cases). The two seasons (rainy and dry/winter) were involved but with only 3 cholera cases in winter; therefore the outbreak was predominant in rainy season. Chi-squared test does not establish any association with cholera cases if the two parameters are considered together.

This study indicated a possible relationship between cholera incidence and the rainy season (humid). The seasonality therefore seems to be related to the ability of vibrios to grow rapidly in warm environmental temperatures. Rainfall and temperatures are the environmental variables that may support the survival and population growth of the cholera bacteria, V. cholerae, in the natural environment and therefore cause cholera outbreaks. The period of outbreak covered the two seasons, rainy and dry seasons with 99.1% of cases in rainy seasons. Consequently the outbreak occurred more likely in rainy season than dry, but if the two variables are considered together there is no association with cholera cases as proven with chi-squared test.

4.4 CLINICAL ASPECTS

4.4.1 Year of admission

The collected data covered the period from 2008 to 2009. According to the admission records, the outbreak in the Vhembe district started in the second week of November 2008 and lasted for a period of 6 months. However, isolated cases were notified in the following 3 years (10 cases in 2010 and 1 case in 2012), and the outbreak come to an end. The cases of cholera reported on a period of 5 years are represented in the following table:

Table 4.24: Distribution of cholera cases per Year of admission

Year of admission	**Frequency**	**%**
No information	01	0.3
2008	86	27.1
2009	219	69.1
2010	10	3.2
2011	0	0
2012	1	0.3
Total	**317**	**100.0**

Most of the patients were admitted in 2009 from January to April amounting 69% of the reported cases, while 27.1% were admitted at the end of the year 2008 from the 15 November to 31st December 2008. Isolated cases represented only 3.5% and were observed in the year 2010 and 2012.

Chi-square test was not computed to establish the association of year of admission with cholera because this form part of descriptive data. The years of admission were mainly 2008 and 2009, which correspond with the period of the cholera outbreak in the Vhembe district. A huge number of cases were observed at the end of the year 2008 and in the beginning of 2009 (January to April). Consequently there was no possible relationship to establish between cholera cases and the two variables (2008 & 2009).

4.4.2 Clinical features

According to the WHO, a case of cholera should be suspected when a patient aged 5 years or more develops acute watery diarrhea, with or without vomiting, in an area where there is a cholera epidemic (WHO, 2015c). The Vhembe district cholera epidemic was a classic outbreak; Watery diarrhea was the commonest symptom representing 98.7% of the cases and followed by Dehydration with 73.8%, as well as vomiting with 68%. A Few patients, representing 3.5%, presented with Coma and only 0.9% had

Abdominal Cramps. Patients who had Fever represented 17.4% of the overall cholera cases. The results of this investigation are indicated in figure 4.8:

