MINI – DISSERTATION

SPATIAL DISTRIBUTION OF MALARIA CASES IN MOPANI DISTRICT, LIMPOPO PROVINCE, SOUTH AFRICA: 2006-2015

by

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[redacted]

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DEDICATION

This research work is dedicated to the following persons:

- To my family, my beloved husband, Cassius and my two lovely children, Charmaine and Cassius Junior.

- My mother, Angelina and my siblings, Victor, Rally, Joyce and Lorraine and lastly my late brother and a companion, Jim who met his untimely death in a car accident in April 2016 and finally to my dear father who passed on when I was eighteen.

- All the survived malaria cases and the families of those who succumbed to this endemic communicable disease in our district, province, country and globally. All those who spend sleepless night to come up and implement malaria elimination strategies to save lives.

DECLARATION

I, Machimana Gabaza Gloria, declare that **SPACIAL DISTRIBUTION OF MALARIA CASES IN MOPANI DISTRICT: 2006 - 2015, LIMPOPO PROVINCE, SOUTH AFRICA** is my own original work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete reference and that this work has not been submitted before any other degree at any other institution.

SIGNATURE **DATE**

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ABSTRACT

Background: Malaria is one of the important communicable diseases transmitted by *Anopheline* mosquitos to humans and is endemic in 108 countries around the world. Most malaria epidemics in African highland countries are caused by *Plasmodium Falciparum (P Falciparum)* and people residing in highlands are said to be having low immunity to malaria and both children and adults are affected by the disease, whereas *vivax* malaria is common in lowlands African countries. The current study was undertaken with an aim to determine the spatial distribution of malarial cases during the period 2006 to 2015 in Mopani District of Limpopo Province, South Africa.

Methods: Quantitative retrospective descriptive methodology was employed to review the malaria distribution in Mopani district. A total of 12 037 malaria cases were identified for the period of the study and the data was kept anonymously by not using the names of the patients. Ethical clearance was received from the Turfloop Research Committee of University of Limpopo in consideration of section 14, 15, 16, and 17 of National Health Act 61 of 2004. The data was exported to excel spreadsheet and cleaned before exported into SPSS 23.0 software which was used for data analysis.

Results: The findings revealed that most malaria cases were found in 2006 and again in 2014 and 2015 respectively. Malaria cases were also seen to be seasonal and were very high during January, February, March and April. Malaria cases also hiked during the month of October. The results also show that most malaria cases were reported between the patients aged of 16 to 25 and 26 to 40 years. There were more males than females who were infected by malaria in Mopani district and the sub district which was found to be having high malaria cases is Greater Giyani with more than 50% of the population (51.1%); followed by Ba Phalaborwa (23.1%); then Greater Tzaneen 13.1%.

Conclusion: Mopani district has halved its malaria transmission for the comparison years, however the slow reduction in numbers of deaths is still a cause for concern.

Key words: Malaria prevalence, spatial distribution, case fatality rate, elimination.

ABBREVIATIONS

ACD	**:**	Active Case Definition
ACT	**:**	Artemisinin-based combination therapy
DDT	**:**	Dichloro- dipheny- trichlorethane
HIV	:	Human immunodeficiency virus
IPT	**:**	Intermittent Preventive Therapy
IRS	**:**	Indoors Residual Spray
ITNs	**:**	Insecticides Treated Nets
LLINs	**:**	Long Lasting Insecticidal Nets
OLE	:	Oil of Lemon Eucalyptus
P. Falciparum	**:**	*Plasmodium Falciparum*
P. vivax	**:**	*Plasmodium* vivax
PCR	**:**	Polymerase Chain Reaction
RDT	:	Rapid Diagnostic Test
SA	**:**	South Africa
SSA	**:**	Sub Saharan Africa
WHO	**:**	World Health Organisation

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1. CHAPTER ONE

1.1 introduction

The study sought to determine the distribution of malaria cases and deaths due to malaria per geographical area in Mopani District over a period of ten (10) years from the year 2006 to 2015. This chapter presents background information on the malaria cases and further outlines the problem statement, significance, research question, aim and objectives of the study

1.2 Background

Malaria is one of the important communicable diseases transmitted by *Anopheline* mosquitos to humans (Griffin, Hollingsworth, Okell, Churcher, White, Hinsley, Bousema, Drakeley, Ferguson, Basáñez, and Ghani, 2010). Malaria is endemic in 108 countries around the world. In 2008, there were an estimated 243 million cases of malaria causing 863 000 deaths, mostly in children under the age of 5 years (Hanafi-Bojd, Azari-Hamidian, Vatandoost, and Charrahy, 2016). The World Health Organisation (WHO) has predicted that the current global population at risk of malaria to be 2.3 billion people that is 41% of the world's population. Around 600 million additional people are at risk of having *falciparum* malaria by 2050 and further indicated that those countries which are affected by climate change including high temperatures are likely to experience an increased risk of infections (Béguin, Hales, Rocklöv, Åström, Louis, V and Sauerborn, 2011).

Most malaria epidemics in African highland countries are caused by *Plasmodium Falciparum (P Falciparum)* (O'Meara, Mangeni, Steketee, and Greenwood, 2010) and people residing in highlands are said to be having low immunity to malaria and both children and adults are affected by the disease, whereas *vivax* malaria is common in lowlands African countries (Solich, 2010). There are also environmental, biological and socio economic factors that govern highlands malaria incidence which are mainly the climate factor like high temperature and rainfall, immigration where people might be bringing foreign infections or imported cases (Dhimal, Ahrens and Kuch. 2015).

South Africa is one of the 34 malaria endemic countries which are currently implementing strategies to eliminate malaria by 2018. Malaria is endemic in the low-altitude areas of the northern and eastern parts of South Africa with seasonal transmission (Gerritsen et al., 2008).

The country has instituted comprehensive malaria programmes reviews, hence the development of National elimination strategy for South Africa (Moonasar, Morris, Kleinshcmidt, Maharaj, Mayet, Benson, Durrheim, and Blumberg. 2013). South Africa further identified gaps in implementation of the programme which include amongst others, active surveillance in response to confirmed cases and treatment of identified cases, to interrupt local transmission (Moonasar et al., 2013).

There are diagnostic and treatment guidelines in most countries which health care workers should adhere to in order to effectively manage malaria cases (Juma and Zurovac, 2011). Diagnosis of all types of malaria has been reliant on the microscopic method and another method has been introduced to support the old method which is called Polymerase chain reaction (PCR) which is more advanced than the microscopic method (Okanga, Cumming, Hockey, Grome, and Peters. 2013).

Malaria is sometimes misdiagnosed and this results in over-usage of malaria drugs hence World Health Organisation (WHO) recommend universal testing for malaria and prescribing treatment for the confirmed cases only (Ndlhovu, Nkhama, Miller, and Hamer. 2015). The challenges in Sub-Saharan Africa (SSA) which contributes to malaria mortality, mostly in children, is lack of access to prompt and effective healthcare services. This sometimes is complicated by parents who delay treatment by giving children medication they have at home and also visiting traditional healers before visiting the clinic or hospital (Ezedinachi, Odey, Esu, Oduwole, Nwachuku and Meremikwa. 2014).

There are many factors that influence malaria infections transmission which include amongst others, environmental factors which include temperature, humidity, altitude, distance from the rivers, standing water as ponds, human settlements (villages), farming areas, bare land, scattered trees and rivers and climate (Hanafi-Bojd et al., 2012). Effective preventative strategies need to be implemented in endemic areas on a continuous basis (Dudley, Goenka, Orellana and Martonosi. 2015). There are successful interventions which have been employed in globally to eradicate malaria (Zhao, Smith and Tatem. 2016).

1.3 Problem statement

Mopani District is one of the districts in Limpopo Province of South Africa which is affected by malaria. Malaria outbreaks have been reported on a seasonal basis in different sub-districts and villages of Mopani district (Moonasar et al., 2013). Taking a malaria control program from the control phases through to elimination is challenging.

The reorientation of the malaria control program involves a shift of focus, from reaching high levels of coverage of interventions to prevent morbidity and mortality, to an emphasis on completeness and timeliness of activities in order to seek out infections and interrupt transmission (Moonasar et al., 2013). Therefore, identification of hotspots was one of the mitigation strategies towards elimination of malaria infections and mapping of hotspots need to be routine to assist in identifying residual sites of malaria transmission (Moonasar et al., 2013).

The understanding of the differences in spatial distribution and areas burdened was crucial for targeted control measures in rural areas like Mopani district. It was therefore necessary to unpack which sub districts or villages were always having cases and deaths of malaria in Mopani district during 2006 to 2015, what measures could be implemented with the limited budget to implement the elimination strategies and thus work through the goal of elimination by 2018 (Moonasar et al., 2013).

1.4 SIGNIFICANCE OF STUDY

Malaria remains a serious global health burden as it is a life-threatening disease affecting the world’s most under-developed countries and regions where basic healthcare infrastructure is lacking. South Africa has targeted to eliminate malaria by the year 2018. Therefore, constant monitoring of malaria morbidity and mortality trends in affected sub-populations is crucial in guiding and refining control interventions.

The reorientation of the malaria control program involves a shift of focus, from reaching high levels of coverage of interventions to prevent morbidity and mortality, to an emphasis on completeness and timeliness of activities in order to seek out infections and interrupt transmission. Thus taking a malaria control program from the control phases through to elimination is challenging.

The study aimed to contribute information which could be used to understand how malaria transmission is occurring in Mopani district with an ultimate aim to develop and strengthen malaria control programme. As malaria transmission is the leading public health problem, the study identified high risk areas or villages within Mopani district with high transmission rates and the vectors causing the disease in those areas. The findings were used to better understand the spatial distribution of malaria and determine the effective targeted control strategies to eliminate malaria in the district.

1.5 Aim of the study

The aim of the study was to determine malaria case distribution in Mopani District during the period 2006 to 2015.

1.6 Objectives of the study

- To determine the distribution of malaria cases and deaths due to malaria per geographical area in Mopani District over the period of 2006 to 2015.
- To determine what measures could be implemented to implement the elimination strategies and thus work through the goal of elimination by 2018

1.7 Research question

The main research question to be answered in the current study was:

• What is the distribution of malaria with regard to morbidity and mortality in Mopani District during the period 2006 to 2015?

2. CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature review on the prevalence of malaria, malaria transmission, malaria diagnoses, malaria treatment and preventive strategies to control malaria.

