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**Assessing the correlation between malaria case mortality rates and specific socio-economic factors**

by

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Submitted in partial fulfilment of the requirements for the degree
Master of Science in Environmental Management

in the

Faculty: Natural and Agricultural Sciences
Department: Geography, Geoinformatics & Meteorology
School: Centre for Environmental Studies

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# SUMMARY

## ASSESSING THE CORRELATION BETWEEN MALARIA CASE MORTALITY RATES AND SPECIFIC SOCIOECONOMIC FACTORS

by

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Keywords: Malaria, mortality, socioeconomic, Vhembe, South Africa, water bodies, medical facilities, distance

### Background

Various local villages in the Vhembe district of South Africa have experienced high malaria infection rates together with a high variability of malaria case mortality rates over the past 20 years. This research project sets out to determine if socioeconomic factors, (specifically the location of medical facilities and a geographical aspects) have a significant influence on the varying malaria case mortality rates. The data from this study could assist societies and authorities in mitigating the negative effects of malaria infections on human life expectancies through improved socioeconomic development.

### Methods

The study used existing medical records of all reported malaria cases in the Vhembe district between 1998 and 2017. The data comprised malaria cases recorded at 263 medical facilities that reported 57 974 infections from 850 source locations across the villages and formal neighbourhoods. The data set was sampled using maximum variation sampling

combined with a stratified sampling approach to select the 30 source locations with the highest reported variations in malaria case mortality. The number of medical facilities used, distances to the medical facilities, and proximity to significant water sources were subsequently spatially and statistically analysed for the sample source locations to determine potential correlations between these factors and the malaria case fatality rates of the source locations.

**Results**

The statistical analysis indicated a significant negative correlation between the case mortality rates and the number of medical facilities used by the sample source locations, the number of infections reported, and the maximum and mean distances travelled to the medical facilities used. This suggested that malaria patients from larger communities, those who had financial or other means to consult more advanced facilities or those with a larger variety of services had a significantly lower risk of mortality. In addition, the analysis indicated a positive correlation between the minimum distances travelled to the medical facilities used and the case mortality rates, indicating that, although maximum and average travelling distances had a negative correlation, medical facilities situated within the vicinities of communities could have a positive impact on reducing case mortality rates. The spatial analysis supported the majority of the findings from the statistical analysis, except for a small cluster of source locations that need further investigation. Proximity to significant water bodies was not found to have any significant impact on case mortality rates.

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| MSc | Master of Science |
| WHO | World Health Organization |
| SAWS | South African Weather Service |
| UP ISMC | University of Pretoria Institute for Sustainable Malaria control |

# DECLARATION

I, Ryno Harm Coetzer, declare that the dissertation, which I hereby submit for the degree MSc Environmental Management at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

**ETHICS STATEMENT**

I declare that I have obtained, for the research described in this work, the applicable research ethics approval via my project supervisor Dr AM Adeola.

I further declare that I have observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for Researchers and the Policy Guidelines for Responsible Research.

Ryno H Coetzer
Jan 2020

Dr Abiodun M Adeola (PhD)
Jan 2020

# ACKNOWLEDGEMENTS

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# CHAPTER 1 INTRODUCTION

## 1.1 BACKGROUND TO THE STUDY

Malaria is a significant vector-borne disease that influences the global population and places a detrimental healthcare burden on many communities globally. The spatial distribution of malaria infections is significantly influenced by climate conditions and the ability of communities to prevent and treat the disease. Caminade et al. (2014) conducted a multi-malaria model, inter-comparison exercise that looked at some of the most prominent malaria risk forecasts and the results indicated an overall net increase in climate suitability for malaria transmission along with a net increase of populations at risk.

The World Health Organization estimates that over 200 000 000 people per year suffer from malaria infections and that over 400 000 of these patients die from the illness. This suggests that, globally, around 0.2% of malaria cases result in patient fatalities (WHO, 2017).

Murray et al. (2012) further investigated malaria-related deaths between 1980 and 2010. The study indicated that overall global malaria deaths increased from approximately 995 000 in 1980 to 1 238 000 in 2010, with the number of deaths peaking at 1 817 000 in 2004. In addition to overall death rates, the study provided insightful regional context. Although the overall global deaths from malaria infections have increased, this increase was primarily influenced by malaria-related deaths in Africa. If African death figures are excluded, global malaria deaths decreased steadily and significantly between 1980 and 2010. During the study period, Murray et al. (2012) observed that Africa experienced an increase of 129% in malaria deaths (up from 493 000 in 1980 to 1 133 000 in 2010) while the rest of the world experienced a decrease of 79% (from 502 000 in 1980 to 104 000 in 2010).

Although malaria case mortalities have continued decreasing since a peak in 2004, it still remains crucial to understand what measures can reduce malaria transmission and related fatalities (Murray et al., 2012).

Sub-Saharan Africa is estimated to be one of the most affected regions in the world in terms of malaria disease control and some studies estimate that around 90% of reported annual malaria infections are from sub-Saharan Africa, although East African highlands have also experienced increasing surges of infections (Mabaso et al., 2004).

This study concentrates on Limpopo, a province in South Africa in sub-Saharan Africa, with specific focus on the Vhembe district, which is identified as a malaria hotspot, as illustrated in the 10-year timeline maps in Figure 1.

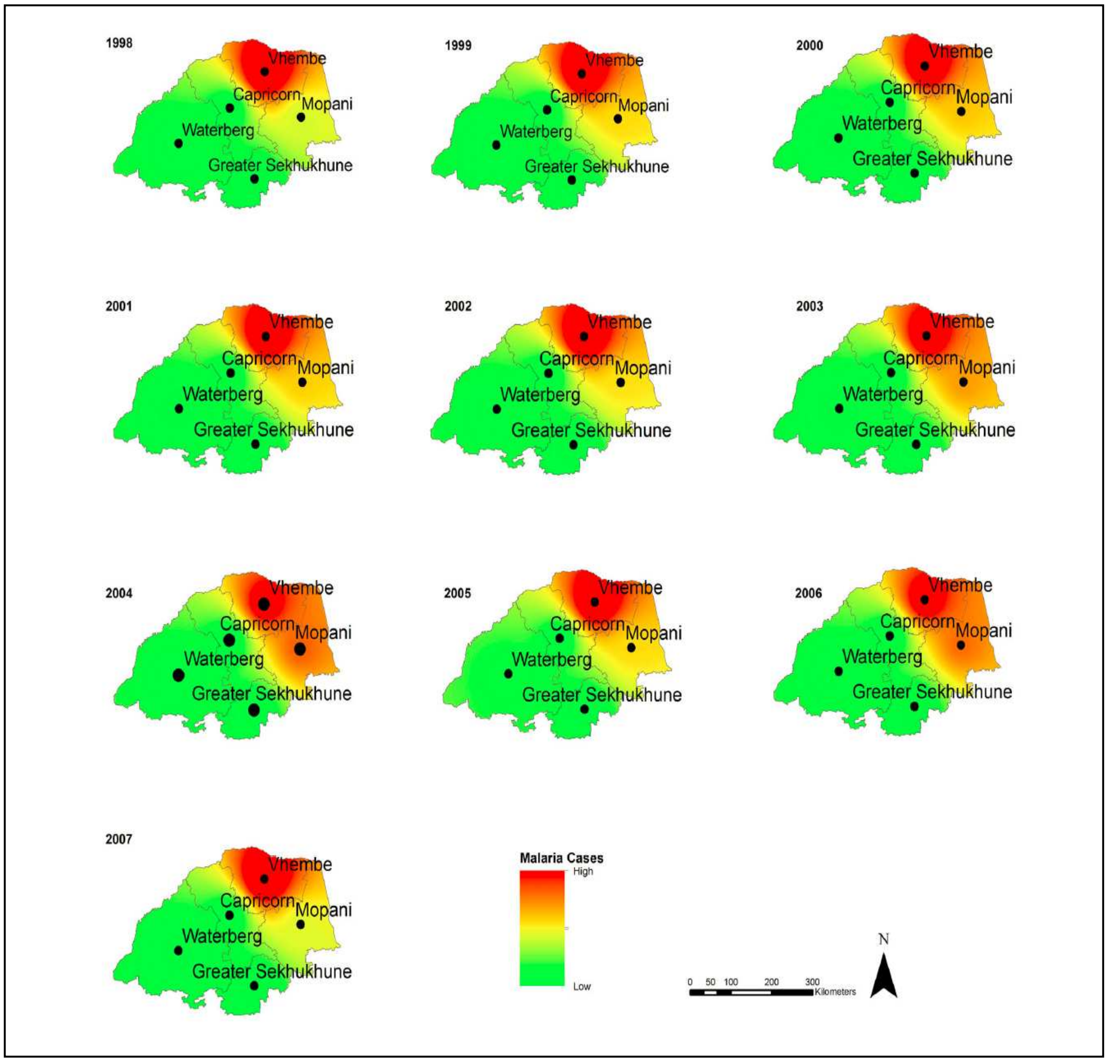


***Figure 1: Malaria cases across Limpopo from 1998 to 2007 (Source: Komen et al., 2014)***

Figure 1 highlights the importance of understanding not only malaria transmission in Africa but also understanding the factors that might influence malaria case fatalities. The primary research question of this dissertation is to determine if the effects of socioeconomic factors (specifically the distance from available medical facilities and the geographical aspects) affect malaria case mortality rates. The intention of this study is to provide data that could assist societies to mitigate the negative effects of malaria infections on human life expectancies through socioeconomic development, specifically focusing on malaria case mortality rates in South Africa.

The primary hypothesis is that the rate of fatalities from malaria infections (referred to as malaria case mortality rates) is influenced by the socioeconomic factors of the individual, particularly access to medical facilities and distances from significant water bodies. The majority of reviewed studies have predicted that climate change will have a significant effect on vector-borne diseases in Africa and a thorough understanding of the possible counter effects that socioeconomic development could have on mortality rates of diseases such as malaria is important in order to help societies mitigate negative impacts from climate change . The hypothesis is that malaria case mortality rates can be substantially mitigated if socio-development efforts are directed towards endemic areas where climate change might result in an increased occurrence of the disease.

## 1.2 LITERATURE REVIEW

The primary focus of this research is the relationship between specific socioeconomic factors and malaria case mortality rates. The rationale is that climate change could lead to a redistribution of malaria infections in South Africa, making it crucial to understand all the measures that could mitigate the effects of infections and potential fatalities on vulnerable societies. Socio-economic factors are not linked to climate change models through the research, socio-economic factors are purely being investigated as mitigation measures to climate change impacts on marginalised societies.

This literature review investigates existing studies on three aspects relating to the rationale behind this study to provide sufficient understanding and context of the topic:

- impact of climate change on malaria distribution
- impact of socioeconomic factors on malaria infections
- impact of socioeconomic factors on malaria case mortality rates.

The overview of available and conclusive literature of these three aspects will provide the foundation to support the investigation of the impact of specific socioeconomic factors on malaria case mortality rates.

### 1.2.1 Impact of climate change on malaria distributions

The foundation of this research is based on the assumption that climate change has the potential to change malaria distribution in South Africa and factors influencing malaria infections and case mortality rates need to be investigated and understood. This section highlights some of the key studies, methodologies and findings with regard to the impact of climate change on malaria distribution.

Previous studies have investigated the impact of climate change on vector-borne diseases with significantly conclusive results indicating that climate change can have a major impact on the spreading of vector-borne diseases, particularly malaria (Aklesso et al., 2011). This has been recorded in multiple areas, including the Northwest Frontier Province of Pakistan, Eastern Africa and South Sudan, where a direct link was found between humidity increases due to climate change and the instances of malaria infections and death (Leedale et al., 2016; Bouma et al., 1996).

Parham et al. (2015) conducted intensive research to determine the link between malaria cases and climatic factors through a semi-parametric econometric model. The findings indicated that a marginal change in temperature and precipitation could result in a substantial change in the number of malaria cases, and further research was recommended in the following three areas to increase the understanding of climate change on the spread of vector-borne diseases:

- Spatial scales of available climate prediction need to be overlaid with socioeconomic data on a local scale to determine if infrastructure and other economic development aspects will affect the level of anticipated transmissions. The majority of socioeconomic data, however, is only available at district and not at local level. This creates challenges for current prediction models.
- Current prediction models consider single disease types and new models that take into account multiple co-occurring diseases need to be developed to determine how changes in climate might affect co-transmission patterns.

- A method needs to be divised to increase the understanding of cross-scale and interrelated issues. A panarchy concept needs to be explored and applied at an environmental and social level to further understand environmental and socioeconomical changes and their effect on mankind.

Frank, Sharp and Le Sueur (2003) used a spatiotemporally validated model of *Plasmodiom falciparum* malaria transmission in Africa and analysed this against the Hadley Centre global climate change model to predict the potential effect of climate change on malaria transmission in Africa. The model suggested that malaria distribution could increase by 5%–7%, mainly altitudinal spreading with limited change expected in latitudinal spreading of the disease.

According to Caminade et al. (2014), studies attempting to forecast future malaria transmission according to climate change predictions could contribute significantly to understanding the future risks posed by malaria transmissions on a global scale. Caminade et al. (2014) highlight the necessity to understand other socioeconomic factors and trends to integrate with climate change malaria transmission models, which will provide for an even more accurate risk assessment.

Based on the suggestion by Caminade et al. (2014), this study aims to build on current malaria risk assessment models by investigating how specific socioeconomic factors are able to influence malaria case fatality rates. This could support decision-makers to not only forecast malaria transmission patterns but also understand and mitigate the malaria case fatalities, which can be considered to be the most significant impact arising from changing malaria transmission patterns.

### 1.2.2 Impact of socioeconomic factors on malaria infections

There are several studies available that investigated the relationship between socioeconomic factors and the rate of malaria infections. This section highlights some of the key studies, their methodologies and findings.

Kavita et al. (2014) researched the link between socioeconomic characteristics and malaria infection rates. The research team investigated the influence of the following socioeconomic variables on malaria risk:

- demographic factors, including age, sex, body complexion, body odour, body clothing, marital status and family size
- socioeconomic status, primarily focused on income groups and education levels
- knowledge, awareness and education on malaria-related topics.

Data on the topics were gathered primarily through a structured and brief bilingual questionnaire administered through community leaders in four different geographical areas over a seven month period. The study concluded that housing types, access to medical facilities, income levels and malaria awareness could be associated with malaria occurrence. In addition, Kavita et al. (2014) determined that exposure to mosquito bites and the use of bed nets were positively associated with malaria occurrence.