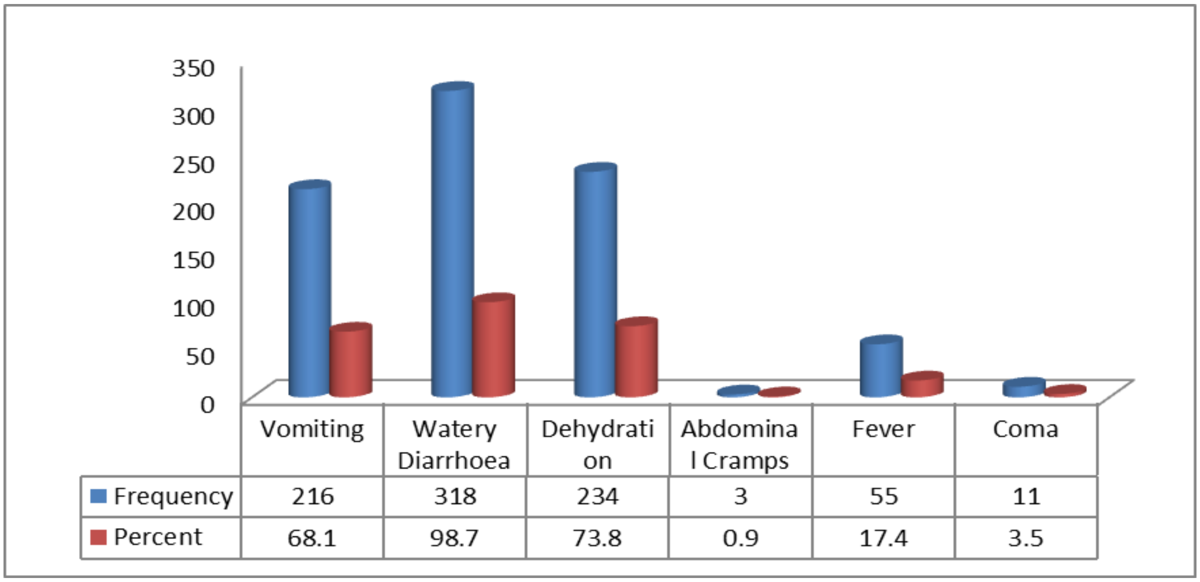

Figure 4.8: Distribution of clinical features

The clinical features of the disease were indistinguishable from those due to V. cholerae 01. Almost all the patients had severe secretory-type watery diarrhea and vomiting, with rapid onset of dehydration. The following table 4.25 summarizes the signs and symptoms of patients with acute watery diarrhea associated with V. cholerae 01.

Table 4.25: Association of clinical symptoms with V. cholerae 01

Clinical features	**Vhembe district** **n = 317**
Ages of patients	All ages
Watery diarrhea	313 (98.7%)
Severe dehydration	234 (73.8%)
Vomiting	216 (68.1%)

Table 4.25 shows the three main clinical symptoms of cholera in all age groups: watery diarrhea, severe dehydration and vomiting.

4.4.3 Cholera confirmation tests

Laboratory tests were performed in order to confirm the presence of V. cholera in the area. V. cholera *serogroup 01 Ogawa* was isolated by the local laboratory at Elim hospital and Polokwane Provincial hospital. The performed tests are indicated in the table below:

Table 4.26: Distribution of confirmation tests

Test results		Frequency	%
Valid	Yes	316	99.7
	No	1	.3
	Total	**317**	**100.0**

The tests were performed on 316 patients which constitutes 99.7% of the overall number of cholera cases. The test for one patient the test was reported invalid because the specimen leaked in transit. These results are reported in order to establish the validity of the research.

4.4.4 Outcomes of treatment

All the patients diagnosed with cholera were admitted at the hospitals and the outcomes are as follows: 312 patients were cured and discharge representing 98.4% of the total number of cases, 5 patients died (1.6%) despite the treatment given, with Case C.F.R. of 1.6%. The results are indicated in figure 4.9 as follows:

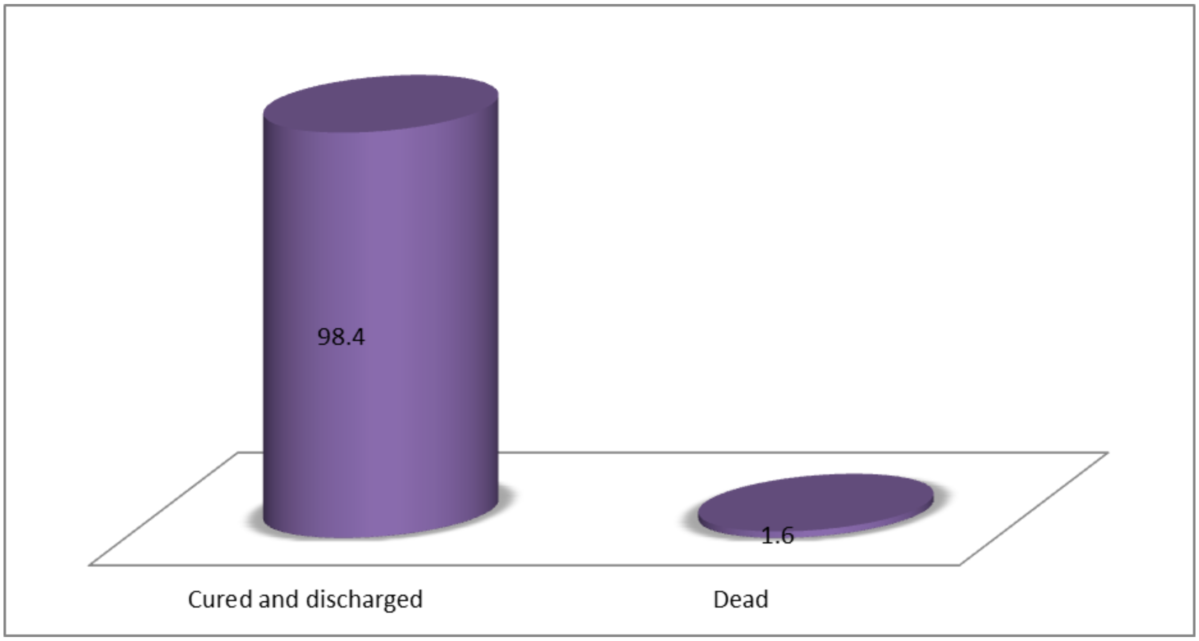

Figure 4.9: Distribution of the treatment outcomes

Figure 4.9 shows that 98.4% of the patients were cured from cholera infection, and 1.6% died despite the treatment.

4.5 EPIDEMIOLOGY OF CHOLERA

The reported monthly cases of watery diarrhea at the Vhembe district were approximately 1827 between November 2008 and April 2009. Eleven isolated cases were observed between 2010 and 2012. In this study, 317 patients with acute watery diarrhea cases accompanied by severe dehydration, and with or without vomiting were admitted at health facilities. There were also 5 deaths (case-fatality ratio 1.6%) between 2008 and 1012. Among the 317 acute watery diarrhea case patients selected, 234 (73.8) had severe dehydration, 216 (68.1%) had vomiting, 55 (17.4%) had fever, 11 (3.5) presented with coma, and only 3 (0.9%) patients had abdominal pain.

The outbreak started in the second week of November 2008, with two peak episodes in the 1st, 2nd and 3rd weeks of January 2009, and lasted until early May 2009. The median age of acute watery diarrhea case patients was 25 years (range 1-72 years), with equal distribution among male (50.5%) and female (48.9%). The attack rate among 0-5 years old was 6.0% and above 5 years 94%. The most health facilities affected by acute watery diarrhea were Messina with 111 (35%) cases and Louis Trichardt with 105 cases

(33.1%). Messina and Louis Trichardt hospitals are the entry point for refugees from Zimbabwe and other countries.

4.6 CONCLUSION

This chapter discussed the research findings with regard to demographic and biographic and clinical aspects data. Tables and figures were used to present the results. Pearson Chi-squared tests were used to establish the relationships or association between possible risk factors and cholera cases. The following chapter discusses the summary, the limitations and recommendations of the study.

CHAPTER 5

SUMMARY, LIMITATIONS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

This chapter discusses the summary of the study results regarding the factors contributing to the prevalence of cholera in Vhembe district of Limpopo province. The chapter also presents the achievement of the aim and objectives of the study as well as its limitations. The conclusions and the recommendations are also presented.

5.2 SUMMARY

5.2.1 The research questions

The research questions of the study were:

- What is the prevalence of cholera infection in Vhembe district?

Prevalence refers to the number of affected persons present in the population at a specific time, divided by the number of persons in the population at that time. It is calculated per 1000. Therefore, the prevalence of cholera was:

$$\textbf{Cholera Prevalence} = \frac{\textbf{1160}}{\textbf{1,302,113}\ \text{(total population)}} \times \textbf{1000} = \textbf{0.89\%}$$

The prevalence of cholera in Vhembe district was estimated at 0.89% per 1000 population. This represents the degree to which cholera was prevalent, or the percentage (proportion) of all individuals in a population that was affected with cholera at a given time (period of outbreak). Cholera disease had a very low prevalence (less than 1%) due to its short duration.

- What are the contributing factors associated with cholera in the Vhembe district as from 2008 to 2012?

Lack of hygienic practices, contaminated water from the streams, lack of safe food preparation and handling, local settlements with poor living conditions and the absence of toilets in the rural community of the Vhembe district were identified as risk factors associated with cholera outbreak. Therefore, the research questions in this study were answered. The objectives were to link the number of confirmed cholera cases in relation to the environmental parameters identified in this study. The aim was to establish statistical relationships between the number of cholera cases and certain environmental factors that may support the survival and population growth of the cholera bacteria, Vibrio cholerae, in the natural environment and therefore cause cholera outbreaks. According to the WHO (2000a), Vibrio cholerae spreads rapidly in situations where living conditions are crowded, water sources unprotected and there is no hygienic disposal of faeces, such as in refugee camps, farms, villages and townships.