Malaria remains a serious global health burden regardless of the progress shown in the fight against malaria Laishram, Sutton, Nanda, Sharma, Sobti, Carlton and Joshi. 2012; Alemu, Abebe, Tsegaye and Golassa. 2011b). This disease continues to have a high incidence of approximately 247 million cases annually and the sad part of the story is that children less than five years of age living in sub-Saharan Africa are mainly the affected groups (Alemu et al., 2011b; Laishram et al., 2012). More than half of the world's population is at risk of acquiring malaria, and the proportion increases each year because of deteriorating health systems, growing drug and insecticide resistance, climate change and natural disasters (Alemu et al., 2011a).

There are four human malaria parasite species which are *Plasmodium falciparum*, *Plasmodium vivax, Plasmodium malariae and Plasmodium ovale*. *P falciparum* and *P vivax* are reported to cause the highest morbidity and mortality in the world (Gerritsen, Kruger, van der Loeff and Grobusch. 2008; Gonçalves, Subtil, de Oliveira, do Rosário, Lee and Shaio. 2012; Laishram et al., 2012) with enormous medical, economic and emotional impact in the world. The World Health Organisation (WHO) recommend major programmatic reorientation to occur when transitioning from malaria control to elimination and high coverage interventions must be geographically targeted while laboratory and clinical services together with case reporting and surveillance are substantially up-scaled (Maharaj, Morris, Seocharan, Kruger, Monaca, Mabuza, Raswiswi and Raman. 2012).

2.2 Prevalence of malaria

The understanding of the number of malaria cases that occur annually in any country is an essential component of planning national health services and evaluating their effectiveness in relation to controlling malaria epidemic. This is mainly achieved by using reliable data from each endemic country to assess progress globally towards the United

Nations Millennium Development Goals (Cibulskis, Aregawi, Williams, Otten and Dye. 2011). Malaria prevalence is highest among the poorest sections of the society, since they cannot afford protection from malaria through improved housing, clean environment and are particularly vulnerable to the impact of ineffective diagnosis and treatment (Alemu et al., 2011b).

Malaria is presently endemic in 97 countries globally and it was that approximately 198 million cases of malaria occurred worldwide in 2013 with 584 000 deaths. The majority of cases are reported in the rural areas with socio economic factors related to poverty, low health consciousness and disease prevention, poor infrastructure and transport systems, hence the higher prevalence rate of malaria in the rural areas as compared to the urban areas (Chua, Lee and Chai. 2013).

2.2.1 Global prevalence of Malaria

Malaria is a global public health problem and affected mostly children under the age of 5 years; hence the World Health Organisation (WHO) has recommended prompt diagnosis and treatment with antimalarial medicines within 24 hours of the onset of fever (Emina and Ye. 2014). The malaria distribution maps show an imperfect representation of global malaria problem but at the same time these maps facilitate an insight in to the progress of malaria control in the 20^{th} century (Hay et al., 2004).

The Global Malaria eradication program launched by WHO resulted in elimination of malaria in 79 countries in the world and remarkable progress has been made by extra-tropics countries such as Eurasia, northern America, most of northern Africa and Australia) (Caminade et al., 2013). There are 158 countries which have showed a remarkable reduction in malaria transmission. This has happened in both their urban and rural areas, whilst urbanisation has been proven to have greater impact in malaria elimination (Tatem, Gething, Smith and Hay. 2013).

The incidence of malaria has been reduced by approximately 17% globally and by 33% in the African regions between the years 2000 and 2010. There were 655 000 deaths in 2010 and 86% were children under the age of 5 years of age while 91% of the deaths occurred in Africa and 98% were due to P. *Falciparum* (Caminade et al., 2013). America and Asia has got most of their population living in urban areas, hence they are considered to have eliminated malaria 100%, whilst in Africa and Arabian Peninsula urbanisation covers only a smaller scale of their land hence transmission malaria is still at a smaller scale (Tatem et al., 2013).

2.2.2 African prevalence of Malaria

The major cause of morbidity and mortality in Africa is malaria and this is more in sub-Saharan African countries with children bearing the highest burden (Ayele et al., 2013). Most of the African countries which are endemic to malaria have most cases (80%) and deaths (90%) (Chua et al., 2013) but a concerted effort to control malaria in Africa has produced dramatic reductions in childhood death in the past decade (Campbell and Steketee. 2011). This early success has prompted the global community to commit to eradication of malaria deaths and eventually all transmission in some parts of Africa (Campbell and Steketee. 2011).

Malaria was thought to be costly in African countries to over $ 12 billion annually in 2009. In the eastern African countries, infrequent malaria epidemics were noted and malaria epidemics were not reported between the 1960s and the early 1980s. This was after a malaria eradication campaign and later, several malaria epidemics were reported during the decades of 1980s and 1990s in most countries of eastern Africa highlands (Himeiden and Kweka, 2012). Kenya has been a country with several episodes of malaria transmission epidemics, but due to the implementation of prevention strategies a marked decline has been marked (Githeko et al., 2011).

2.2.3 South African prevalence of Malaria

South Africa is at the very southern-most fringe of malaria distribution on the African continent and has a long history of intense malaria control activities (Gerritsen et al., 2008; Coetzee, Kruger, Hunt, Durrheim, Urbach and Hansford. 2013). South Africa has three malaria-endemic provinces which are Limpopo, Mpumalanga and KwaZulu-Natal (Moonasar et al., 2012; South Africa. 2013). However, almost all South Africans lack acquired immunity, including residents of seasonal malaria transmission areas, and are, therefore, at risk for developing severe malaria (Gerritsen et al., 2008). Ninety-five percent of all malaria infections in South Africa are due to the parasite species *Plasmodium falciparum* and the local vector is predominantly Anopheles arabiensis (Maharaj et al., 2012; Moonasar et al., 2012). Malaria is transmitted mainly during the rainy season from October to May and transmission peaks normally in January and April (Moonasar et al., 2012).

South Africa has made remarkable progress in fighting malaria; however, the country still needs to reduce local malaria infections to zero by implementing elimination strategy and attention should be given to the migrant workers who are moving between the countries as well as travellers in order to meet the goal of malaria elimination (Mopani District Municipality. 2007).

SA has actively controlled malaria since the 1940s using the World Health Organization (WHO) recommended strategies of: vector control; case management; surveillance; and information, education and communication (IEC). Through these interventions, SA has succeeded in reducing the burden of the disease and is now targeting malaria elimination (zero local malaria cases) by the year 2018 (Morris et al., 2013). South Africa has made steady progress in controlling malaria between the year 2000 and 2012.

There have been a dramatic reduction in malaria incidence from 147.9 per 100 000 population in 2000 to 13.4 per 100 000 in 2012 (South Africa. 2013) and the province which has been associated with the greatest decline in malaria-associated deaths was KZN, while the highest number of deaths in 2010 was reported in Limpopo (Maharaj, Raman, Morris, Moonasar, Durrheim, Seocharan, Kruger, Shandukani and Kleinschmidt. 2013).

2.2.4 Malaria in Limpopo Province

Limpopo Province lies in the low-altitude area pre-disposed to malaria due to warm conditions (Komen, Olwoch, Rautenbach, Botai and Adebayo. 2015). The low risk area for malaria in Limpopo, previously was extending as far west as Swartwater but it now ends east of Alldays. The moderate risk area ends east of Musina although a fair number of cases are reported at Musina and most of these cases are typically imported infections associated with border crossings in the proximity of the town (Morris et al., 2013).

The occurrence of malaria cases in the Limpopo province has been reported to be highly dependent on seasons (Komen et al., 2015) and the average annual temperature is about 22ºC, with the highest temperatures, about 25ºC, recorded between December and January, while the lowest is felt in July, about 15ºC (Tshiala, Olwoch and Engelbrecht. 2011; Komen et al., 2015). The number of malaria cases and deaths in Limpopo have declined from 9 487 in 2000 to 4 215 in 2010 and from 459 in 2000 to 87 in 2010 respectively. However, this province has become the largest contributor to malaria incidence of the three endemic provinces in South Africa (Maharaj et al., 2013).

Limpopo Province has five districts (Capricorn, Greater Sekhukhune, Mopani, Vhembe and Waterberg) and the prevalence of malaria in all the five districts are heterogeneously distributed. The Vhembe district consistently shows more malaria cases while Mopani district appear to have unpredictable malaria cases. The other three districts have very few cases reported each malaria season period of analysis (Komen et al., 2015).

Over the past decade, Limpopo Province has reported the largest proportion of the malaria cases diagnosed in South Africa each year. The majority of the cases have been diagnosed in Mutale Local Municipality, which is located at the north-eastern border of Vhembe District, along the border with Zimbabwe and Mozambique (Khosa, Kuonza, Kruger and Maimela. 2013.). Malaria outbreaks have been reported on a seasonal basis in different sub-districts and villages of Mopani district. Identification of hotspots is one of the mitigation strategies towards elimination of malaria infections and mapping of hotspots need to be routine to assist in identifying residual sites of malaria transmission (Moonasar et al., 2013).

2.3 Malaria transmission

Malaria is transmitted by the blood feeding of infectious female Anopheles mosquitoes, and understanding mosquito ecology and population dynamics can inform how best to defeat malaria (Eckhoff, 2011). It is very much critical to understand how malaria transmission intensity affects malaria prevalence, incidence, severe disease, and mortality in order to assist in developing sound malaria control programmes (Mwangangi, Mbogo, Orindi, Muturi, Midega, Nzovu, Gatakaa, Githure, Borgemeister, Keating and Beier. 2013).

The elements of focus when identifying hotspots for malaria transmission areas should include amongst others the availability of children, host-genetic polymorphisms, socio-economic status, use of vector measures and the type of housing including micro environmental factors (Mosha, Sturrock, Greenhouse, Greenwood, Sutherland, Gadalla, Atwal, Drakeley, Kibiki Bousema and Chandramohan. 2013).

The most important drivers of malaria transmission are meteorological factors which are affecting both malaria parasites and vectors directly or indirectly. These factors include temperature, rainfall and humidity as they are associated with the dynamics of malaria vector populations and, therefore, with spread of the disease (Alemu et al., 2011a). Climatic factors alone cannot be attributed to malaria transmission, therefore, other factors such as socio- economic, geographical, increased communications, improved health services, housing and increased wealth including the availability of resources contribute to the malaria transmission (Tatem et al., 2013). Public health specialists should quantitatively define the extent to which site-specific malaria transmission indicators should be reduced in order to measure the levels of malaria control with an aim of achieving meaningful public health improvements (Mwangangi et al., 2013).