Lowassa et al. (2012) conducted research that links socioeconomic factors with malaria-related aspects, but the study focused on the effect of socioeconomic characteristics of an individual's response (treatment seeking behavious) to malaria infection as opposed to actual malaria infections, which Kavita et al. (2014) researched.

The study by Lowassa et al. (2012) was conducted in northern Tanzania where approximately 95% of the population live in high malaria risks areas. In northern Tanzania, over 17 million cases of malaria infections are clinically recorded each year with almost 80 000 of these cases resulting in fatalities. The study specifically focused on Lower Moshi, which has an elevation of between 7 00 m and 8 00 m above sea level.

Lowassa et al. (2012) collected information on socioeconomic characteristics through structured questionnaires administered to randomly selected households within Lower Moshi. The questionnaire gathered information on the following socioeconomic aspects:

- knowledge of malaria vectors and larva control
- ownership and use of malaria prevention tools
- wealth of the household head
- exposure to malaria prevention programmes, for example the distribution of bed nets
- formal education levels
- distance from healthcare centres.

Lowassa et al. (2012) analysed the results of these characteristics against household willingness to prevent and treat malaria infections. The study found that the distance to health centres was the greatest factor influencing willingness to treat infections, while the education levels of household heads were positively associated with efforts to prevent infections (Lowassa et al., 2012).

### 1.2.3 Impact of socioeconomic factors on malaria case mortality rates

The literature review of research that investigated potential relationships between socioeconomic factors and malaria case mortality rates revealed that limited knowledge of the topic is currently available, although there are several studies that indirectly provide insight on the topic. The rationale, methodologies and findings of these studies are briefly described in this section.

The faculty of Medicine and Health Sciences at Sana'a University in Yemen investigated the impact of socioeconomic and environmental factors on developing severe malaria in comparison with mild malaria. The study focused on two groups of children from Yemen communities between the ages of six and 10 years. One group of children had experienced severe malaria and the other group had experienced mild infections. The study found that the distance travelled to medical facilities was significantly associated with disease progression from mild to severe, while environmental and vector control factors were not associated with moving from mild to severe disease (Al-Taiar, Shabbar, Assabri, Al-Habori, Azazy, Al-Gabri, Al-Ganadi, Attal & Whitty, 2008).

A study by O'meara, Noor, Gatakaa, Tsofa, McKenzie & Marsh (2008) investigated the impact of access to primary healthcare on the severity of malaria morbidity, with a specific focus on children between birth and five years of age. The study aimed to understand the effectiveness of providing primary healthcare as a tool to minimise the effects of malaria on vulnerable communities. The study concentrated primarily on the relationship between travel times to the nearest primary healthcare facility and the incidence of hospitalisation due to malaria infections. Through this approach, Omeara et al. (2008) found that access to primary healthcare facilities could reduce the burden of malaria disease by up to 66%, and that an increase from ten minutes to two hours in travel time to healthcare facilities could double the likelihood of hospitalisation from malaria infection.

Researchers from Ruprecht Karls University in Germany conducted research on the pattern of malaria-related deaths in patients between the ages of six and 31 years across 18 villages surrounding Centre de Recherche en Santé de Nouna in Nouna Health District in north-western Burkina Faso. The research was conducted primarily through field observations by village workers over a six month period. The analysis revealed that a lack of appropriate second-line treatment at formal healthcare facilities was one of the leading causes of malaria-related deaths in the area. In addition, the study revealed that ease of access to medical facilities had a significant impact on a patient's willingness to seek medical attention, which in turn could result in fatalities (Muller, Becher, Traore & Kouyate, 2003).

Christopher, Le May, Lewim and Ross (2011) found that the roll out of national programmes that enable community health workers to support vulnerable communities can reduce malaria mortality rates by between 36% and 63% in sub-Saharan Africa. This was indicated through a study that investigated and compared the changes in malaria case mortality rates before and after community health worker programmes were implemented. The data were obtained through researching existing databases of published and unpublished studies for community health worker programmes and their effectiveness in communities (Christopher et al., 2011).

The literature review identified many other studies that could be considered relevant but they were not specifically related to malaria infections. One example is the study conducted by Rutherford, Mulholland and Hill (2010) from the Centre for International Health in New Zealand. Rutherford et al. (2010) investigated the relationship between access to healthcare and the mortality rates of children younger than five years of age. Similar to the results observed in the previously mentioned studies, this study identified that removing barriers to healthcare (cost, distance, willingness to seek medical attention) could have a positive impact on reducing premature deaths in vulnerable communities (Rutherford, Mulholland & Hill, 2010). Schoeps, Gabrysch, Niamba, Sie and Becher (2011) conducted a similar study in which the relationship between travel time to medical facilities and mortality among children under the age of five in Burkina Faso was investigated. Similar to the study by Rutherford et al. (2010), Schoeps et al. (2011) found a significant relationship between mortality and travel time to medical facilities. The study illustrated that the mortality rate was 50% higher in areas with travel times of more than four hours compared with villages that had medical facilities in the vicinity (Schoeps et al., 2011; Rutherford et al., 2010).

The literature review illustrates that there is a definite relationship between overall mortality rates and certain socioeconomic factors, specifically ease of access to medical facilities. In addition, the literature reveals that the level of medical facilities available to patients can play a significant role in disease survival rates. These factors highlight the need to gain a better understanding of both the mitigating levers that are available to countries to combat the health effects of climate changes, and the extent to which corporate organisations could be held accountable for combatting these health effects

## 1.3 RESEARCH RATIONALE

Initial research indicates that there is a strong relationship between socioeconomic factors and malaria infections and severity. According to Gwatkin and Guillot (2000), malaria has the highest inequality distribution of all public health-related diseases. Approximately 58% of malaria deaths occur in the poorest 20% of the world's population.

Many studies have been undertaken on how to manage malaria through the control of disease-bearing insects, but limited research has been undertaken in South Africa on how malaria can be controlled through socioeconomic levers. In addition to a fresh malaria control perspective, socioeconomic levers could also gain stronger support through communities and other stakeholders buy in than traditional control measures. Support will be driven by the fact that socioeconomic malaria prevention levers will be implemented in malaria endemic countries where poverty, hunger and related diseases are prevalent and traditional malaria prevention would seem inadequate and untimely (Kavita et al., 2014; Enayati & Hemingway, 2010).

In addition to community and stakeholder engagement, socioeconomic levers could have greater mitigation effects through relieving the barriers caused by the economic status of recipients, as is currently experienced by current and historical malaria control programmes (Kavita et al., 2014).

Overall, the rationale behind the research is that malaria appears to be a larger health risk in lower income areas. Therefore, investigating and understanding the relationships between socioeconomic factors and malaria mortality could allow authorities to undertake more holistic and effective malaria control programmes.

## 1.4 AIM AND OBJECTIVES

The aim of this study is to investigate the relationship between malaria case mortality rates and specific socioeconomic factors. The objectives include:

- identifying socioeconomic factors with potential for malaria mortality control
- investigating the relationship between the selected socioeconomic factors and malaria mortality rates
- examining the possible effects of socioeconomic development on malaria mortality rates.

# CHAPTER 2 **RESEARCH METHODOLOGY**

This chapter provides an overview of the research methodology used for the study. The research process was designed to provide information on the impact of socioeconomic variables, specifically demographical data, on malaria case mortality rates.

## 2.1 RESEARCH DESIGN AND APPROACH

According to literature, in addition to the research designs, there are two distinct approaches to research; a deductive approach and an inductive approach. Snieder (2009) describes the deductive approach as research that initiates with a certain idea and expectation which is investigated against research findings and finally rejected or confirmed. In contrast, the inductive approach starts with observations and research findings that are used to develop a theory (Goddard & Melville, 2004). In essence, the research of this study can be considered to test the validity of the theory that socioeconomic factors have a direct effect on negative influences from climate change on communities. This proposes that an overarching approach is a deductive approach, although there are traces of inductive theorising as additional theories were investigated throughout the research process.

Due to the limitations and legal requirements related to medical surveys and interactive medical data collection methods, this study used secondary data sourced from the Malaria Control Programme at the Limpopo Provincial Department of Health. The data was obtained from the South African Weather Service through its collaborative research with the University of Pretoria Institute for Sustainable Malaria Control.

Bless and Higson-Smith (1995) describe research design as the ‘planning of any scientific research from the first to the last step’. This indicates that the design provides a step by step plan through the process of collecting, analysing and interpreting data. Additionally, research design can be considered as the ‘blueprint’ for procedures that guide academics through initiation, sample selection and operationalisation of a specific study process (De Vos & Fouche, 1998).

Research designs generally fall into one of two categories. The design can be exploratory, focusing on generating certain insights, or conclusive, verifying pre-existing insights with regard to a specific topic. The research design for this specific study is described as conclusive research with certain exploratory characteristics. The research can further be described as ‘casual research’ as the focus is to analyse relationships between predetermined variables (Malhotra, 2000; Pride, 2007).

The deductive approach to research initiates with a certain idea or expectation that is tested against specified observations or research findings. The idea or expectation is the rejected or confirmed based on the findings (Snieder, 2009). The opposite research approach can be seen as an inductive approach, which starts with observations and research findings that build a theory based on these findings (Goddard & Melville, 2004). This research study can be considered to test the theory that specific socioeconomic variables (distance and access to medical facilities as well as topographical characteristics of source locations) have an effect on malaria case mortality rates. This suggests that the primary approach of the study can be classified as deductive.

In addition, the research study can be defined as applied and basic research. This study aims to broaden existing knowledge regarding the relationship between malaria case mortality rates and socioeconomic factors. The findings could be used to assist in developing strategies or policies to decrease case mortality rates through socioeconomic development (Neuman, 2012).

The research was conducted by analysing malaria case data from various medical facilities in the Vhembe district over a twenty year period. The study was primarily quantitative in terms of data usage as the hypotheses has been tested against existing quantitative data sets. In terms of time dimensions, the study can be described as longitudinal as the medical data span several years and focus on the same geographical locations (Neuman, 2012).

## 2.2 RESEARCH SETTING

The majority of the research was carried out through desktop reviews of existing research, spatial analytics and malaria data sets from the Limpopo Department of Health.

The primary data set that was investigated and analysed contained malaria case records from the Vhembe district (illustrated in Figure 2) and covered almost twenty years, between 1998 and 2017.

The records included consolidated malaria infection reports from 263 medical facilities servicing residents from 850 source locations (villages and formal neighbourhoods). The total number of records amounted to 57 974, of which 25 943 were female patients and 32 020 male patients. Of importance to note is that the data set only included maleria cases that were captured by medical facilities and did not include unreported cases in isolated areas.


***Figure 2: Location of Vhembe District (Source: Landsat, 2018)***

## 2.3 SAMPLING METHOD

Levy and Lemeshow (2013) define a specific study population as consisting of the entire group of elements (households, individuals and species, among others) which adhere to the respondent criteria (a specific area which is prone to malaria infection fatalities) which have been selected for the research. This suggested the population of this study would be all reported malaria cases in a defined parameter within a malaria-prone area. In summary, the total target population of this study were all reported malaria cases within the Vhembe district in Limpopo between 1998 and 2017.

The entire target population was required to be sampled to obtain as much information from the data as possible. Due to the large data set but the limited variance of the studied malaria mortality rates, a maximum variation sampling technique combined with a stratified sampling approach was used. Maximum variation sampling is a nonprobability, purposive sampling technique which allows for a comparision to be made of the characteristics between the most differing samples in a data set (Etikan et al., 2016; Medhi, 1992; Ilker et al., 2016).

The target population was divided into three different sections based on malaria case mortality rates, and within these three groups, the top ten areas were selected for the analysis. This approach ensured that the most significant variance of case mortality rates within the population were compared with variables among the most differing cases (Etikan et al., 2016; Medhi, 1992).

## 2.4 DEPENDENT AND INDEPENDENT VARIABLES

The dependent variable in the data set was malaria case mortality rates, against which all other independent variables were measured to determine potential correlations across various source locations of reported malaria infections within the data set. The malaria case mortality rate was calculated by determining the total number of infections reported in a specific source location (villages, neighbourhoods etc), and measuring the total against the number of fatalities from infections in that specific location. In a simple equation:

$$Malaria\ case\ mortality\ rate = \frac{Number\ of\ fatal\ malaria\ cases}{Total\ malaria\ cases}$$

The independent variables that were investigated against the dependent variables were divided into four main socioeconomic categories relating to housing locality and demographics: the number of medical facilities used; the number of infections reported; the distance to medical facilities; and the exposure to significant water bodies. The four independent variables that fall into the three main categories are discussed in sections 2.4.1, through to 2.4.4.

### 2.4.1 Number of medical facilities used

This independent variable refers to the number of medical facilities that a specific source location used to report and/or treat malaria infections. The number was calculated analysing the medical data set of the study population and the number of medical facilities that received patients or infection reports from a specific source location.

### 2.4.2 Number of infections reported

This independent variable refers to the number of malaria cases that a specific source location reported over the data set time period. The number was calculated analysing the medical data set of the study population and the number of cases that medical facilities reported for each source location.

### 2.4.3 Distance to medical facilities

This refers to the distances between a specific source location and the medical facility that the patient used. The number was calculated by analysing the medical data set of the study population, identifying the sites of source locations and medical facilities used, and determining the road distances between the source locations and medical facilities. This independent variable was divided into three sections: (a) maximum distance between centre of source location and medical facility; (b) minimum distance between centre of source location and medical facility; (c) mean distance between centre of source location and medical facility.

### 2.4.4 Distance between source location and water bodies

This refers to the distance between a significant water body and the centre of a source location of a reported malaria case. Any water body that was distinctly identified through aerial photography was considered as a significant water body, including stagnant and river water bodies.

## 2.5 RELIABILITY AND VALIDITY

### 2.5.1 Reliability

The reliability of data obtained through a test or procedure can be explained as the extent of consistency in which an instrument measures the target data points or variables as intended (Bell, 2005). Various steps were taken to ensure the reliability of the study results. The first contributor to data reliability was that the majority of the research was based on existing health records and quantitative data sets. This minimised the possibility of bias during the capturing of data. Additionally, all investigated source locations were analysed in a similar manner, ensuring data consistency throughout the process. The data for all source locations in the study originated from the same data set and analytical findings illustrated consistent findings which contributed to the assumption that the data were sufficiently reliable to create accurate conclusions.