- What are the clinical aspects associated with cholera?

Three main clinical aspects were found to be associated with cholera:

- Acute watery diarrhea
- Dehydration
- Vomiting

Therefore the research question in this study was answered.

5.2.2 Objectives of the study

The objectives of the study were:

- To determine the number of cholera cases at the Vhembe district.

A total of 1, 149 cholera cases with 14 deaths (CFR of 1.22%) were reported in the Vhembe district during the period of 2008 and 2009 cholera outbreak. Thereafter, 10 cholera cases were reported in 2010, and 1 case in 2012, which are referred to as isolated cases because they were reported after the main period of the outbreak (2008 & 2009). The total number of confirmed cholera cases during the period under survey was 1, 160. This objective was also achieved.

- To identify the contributing factors for cholera at the Vhembe district.

The results identified the factors for cholera outbreak at the Vhembe district as lack of hygiene practices, contaminated water sources from the streams, lack of safe food preparation and handling, type of settlements and the absence of toilets. Therefore, this objective was attained.

- To identify the clinical aspects of cholera in the population.

The main clinical aspects were: Acute watery diarrhea (98.7%), dehydration (73%) and vomiting (68%), which is in line with the classic definition of cholera (WHO, 2015c). Therefore this objective was achieved.

5.3 LIMITATIONS OF THE STUDY

The study was limited to Vhembe district and cannot be generalized to the entire Limpopo province and other provinces of South Africa.

5.4 RECOMMENDATIONS

The study recommends the following:

5.4.1 Prevention of cholera

Measures for the prevention of cholera mostly consist of providing clean water and proper sanitation to populations who do not yet have access to basic services. Health education and good food hygiene are equally important; Communities should be reminded of basic hygienic behaviors, including the necessity of systematic hand-washing with soap after defecation and before handling food or eating, as well as safe preparation and conservation of food. Appropriate media, such as radio, television or newspapers should be involved in disseminating health education messages. Community and religious leaders should also be included in the social mobilization campaigns (WHO, 2015d).

In addition, awareness campaigns and health education to communities at risk of cholera infection should be done.

5.4.2 Control of cholera

Among the people developing symptoms, 80% of the episodes are mild or moderate severity; the remaining 10%-20% of the cases develop severe watery diarrhea with signs of dehydration (WHO, 2015d). Once an outbreak is detected, the usual intervention strategy aims to reduce mortality by ensuring access to treatment and controlling the spread of disease. To achieve this, all partners involved should be properly coordinated and those in charge of water and sanitation must be included in the response strategy.

The fact that cholera is a fecal-oral highly transmissible water-borne disease means that water sanitation, clean water supply, sewage treatment, and an awareness and adoption of hygienic practices to should be improved or implemented to eliminate an outbreak. Even if improved water and sanitation are the mainstay of the prevention and a sustained control of cholera, those goals need time and a long term investment for results to be achieved, especially in impoverished countries where enteric diseases are endemic.

Recommended control methods, including standardized case management, have proven effective in reducing the case-fatality.

According to WHO (2015d), the main tools for cholera control are:

- Proper and timely case management in cholera treatment centers;
- Specific training of health care professionals for proper case management, including avoidance of nosocomial infections;
- Sufficient pre-positioned medical suppliers for case management (e.g. diarrheal disease kits);
- Improved access to safe water, effective sanitation, proper waste management and vector control;
- Enhanced hygiene and food safety practices;
- Improved communication and public information.
- Epidemiologic surveillance for early case detection.

5.4.3 Case management

According to the WHO Standard case definition, a case of cholera should be suspected when:

- In an area where the disease is not known to be present, a patient aged 5 years or more develops severe dehydration or dies from acute watery diarrhea;
- In an area where there is cholera epidemic, a patient aged 5 years or more develops acute watery diarrhea, with or without vomiting.

A case of cholera is confirmed when Vibrio cholerae 01 or 0139 is isolated from any patient with diarrhea (WHO 2015c).