2.4 Malaria diagnosis

The proper management of malaria infected people depends on the accurate diagnosis of malaria. This will lead to good prevention strategies to reduce mortality, improve disease surveillance, and futher recommend effective control measures (Putaporntip, Buppan and Jongwutiwes. 2011). According to the recommendations of the World Health Organization (WHO, 2012), diagnosis and treatment should be based on parasitological confirmation by either microscopy or malaria rapid diagnostic tests (RDTs) (Maltha, Gamboa, Bendezu, Sanchez, Cnops, Gillet and Jacobs. 2012). However, the good clinical practice recommends the parasitological confirmation of the diagnosis of malaria through microscopy (Gonçalves, Subtil, de Oliveira, do Rosário, Lee and Shaio. 2012.) mainly to prevent the misuse of antimalarial drugs especially Artemisinin-based combination therapies thereby preventing the possible development of resistance in the parasite to these drugs (Nkrumah, Acquah, Ibrahim, May, Brattig, Tannich, Nguah, Adu-Sarkodie and Huenger. 2011).

Malaria can be misdiagnosed due to the presence of other febrile illnesses in the Sub Saharan Africa e.g. dengue fever particularly in West Africa and malaria treatment regimen can be costly both financially and morbidity due to the unnecessary side effects that the patient will experience unnecessarily (Oladosu and Oyibo. 2012).

Even if microscopy is the gold standard for malaria diagnosis, there are some exceptions which could be on the basis of clinical suspicion and this should be considered only when parasitological diagnosis is not accessible (Nkrumah et al., 2011). This is mainly with children under the age of 5 years in high prevalence areas where is no evidence that the benefits of microscopy confirmation exceed the risk of not treating false negatives, for cases of fever in established malaria epidemics where resources are limited and for locations where good quality microscopy is not feasible (Gonçalves et al., 2012). Therefore, the application of PCR for malaria detection has revealed a number of cryptic infections and co-infections with malarial species in several endemic areas.

Despite remarkable progress in the development of diagnostic tools for malaria, all of the tools require blood samples to be taken from patients (Putaporntip et al., 2011). Other specimens such as saliva and urine from malaria-infected individuals could be used as alternative specimens for diagnosis as they contain trace amounts of Plasmodium DNA (Putaporntip et al., 2011).

2.5 Malaria treatment

Malaria remains a major cause of death and illness in children and adults in tropical settings. An integrated strategy is recommended which ensures access to treatment with effective anti-malarials, while also undertaking preventative measures that target vector control (Mangham, Cundill, Ezeoke, Nwala, Uzochukwu, Wiseman and Onwujekwe.

2011). Malaria treatment solely on the basis of clinical suspicion should be considered only when parasitological diagnosis is not accessible. Thus, it is of concern that poor diagnostic standards such as the lack of skilled microscopists and inadequate or absence of quality control systems continue to hinder effective malaria control (Nkrumah et al., 2011). All children with febrile illnesses in the Sub Saharan Africa need urgent treatment of malaria as per Integrated Management of Childhood Illness guidelines to prevent mortality due to malaria, hence the WHO recommend best practice in prescribing treatment which include proper diagnosis of malaria (parasitological diagnosis) to avoid resistance to medicines by the patients and further stated that Rapid Diagnostic tests is a cheap and timely method to be used to diagnose malaria (Oladosu and Oyibo. 2012).

The introduction of Rapid Diagnostic tests (RDT) for malaria was a great improvement for managing malaria unlike using clinical symptoms like fever to diagnose malaria and only those with positive results will be treated, this has reduced the costs of treating all malaria suspects and curb malaria drugs resistance (Bisoffi, Gobbi and Van den Ende, 2014). After 2006 Artemisinin- based combination drugs were introduced and Artemisinin-based combination therapy (ACT) became the first line treatment of malaria in endemic African countries (Mangham et al., 2011; Trape et al., 2011). ACT became the recommended treatment for uncomplicated malaria, as resistance emerged to conventional monotherapies, including sulphadoxine-pyrimethamine (SP), chloroquine and amodiaquine, thereby reducing their therapeutic efficacy. National policies have been revised by many countries to adopt ACT as the first-line recommended treatment for uncomplicated malaria but there are still problems with their implementation (Mangham et al., 2011).

2.6 Preventive strategies to control malaria

Malaria prevention strategies need to identify the species which are predominantly available in the community (Sinka, Golding, Massey, Wiebe, Huang, Hay, and Moyes. 2016) and be implemented on a continuous basis in all areas identified as the most endemic areas (Dudley et al., 2016). The reduction of malaria cases is associated with the socio-economic improvements such as wealth, life expectancy and urbanisation whereas climatic and land use changes have a weak association (Zhao et al., 2016).

There are successful interventions which have been employed in globally to eradicate malaria and these include amongst others, human interventions by identifying malaria vectors and employing control measures, anti-mosquitoes' measures like water drainage and larviciding (Zhao et al., 2016). Several strategies which needs to be properly identified to selectively reduce the level of malaria transmission include indoor residual spraying (IRS), intermittent preventive therapy (IPT), sleeping under long-lasting insecticidal bed nets (LLINs), larval habitat management (LHM), and the use of repellents and other vector control measures (Caminade et al., 2013; Mwangangi et al., 2013; Dudley et al., 2016).

2.6.1 Elimination strategy

2.6.1.1 What is malaria elimination strategy?

According to WHO, 2016, malaria control is the reduction of disease incidence, prevalence, morbidity and mortality to a locally acceptable level as results of deliberate efforts. Malaria elimination is the interruptions of local transmission i.e. reducing the rate of cases to zero) of a specified malaria parasite in a defined geographic area and continued measures are required to prevent reestablishment of transmission. Malaria eradication is the permanent reduction to zero of the world wide incidence of infection caused by human malaria parasites as a result of deliberate efforts. Once eradication has been achieved, intervention measures are no longer needed.

2.6.1.2 When was malaria elimination strategy initiated?

Global Malaria Eradication Programme (GMEP) was instituted by the World Health Organisation in 1955 and 15 countries and one territory eliminated malaria. Many other countries succeeded in reducing their malaria burden, but no major success occurred in Sub- Saharan Africa and many other settings, hence resurgence of malaria in 1969 and GMEP was discontinued. There was a marked increase in malaria incidence worldwide due to the abandonment of the GMEP and reduced investment in malaria control (WHO, 2016).

In 1970 there was economic crisis and funding for malaria was cut further. There was also a rise in mosquito resistance to DDT and parasite resistance to chloroquine in some regions and many areas lost substantial gain in malaria control. In 1992 WHO convened a Ministerial conference in Amsterdam which marked turning point in global efforts to contain malaria and a new Global Malaria Control strategy was endorsed and adopted the following year by World Health Assembly (WHO, 2016).

In 1997, a Multilateral Initiative on Malaria brought together prominent scientist and key funding organisations to identify priority research areas for malaria and over the next decade, increased investment in research yielded the development of highly effective malaria control tools including Long Lasting Insecticides Treated Nets (LLINs), Rapid Diagnostic Tests (RDTs) and Artemisinin- based combination therapies (ACTs) (WHO, 2016). In 1998, WHO, the World Bank, the United Nations Development Programme (UNDP) and the United Nations Children's Funds (UNICEF) created the Roll back Malaria Initiative with the goal of halving the global burden of malaria by 2010. Two years later (2000), leaders of malaria endemic countries in Africa signed the Abuja Declaration on Roll Back Malaria in Africa which aimed to reduce malaria mortality on the African continent by 50% by the year 2010 (WHO, 2016).

2.6.1.3 In which countries was malaria elimination strategy implemented?

More than 57% of the 106 countries with malaria in 2000 had achieved reductions in new malaria cases of at least 75% by 2015. During the same period of time, 18 countries reduced their malaria cases by 50% - 75% and an estimated 13 countries had fewer than 1000 cases of malaria. By 2015, 33 countries had achieved their milestones (WHO, 2016). Of the 13 countries with fewer than 1000 malaria cases in the year 2000, 4 have been certified as malaria free: Armenia, Morocco, Turkmenistan and the United Arab Emirates and again in 2014 six additional countries reported zero indigenous cases of malaria: Argentina, Georgia, Kyrgyzstan, Oman, Syrian Arab Republic and Uzbekistan (WHO, 2016). By the year 2000, malaria control efforts had succeeded in greatly in reducing the burden of disease across European Region and in 2015, all countries in European Region reported zero indigenous cases of malaria (WHO, 2016).

2.6.1.4 How is malaria elimination strategy implemented?

Malaria elimination efforts are driven by the Ministries of health through their domestic resources with the support from WHO and partners with financial support from the Global Funds and other donors. Ministries of health need to utilise WHO recommended package of effective tools to prevent, diagnose and treat malaria (WHO, 2016). Countries need to have enhanced surveillance systems to detect every infection, treat and report to national malaria registry. There is also certification of countries with malaria – free status by WHO. The country should proof beyond reasonable doubt that the chain of local transmission by Anopheles mosquitoes has been interrupted nationwide for at least three consecutive years and WHO maintained an official register of areas where malaria elimination has been achieved and all the 33 countries have been certified and entered in the WHO registrars having eliminated malaria through specific measures (WHO, 2016).

2.6.1.5 Elimination strategy in South Africa (Mopani District)

South Africa is one of the 6 countries in the African region with the potential to eliminate local transmission of malaria by 2020 (WHO, 2016). The country set national target to eliminate malaria by 2018 and in 2014 the country reported nearly 11 700 cases of malaria down from more than 64 00 cases in 2000 (WHO, 2016). Since the country is experiencing geographically concentrated high number of malaria cases along the border with Zimbabwe, Swaziland and Mozambique, targeted actions and cross border collaboration can assist the country to eliminate malaria by 2020 (WHO, 2016).

2.6.2 Indoor residual spraying (IRS)

Indoor residual spraying (IRS) was introduced with the availability of Dichloro-dipheny-trichlorethane (DDT) chemicals in the late 1940s to control mosquito vectors of malaria that entered houses (Matthews et al., 2012). IRS has been used globally to reduce malaria and it started in countries like Asia, Russia, Europe and Latin America (Pluess et al 2010). The IRS has been effective in malaria prevention in 13 million people in South Africa, Swaziland, Namibia, Zimbabwe and Mozambique and eliminations occurred in some areas of these countries (Pluess et al 2010). IRS is one of the methods which have been proven to be effective in reducing the risk of infection with malarial parasites, clinical disease and child mortality (Rehman, Coleman, Schwabe, Baltazar, Matias, Gomes, Yellott, Aragon, Nchama, Mzilahowa and Rowland. 2011).