### 2.5.2 Validity

Data validity is a more complex criteria when compared with data reliability. While data reliability is used to determine if what is intended to be measured is being correctly measured, data validity refers to the extent to which a data gathering instrument, measure or procedure determines the correct variables that are required to provide a credible conclusion (Bell, 2005). The raw data that were used in this study was not designed for the desired outcome, although additions were made to ensure that the data accurately reflected the information required to determine if the relationships existed. To measure the relationships, the variances in malaria case mortality rates across the study population needed to be understood and, subsequently, the variances in the variable socioeconomic factors within a sampled group of source locations also needed understanding. This was done, firstly, through determining the malaria case mortality rates for each source location and ranking them from highest to lowest and, secondly, through plotting and ranking travel distances by road between source locations, medical facilities and water sources. The malaria case mortality rates were readily available in the existing case records and were devised using a simple mathematical equation. The socioeconomic variables for the sampled cases were obtained primarily through comparing the geographical variances between the source locations, medical facilities and significant water bodies.

## 2.6 ANALYSIS METHOD

### 2.6.1 Research design

According to Malhotra (2000:75-76) and Pride (2007), overall research designs can be classified into two categories, namely exploratory and conclusive. The primary focus of exploratory research is to generate insight and create an overall knowledge on a subject, and that of conclusive research is to verify an existing hypothesis or provide additional detail to an existing field.

The overall design of this study was of a conclusive and causal research approach as the hypothesis was clear and literature on related subjects existed. The intent was to determine a cause and effect relationship between positive socioeconomic growth and the negative impacts of climate change.

The research was split into two primary sections, namely statistical analysis and spatial analysis:

- Statistical analysis: The data pertaining to the investigated variables was statistically analysed to determine if there were significant relationships between dependent and independent variables to establish potential malaria case mortality rate determinants.
- Spatial analysis: The locations and statistical information from the study sample and relevant variables were plotted on geographical maps to interpret qualitative information with regard to malaria case mortality rates and potential determinants.

### 2.6.2 Ethical considerations

The data for this project were collated by the Malaria Control Programme at the Limpopo Provincial Department of Health, and were obtained from the South African Weather Service through its collaborative research with the University of Pretoria's Institute for Sustainable Malaria Control. No other personal data of patients were collected and no interviews were conducted.

# CHAPTER 3 THE RESEARCH FINDINGS

The results from sampling and analysing the 57 974 malaria cases from various health centres across the Vhembe district is covered in this section of the report. The primary analytical tests and techniques used to analyse the data were normality tests, correlations and frequency tests. Although opinions among authors vary, Pallant (2005) states that the correlation coefficient from Pearson’s product moment correlation is only applicable when applied to data that are normally distributed. Spearman's rank correlation coefficient is applicable for relationship analysis of data that are not normally distributed or linear. This conclusion is based on the premise that Spearman’s rank correlation coefficient analysis procedure does not assume any linearity or normality. In order to ensure consistency across this relationship analysis, the primary correlation coefficient used was Spearman’s rank correlation coefficient, which allowed the same correlation analysis to be applied across all variables, whether normally distributed or not.

The Spearman correlation coefficients(r) were interpreted according to Cohen’s (1988) guidelines which state that r=0.5-1.0 indicates a large relationship, r=0.3-0.49 indicates a medium relationship, and r=0.1-0.29 indicates a small relationship. In addition to the Spearman’s correlation coefficient, the findings illustrate Kendall's tau coefficient and Pearson’s product moment correlation to ensure that no abnormalities existed within the data. All correlation coefficients were interpreted against a certainty value (p-value) based on the following principle: A p-value <0.05 was considered to indicate statistical significance of the respective correlation coefficient, while a p-value >0.05 rendered the respective correlation coefficient not significant. All survey results were first tested for consistency, normality and linearity in order to select the relevant approaches for analysis on inter-variable correlations (Pallant, 2005).

The results are presented in six sections that represent the correlation analysis of a specific variable factor against the selected fixed factor (which is the malaria case mortality rate).

The entire process of statistical analysis was conducted under supervision of qualified researchers to prevent analysis errors and misinterpretation (Pallant, 2005).

## 3.1 STUDY SAMPLE

The study sample consisted of three groups of locations within the Vhembe district, selected through the sampling method described in the research design section in Capter 2. The three groups of locations were selected on their malaria case mortality rates between 1998 and 2017 and ensured optimal focus areas across high, medium and low case mortality rates. The three groups are illustrated on the malria case mortality rates graph in Figure 3.


***Figure 3: Malaria case mortality rates across the source locations in the Vhembe District between 1998 and 2017***

Location set A consists of the ten locations in the data set with the highest case mortality rates. The case mortality rates ranged between 8% and 12% and the details are listed in Table 1.

**Table 1: Location set A**

| Source location | No. of malaria cases | No. of malaria deaths | % case mortality rate |
|---|---|---|---|
| Phaphazela | 25 | 3 | 12.00 |
| Tshirolwe | 17 | 2 | 11.76 |
| Manyii | 21 | 2 | 9.52 |
| Gombani | 21 | 2 | 9.52 |

| | | | |
|---|---|---|---|
| Maelula | 11 | 1 | 9.09 |
| Tshiphuseni | 11 | 1 | 9.09 |
| Khavambe | 22 | 2 | 9.09 |
| Maraxwe | 11 | 1 | 9.09 |
| Shadani | 12 | 1 | 8.33 |
| Manvuka | 25 | 2 | 8.00 |

Location set B consists of the ten locations in the data set with the lowest case mortality rates among all locations that reported fatalities. The case mortality rates in this group ranged between 0.15% and 0.35% and the details are listed in Table 2.

**Table 2: Location set B**

| Source location | No. of malaria cases | No. of malaria deaths | % case mortality rate |
|---|---|---|---|
| Tshifudi | 287 | 1 | 0.35 |
| Tshikuyu | 292 | 1 | 0.34 |
| Tshivaloni | 585 | 2 | 0.34 |
| Ntlhaveni d | 297 | 1 | 0.34 |
| Mukumawabane | 319 | 1 | 0.31 |
| Sanari | 649 | 2 | 0.31 |
| Masisi | 366 | 1 | 0.27 |
| Gumbu | 273 | 1 | 0.37 |
| Mutele b | 590 | 1 | 0.17 |
| Bendmutale | 674 | 1 | 0.15 |

Location set C consists of the ten locations in the data set with the highest number of infections and no reported malaria deaths. The case mortality rates in this group are 0% and the number of infections ranged between 171 and 304. The details are illustrated in Table 3.

**Table 3: Location set C**

| Source location | No. of malaria cases | No. of malaria deaths | % case mortality rate |
|---|---|---|---|
| Hafolovhodwe | 304 | 0 | 0.00 |

| | | | |
|---|---|---|---|
| Mutele a | 295 | 0 | 0.00 |
| Magona | 293 | 0 | 0.00 |
| Tshikundamalema | 254 | 0 | 0.00 |
| Matatani | 222 | 0 | 0.00 |
| Maphophe | 211 | 0 | 0.00 |
| Gwakwani | 204 | 0 | 0.00 |
| Lamvi | 188 | 0 | 0.00 |
| Makahlule h | 179 | 0 | 0.00 |
| Govhu | 171 | 0 | 0.00 |

## 3.2 STATISTICAL ANALYSIS FINDINGS

The data collection and research focused on the 30 locations (illustrated in Tables 1, 2 and 3) and the correlation between the fixed factor: malaria case mortality rates between 1998 and 2017 and the variable factors, which are discussed in the research design section in Chapter 2.

Table 4 illustrates the outcome of the data collection for the dependent and independent variables in the 30 source locations that made up the study sample.

**Table 4: Overview of socioeconomic factors per source location in the study sample**

| Source location | No. of medical facilities used by location | Max. km distance between location and facilities | Min. km distance between location and facilities | Avg. km distance between location and facilities | Distance (km) from centre of neighbourhood to closest significant body of water |
|---|---|---|---|---|---|
| Phaphazela | 5 | 58.6 | 3 | 22.56 | >1000 |
| Tshirolwe | 2 | 36.2 | 34.9 | 35.55 | >1000 |
| Gombani | 5 | 66.9 | 36 | 55.36 | >1000 |
| Manyii | 2 | 84.9 | 54.3 | 69.6 | 359 |
| Khavambe | 9 | 87.8 | 0.65 | 37.91 | >1000 |
| Maelula | 3 | 102 | 20.4 | 57.9 | 189 |
| Maraxwe | 6 | 67.3 | 5.7 | 27.48 | >1000 |
| Tshiphuseni | 3 | 41.6 | 2.5 | 21.23 | >1000 |
| Shadani thulamela | 8 | 55 | 20.2 | 35.13 | >1000 |

| | | | | | |
|---|---|---|---|---|---|
| Manvuka | 3 | 86.3 | 31.3 | 61.7 | 557 |
| Gumbu | 11 | 114 | 13.4 | 65.49 | >1000 |
| Tshifudi | 11 | 211 | 1.5 | 50.27 | >1000 |
| Tshikuyu | 7 | 126 | 9.2 | 56.99 | >1000 |
| Tshivaloni | 14 | 128 | 5.8 | 56.81 | 531 |
| Ntlhaveni d | 12 | 650 | 1.5 | 104.76 | 695 |
| Mukumawabane | 16 | 127 | 3.3 | 63.7 | 381 |
| Sanari | 14 | 124 | 0.7 | 62.82 | 178 |
| Masisi | 15 | 165 | 0.55 | 69.63 | >1000 |
| Mutele b | 12 | 172 | 1.8 | 66.08 | 298 |
| Bendmutale | 13 | 136 | 19.2 | 80.35 | 193 |
| Govhu | 9 | 63.9 | 2.5 | 24.97 | >1000 |
| Gwakwani | 12 | 72.7 | 16.4 | 46.06 | 411 |
| Hafolovhodwe | 11 | 148 | 11 | 65.97 | 656 |
| Lamvi | 13 | 200 | 8.4 | 53.19 | >1000 |
| Magona | 12 | 214 | 0.6 | 41.69 | >1000 |
| Makahlule | 10 | 168 | 0.35 | 41.61 | >1000 |
| Maphophe | 9 | 53.6 | 11.3 | 27.47 | >1000 |
| Matatani | 10 | 110 | 19.6 | 55.34 | >1000 |
| Mutele | 14 | 278 | 1.3 | 83.76 | 493 |
| Tshikundamalema | 13 | 153 | 35.5 | 79.19 | >1000 |

*(Annexure A details the preferred medical facilities used by all source locations in the study population)*

The findings from the correlation investigation between the results in Table 4 and the malaria case mortality rates are discussed in detail in sections 3.2.1 through to 3.2.6.

### 3.2.1 The correlation between the number of medical facilities used by the source locations and the malaria case mortality rates

This correlation analysis focused on individual malaria infection source locations and determined the number of medical facilities that individuals from these locations used during the study timeframe. The number of facilities were compared with the malaria case mortality rates to determine the relationship between the two factors.

Figure 4 graphically illustrates the relationship between the two factors and the statistical correlation analysis results indicated:

- Spearman's rank correlation coefficient of -0.7952 with a p-value of 0.0000
- Pearson's product moment correlation coefficient of -0.8465 with a p-value of 0.0000
- Kendall's tau correlation coefficient of -0.6614 with a p-value of 0.000

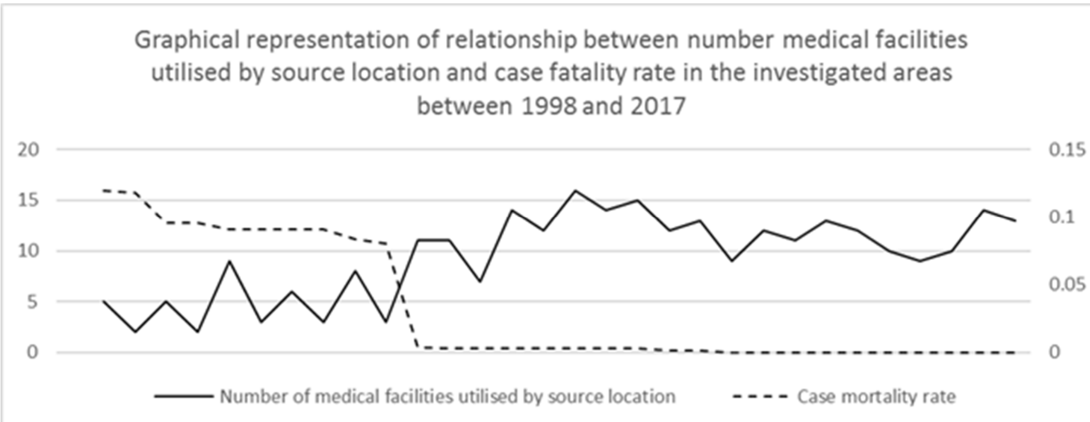


***Figure 4: Number of medical facilities used by the source locations and the malaria case mortality rates***

### 3.2.2 The correlation between the maximum distance from the medical facilities used and the malaria case mortality rates

The correlation analysis focused on individual malaria infection source locations and determined the maximum distance that individuals in this area travelled to the medical facilities. The maximum distance between source location and medical facility used was compared with the malaria case mortality rates to determine the relationship between the two factors.

Figure 5 illustrates the relationship between the two factors and the statistical correlation analysis indicated:

- Spearman's rank correlation coefficient of -0.6723 with a p-value of 0.0000
- Pearson's product moment correlation coefficient of -0.4340 with a p-value of 0.0166
- Kendall's tau correlation coefficient of -0.5493 with a p-value of 0.0002

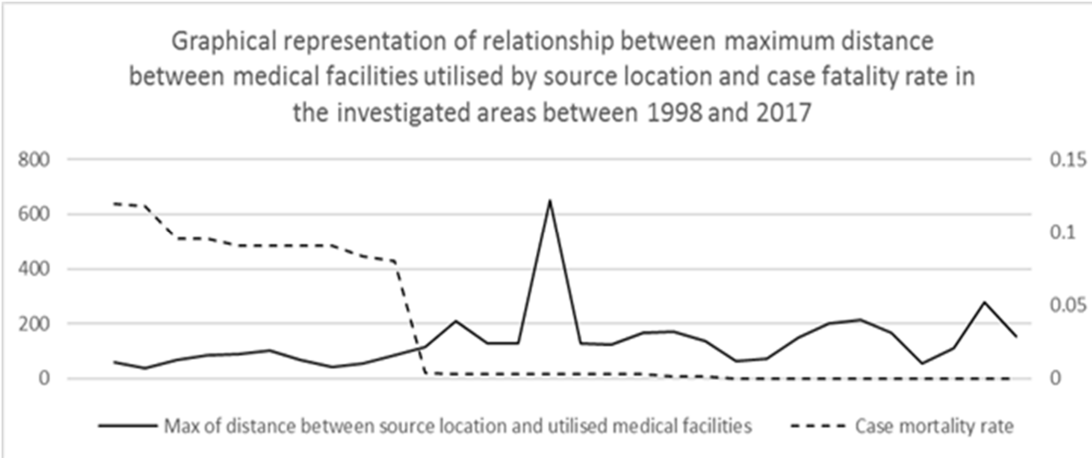


***Figure 5: Maximum km travel distance to medical facilities used across the source locations***

### 3.2.3 The correlation between the minimum distance from medical facilities used and the malaria case mortality rates

This correlation analysis focused on individual malaria infection source locations and determined the minimum distance that individuals travelled to the medical facilities used. The minimum distance between the source location and the medical facility was compared with the malaria case mortality rate to determine the relationship between the two factors.