Efficient treatment resides in prompt rehydration through the administration of oral rehydration salts (ORS) or intravenous fluids, depending of the severity of cases. Up to 80% of patients can be treated adequately through the administration of ORS (WHO/UNICEF ORS standard sachet). Very severely dehydrated patients are treated with the administration of intravenous fluids, preferably Ringer lactate. Appropriate antibiotics can be administrated in severe cases to diminish the duration of diarrhea, reduce the volume of rehydration fluids needed and shorten the duration of V. cholerae excretion. For children up to five years, supplementary administration of zinc has a proven effective in reducing the duration of diarrhea. In order to ensure timely access to treatment, cholera treatment centres should be set up among the affected populations whenever feasible (WHO, 2015d).

5.4.4 Travel and trade

Today, no country requires proof of cholera vaccination as a condition for entry and the International Certificate of Vaccination no longer provides a specific space for recording cholera vaccinations. In 1973, the World Health Assembly deleted from the International Health Regulations the requirement for presentation of cholera vaccination certificate. Past experience clearly showed that quarantine measures and embargoes on movements of people and goods – especially food products – are unnecessary. At present, the WHO has no information that food commercially imported from affected countries has been implicated in outbreaks of cholera in importing countries (WHO, 2015d).

The isolated cases of cholera that have been related to imported food have been associated with food which had been in the possession of individual travelers. Therefore, it may be concluded that food produced under good manufacturing practices poses only a negligible risk for cholera transmission. Consequently, the WHO believes that food import restrictions, based on the sole fact that cholera is epidemic or endemic in a country, are not justified. However, countries can confiscate any perishable unprocessed foods carried by travelers.

In summary:

- Imposing travel and trade restrictions have proven inefficient and risk to divert useful resources.
- The WHO has no information that food commercially imported from affected countries has ever been implicated in outbreaks of cholera in importing countries.
- Countries have the right to confiscate any perishable and unprocessed food carried by travelers crossing borders or entering through International airports.

5.4.5 Unaffected neighboring regions

According to the WHO (2015d), countries or any other regions neighbouring an area affected by cholera should implement the following measures:

- Improve preparedness to rapidly respond to an outbreak, should cholera spread across borders, and limit its consequences;
- Improve surveillance to obtain better data for risk assessment and early detection of outbreaks, including establishing an active surveillance system.

However, the following measures should be avoided, as they have been proven ineffective, costly and counter-productive:

- Routine treatment of a community with antibiotics, or mass chemoprophylaxis, has no effect on the spread of cholera, can have adverse effects by increasing antimicrobial resistance and provides a false sense of security;
- Restrictions in travel and trade between countries or between different regions of a country;

- Set up a "*cordon sanitaire"* at borders, a measure that diverts resources hampers good cooperation spirit between institutions and countries instead of uniting efforts.

In summary, the probable cholera outbreak affected a high-risk population in the northern part of Limpopo province. Transmission of the outbreak presented a unique characteristic: the first part due to the contaminated non-chlorinated drinking water, and the second part mainly by unsafe water and food handling practices; the third poor sanitary situation and inadequate hygienic practices. On the basis of these conclusions, a number of recommendations were planned:

- Repair of water pipelines, daily chlorination, periodic monitoring of water pipelines, and water quality assurance by testing.
- The district and municipal authority must ensure the implementation of these recommendations through several meetings with local authorities, leaders and engineers.

The cholera outbreak led to substantial death, disease and economic loss. A number of recommendations are made to prevent recurrences in the long term:

- Early diagnosis of cholera in the remote areas (village, farms, townships); thus the use of culture should be substituted with the use of rapid kit tests. Rapid detection, epidemiological investigation of diarrhea outbreaks and oral vaccination may be the only way to prevent death and disease (WHO, 2010a).
- Safe water must be made easily accessible at different points with less distance in these remote areas of the Vhembe.
- Rainwater harvesting followed by chlorination at household level, or solar disinfection may be achieved to prevent the type of environmental contaminations that triggered a waterborne outbreak followed by person-to-person transmission during this disaster (WHO, 2005).
- Owing to the complex situation of the Vhembe district, a large–scale intervention may possibly be needed to increase access to safe water at household level by improving hygienic practices such as the use of narrow-mouthed containers for

storage of drinking water, boiling of water and treating water with chlorine at the household level.

5.4.6 Areas for local environment development

Based on the findings of this research, some recommendations are suggested to the Municipalities' managers or mayors, the provincial government, government agencies, and lastly the National government.