2.6.3 Intermittent Preventive Therapy (IPT)

Intermittent preventive therapy (IPT) is administered to infants, children and pregnant mothers to decrease chances of developing symptoms after being beaten by mosquitoes (Dudley et al., 2016). A policy on IPT has been adopted by 31 of 37 endemic countries in Africa and 5 countries are using the 3 dose or monthly regimen (Dudley et al., 2016). The World Health Organisation recommends IPT during pregnancy with at least 2 full treatment doses of sulfadoxine – pyrimethamine for HIV negative women and at least 3 doses for HIV positive women not receiving cotrimoxazole, in second and third trimester at least 1 month apart (Dudley et al., 2016).

2.6.4 Long Lasting Insecticides treated Nets (LLITs) (ITN) /Bed nets

Insecticides treated nets (ITN) is anther method which has been proven to be effective in reducing the risk of infection with malarial parasites, clinical disease and child mortality (Rehman et al., 2011). There have been high levels of resistance to chloroquine in *P. Falciparum* in many African countries and this led to the abandonment of the drug during 2004 to 2008 and the combination drug therapies were used, sulfadoxine with pyrimethamine (Trape et al., 2011). The combination of ITNs and IRS has been effective in reduction of malaria morbidity and mortality (Ranson, N'Guessan, Lines, Moiroux, Nkuni and Corbel. 2011).

The only approved insecticides, pyrethroids has been approved in Africa and can also be used to control agricultural pests in the world (Ranson et al., 2010). The use of the bed nets has reduced the burden of disease in the African continent whereas ACT resistance has been marked in South America and South Asia and resistance to pyrethroid has been a challenge in African countries (Trape et al., 2011).

2.6.5 Mosquito repellents

A mosquito repellent is a substance applied to skin, clothing, or other surfaces which discourages insects (and arthropods in general) from landing or climbing on that surface

(Patel, Gupta and Oswal. 2012). The control of mosquitoes is something of utmost importance in the present day with rising number of mosquito borne illnesses and there are different types of mosquito repellents for different age groups, and with different methods of applications (Cox. 2005). With the use mosquito repellent, people complained of ill health effect and sometimes required medical treatment (Govindarajan, Mathivanan, Elumalai, Krishnappa, and Anandan. 2011). Plant-based repellents have been used for generations in traditional practice as a personal protection measure against host-seeking mosquitoes. However, it is most likely that many plant volatiles are deterrent or repellent because they have high vapour toxicity to insects (Maia and Moore, 2011).

2.6.6 Other interventions

There is a need for integrated sets of control methods adapted to local settings in order to control malaria. These should be provided at minimal cost and are thus accessible to local people. One such key intervention methods may be the use of locally available plants which are traditionally used to deter mosquitoes (Maia and Moore, 2011). These plants may be effective when burnt to produce smoke or placed as potted plants inside houses (Dekker, Ignell, Ghebru, Glinwood and Hopkins. 2011).

Active Case Detection (ACD) in the form of mass screen campaigns, mass blood surveys, Rapid Diagnostic Tests (RDT) and Polymerase
Chain Reaction (PCR) can be used to identify infections to individuals especially those located in the so called hotspots for malaria transmission to avoid morbidity and mortality (Mosha et al., 2016).

2.7 Summary

The studies cited above indicated malaria prevalence globally, regionally, nationally, provincially and district level. Malaria transmission and diagnoses were also discussed. Malaria treatment and prevention strategies were also highlighted and all the researchers were aiming to come up with the best strategies to eliminate malaria with the hope of meeting the elimination strategies by 2018.

3. CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

In this chapter research approach, , study site, research design, study population, sampling and sample size used to acquire subjects, including data collection procedure, data analysis, measures taken to ensure validity and reliability and ethical considerations was discussed.

3.2 Research approach

The methodology employed in the study was quantitative in nature. Quantitative research can be construed as a research strategy that emphasises quantification in the collection and analysis of data and that entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories; has incorporated the practices and norms of the natural and positivism in particular; and embodies a view of social reality as an external, objective reality (Bryman, 2012).

3.3 Study site

The study was conducted in Mopani District which is situated in the North-eastern part of the Limpopo Province, 70 km from Polokwane (main City of the Limpopo Province). It is bordered in the east by Mozambique, in the north, by Zimbabwe and Vhembe District Municipality, in the south, by Mpumalanga province through Ehlanzeni District Municipality and, to the west, by Capricorn District Municipality and, in the south-west, by Sekhukhune District Municipality.

The district spans a total area of 2 534 413 ha (25 344, 13 km^2), inclusive of Kruger National Park, 15 urban areas (towns and townships), 325 villages (rural settlements) and a total of 118 wards. (Mopani District Municipality. 2006 - 2011). The total population size of Mopani district is 1 092 507 (Maharaj et al, 2013).

3.4 Research design

A cohort retrospective study was used in the current study as this is a study design which is powerful to determine the incidence and natural history of a condition and can also be helpful in investigating potential causes of a condition. In retrospective study the sample selection, baseline and follow-up measurement will have happened in the past, meaning that it can be more complete and accurate (National Council for Osteopathic Research. 2014).

3.4.1 Sampling

3.4.1.1 Study population, sampling and sample size

For the purpose of the current study, the population was all the reported suspected and confirmed malaria cases for Mopani District during 2006 to 2015. Therefore, all confirmed malaria cases during the period 2006 to 2015 was used as the sample size.

3.4.1.2 Data collection

Data for malaria infections for all sub districts/villages and the time (month and year) was retrieved from the archives at Malaria Control Program which is situated at Malaria Institute under the Limpopo Provincial Department of Health. A data collection tool or a recording sheet was developed which included the demographic data of the population; year and month of the reports; epidemiologic week reported; type of malaria, origin of infection; laboratory confirmatory tests results and the outcome of the disease.

3.4.1.3 Piloting

Piloting in the current study was not done because this study used secondary data. The main thing which was done was to clean the data according to standard reporting procedures for malaria control programme in Limpopo Province.

3.4.1.4 Inclusion and exclusion criteria

All reported malaria cases of all ages in Mopani District during the period 2006 and 2015 were included in the study. All the data that was collected before 2006 and after 2015 will not be included in the study.

3.5 The process to minimize bias in the current study

Bias is defined as any propensity which prevents fair consideration of a request. In research it occurs when systematic error is introduced into sampling or testing by selecting or encouraging one outcome or answer over others (Pannucci and Wilkins.

2010). Sampling and selection biases will be minimized by using all the reported confirmed malaria cases for the period 2006 to 2015.

It might be impossible for the researcher to minimise sampling and selection biases if there are missing records or manuals to compare with the database in the Malaria Institute. Interpretation bias as well as the analysis and presentation of results bias will also be minimized by making sure accurate analysis and interpretations are done using statistical software and the outcome will be reported as a true reflection of the analysis.

3.6 Reliability, validity and objectivity

Reliability refers to the consistency of a measure of a concept and validity refers to the issue of whether an indicator that is devised to gauge a concept really measures that concept (Bryman. 2012). Therefore, to ensure credibility, the secondary data for confirmed malaria cases were accurately cleaned from the database. Both inclusion and exclusion criteria were adhered to as described in the methodology above. The database was compared with the manual or original records (depending on the availability of such records) from the Malaria Control Program to ensure validity and reliability.

3.7 Data analysis

For straightforward analyses the Statistical Package for the Social Science (SPSS) is the most popular and Epi Info is another popular package used in public health research (Bryman, 2012). The researcher cleaned the data and entered it into the Microsoft excel and then transferred the data in to the SPSS for analysis. After consulting with the biostatistician from the University of Limpopo, analyses of the data were done to make comparisons between age groups, sub-districts and village distributions of malaria cases. The following statistical techniques were employed in the data analysis:

3.7.1 Frequency distributions

The analysis involved descriptive analysis whereby frequency distribution of variables was determined to display distributions of the study participants in relation to the outcome measure which is malaria. Subsequently this was used to estimate the spatial distribution of malaria cases by age and by gender. The mean and median was also used.

3.7.2 Coding of variables

The coding of variables was used in such a way that 1 was a coding for the event occurring (the focus of the analysis/study) and 0 for coding the absence of an event (the reference category) for the dependent variable. For independent variables the researcher also used coding 1 and 0 as the category that is the focus of the study and for the category of reference, respectively. Data was interpreted by the researcher using the 2x2 frequency tables to determine the odd ratios and case fatality rates of malaria cases, deaths and demographic characteristics.

3.7.3 T-test

The independent t-test was used for variables having two categories as it assesses whether the means of two groups are statistically significant. This test was performed at the 95% confidence level. The p-value of less than 0.05 in the study results was used for statistical significant difference in means between the categories which was investigate

3.8 Ethical consideration

3.8.1 Consent forms

The study did not require consent forms as it was using secondary data which was available from Malaria Control Programme in Limpopo Department of Health. The secondary data from Malaria Control Programme was requested in accordance with the Promotion of Access to Information Act 2000 (Act 2 of 2000) which is meant for giving effect to the constitutional right of access to any information held by the state, as well as information held by another person that is required for the exercise or protection of any right. Ethical clearance was sought from the TREC and the researcher applied for a permission to conduct research from Limpopo Provincial Department of health.

3.8.2 Principles of beneficence and justice

Beneficence is the group of norms for producing benefits and balancing benefits against risks and costs. Justice is a group of norms for distributing benefits, risks and costs fairly (Gillon, 1994). The current study will not exclude the malaria cases or deaths based on sex, age, race, and socio-economic status. However, all available records were used in the study. Lastly, adherence to the principles of respect for persons who had malaria and communities affected by malaria was also maintained.

3.8.3 Non-maleficence

The concept of non-maleficence is based on the principle not to inflict harm on others or a norm of avoiding the causation of harm (Gillon, 1994). So the principle of non-maleficence in the study was balanced against the principle of beneficence.

3.8.4 Autonomy and confidentiality

Respect for autonomy is a norm of respecting the decision making capacity of autonomous people or people with independence from controlling influence (Gillon, 1994). Confidentiality was maintained with reporting of the data which was used in the study as it involves a respect for autonomy and also beneficence towards the patient and a desire to act non-maleficently. Unique identifiers were assigned to all reported malaria cases and deaths during the year 2006 and 2015 which was used in the current study.

3.8.5 Anonymity and privacy

No names of the participants were included in the study as secondary data was used. To maintain privacy, the researcher did not share the information with any person except those who are legitimate to access the results.