The relationship between the two factors is graphically illustrated in Figure 6 and the statistical correlation analysis results indicated:

- Spearman's rank correlation coefficient of 0.3816 with a p-value of 0.0375
- Pearson's product moment correlation coefficient of 0.4459 with a p-value of 0.0135
- Kendall's tau correlation coefficient of 0.3097 with a p-value of 0.0339

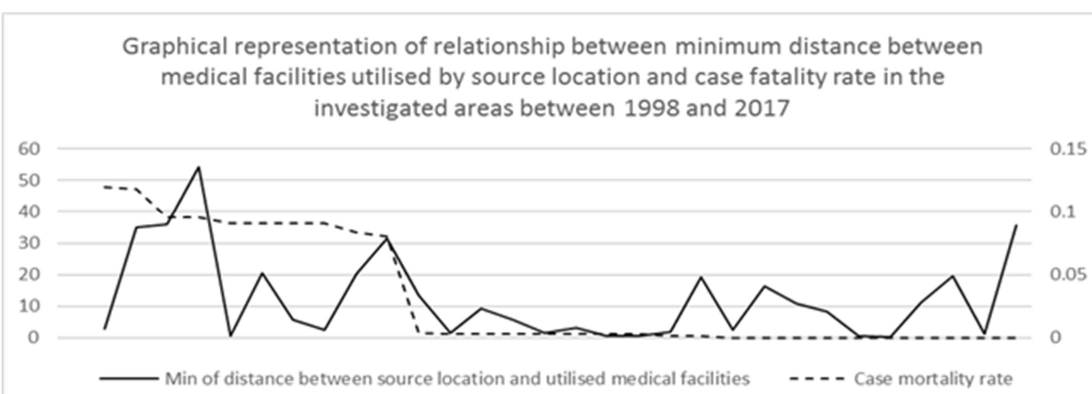

*Figure 6: Minimum km travel distance to medical facilities across the source locations*

### 3.2.4 The correlation between the mean distance from the medical facilities used and the malaria case mortality rates

This correlation analysis focused on individual malaria infection source locations and determined the mean distance that individuals travelled to the medical facilities used. The mean distance between the source location and the medical facility was compared with the malaria case mortality rate to determine the relationship between the two factors.

Figure 7 ilustrates the relationship between the two factors and the statistical correlation analysis results indicated:

- Spearman’s rank correlation coefficient of -0.3990 with a p-value of 0.0289
- Pearson’s product moment correlation coefficient of -0.4291 with a p-value of 0.0180
- Kendall's tau correlation coefficient of -0.3183 with a p-value of 0.0289

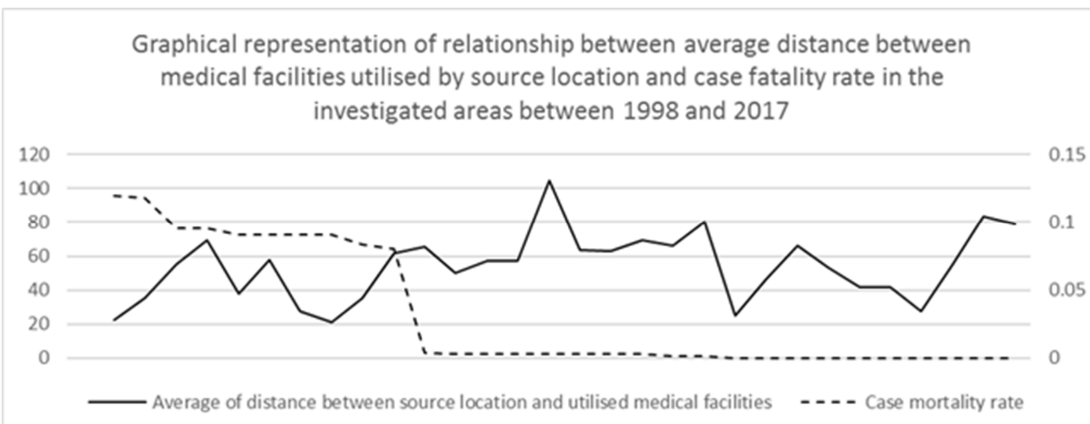


*Figure 7: Average km travel distance to the medical facilities across the source locations*

### 3.2.5 The correlation between the distance from significant water bodies and the malaria case mortality rates

This correlation analysis focused on individual malaria infection source locations and determined the distance between the source location and the nearest significant water body. This distance was compared with the malaria case mortality rate to determine the relationship between the two factors.

Figure 8 graphically illustrates the relationship between the two factors and the statistical correlation analysis results indicated:

- Spearman’s rank correlation coefficient of 0.1320 with a p-value of 0.4869
- Pearson’s product moment correlation coefficient of 0.1258 with a p-value of 0.5076
- Kendall's tau correlation coefficient of 0.1163 with a p-value of 0.4677

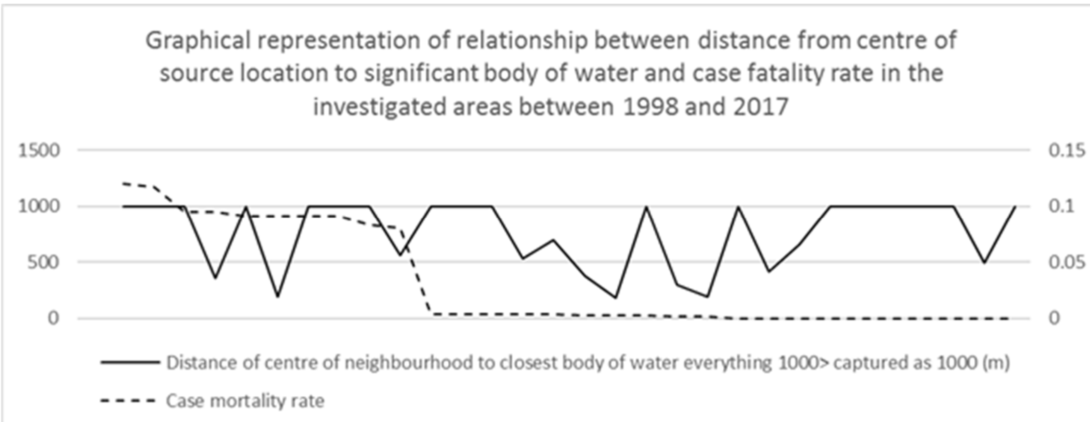


***Figure 8: Distance between the source locations and significant bodies of water***

### 3.2.6 The correlation between the number of infections reported by the source locations and the malaria case mortality rates

This correlation analysis focused on individual malaria infection source locations and determined the number of malaria cases reported in the study timeframe. The number of cases reported were compared with the malaria case mortality rates to determine the relationship between the two factors.

Figure 9 graphically illustrates the relationship between the two factors and the statistical correlation analysis indicated:

- Spearman’srank correlation coefficient of -0.7890 with a p-value of 0.0000
- Pearson’s product moment correlation coefficient of -0.7489 with a p-value of 0.0000
- Kendall's tau correlation coefficient of -0.6121 with a p-value of 0.0000

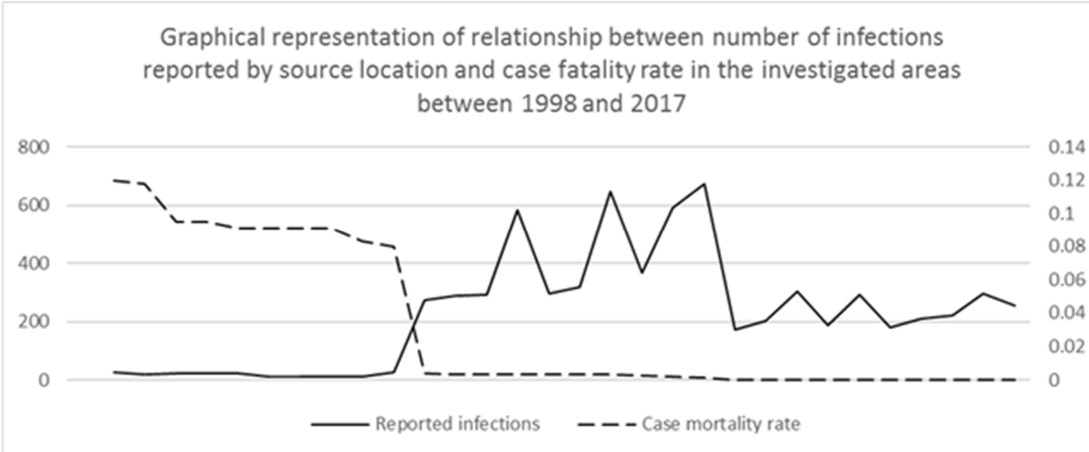


***Figure 9: Number of infections reported across the source locations and the malaria case fatality rates***

## 3.3 SPATIAL ANALYSIS

To supplement the statistical findings and improve the comprehension and accurate interpretation of the findings, a spatial analysis was conducted to provide an overview of the spatial aspects.

### 3.3.1 Overview of the locations of investigated facilities and the number of malaria cases reported to them during the study timeframe

The spatial analysis illustrated in Figure 10 was conducted through identifying all medical facilities used by the investigated source locations, determining the number of malaria cases they reported over the study period, and classifying them into three categories in terms of the number of reported malaria cases: (a) 1 to 850 reported cases; (b) 851 to 3 000 reported cases; and (c) 3 001 to 7 800 reported cases. This information was plotted geographically to provide an understanding of medical facility preferences among study source locations.

The analysis indicated that 52 of the health facilities used by the investigated source locations reported between 1 and 850 malaria cases within the investigated period. The 52 medical facilities with the lowest number of malaria case reports comprised 46 clinics, five health centres and three hospitals. The second category of health facilities, those that reported between 851 and 3 000 malaria cases, consisted of 11 medical facilities. These 11 medical facilities comprised nine clinics (the majority of which were located in north-eastern Vhembe and isolated from hospitals or health centres) and two hospitals in south-western Vhembe. The third category of medical facilities, those that recorded between 3 001 and 7 600 malaria cases, consisted of four hospitals, with three of the hospitals located relatively in the centre of the Vhembe district and one isolated in the north-western part of Vhembe.

Overall, the spatial analysis of the investigated medical facilities and the number of cases reported indicates a strong distribution of clinics across northern, southern and central Vhembe. There is a limited distribution of hospitals and health centres, with the majority of these facilities located in the south to south-western areas of the district. In addition, the spatial analysis indicates that the clinics that are located furthest from health centres or hospitals reported significantly higher malaria case numbers than clinics in closer proximity to the health centres or hospitals. This suggests that patients who are able to access health centres or hospitals prefer those facilities over the clinics. Patients in the more isolated areas, however, have no choice but to use the clinics they able to access.

These findings could be considered to support the statistical findings that suggested higher case mortality rates were observed in areas that have shorter travel distances to medical facilities. This suggests that patients in Vhembe consider healthcare provided by local clinics to be less effective than service delivery from the larger hospitals and health centres.

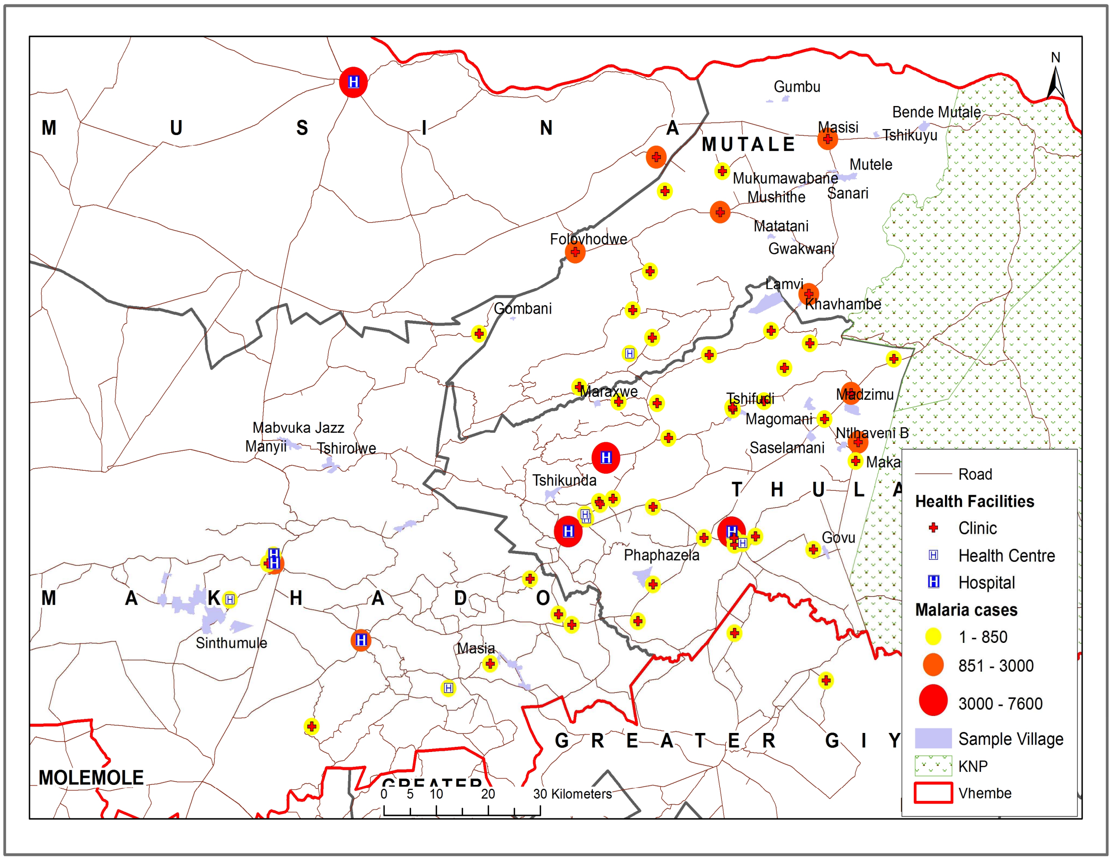


***Figure 10: Investigated medical facilities and total number of reported cases within the study timeframe***

### 3.3.2 Overview of the case mortality rates across the source locations within the study sample

The spatial analysis as indicated in Figures 11 and 12 investigated the geographical distribution of malaria cases and malaria case mortality rates among the study sample. The analysis was conducted on the number of reported malaria cases and malaria case fatalities across the investigated source locations. This information was used to determine malaria case mortality rates, which were geographically plotted together with the number of reported malaria cases. The objective of this spatial analysis was to provide geographic insight into the varying malaria case mortality rates within the Vhembe district and to determine if any additional insights could be drawn from the geographical distribution of the data.