5.4.6.1 Municipalities' managers

It has to be noted that Mayors and other managers at the municipality level are responsible for the development of their local areas, most of which are still underdeveloped. In line with the MDGs, they should achieve the following goals for the community:

Goal 1: Eradicate extreme poverty and hunger

Goal 2: Achieve universal primary education

Goal 3: Reduce child mortality rates (e.g. from waterborne diseases)

Goal 6: Combat HIV/AIDS, Malaria, and other diseases (e.g. cholera…)

Goal 7: Ensure environmental sustainability, for example: sustainable access to an improved water source, and access to improved sanitation. Ensure housing at RDP standards.

5.4.6.2 Governments Agencies

Government agencies should effectively provide services to the people that they ought to serve. They have to implement sustainable strategies that can improve the health of the population. It is also suggested that Government agencies work hand in hand with the local government to improve access to safe water, sanitation and education on hygiene practices. Government agencies need to do more; instead of just focusing on the provision of resources. They should also equip health professionals with the necessary skills by providing training.

5.4.6.3 Provincial and National governments

National and provincial governments should assist in the provision of access to safe water, adequate sanitation and proper housing. Adequate water supply and sanitation are basic requirements for life. Access to clean water and improved sanitation facilities is a fundamental human right. Yet, in many developed and developing countries, water source quality shows continued deterioration and in many cases depletion. These effects are a function of increasing population pressure, agricultural misuse and the inability to keep pace with the increasing demands on the resource.

The authorities at national and provincial level should understand that in developing countries where resources may be inadequate, particularly in rural communities, basic hygiene education and sanitation programs can be used to improve human health. They should work as a team with the governments' agencies to ensure and provide necessary training of health professionals, supply necessary equipment and medicines, upgrade the existing health facilities or build new ones with improved technology. Vaccines should be made available at any time.

5.4.7 Areas for further research

Critical needs for future microbiological safety of water include a more realistic valuation of water. This requires better education on the value and limitations of the resources for both public and policy makers. The burden of water supply and sanitation related disease is constantly underreported and the surveillance systems are inadequate; thus intervention studies and aggressive surveillance systems are necessary to provide a clear understanding of disease burden from contaminated water.

There is a need for a better understanding of increasingly susceptible populations in transmission of such diseases. Microbiologically safe water cannot be assumed, even in developed countries. The situation will worsen unless measures are immediately taken. The need for safe drinking water as well as adequate sanitation is a need that binds all of humanity into a single, global community. It is suggested that the same study be carried out at national level in order to investigate the microorganisms in the local environment, commonly associated with diarrheal diseases in general.

5.5 CONCLUSION

The study concluded that factors associated with cholera in the Vhembe district include lack of hygiene practices, unsafe drinking water sources, lack of safe food preparation and handling, local settlements (villages, farms and refugee camp) due to poor living conditions and the absence of toilets. Sanitation inadequacies remain a major challenge in the Vhembe district where a majority of people commonly uses Pit latrines. Inappropriate sanitation, such as the use of open-air defecation, plays a key role in cholera transmission in rainy seasons. The limitations and recommendations of the study were also discussed.

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APPENDIX 1: **AUDIT TOOL FOR PATIENTS RECORDS**

CHOLERA DATA COLLECTION TOOL

SECTION 1: DEMOGRAPHIC DATA

Tick one response or fill in where applicable.

1. **PLACE**

1. **Location (municipality)**

Makhado	1	
Musina	2	
Muthale	3	
Thulamela	4	

2. **Settlements**

Town	1	
Township	2	
Village	3	
Farms	4	
Refugees camp	5	

3. **In- migrations**

South- African Citizen	1	
Foreigner	2	

4. **Health facilities**

Donald Frazer Hospital	1	
Elim Hospital	2	
Louis Trichardt Hospital	3	
Malamulele Hospital	4	
Messina Hospital	5	
Siloam Hospital	6	
Tshilidzini Regional Hospital	7	

5. **Water sources**

Tap/ Piped water	1	
Rivers	2	
Streams	3	
Dams	4	
Boreholes	5	
Fountains	6	
Protected	7	
Unprotected	8	
Boiled water	9	
Supply continuity	10	