3.9 Summary

This chapter discussed methods which included study design, site, population, sampling, data collection, reliability and validity, data analysis and ethical consideration. The results will be presented in the next chapter.

4. CHAPTER FOUR: PRESENTATION OF THE RESULTS

4.1 Introduction

The purpose of this study was to determine the geographical distribution of malaria cases in Mopani District of the Limpopo Province. This chapter presents the findings and made out of the following sub-sections: (1) Geographic distribution of malaria cases (2) demographic profile and (3) seasonal variation of malaria incidence.

4.2 Geographical distribution of Malaria in Mopani District

A total of 12 037 malaria cases were identified during the period of the study. Figure 4.1 below illustrates the spatial distribution of malaria cases in Mopani district for the period 2006 to 2015 and of these cases, 51% were observed in Greater Giyani followed by Ba-Phalaborwa 23% and 13% Greater Tzaneen. Greater Letaba and Maruleng accounted for 7% and 4% of malaria cases, respectively. Approximately 2% of malaria cases reported in Kruger National Park.

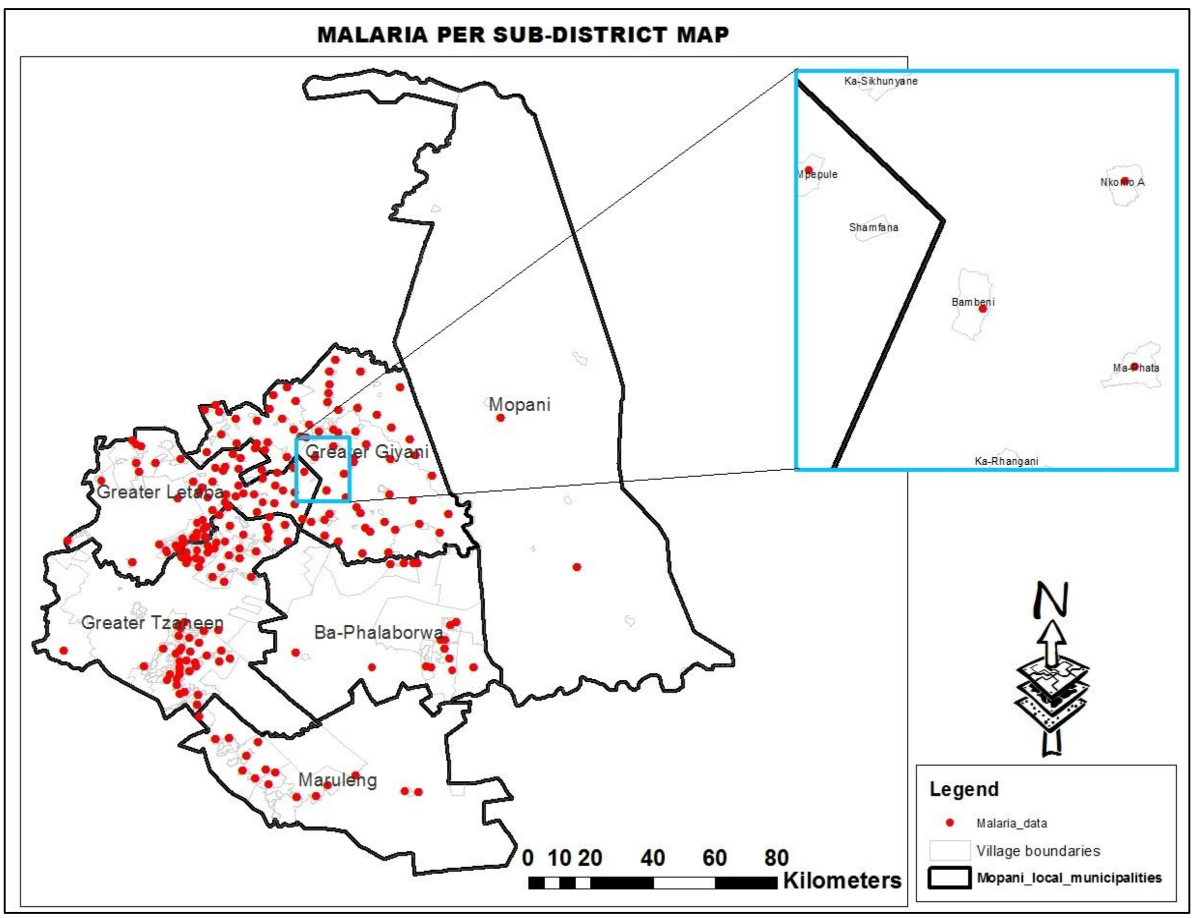

Figure 4.1: Spatial distribution of Malaria cases in Mopani District, 2006 - 2015

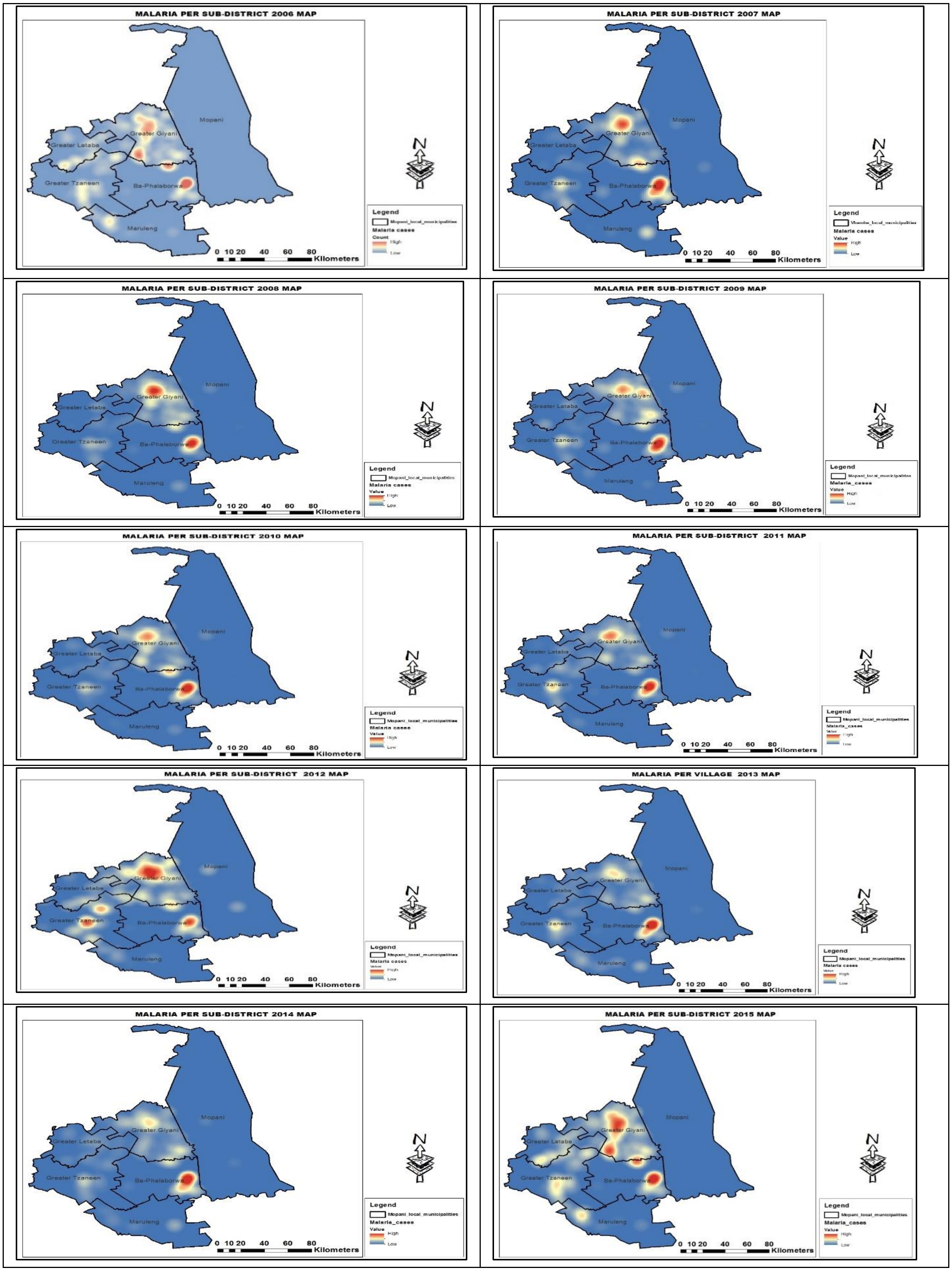

Figure 4.2: Spatial distribution of Malaria cases in by Sub-District in Mopani District, 2006 - 2015

Figure 4.2 above present the spatial distribution of malaria cases by sub-districts in Mopani district for the period 2006 to 2015. It shows that two (2) sub-districts been Ba-Phalaborwa and Greater Giyani had high malaria incidence for the study period while other sub-districts had low malaria incidence. Greater Tzaneen sub-district had medium-high malaria incidences during 2012 to 2015 whereas Greater Letaba and Maruleng had a very low malaria incidence throughout the ten-year period. Kruger National Park has shown sporadic malaria cases throughout the study period as is illustrated in figure 4.2 above.