The spatial analysis indicated that although the areas with the higher case mortality rates are distributed relatively equally across north, south and central Vhembe, there is a cluster of areas with high case mortality rates in the western area that appears to be isolated from medical facilities. This cluster consists of the Mabvuka, Tshirolwe and Manyii source locations. If this information is compared with the spatial analysis in Figure 10, it can be seen that these three areas are the most isolated in terms of distance to medical facilities when compared with the other source locations. This information appears to contradict the statistical analysis, which indicated that further travel distances have a negative correlation with malaria death rates.

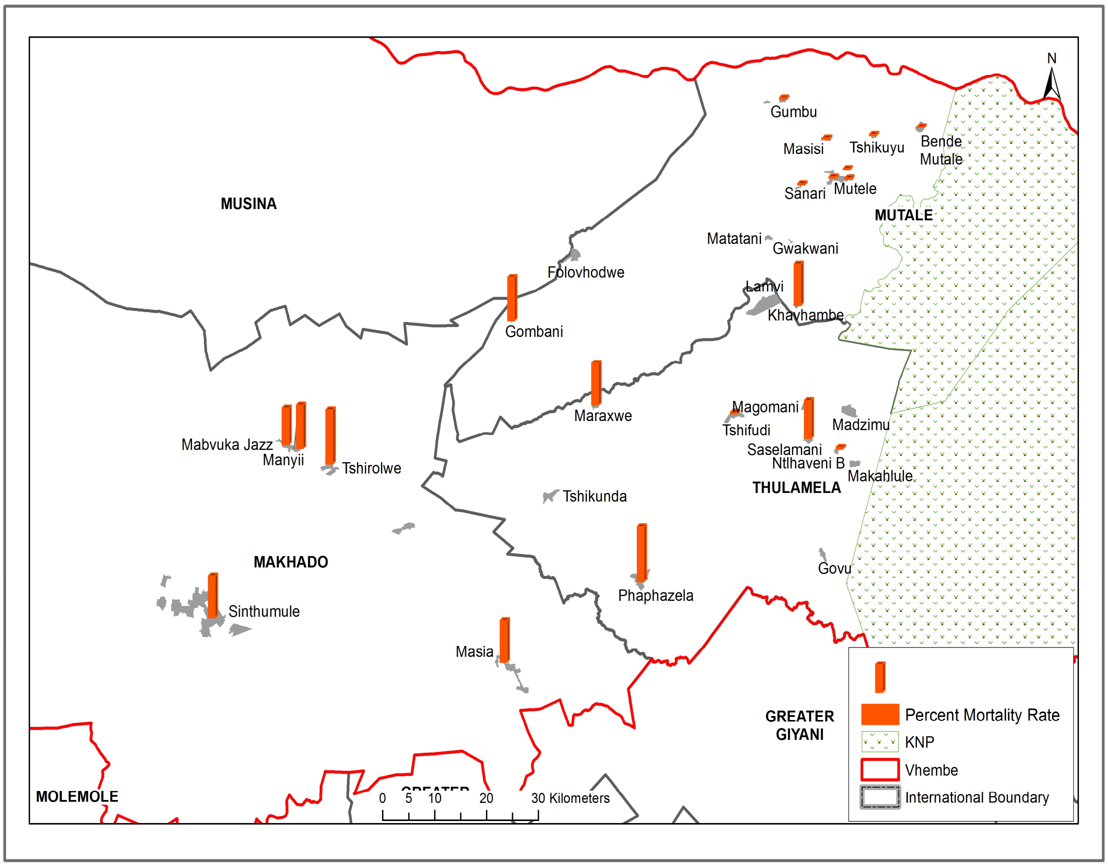


***Figure 11: Case mortality rates across the source locations in the study sample***

An important observation from the spatial analysis is that the Mabvuka, Manyii and Tshirolwe cluster is the only area with high malaria case mortality rates, but they are also outliers in terms of distances from medical facilities among the ten highest case fatality rate areas. The average distances travelled to medical facilities among this cluster is 55.6 km, significantly higher than the average 36.7 km across the rest of the highest case fatality rate areas. This information might suggest that distance to medical facilities does not have a positive correlation with malaria case mortality rates when the community members have financial or other means to access medical facilities further away. However, it could have a positive correlation with case mortality rates in instances where community members do not have any option but to travel the further distances.

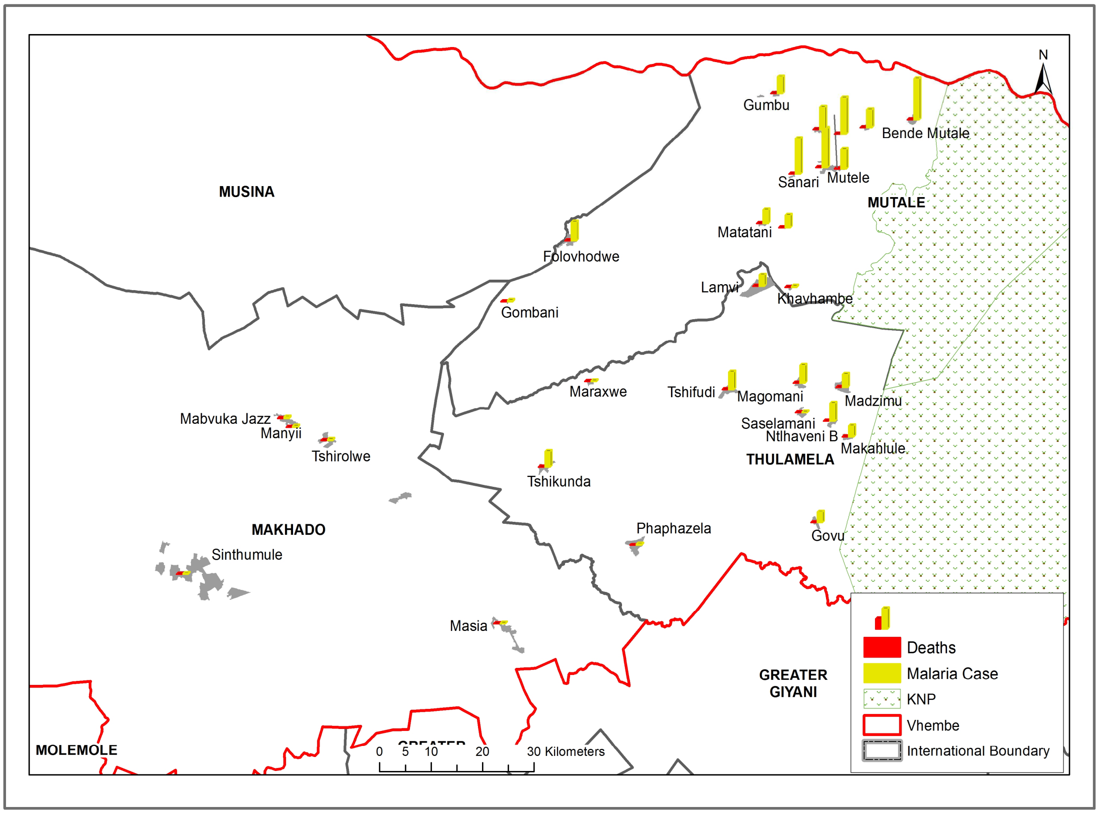


***Figure 12: Number of infections and related deaths reported in the source locations across the study sample***

In addition, the spatial analysis could be considered to support the statistical findings that areas with lower numbers of reported malaria cases are more likely to have high case mortality rates.

In Figure 12, a cluster of source locations with the highest number of reported malaria cases is seen in the north-eastern region of Vhembe, consisting of Bende Mutale, Sanari, Mutele A, Mutele B, Tshikuyu, Masisi and Gumbu. Figure 12 clearly illustrates high case mortality rates across these areas however, when compared with the case mortality rates in Figure 11, it is clear that among all the high infection rate clusters, the case mortality rates appear to be significantly lower than in areas with lower infection numbers.

### 3.3.3 Overview of distances between the source locations and the medical facilities in the study sample

This spatial analysis focused on providing a spatial perspective on geographical distances between the various investigated source locations and the respective medical facilities in the study sample. The spatial analysis involved identifying all the medical facilities used by the sample source locations during the timeframe and geographically plotting them together with the source locations. The spatial analysis further imposed spatial buffers around the medical facilities to identify geographically isolated source locations and potentially draw insight from the relationship between geographical isolation and malaria case mortality rates. The spatial analysis figures illustrate source locations against medical facilities with respective buffer radii of 5 km (Figure 13), 10 km (Figure 14) and 15 km (Figure 15) respectively, each of which is discussed and interpreted separately.

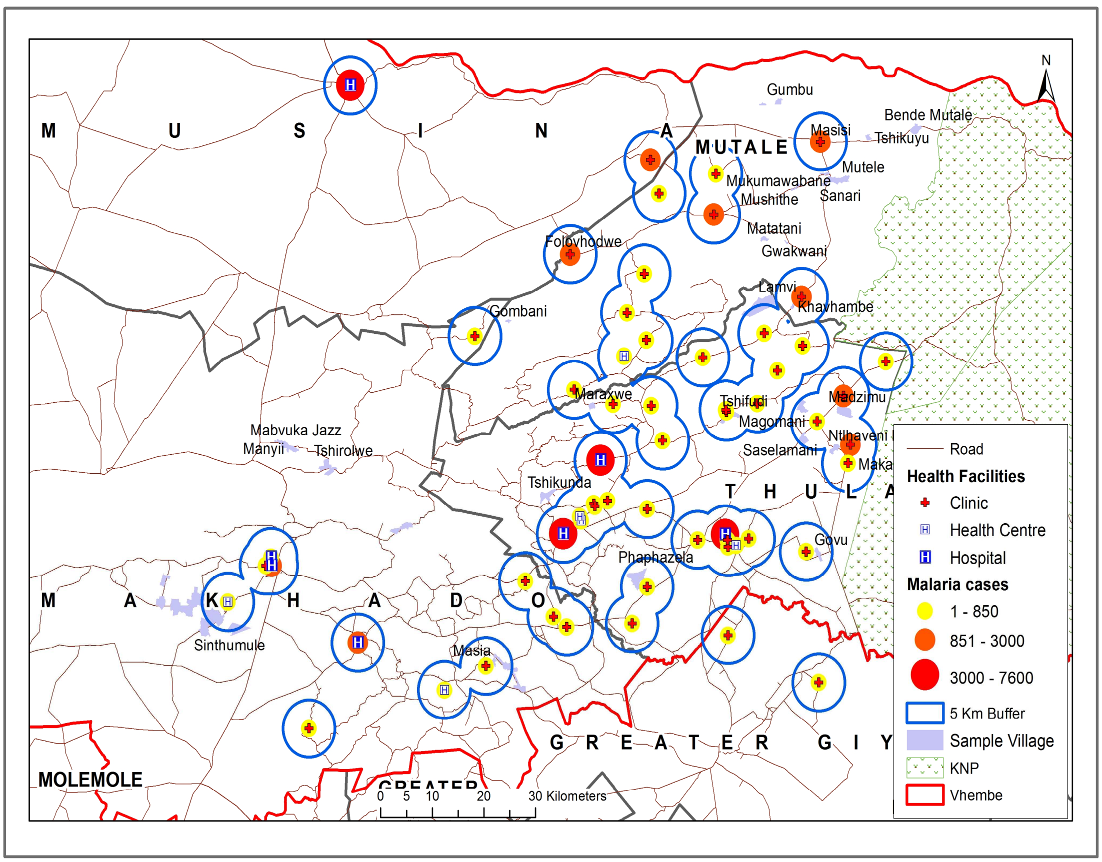


*Figure 13: Malaria case source locations within a 5 km buffer of medical facilities*

Figure 13, which illustrates the source locations within a 5 km buffer of medical facilities, indicates that only four of the 10 source locations with the highest malaria case fatalities are located outside a 5 km radius of medical facilities. In total, 14 of the 30 source locations are located outside a 5 km radius of any medical facility. This suggests that only 40% of the 10 highest case fatality rate source locations are beyond the 5 km buffer, while 46% of the total study sample is located further than 5 km from the nearest medical facility. This supports the statistical findings that suggested that closer proximity to health facilities does not decrease the malaria case mortality rates.