6. **Sanitation**

Presence of sanitation services	1	
Absence of toilets	2	
Pit Latrines	3	
VIP Latrines	4	
Waste water and refuse	5	
Water-borne sewerage	6	

7. **Food sources**

Shops	1	
Funeral/ Public catering	2	
Self- cooked	3	

2. **BIOGRAPHIC DATA**

8. **Age**

< 5 Years	1	
5- 15 Years	2	
>15 Years	3	

9. **Gender**

Male	1	
Female	2	

10. Ethnicity

Black	1	
White	2	
Colored	3	
Indian or Asian	4	

11. **Religions**

Christian	1	
Muslim	2	
Others (specify)	3	

12. Employment status

Unemployed	1	
Employed	2	
Self- employed	3	
Student	4	

13. Hygiene

Hands washing before eating	1	
Hands washing before cooking	2	
Hands washing after use of toilets	3	

14. **Size of household**

Live alone	1	
2	2	
3	3	
4	4	
5 or 6	5	
More than 6	6	

15. Period of occurrence

Rainy Season (Humid)	1	
Dry Season (Warm)	2	

SECTION 2: CLINICAL ASPECTS

This section includes all cholera cases and deaths. Tick one response or fill in where applicable.

16. Year of admission

2008	1	
2009	2	
2010	3	
2011	4	
2012	5	

17. Clinical features

Vomiting	1	
Watery Diarrhoea	2	
Dehydration	3	
Abdominal Cramps	4	
Fever	5	
Coma	6	

18. Cholera confirmation tests

Yes	1	
No	2	

19. Results

Positive	1	
Negative	2	

20. Outcomes of treatment

Cured and discharged	1	
Dead	2	

Appendix 2: Ethical Clearance letter from MREC

UNIVERSITY OF LIMPOPO
Medunsa Campus

MEDUNSA RESEARCH & ETHICS COMMITTEE

CLEARANCE CERTIFICATE

MEETING:	**02/2014**
PROJECT NUMBER:	**MREC/HS/53/2014: PG**

PROJECT:

Title:	Factors contributing to the prevalence of cholera in the Vhembe district of Limpopo province, South Africa
Researcher:	Dr DK Kazaji
Supervisor:	Prof ME Lekhuleni
Co-supervisor:	Prof NP Mbambo-Kekana
Hospital Superintendent:	Dr IM Malatji
Department:	Medical Sciences, Public Health & Health Promotion
School:	Health Sciences
Degree:	MPH

DECISION OF THE COMMITTEE:

MREC approved the project.

DATE: 06 March 2014

UNIVERSITY OF LIMPOPO
Medunsa Campus
2014 -03- 06
MEDUNSA RESEARCH ETHICS COMMITTEE
MREC CHAIRPERSON

PROF GA OGUNBANJO
CHAIRPERSON MREC

The Medunsa Research Ethics Committee (MREC) for Health Research is registered with the US Department of Health and Human Services as an International Organisation **(IORG0004319)**, as an Institutional Review Board **(IRB00005122)**, and functions under a Federal Wide Assurance **(FWA00009419)**
Expiry date: **11 October 2016**

Note:
i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**
ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding Solutions for Africa

PROUDLY SOUTH AFRICAN

Appendix 3: Letter from Limpopo Province DoH

LIMPOPO

PROVINCIAL GOVERNMENT

REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH

Enquiries: Latif Shamila Ref:4/2/2

Kazaji DKN

University of Limpopo

Sovenga

0727

Greetings,

Re: Factors contributing to the prevalence of Cholera in the Vhembe District of Limpopo province, South Africa.

1. The above matter refers.
2. Permission to conduct the above mentioned study is hereby granted.
3. Kindly be informed that:-
   - Further arrangement should be made with the targeted institutions.
   - In the course of your study there should be no action that disrupts the services.
   - After completion of the study, a copy should be submitted to the Department to serve as a resource.
   - The researcher should be prepared to assist in the interpretation and implementation of the study recommendation where possible.

Your cooperation will be highly appreciated.