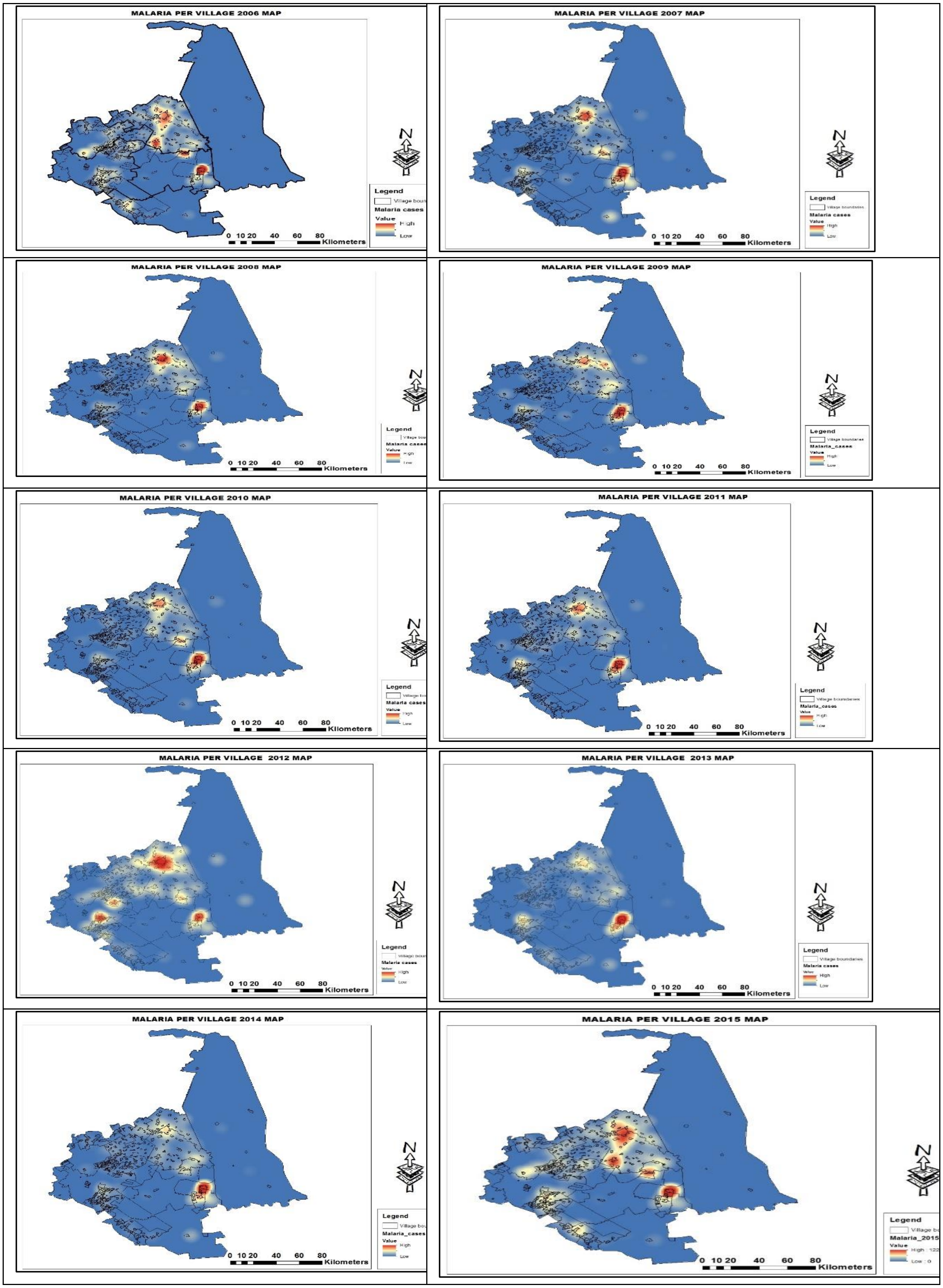

Figure 4.3: Spatial distribution of Malaria cases by village in Mopani District, 2006 - 2015

Figure 4.3 above represent spatial distribution of Malaria Incidence by village in Mopani District. The reported malaria cases per village in Mopani District during 2006 to 2014 were high in Ba-Phalaborwa villages, followed by Greater Giyani. It also shows medium incidences in Greater Tzaneen, then low incidences in Greater Letaba and Maruleng. During 2015 there were more incidences in Greater Giyani followed by Ba-Phalaborwa villages and it was medium in Greater Tzaneen, Greater Letaba and Maruleng respectively. The figure shows that most of the villages in the three sub districts (greater Giyani, Ba-Phalaborwa and Greater Tzaneen) were having high rate of malaria incidences during 2012 and 2015.

4.3 Demographic characteristics of malaria cases

A total number of 12037 malaria cases were reported in Mopani district of Limpopo Province from the year 2006 to 2015. Approximately 57% of the malaria cases reported in Mopani District were males and all the sub-districts had a statistical significant higher percentage of cases in males than females as illustrated in figure 4.1 below. Greater Giyani and Ba-Phalaborwa sub-districts reported the highest number of malaria cases during the study period at 51.1% and 23.1% respectively. Kruger National Park had approximately 1.8% of malaria cases which were reported into the database form Mopani district.

Table 4.1: Malaria cases by gender stratified by sub-district in Mopani District

	*Both gender	Male (n=6826)	Female (n=5208)	P-value for trend
Sub-district	N (%)	% (95% CI)	% (95% CI)	
Ba-Phalaborwa	2784 (23.1)	57.9 (56.1 – 59.7)	42.1 (40.3 – 43.9)	0.002
Greater Giyani	6152 (51.1)	53.8 (52.5 – 55.0)	46.2 (44.9 – 47.5)	
Greater Letaba	818 (6.8)	56.5 (53.1 – 59.9)	43.5 (40.1 – 46.9)	
Greater Tzaneen	1573 (13.1)	63.8 (61.2 – 65.9)	36.4 (34.0 – 38.8)	
Maruleng	493 (4.1)	61.7 (57.4 – 65.9)	38.3 (34.0 – 42.6)	
Kruger Park	217 (1.8)	65.0 (58.6 – 71.3)	35.0 (28.7 – 41.4)	

*There were 3 records with unspecified gender.

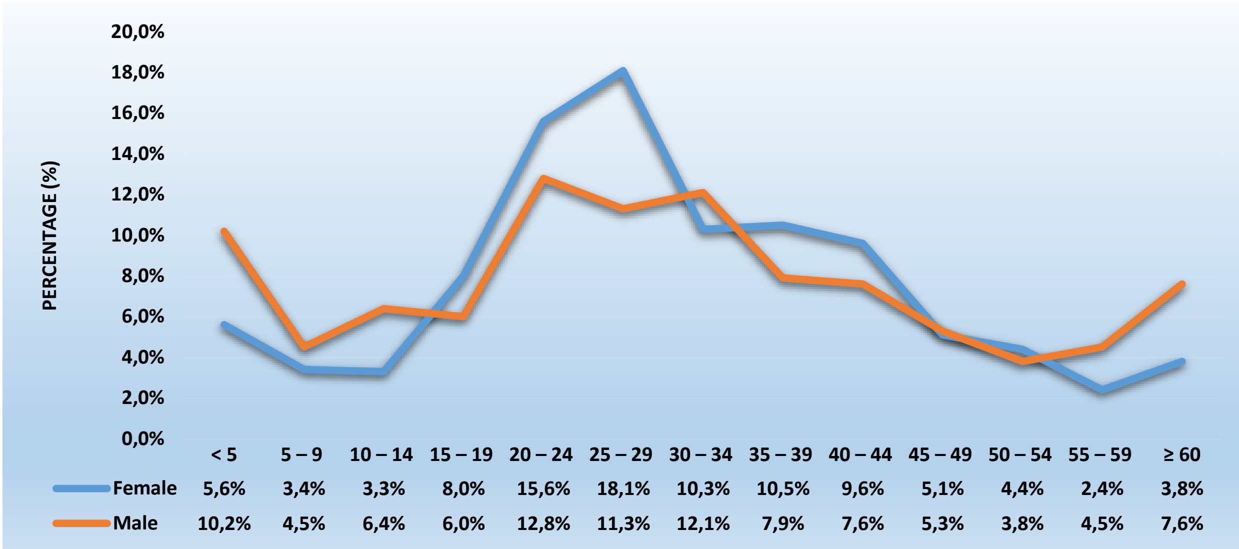

Figure 4.4: Malaria cases by gender stratified by age groups in Mopani District

Figure 4.4 above presents the distribution of malaria cases by age group stratified by gender. The reported number of malaria cases during the period 2006 to 2015 were significantly higher in males than females amongst age groups less than 5 years, 10 – 14 years and 60 years and above at 10.2%, 6.4% and 7.6% respectively. The significant high number of malaria cases in females was reported amongst the age group 20 – 24 years, 25 – 29 years and 35 – 39 years at 15.6%, 18.1% and 10.5% respectively.

Table 4.2: Malaria cases by gender and age groups stratified by sub-district in Mopani District, 2006 – 2015 (n=12034)

Age in years	Ba-Phalaborwa		Greater Giyani		Greater Letaba		Greater Tzaneen		Maruleng		Kruger Park	
	Male % (95% CI)	**Female** % (95% CI)	**Male** % (95% CI)	**Female** % (95% CI)	**Male** % (95% CI)	**Female** % (95% CI)	**Male** % (95% CI)	**Female** % (95% CI)	**Male** % (95% CI)	**Female** % (95% CI)	**Male** % (95% CI)	**Female** % (95% CI)
< 5	5.9 (1.8 – 9.9)	11.7 (4.4 – 18.9)	7.1 (2.6 – 11.6)	9.6 (2.7 – 16.4)	9.6 (2.7 – 16.5)	7.7 (-2.9 – 18.3)	2.6 (0.3 – 4.8)	11.3 4.3 – 18.2)	6.3 (-6.7 – 19.2)	-	16.7 (-24.1 – 57.4)	-
5 – 9	5.1 (1.4-8.9)	7.8 (1.7-13.9)	5.5 (1.5-9.5)	2.7 (-0.1-6.5)	2.7 (-1.1-6.6)	-	1.5 (-0.2 – 3.3)	5.0 (0.2 – 9.8)	-	-	-	
10 – 14	1.5 (-0.5-3.5)	5.2 (0.2-10.2)	3.1 (0.1-6.2)	4.1 (-0.5-8.7)	1.4 (-1.3-4.1)	-	5.2 (2.0 – 9.8)	12.5 (5.2 – 19.8)	6.3 (-6.7 – 19.2)	-	-	-
15 – 19	6.6 (2.4-10.8)	5.2 (0.2 (10.2)	10.2 (4.9-15.6)	8.2 (1.8-14.6)	5.5 (0.2-10.8)	7.7 (-2.9-18.3)	8.2 (4.4 – 12.1)	2.5 (-0.9 – 5.9)	12.5 (-5.2 – 30.2)	25.0 (-8.9 – 58.9)	-	-
20 – 24	20.6 (13.7-27.4)	6.5 (0.9-12.1)	16.5 (10.0-23.1)	12.3 (4.7-19.9)	13.7 (5.7-21.7)	11.5 (-1.1-24.2)	12.4 (7.7 – 17.0)	17.5 (9.1 – 25.9)	-	25.0 (-8.9 – 58.9)	50.0 (-4.7 – 100.5)	100
25 – 29	15.4 (9.3-21.6)	9.1 (2.6-15.6)	18.9 (12.0-25.8)	8.2 (1.8-14.6)	24.7 (14.6-34.7)	26.9 (9.3 – 44.5_	17.5 (12.1 – 22.9)	10.0 (3.4 – 16.6)	18.8 (-2.1 – 36.6)	25.0 (-8.9 – 58.9)	-	-
30 – 34	10.3 (5.1-15.4)	15.6 (7.4-23.8)	11.8 (6.1-17.5)	9.6 (2.7-16.4)	16.4 (7.8 – 25.1)	23.1 (6.4 – 39.8)	6.7 (3.2 – 10.2)	7.5 (1.7 – 13.3)	18.8 (-2.1 – 36.6)	12.5 (-13.4 – 38.4)	-	-
35 – 39	4.4 (0.9-7.9)	6.5 (0.9-12.1)	8.7 (3.7-13.6)	12.3 (4.7-19.9)	8.2 (1.8 – 14.6)	7.7 (-2.9 – 18.3)	17.5 (12.1 – 22.9)	6.3 (0.8 – 11.6)	6.3 (-6.7 – 19.2)	-	-	-
40 – 44	14.0 (8.1-19.9)	6.5 (0.9-12.1)	6.3 (2.0-10.6)	6.8 (0.9-12.7)	8.2 (1.8 – 14.6)	7.7 (-2.9 – 18.3)	8.8 (4.8 – 12.8)	8.8 (2.5 – 15.0)	12.5 (-5.2 – 30.2)	12.5 (-13.4 – 38.3)	16.7 (-24.1 – 57.4)	-
45 – 49	4.4 (0.9-7.9)	6.5 (0.9-12.1)	5.5 (1.5-9.5)	2.7 (-1.1-6.5)	1.4 (-1.3 – 4.1)	3.8 (-3.8 – 11.5)	6.7 (3.2 – 10.2)	7.5 (1.7 – 13.3)	6.3 (-6.8 – 19.2)	-	-	-
50 – 54	4.4 (0.9-7.9)	9.1 (2.6-15.6)	3.9 (0.5-7.4)	1.4 (-1.3-4.1)	4.1 (-0.5 – 8.8)	-	4.6 (1.7 – 7.6)	2.5 (-0.9 – 5.9)	6.3 (-6.8 – 19.2)	-	-	-
55 – 59	2.2 (-0.2-4.7)	3.9 (-0.5-8.3)	1.6 (-0.6-3.8)	8.2 (1.8-14.6)	2.7 (-1.1 – 6.6)	-	2.5 (0.3 – 4.8)	0.4 (-0.5 – 7.9)	6.3 (-6.7 – 19.2)	-	-	-
≥ 60	5.1 (1.3-8.9)	6.5 (0.9-12.1)	0.8 (-0.8-2.3)	13.7 (5.7-21.7)	13.7 (-1.3 – 4.1)	3.8 (-3.8 – 11.5)	5.6 (2.3 – 8.9)	5.0 (.02 – 9.8)	-	-	16.7 (-24.1 – 57.4)	