Figure 14, which illustrates source locations within a 10 km buffer of medical facilities, indicates that three out of the 10 source locations with the highest malaria case fatalities are located outside of a 10 km radius of medical facilities. In total, six of the 30 source locations are located outside a 10 km radius of any medical facility. This suggests that 30% of the 10 highest case fatality rate source locations are outside the 10 km buffer, while

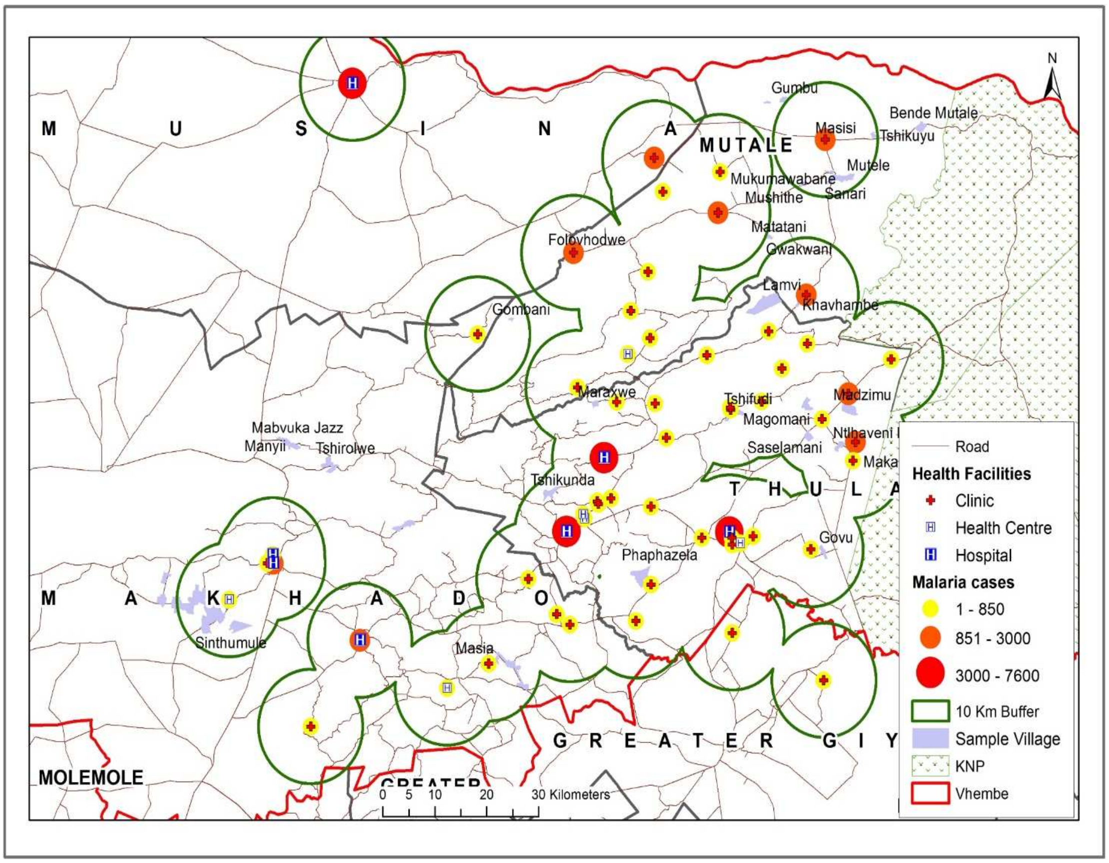


***Figure 14: Malaria case source locations within a 10 km buffer of medical facilities***

20% of the total study sample is located further than 10 km from the nearest medical facility. This finding supports the observation that the cluster of high case mortality rates, consisting of Mabvuka, Tshirolwe and Manyii source locations, could indicate that financial or other means to access medical facilities have a stronger influence on reducing the malaria case mortality rates than merely the distance to medical facilities.

Figure 15, which illustrates source locations within a 15 km buffer of medical facilities, indicates that three out of the 10 source locations with the highest malaria case fatalities are located outside of a 15 km radius of medical facilities, while none of the other source locations are located outside this buffer. This further supports the findings from Figure 14 which indicate that financial or other means to access medical facilities could have a stronger influence on reducing the malaria case mortality rates than distance to medical facilities.

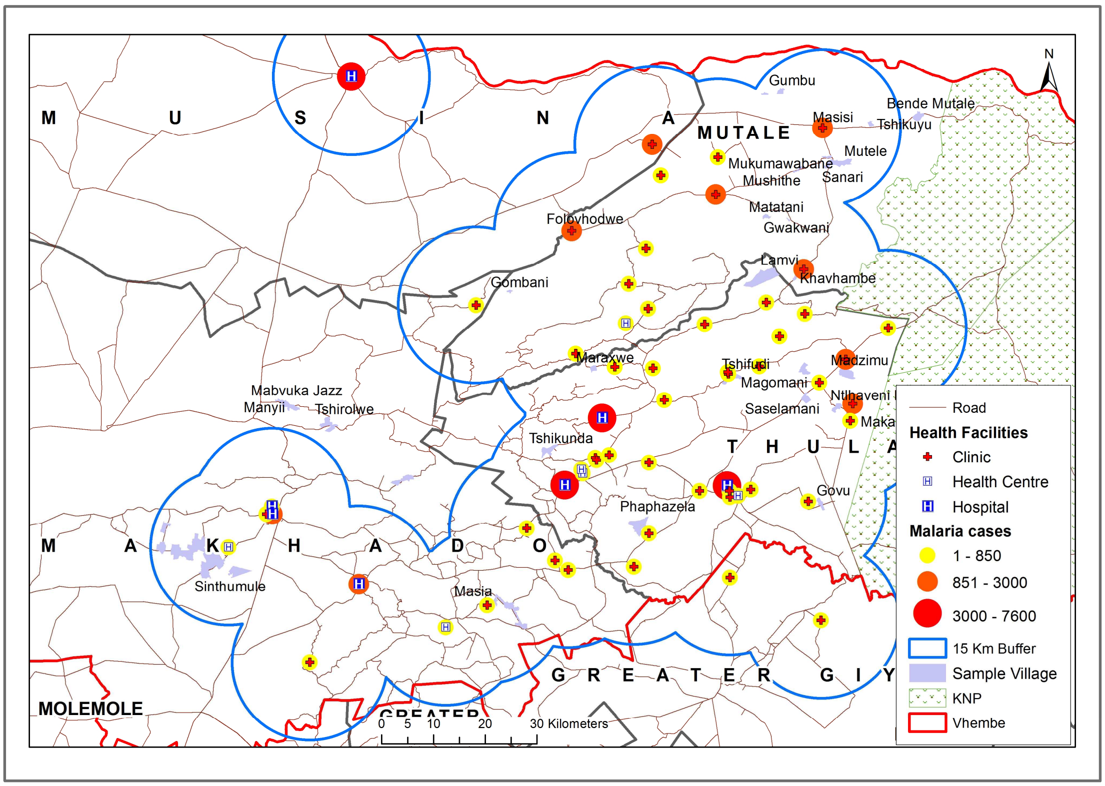


*Figure 15: Malaria case source locations within a 15 km buffer of medical facilities*

The most significant observation from this section of the spatial analysis is that the three most isolated source locations in terms of distances to medical facilities, namely Tshirolwe, Manyii and Manvuka, also form part of the 10 source locations with the highest case mortality rates in the study population. Tshirolwe experienced the second highest case fatality rate among the investigated source locations, while Manyii and

Manvuka had the fourth and tenth highest case mortality rates respectively.There is a clear contradiction between this spatial finding, which suggests that distance to medical facilities has a positive correlation with malaria case mortality rates, and the statistical finding that indicated a negative correlation between these variables. This contradiction highlights the need for further investigations to determine what other socioeconomic factors vary between the studied source locations, specifically between source locations with high case mortality rates and varying distances to medical facilities.

### 3.3.4 Spatial overview of distance between significant water bodies and malaria infections in the study sample

This spatial analysis focused on providing a spatial perspective on geographical distances between the various investigated source locations and significant water bodies in the study sample. The spatial analysis involved identifying all significant water bodies in the study area and plotting them geographically together with source locations. The spatial analysis further imposed a 1 km spatial buffer around the significant water bodies to identify source locations that fell within these buffers. The intention was to gain potential, additional insight into the relationship between significant water bodies and malaria case mortality rates.

Figure 16, which illustrates source locations within a 1 km buffer of significant water bodies indicates that nine of the 30 investigated source locations fall within the 1 km buffer. Only one of the 10 source locations with the highest malaria case fatality rates is located within the 1 km radius of significant water bodies, while 4 from the 10 source locations with the lowest malaria case fatalities rates but reported fatalities and 4 from the 10 source locations with the highest number of infections but no reported fatalities, fall within the 1 km buffer. This spatial analysis supports the statistical findings that suggested that proximity to water bodies does not have a significant positive relationship with malaria case fatality rates.

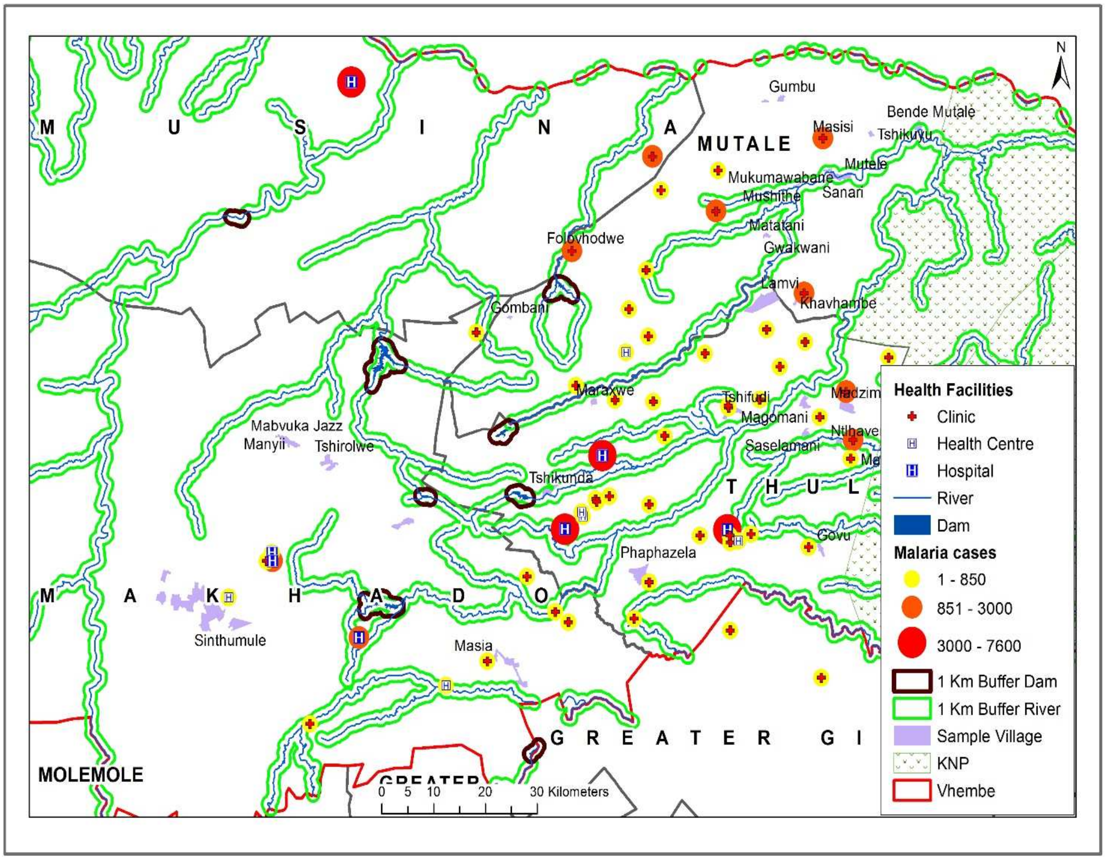


***Figure 16: Malaria case source locations within a 1 km buffer of significant water bodies***

## 3.4 INTERPRETATION OF THE FINDINGS

### 3.4.1 The correlation between the number of medical facilities used by the source locations and the malaria case mortality rates

This section of the research aimed to determine if there was a statistically significant relationship between the malaria case mortality rates in a specific source location and the number of medical facilities that malaria patients from this specified source location used during the study period. The number of medical facilities used by the investigated source locations varied between two and 16 facilities per source location. This could indicate that there are considerable imbalances between access to a variety of medical facilities in villages across Vhembe.

In addition, the statistical analysis of the results across the three mentioned correlation theories indicated a strong to very strong negative relationship between the two variables, with the Spearman's rank correlation coefficient indicating a negative correlation coefficient of -0.7952 with a p-value of 0.0000. This suggests that if all other variables are considered equal, the number of medical facilities available to a specific source location can attribute for up to 79.5% of variance in malarial case mortality rates, with a 0% probability of the findings being coincidental.

The data suggest there is a very strong likelihood that an increase in the number of medical facilities accessible to a specific source location could lead to a significant decrease in the source location's malaria case mortality rates. It is important to note that these results were calculated only on the number of medical facilities used, but this number could have been influenced by various other factors such as access to transportation, financial means to visit medical facilities, and willingness to seek treatment, for example.

### 3.4.2 The correlation between the maximum distance from the medical facilities used and the malaria case mortality rates

This section of the research aimed to determine if there was a statistically significant relationship between the malaria case mortality rate in a specific source location and the maximum distance between the medical facilities used and the source location. The maximum distance between the medical facilities and the specific source location varied between 36.2 km and 278 km, with one outlier at 650 km. This indicates that there were considerable variances between the maximum distances that patients travelled to medical facilities across the source locations.

In addition, the statistical analysis of the results across the three correlation theories indicated a medium to strong negative relationship between the two variables, with the Spearman's rank correlation coefficient indicating a negative correlation coefficient of -0.6723 with a p-value of 0.0000. This suggests that if all other variables are considered equal, the maximum distance between the medical facilities that patients used and the source location could attribute for up to 67% of variances in malaria case mortality rates, with a 0% probability of the findings being coincidental.

The data suggest there is a likelihood that an increase in the maximum distance between the medical facilities that patients used and the source location could lead to a significant decrease in the source location's malaria case mortality rates. This result is contrary to the researchers assumptions that closer access to medical facilities was expected to have a negative impact on malaria case mortality rates. The results indicate there could be additional factors that need to be investigated. One possible explanation that should be investigated is that further maximum distances travelled to medical facilities could indicate that patients had financial or other means to access more advanced medical services at larger facilities and, as a result, this translated into smaller case mortality rates.

### 3.4.3 The correlation between the minimum distance from the medical facilities used and the malaria case mortality rates

This section of the research aimed to determine if there was a statistically significant relationship between the malaria case mortality rate in a specific source location and the minimum distance between the medical facilities that patients used. The minimum distance between the medical facilities and the specific source location varied between 0.35 km and 54.3 km with no significant outliers. This indicates there are considerable variances between the minimum distances that patients travelled to medical facilities across the source locations.

In addition, the statistical analysis of the results across the three correlation theories indicated a medium positive relationship between the two variables, with the Spearman's rank correlation coefficient indicating a positive correlation coefficient of 0.3816 with a p-value of 0.0375. This suggests that if all other variables are considered equal, the minimum distance between the medical facilities used and the source location could attribute for up to 38.16% of variances in malaria case mortality rates, with a 3.75% probability of the findings being coincidental.

The data suggest there is a likelihood that a decrease in the minimum distance between the medical facilities used and the source location could lead to a potential decrease in the source location's malaria case mortality rates. This result is in line with the researchers assumptions that closer access to medical facilities was expected to have a negative impact on malaria case mortality rates. The results could indicate that immediate or lower than average access times to medical facilities could decrease malaria case mortality rates.

### 3.4.4 The correlation between the mean distance from medical facilities used and the malaria case mortality rates

This section of the research aimed to determine if there was a statistically significant relationship between the malaria case mortality rate in a specific source location and the average distance between the medical facilities used and the source location. The average distance between the medical facilities and the specific source location varied between 21.2 km and 104.7 km with no significant outliers. This indicates that there are considerable variances between the average distances that patients travelled to medical facilities across the source locations.