Head of Department 12/05/2014

Date

18 College Street, Polokwane, 0700, Private Bag x9302, POLOLKWANE, 0700
Tel: (015) 293 6000, Fax: (015) 293 6211/20 Website: http/www.limpopo.gov.za

The heartland of Southern Africa – *development is about people*

Appendix 4: Letter from the Statistician

RESEARCH DEVELOPMENT
UNIVERSITY OF LIMPOPO

2013 -10- 23

PRIVATE BAG X1106 SOVENGA 0727
TEL NO. (015) 268 2401

Ref No: **Research and Statistical Support**

Date: **23 October 2013**

To: **University of Limpopo**

From: Mr MV Netshidzivhani
University Research Statistician

Subject: **Data Management and Statistical Support for research titled the FACTORS CONTRIBUTING TO THE PREVALENCE OF CHOLERA IN VHEMBE DISTRICT OF LIMPOPO PROVINCE, SOUTH AFRICA.**

Dear Sir/Madam

1. The above matter refers.

2. I have studied the research protocol of Dr D.K Kazaji student no 200816817. Titled **FACTORS CONTRIBUTING TO THE PREVALENCE OF CHOLERA IN VHEMBE DISTRICT OF LIMPOPO PROVINCE, SOUTH AFRICA** and I agree to assist with data management and the statistical analyses.

3. Hope that you find this in order.

Yours sincerely,

Victor Netshidzivhani
Research Statistician: Research Development and Administration
Tel : 015 268 3702
Fax : 015 268 2306 \ 086 696 0812
Mobile : 072 246 4551
E-mail : mmbengeni.netshidzivhani@ul.ac.za
mnetshid23@gmail.com

UNIVERSITY OF LIMPOPO

Finding Solutions for Africa

PROUDLY AFRICAN

Appendix 5: Certificate of Proofreading

From : Dr. I. Manase

Department of English

University of the Free State

Bloemfontein

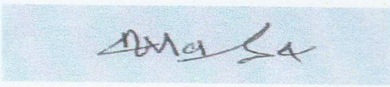
Date : 24 August 2015

To : Whom it may concern

Certificate of proofreading and editing: Dr Dieudonne Kangweji Kazaji, Student ID: 200816817, Master of Public Health research dissertation titled: *Factors contributing to the prevalence of cholera in Vhembe District of Limpopo Province, South Africa*

This serves to confirm that I have proofread and edited Dr Dieudonne Kangweji Kazaji's Master of Public Health dissertation. The suggested language and grammatical construction errors have been attended to and as such the dissertation is now ready for submission for examination.

Sincerely,



Dr. I. Manase

Phone: 051 401 7879

Cell: 082 298 6137

Email: Manasel@ufs.ac.za & imanase@yahoo.com

Appendix 6: Data collection team

FACTORS CONTRIBUTING TO THE PREVALENCE OF CHOLERA IN THE VHEMBE DISTRICT OF LIMPOPO PROVINCE, SOUTH AFRICA

DATA COLLECTION IN HOSPITALS AND HEALTH CENTRES

PERIOD: 22 MAY TO 05 JUNE 2014

DATE	HOSPITAL/HC	ASSISTANT DATA COLLECTORS	DESIGNATION	CONTACT NO	SIGNATURE
22/05/2014	Louis Trichardt Hosp.	MAIWASHE A.P.	QA deputy Manager	082 790 5391	[illegible]
22/05/2014	Louis Trichardt Hosp	BALOYI J. NORMAN	INFORMATION OFFICER	0792260157	[illegible]
23/05/2014	Tshilwavhusiku HC	LETHOLE M.M.	Operational Manager	0714515309	[illegible]
26/05/14	Messina Hosp	Sibanda T.E.	Operations Mx	0721451290	[illegible]
26/05/14	Madimbo Clinic	Chauke S.N	Acting Sub-District Mngr	0837652085	[illegible]
28/05/14	~~A~~ Siloam Hosp	MASAKONA N.J	INFECTION CONTROL	0827132602	[illegible]
29/5/14	Elim	Mungulu CA	O/M (infection control)	0846962554	[illegible]
02.06.14	TSHILIDZINI Hos	LURULI AJ	O/m IPC	082 254 1990	[illegible]
~~02-06-14~~	~~Khangalele~~				
02-06-14	D/OFFICE	KHANGALA ER	Public Health Coordinator	082 300 2435	[illegible]
02/06/14	DONALD FRASER H.	SIBASA E	INFECTION CONTROL	0737232985	[illegible]
02/06/14	Malamulele Hosp	Maphote J	OM OHS / IPC	0732446504	[illegible]