-No observations in the age group.

Table 4.2 above presents the distribution of malaria cases by sub-district and gender stratified by age groups in Mopani district for a period of 2006 to 2015. Female children under the age of 5 years as compared to male children were mostly affected by malaria in Ba-Phalaborwa, Greater Giyani and Greater Tzaneen at 11.7%, 9.6% and 11.3% respectively. A greater proportion (57%) were adolescents and young adults in the age group 15-49 years. A statistical significant higher proportion of malaria cases were observed from male gender in Greater Tzaneen, Maruleng and Kruger Park, while Greater Giyani recorded a greater proportion of infections amongst children age less than 15 years. There was only one female malaria case in age group 20- 24 years from Kruger National Park.

4.4 Pattern of Malaria distribution in Mopani District

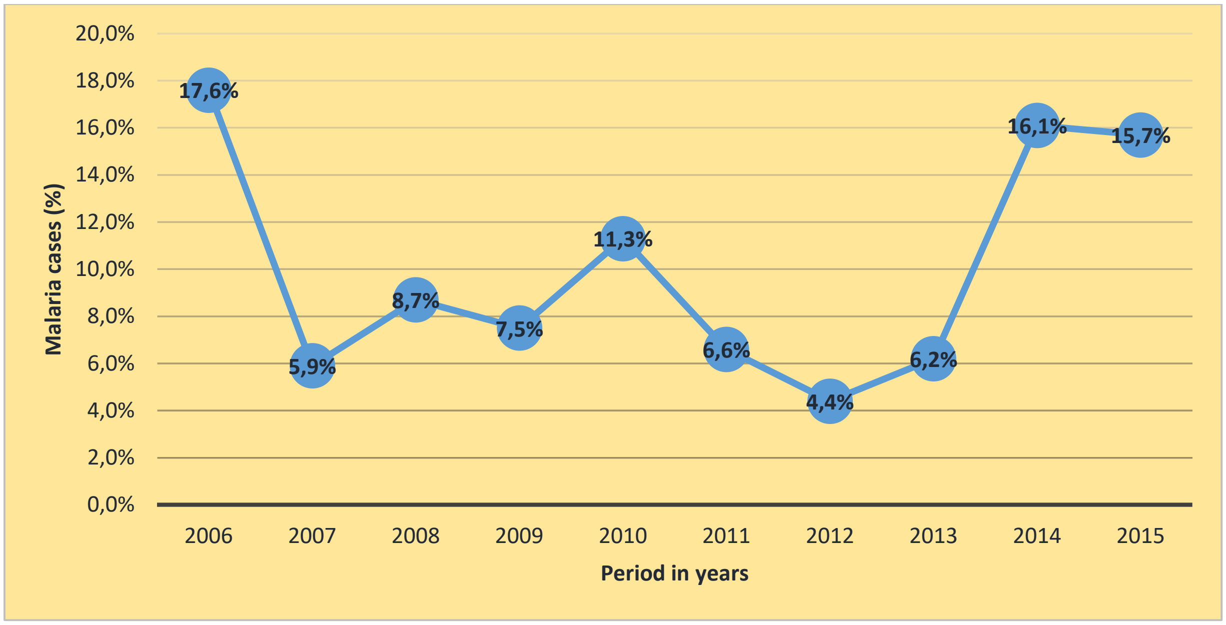

Figure 4.5: Trends of Malaria cases in Mopani District, 2006 to 2015

Figure 4.5 above illustrates the annual distribution of malaria cases in Mopani district and a fluctuating trend has been seen during the study period. A high percentage of 17.6% was recorded in 2006 then dropped to 5.6% in 2007. An increase of 2.8% was recorded in 2008 then dropped by 1.5% in 2009. From 2009, an increase of 3.8% to 11.3% in 2010 was recorded then a decline in malaria cases was observed in the following years until 2014 when there was a high percentage of malaria cases again of 16.1% then lastly a decline of 0.4% was recorded in 2015.

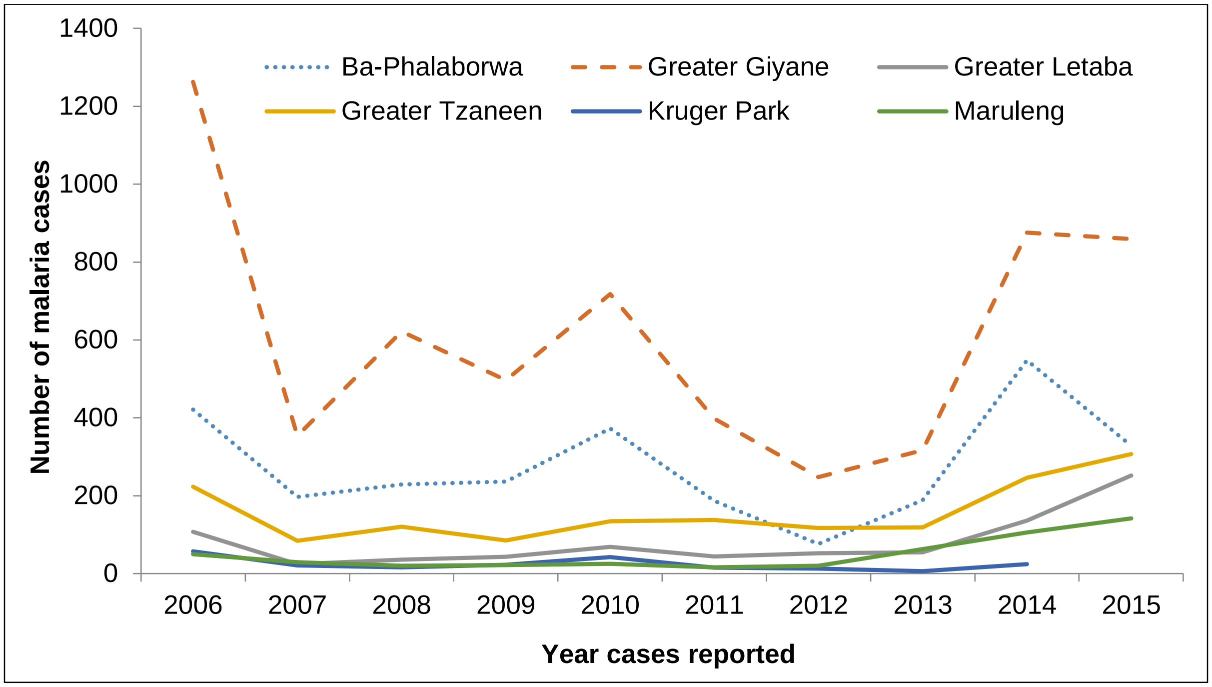

Figure 4.6: Trends of Malaria incidence stratified by sub-district in Mopani District

Figure 4.6 above shows the distribution of malaria cases per district for the study period 2006 to 2015. All the municipalities in Mopani district had shown a fluctuating trend of malaria cases. Overall, Greater Giyani municipality had a high number of cases in all the years from 2006 to 2015 followed by Ba-Phalaborwa municipality except in 2012. Maruleng and Greater Letaba municipalities had the lowest number of cases including Kruger National Park which is not a municipality but people from Limpopo Province more especially Mopani District work and resides in there.