In addition, the statistical analysis of the results across the three correlation theories indicated a medium negative relationship between the two variables, with the Spearman's rank correlation coefficient indicating a negative correlation coefficient of -0.3990 with a p-value of 0.0289. This suggests that if all other variables are considered equal, the average distance between the medical facilities that patients used and the source location could attribute for up to 39.9% of variances in malaria case mortality rates, with a 2.89% probability of the findings being coincidental.

The data suggest there is a likelihood that an increase in the average distance between the medical facilities used and the source location could lead to a significant decrease in the source location's malaria case mortality rate. This result is contrary to the researchers assumptions that closer access to medical facilities was expected to have a negative impact on malaria case mortality rates. The results indicate that there may be additional factors to be investigated. One possible explanation that should be investigated is that the further average distances travelled to medical facilities could indicate that patients had financial or other means to access more advanced medical services at larger facilities and, as a result, that translated into smaller case mortality rates.

### 3.4.5 The correlation between the distance from significant water bodies and the malaria case mortality rates

This section of the research aimed to determine if there was a statistically significant relationship between the malaria case mortality rate in a specific source location and the distance from a significant water body. The distance between the centre of the source locations and significant water bodies varied between 178 m and >1 000 m. This could indicate that the study sample provided a strongly varying data set.

In addition, the statistical analysis of the results across the three correlation theories indicated a potentially small positive relationship between the two variables, with the Spearman's rank correlation coefficient indicating a positive correlation coefficient of 0.1320 with a p-value of 0.4869. The potential correlation is however not statistically significant due to the 48.6% probability that the correlation coefficient is coincidental.

The statistical and spatial analysis suggest that there is no significant correlation between the malaria case mortality rate in an area and source location distance to significant water bodies. It is important to note that these results only considered malaria case mortality rates. It should be further investigated if the distance to significant water bodies in Vhembe has an impact on the number of malaria infections.

### 3.4.6 The correlation between the number of infections reported by the source locations and the malaria case mortality rates

This section of the research aimed to determine if there was a statistically significant relationship between the malaria case mortality rate in a specific source location and the number of malaria infections from this specified source location during the study period. The number of infections reported from the various source locations varied between 11 and 674 medical facilities used per source location. This indicates that there are considerable variances among the number of malaria cases across the study sample.

In addition, the statistical analysis of the results across the three correlation theories indicated a strong to very strong negative relationship between the two variables, with the Spearman's rank correlation coefficient indicating a negative correlation coefficient of -0.7890 with a p-value of 0.0000. This suggests that if all other variables are considered equal, the number of malaria infections in a specific source location could attribute for up to 78.9% variance in malaria case mortality rates with a 0% probability of the findings being coincidental.

The data suggest there is a very strong likelihood that an increase in the number of reported malaria infections in a specific source location could lead to a decrease in the source location's malaria case mortality rate. It is important to note that these results were calculated only on the number of malaria infections reported and not correlated with population numbers in the various source locations. Investigations should be undertaken on the following potential theories to further explain this finding:

- Lower numbers of infections in source locations could result in populations that are uneducated in malaria treatment, resulting in higher case mortality rates.
- Lower numbers of infections in source locations reflect smaller source location populations which could result in limited societal support, resulting in higher case mortality rates.
- Lower numbers of infections in source locations reflect smaller populations that are socioeconomically segregated from larger, more advanced communities with easier access to medical facilities, which could result in higher case mortality rates.

# CHAPTER 4 CONCLUSION AND RECOMMENDATIONS

## 4.1 CONCLUSION

The statistical analysis indicated a significant negative correlation between case mortality rates and the number of medical facilities used by the sample source locations, numbers of infections reported, and the maximum and mean distances travelled to the medical facilities used. This suggested that malaria patients from larger communities with financial or other means to access more advanced or a bigger variety of medical facilities had a significantly lower risk of mortality. The negative correlation between average distances travelled to medical facilities and case mortality rates could also suggest that patients who were willing or educationally informed to seek medical assistance during malaria infections, despite long travel distances, had a significantly higher chance of survival.

The two independent variables that indicated the strongest correlations to malaria case fatality rates were the number of medical facilities used by source locations followed by the number of infections reported during the study timeframe. The negative correlation with the number of medical facilities used could suggest that malaria patients from larger communities, those who had access to a larger variety of medical facilities, had a significantly higher survival rate than patients from smaller communities. The negative correlation with the number of infections reported supports this statement, but could also suggest that communities with high numbers of infections result in improved malaria preparedness in terms of readily available resources to treat malaria infections and prevent related deaths.

The analysis indicated a positive correlation between the minimum distances travelled to medical facilities and case mortality rates, indicating that although longer maximum and average travelling distances had a negative correlation, medical facilities situated directly in the communities could have a positive impact on reducing case mortality rates. Proximity to significant water bodies was not found to have any significant impact on malaria case mortality rates, however, it is suspected that it could have an impact on the number of infections.

The spatial analysis supported the majority of the findings from the statistical analysis, except for a small cluster of source locations, namely Tshirolwe, Manyii and Manvuka, that also formed part of the ten source locations with the highest case mortality rates in the study population. In addition, the findings highlight that further investigation into root causes of the above findings will provide valuable insights to policy makers.

## 4.2 RECOMMENDATIONS

The research findings suggest that South African authorities could reduce malaria case mortality rates in the Vhembe district though improving the local communities access to more advanced healthcare facilities and a larger variety of healthcare facilities. This could be accomplished through two primary approaches:

- Physically enabling the communities to access a larger network of healthcare facilities, either through subsidised or improved public transport systems, increased economic development in the regions, improved road networks, or other measures that could decrease the physical and financial barriers that certain communities experience with regard to accessing healthcare facilities.
- Socially increasing local communities willingness to access more advanced healthcare facilities, which could be achieved through increased educational campaigns and activities to increase community networks and malaria treatment awareness.

In addition, the findings suggest that the distribution of medical treatment facilities in direct proximity of communities could result in decreased malaria case mortality rates.

In terms of future research, the research findings suggest that patients from various source locations in the Vhembe district prefer to use medical facilities that are significantly further away than the medical facilities closest to them, and this decreases the malaria case mortality rates. Further research into understanding the drivers behind the medical facility preferences and medical-seeking behaviour in general in the Vhembe district could enable South African authorities to drive even more effective malaria management principles.

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# CHAPTER 6 **APPENDIX A**

Comprehensive list of source locations in the Vhembe district with their preferred medical facilities:

| Source location | Medical centre reported | Distance travelled to (km) | Number of non-fatal cases | Number of fatal cases | Total cases |
|---|---|---|---|---|---|
| BENDMUTALE | Masisi Clinic | 19.2 | 468 | 0 | 468 |
| | Donald Fraser Hospital | 97.9 | 56 | 0 | 56 |
| | Mulala Clinic | 25.3 | 26 | 1 | 27 |
| | Makuya Clinic | 47 | 10 | 0 | 10 |
| | Musina Hospital | 136 | 6 | 0 | 6 |
| | Tshilidzini Hospital | 124 | 3 | 0 | 3 |
| | Folovhodwe Clinic | 82.2 | 2 | 0 | 2 |
| | Madimwo/Madimbo Clinic | 59.3 | 2 | 0 | 2 |
| | Manenzhe Clinic | 45.5 | 1 | 0 | 1 |
| | Mutale Health Centre | 89.5 | 1 | 0 | 1 |
| | Sibasa Clinic | 103 | 1 | 0 | 1 |
| | Siloam Hospital | 134 | 1 | 0 | 1 |
| | Tshifudi Clinic | 81.7 | 1 | 0 | 1 |
| GOMBANI | Siloam Hospital | 36 | 11 | 2 | 13 |
| | Khomela Clinic | 56.1 | 5 | 0 | 5 |
| | Donald Fraser Hospital | 54.3 | 1 | 0 | 1 |
| | Tshifudi Clinic | 63.5 | 1 | 0 | 1 |
| | Tshilidzini Hospital | 66.9 | 1 | 0 | 1 |
| GOVHU | Malamulele Hospital | 23.5 | 64 | 0 | 64 |
| | Ntlhaveni E Clinic | 17.3 | 50 | 0 | 50 |
| | Peninghotsa Clinic | 3.1 | 42 | 0 | 42 |
| | Ntlhaveni C Clinic | 17.3 | 11 | 0 | 11 |
| | Malamulele Clinic | 21.9 | 2 | 0 | 2 |
| | Donald Fraser Hospital | 63.9 | 1 | 0 | 1 |
| | Mavambe Clinic | 27.6 | 1 | 0 | 1 |
| | Mtititi Clinic | 2.5 | 1 | 0 | 1 |
| | Tlangelani Clinic | 47.6 | 1 | 0 | 1 |
| GUMBU | Masisi Clinic | 13.4 | 210 | 0 | 210 |
| | Donald Fraser Hospital | 92.8 | 14 | 1 | 15 |

| | | | | | |
|---|---|---|---|---|---|
| | Manenzhe Clinic | 23.5 | 13 | 0 | 13 |
| | Musina Hospital | 114 | 6 | 0 | 6 |
| | Lambani Clinic | 57 | 5 | 0 | 5 |
| | Mulala Clinic | 20.2 | 4 | 0 | 4 |
| | Madimwo/Madimbo Clinic | 37.3 | 3 | 0 | 3 |
| | William Eadie Health Centre | 103 | 2 | 0 | 2 |
| | Makonde Clinic | 80.6 | 1 | 0 | 1 |
| | Tshaulu Clinic | 70.6 | 1 | 0 | 1 |
| | Tshilidzini Hospital | 108 | 1 | 0 | 1 |
| **GWAKWANI** | Tshipise Clinic | 50 | 137 | 0 | 137 |
| | Donald Fraser Hospital | 67.2 | 20 | 0 | 20 |
| | Matavhela Clinic | 39.5 | 19 | 0 | 19 |
| | Makuya Clinic | 16.4 | 13 | 0 | 13 |
| | Mulala Clinic | 16.8 | 5 | 0 | 5 |
| | Tshififi Clinic | 72.7 | 2 | 0 | 2 |
| | Tshikundamalema Clinic | 50.9 | 2 | 0 | 2 |
| | Makuleke clinic | 67.2 | 1 | 0 | 1 |
| | Manenzhe Clinic | 50 | 1 | 0 | 1 |
| | Masisi Clinic | 23.1 | 1 | 0 | 1 |
| | Shakadza Clinic | 39.5 | 1 | 0 | 1 |
| | Tshiombo Clinic | 59.4 | 1 | 0 | 1 |
| **HAFOLOVHODWE** | Folovhodwe Clinic | 27.8 | 231 | 0 | 231 |
| | Donald Fraser Hospital | 74.5 | 64 | 0 | 64 |
| | Musina Hospital | 99.5 | 12 | 0 | 12 |
| | Masisi Clinic | 50.2 | 4 | 0 | 4 |
| | Louis Trichardt Hospital | 148 | 3 | 0 | 3 |
| | Tshilidzini Hospital | 89.5 | 2 | 0 | 2 |
| | Madimwo/Madimbo Clinic | 19.5 | 1 | 0 | 1 |
| | Siloam Hospital | 111 | 1 | 0 | 1 |
| | Thengwe Clinic | 44.5 | 1 | 0 | 1 |
| | Tshiungani Clinic | 11 | 1 | 0 | 1 |
| | Dr Chaya | 50.2 | 0 | 0 | 0 |
| **KHAVAMBE** | Makuya Clinic | 0.65 | 94 | 2 | 96 |
| | Donald Fraser Hospital | 51.5 | 20 | 0 | 20 |
| | Vhurivhuri Clinic | 10.2 | 6 | 0 | 6 |
| | Siloam Hospital | 87.8 | 3 | 0 | 3 |
| | Madimwo/Madimbo Clinic | 68.5 | 1 | 0 | 1 |
| | Makuleke clinic | 51.5 | 1 | 0 | 1 |

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|---|---|---|---|---|---|
| | Masisi Clinic | 27.8 | 1 | 0 | 1 |
| | Mulala Clinic | 21.4 | 1 | 0 | 1 |
| | Sambandou Clinic | 21.9 | 1 | 0 | 1 |
| **LAMVI** | Makuya Clinic | 8.4 | 102 | 0 | 102 |
| | Donald Fraser Hospital | 45.2 | 55 | 0 | 55 |
| | Vhurivhuri Clinic | 17.1 | 17 | 0 | 17 |
| | Tshikundamalema Clinic | 56.2 | 7 | 0 | 7 |
| | Mutale Health Centre | 29.4 | 4 | 0 | 4 |
| | Tshilidzini Hospital | 60.1 | 3 | 0 | 3 |
| | Masisi Clinic | 36.8 | 2 | 0 | 2 |
| | Folovhodwe Clinic | 57.6 | 1 | 0 | 1 |
| | Malamulele Hospital | 69.5 | 1 | 0 | 1 |
| | Manenzhe Clinic | 63.7 | 1 | 0 | 1 |
| | Maphutha L Malatjie Hospital | 200 | 1 | 0 | 1 |
| | Mulala Clinic | 30.5 | 1 | 0 | 1 |
| | Sambandou Clinic | 17 | 1 | 0 | 1 |
| **MAELULA** | Siloam Hospital | 20.4 | 10 | 0 | 10 |
| | Donald Fraser Hospital | 51.3 | 0 | 1 | 1 |
| | Musina Hospital | 102 | 1 | 0 | 1 |
| **MAGONA** | Ntlhaveni E Clinic | 25.3 | 128 | 0 | 128 |
| | Malamulele Hospital | 26.5 | 106 | 0 | 106 |
| | Ntlhaveni C Clinic | 25.3 | 47 | 0 | 47 |
| | Magona Clinic | 0.6 | 7 | 0 | 7 |
| | Mtititi Clinic | 6.2 | 4 | 0 | 4 |
| | Makuleke clinic | 19.3 | 2 | 0 | 2 |
| | Tshilidzini Hospital | 57.6 | 2 | 0 | 2 |
| | Malamulele Clinic | 24.9 | 1 | 0 | 1 |
| | Mphambo Health Centre | 24.7 | 1 | 0 | 1 |
| | Ntlhaveni D Clinic | 25.3 | 1 | 0 | 1 |
| | Polokwane Hospital | 214 | 1 | 0 | 1 |
| | Tlangelani Clinic | 50.6 | 1 | 0 | 1 |
| **MAKAHLULE H** | Makuleke clinic | 4.8 | 96 | 0 | 96 |
| | Malamulele Hospital | 37 | 58 | 1 | 59 |
| | Makahlule Clinic | 0.35 | 29 | 0 | 29 |
| | Ntlhaveni C Clinic | 30.7 | 8 | 0 | 8 |
| | Ntlhaveni D Clinic | 30.7 | 5 | 0 | 5 |
| | Mhinga Clinic | 22.3 | 2 | 0 | 2 |
| | Makhushane Clinic | 168 | 1 | 0 | 1 |
| | Malamulele Clinic | 31 | 1 | 0 | 1 |
| | Mphambo Health Centre | 30.7 | 1 | 0 | 1 |

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|---|---|---|---|---|---|
| | Tshilidzini Hospital | 60.6 | 1 | 0 | 1 |
| MANVUKA | Siloam Hospital | 31.3 | 24 | 2 | 26 |
| | Donald Fraser Hospital | 67.5 | 1 | 0 | 1 |
| | Ha-mutsha Clinic | 86.3 | 1 | 0 | 1 |
| MANYII | Siloam Hospital | 54.3 | 19 | 2 | 21 |
| | Elim Hospital | 84.9 | 1 | 0 | 1 |
| MAPHOPHE | Malamulele Hospital | 33.5 | 103 | 0 | 103 |
| | Mhinga Clinic | 36.6 | 67 | 0 | 67 |
| | Makuleke clinic | 11.3 | 37 | 0 | 37 |
| | Malamulele Clinic | 36 | 1 | 0 | 1 |
| | Ntlhaveni C Clinic | 14.5 | 1 | 0 | 1 |
| | Ntlhaveni E Clinic | 14.5 | 1 | 0 | 1 |
| | Shikundu Clinic | 11.3 | 1 | 0 | 1 |
| | Shingwedzi Clinic | 35.9 | 1 | 0 | 1 |
| | Shivulani Clinic | 53.6 | 1 | 0 | 1 |
| MARAXWE | Tshiombo Clinic | 41.1 | 4 | 0 | 4 |
| | Donald Fraser Hospital | 26.2 | 3 | 0 | 3 |
| | Tshilidzini Hospital | 7 | 1 | 1 | 2 |
| | Mulala Clinic | 67.3 | 1 | 0 | 1 |
| | Mutale Health Centre | 17.6 | 1 | 0 | 1 |
| | Rambuda Clinic | 5.7 | 1 | 0 | 1 |
| MASISI | Masisi Clinic | 0.55 | 296 | 0 | 296 |
| | Donald Fraser Hospital | 79.9 | 25 | 1 | 26 |
| | Makuya Clinic | 29.1 | 9 | 0 | 9 |
| | Mulala Clinic | 7.3 | 8 | 0 | 8 |
| | Madimwo/Madimbo Clinic | 40 | 4 | 0 | 4 |
| | Musina Hospital | 117 | 4 | 0 | 4 |
| | Vhurivhuri Clinic | 63.7 | 4 | 0 | 4 |
| | Tshipise Clinic | 26.2 | 3 | 0 | 3 |
| | Mutale Health Centre | 71.5 | 2 | 0 | 2 |
| | Tshilidzini Hospital | 94.9 | 2 | 0 | 2 |
| | De Hoop Clinic | 132 | 1 | 0 | 1 |
| | Folovhodwe Clinic | 63 | 1 | 0 | 1 |
| | Louis Trichardt Hospital | 165 | 1 | 0 | 1 |
| | Malamulele Hospital | 104 | 1 | 0 | 1 |
| | Sambandou Clinic | 50.3 | 1 | 0 | 1 |
| MATATANI | Tshipise Clinic | 29.5 | 153 | 0 | 153 |
| | Donald Fraser Hospital | 73 | 21 | 0 | 21 |
| | Makuya Clinic | 22.2 | 10 | 0 | 10 |
| | Masisi Clinic | 27 | 6 | 0 | 6 |

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|---|---|---|---|---|---|
| | Tshififi Clinic | 78.6 | 3 | 0 | 3 |
| | Mulala Clinic | 19.6 | 2 | 0 | 2 |
| | Madimwo/Madimbo Clinic | 34.5 | 1 | 0 | 1 |
| | Musina Hospital | 110 | 1 | 0 | 1 |
| | Rambuda Clinic | 71 | 1 | 0 | 1 |
| | Tshilidzini Hospital | 88 | 1 | 0 | 1 |
| **MUKUMAWABANE** | Mulala Clinic | 3.3 | 221 | 0 | 221 |
| | Donald Fraser Hospital | 75.7 | 56 | 0 | 56 |
| | Masisi Clinic | 9.5 | 30 | 0 | 30 |
| | Makuya Clinic | 24.9 | 13 | 0 | 13 |
| | Tshilidzini Hospital | 90.7 | 8 | 1 | 9 |
| | Mutale Health Centre | 67.3 | 3 | 0 | 3 |
| | Mukula clinic | 71.3 | 2 | 0 | 2 |
| | Shakadza Clinic | 50.1 | 2 | 0 | 2 |
| | Siloam Hospital | 112 | 2 | 0 | 2 |
| | Madimwo/Madimbo Clinic | 50.2 | 1 | 0 | 1 |
| | Manenzhe Clinic | 36.4 | 1 | 0 | 1 |
| | Mhinga Clinic | 60.5 | 1 | 0 | 1 |
| | Mhlava Willem Clinic | 118 | 1 | 0 | 1 |
| | Musina Hospital | 127 | 1 | 0 | 1 |
| | Tshipise Clinic | 36.4 | 1 | 0 | 1 |
| | William Eadie Health Centre | 85.9 | 1 | 0 | 1 |
| **MUTELE A** | Mulala Clinic | 1.3 | 166 | 0 | 166 |
| | Masisi Clinic | 5.9 | 64 | 0 | 64 |
| | Donald Fraser Hospital | 73.9 | 52 | 0 | 52 |
| | Tshilidzini Hospital | 88.9 | 4 | 0 | 4 |
| | Makuya Clinic | 23 | 3 | 0 | 3 |
| | Manenzhe Clinic | 32.8 | 2 | 0 | 2 |
| | Siloam Hospital | 110 | 2 | 0 | 2 |
| | Elim Hospital | 193 | 1 | 0 | 1 |
| | Madimwo/Madimbo Clinic | 46.6 | 1 | 0 | 1 |
| | Matavhela Clinic | 46.2 | 1 | 0 | 1 |
| | Musina Hospital | 123 | 1 | 0 | 1 |
| | Polokwane Hospital | 278 | 1 | 0 | 1 |
| | Tshiombo Clinic | 66.1 | 1 | 0 | 1 |
| | William Eadie Health Centre | 84 | 1 | 0 | 1 |
| **MUTELE B** | Mulala Clinic | 1.8 | 422 | 0 | 422 |

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|---|---|---|---|---|---|
| | Masisi Clinic | 6.8 | 84 | 0 | 84 |
| | Donald Fraser Hospital | 74.5 | 75 | 1 | 76 |
| | Makuya Clinic | 23.6 | 12 | 0 | 12 |
| | Musina Hospital | 124 | 6 | 0 | 6 |
| | Mutale Health Centre | 66 | 2 | 0 | 2 |
| | Tshilidzini Hospital | 89.4 | 1 | 1 | 2 |
| | Tshipise Clinic | 33.7 | 2 | 0 | 2 |
| | William Eadie Health Centre | 84.6 | 2 | 0 | 2 |
| | Louis Trichardt Hospital | 172 | 1 | 0 | 1 |
| | Tshifudi Clinic | 58.3 | 1 | 0 | 1 |
| | Vhurivhuri Clinic | 58.3 | 1 | 0 | 1 |
| **NTLHAVENI D** | Ntlhaveni C Clinic | 650 | 110 | 0 | 110 |
| | Malamulele Hospital | 31.9 | 104 | 1 | 105 |
| | Ntlhaveni D Clinic | 1.5 | 80 | 0 | 80 |
| | Makuleke clinic | 4.9 | 20 | 0 | 20 |
| | Ntlhaveni E Clinic | 1.5 | 2 | 0 | 2 |
| | Tshilidzini Hospital | 55 | 2 | 0 | 2 |
| | Elim Hospital | 106 | 1 | 0 | 1 |
| | Malamulele Clinic | 34.4 | 1 | 0 | 1 |
| | Mhinga Clinic | 35 | 1 | 0 | 1 |
| | Mtititi Clinic | 23.9 | 1 | 0 | 1 |
| | Musina Hospital | 185 | 1 | 0 | 1 |
| | Nthabalala Clinic | 128 | 1 | 0 | 1 |
| **PHAPHAZELA** | Mukhomi Clinic | 3 | 11 | 0 | 11 |
| | Malamulele Hospital | 22.8 | 9 | 1 | 10 |
| | Tshilidzini Hospital | 19.2 | 2 | 1 | 3 |
| | Elim Hospital | 58.6 | 0 | 1 | 1 |
| | Tlangelani Clinic | 9.2 | 1 | 0 | 1 |
| **SANARI** | Mulala Clinic | 0.7 | 465 | 1 | 466 |
| | Donald Fraser Hospital | 73 | 57 | 1 | 58 |
| | Masisi Clinic | 7.2 | 41 | 0 | 41 |
| | Makuya Clinic | 21.5 | 22 | 0 | 22 |
| | Tshipise Clinic | 34.1 | 4 | 0 | 4 |
| | Lambani Clinic | 36.5 | 3 | 0 | 3 |
| | Siloam Hospital | 109 | 3 | 0 | 3 |
| | Madimwo/Madimbo Clinic | 47.9 | 2 | 0 | 2 |
| | Musina Hospital | 124 | 2 | 0 | 2 |
| | Tshiungani Clinic | 39.8 | 2 | 0 | 2 |
| | Mhlava Willem Clinic | 114 | 1 | 0 | 1 |
| | Mtititi Clinic | 94 | 1 | 0 | 1 |

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|---|---|---|---|---|---|
| | Mulenzhe Clinic | 90.5 | 1 | 0 | 1 |
| | Tshilidzini Hospital | 87.3 | 1 | 0 | 1 |
| SHADANI Thulamela | Mutale Health Centre | 35.5 | 24 | 0 | 24 |
| | Donald Fraser Hospital | 20.2 | 19 | 0 | 19 |
| | William Eadie Health Centre | 22.2 | 3 | 0 | 3 |
| | Makonde Clinic | 26.1 | 1 | 1 | 2 |
| | Thengwe Clinic | 38.1 | 2 | 0 | 2 |
| | Rambuda Clinic | 40.9 | 1 | 0 | 1 |
| | Tshino Clinic | 43.1 | 1 | 0 | 1 |
| | Vhurivhuri Clinic | 55 | 1 | 0 | 1 |
| TSHIFUDI | Donald Fraser Hospital | 25.7 | 129 | 0 | 129 |
| | Tshifudi Clinic | 1.5 | 114 | 1 | 115 |
| | Tshaulu Clinic | 7.7 | 15 | 0 | 15 |
| | Tshilidzini Hospital | 42.9 | 15 | 0 | 15 |
| | Tshififi Clinic | 23.5 | 4 | 0 | 4 |
| | Masisi Clinic | 63.4 | 1 | 0 | 1 |
| | Polokwane Hospital | 211 | 1 | 0 | 1 |
| | Siloam Hospital | 63.5 | 1 | 0 | 1 |
| | Tshiungani Clinic | 76.5 | 1 | 0 | 1 |
| | Vhurivhuri Clinic | 1.5 | 1 | 0 | 1 |
| | William Eadie Health Centre | 35.8 | 1 | 0 | 1 |
| TSHIKUNDAMALEMA | Tshikundamalema Clinic | 98.9 | 195 | 0 | 195 |
| | Donald Fraser Hospital | 87.9 | 66 | 0 | 66 |
| | Mutale Health Centre | 79.5 | 19 | 0 | 19 |
| | Musina Hospital | 153 | 3 | 0 | 3 |
| | Folovhodwe Clinic | 72.3 | 1 | 0 | 1 |
| | Madimwo/Madimbo Clinic | 49.3 | 1 | 0 | 1 |
| | Makuya Clinic | 37.1 | 1 | 0 | 1 |
| | Manenzhe Clinic | 35.5 | 1 | 0 | 1 |
| | Thengwe Clinic | 81.4 | 1 | 0 | 1 |
| | Thohoyandou Health Centre | 98 | 1 | 0 | 1 |
| | Tshilidzini Hospital | 103 | 1 | 0 | 1 |
| | Tshipise Clinic | 35.5 | 1 | 0 | 1 |
| | William Eadie Health Centre | 98.1 | 1 | 0 | 1 |
| TSHIKUYU | Masisi Clinic | 9.2 | 240 | 0 | 240 |
| | Donald Fraser Hospital | 87.9 | 20 | 1 | 21 |
| | Mulala Clinic | 15.3 | 6 | 0 | 6 |

| | | | | | |
|---|---|---|---|---|---|
| | Musina Hospital | 126 | 2 | 0 | 2 |
| | Madimwo/Madimbo Clinic | 49.3 | 1 | 0 | 1 |
| | Makonde Clinic | 75.7 | 1 | 0 | 1 |
| | Tshipise Clinic | 35.5 | 1 | 0 | 1 |
| **TSHIPHUSENI** | De Hoop Clinic | 2.5 | 6 | 0 | 6 |
| | Elim Hospital | 41.6 | 2 | 1 | 3 |
| | Bungeni Health Centre | 19.6 | 1 | 0 | 1 |
| **TSHIROLWE** | Siloam Hospital | 34.9 | 13 | 2 | 15 |
| | Du Buisson (Louis Trichardt) | 36.2 | 2 | 0 | 2 |
| **TSHIVALONI** | Mulala Clinic | 5.8 | 312 | 0 | 312 |
| | Masisi Clinic | 10.7 | 68 | 0 | 68 |
| | Donald Fraser Hospital | 78.4 | 49 | 2 | 51 |
| | Tshipise Clinic | 37.6 | 18 | 0 | 18 |
| | Mutale Health Centre | 67.6 | 4 | 0 | 4 |
| | Makuya Clinic | 27.6 | 3 | 0 | 3 |
| | Duvhuledza Clinic | 44.9 | 1 | 0 | 1 |
| | Folovhodwe Clinic | 45.3 | 1 | 0 | 1 |
| | Makonde Clinic | 66.2 | 1 | 0 | 1 |
| | Rambuda Clinic | 75.5 | 1 | 0 | 1 |
| | Tshaulu Clinic | 56.2 | 1 | 0 | 1 |
| | Tshifudi Clinic | 62.2 | 1 | 0 | 1 |
| | Tshikundamalema Clinic | 89.4 | 1 | 0 | 1 |