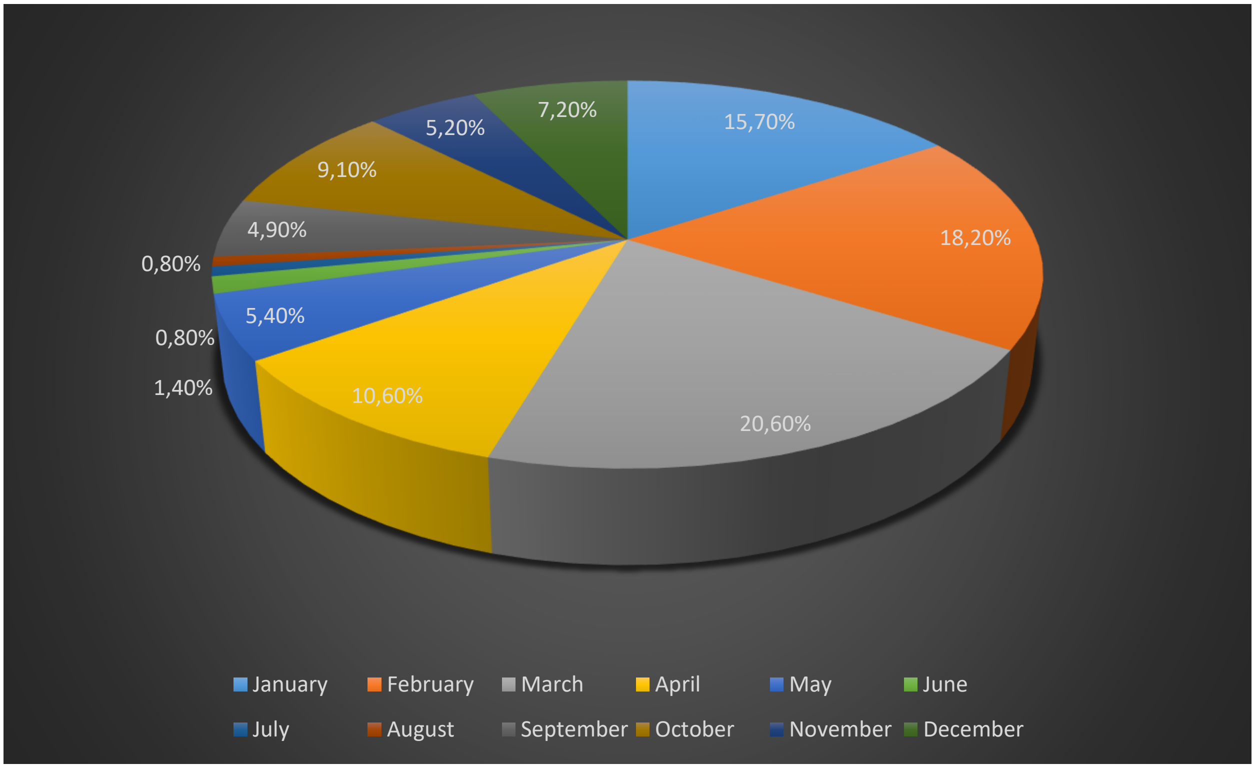

Figure 4.7 Monthly distribution of malaria cases in Mopani district, 2006 - 2015

During the study period, approximately 21% of the cases were reported during the month of March followed by February, January and April at 18.2%, 15.7% and 10.6% respectively as illustrated in figure 4.7 above. The least number of malaria cases were reported during the month of July, August and June at 0.8% and 1.4% respectively.

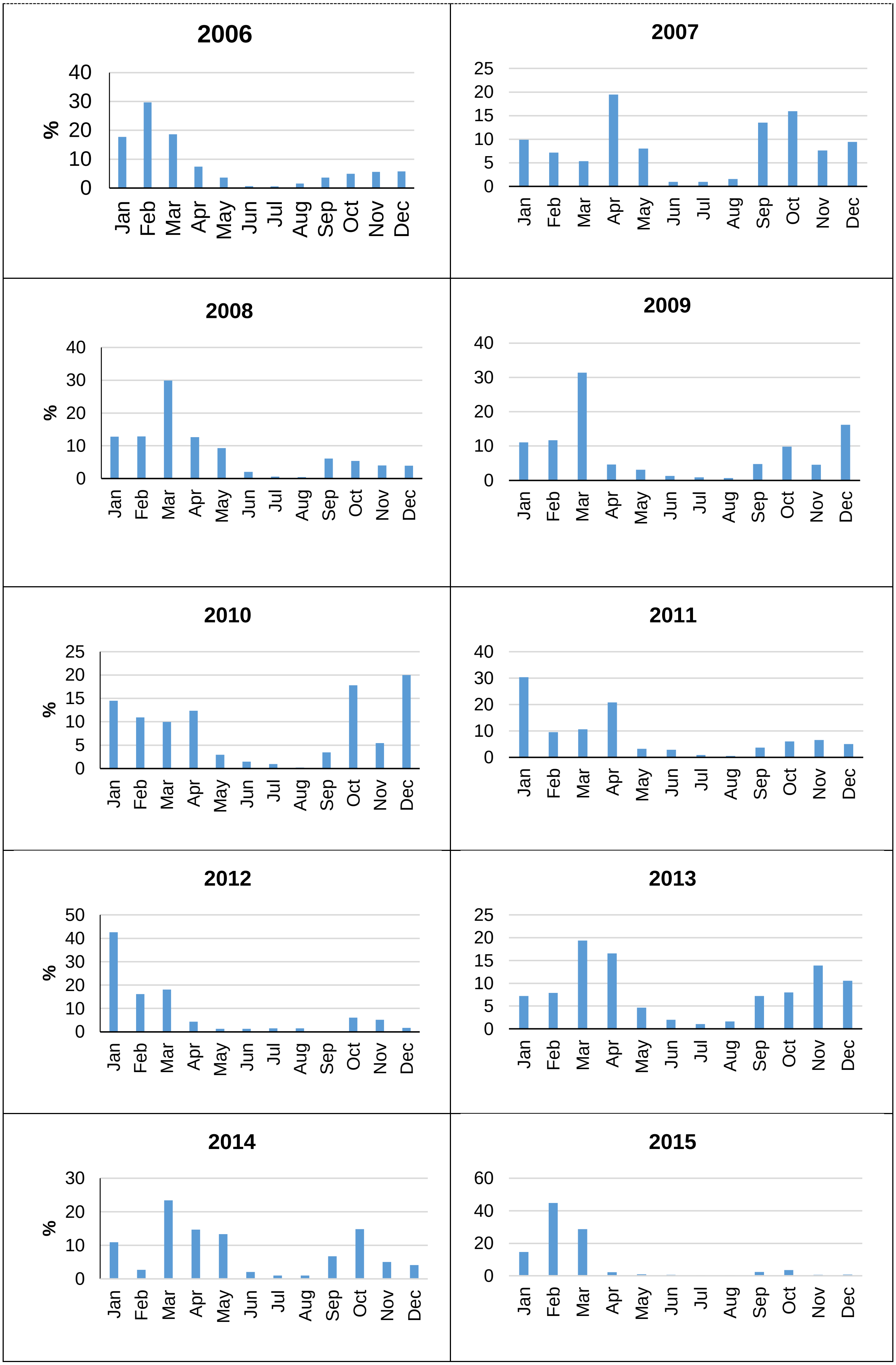

Figure 4.8: Seasonal variation of malaria incidence per year

Figure 4.8 above presents the monthly distribution of malaria cases by year from 2006 to 2015. On an annual basis the increase in malaria cases was not consistent in all the years of the study period. In the years 2011 and 2012 the highest pick of malaria cases was recorded during the month of January. In the years 2006 and 2015 the highest pick of malaria cases was recorded during the month of February while in the years 2008, 2009, 2013 and 2014 the highest pick of malaria cases was recorded in during the month of March. During the month of April the highest pick of malaria cases was in 2007 and in other years more malaria cases reappeared from the month of September to December except in the year 2012 and 2015 which recorded lowest number of cases during September and December.

Table 4.3: Malaria cases by origin and Malaria Type

	*Both gender	Male (n=6826)	Female (n=5208)	P-value for trend
	n (%)	n (%)	n (%)	
Origin				
Local cases	8986 (74.7)	4915 (72.0)	4069 (78.1)	0.002
Imported cases	817 (6.8)	552 (8.1)	265 (5.1)	
Unspecified	2234 (18.5)	1359 (19.9)	874 (16.8)	
Malaria Type				
P. Falciparum	11897 (98.8)	6759 (99.0)	5135 (98.6)	0.026
P.Ovale	23 (0.2)	13 (0.2)	10 (0.2)	
P. Vivax	3 (0.02)	2 (0.03)	1 (0.02)	
Plasmodium Malariae	4 (0.03)	4 (0.06)	0 (0.0)	
Unspecified	110 (0.9)	48 (0.7)	62 (1.2)	

*There were 3 records with unspecified gender.

Table 4.3 above presents the distribution of malaria cases by origin of infection as either local or imported malaria cases. Most of the malaria infections (75%) happened in South Africa and 6.8% happened outside the borders of South Africa and are classified as imported cases while 18.5% malaria cases were not recorded as whether local or imported cases therefore classified as unknown origin. Amongst the imported cases, approximately 68% were males and 5% of the imported cases were from Mozambique, 1.3% from Zimbabwe and 0.5% from other African countries. *Plasmodium Falciparum* was the most common type of malaria reported followed by type *Plasmodium Ovale* at 98% and 0.2% respectively. The other malaria species were reported to be less than 0.1%.

Table 4.4: Imported malaria cases by gender stratified by age group

Age in years	*Both gender (n=817) n (%)	Male (n=552) n (%)	Female (n=265) n (%)
< 5	58 (7.1)	31 (5.6)	27 (10.2)
5 – 9	31 (3.8)	19 (3.4)	12 (4.5)
10 – 14	35 (4.3)	18 (3.3)	17 (6.4)
15 – 19	60 (7.3)	44 (8.0)	16 (6.0)
20 – 24	120 (14.7)	86 (15.6)	34 (12.8)
25 – 29	130 (15.9)	100 (18.1)	30 (11.3)
30 – 34	89 (10.9)	57 (10.5)	32 (12.1)
35 – 39	79 (9.7)	58 (10.3)	21 (7.9)
40 – 44	73 (8.9)	53 (9.6)	20 (7.6)
45 – 49	42 (5.1)	28 (5.1)	14 (5.3)
50 – 54	34 (4.2)	24 (4.4)	10 (3.8)
55 – 59	25 (3.1)	13 (2.4)	12 (4.5)
≥ 60	41 (5.0)	21 (3.8)	20 (7.6)
P-value for trend		<0.001	

Table 4.4 above presents the distribution of imported malaria cases in Mopani district for the period 2006 to 2015.

The proportion of imported cases was high in age group 25 – 29 years, 20 – 24 years and 30 – 34 years at 15.9%, 14.7% and 10.9% respectively. Similar increasing trend was seen in males at same age groups at 18.1% 15.6% and 10.3% respectively. A significant high proportion of imported malaria cases were reported in female children less than 5 years at 10.2% as compared to the 5.6% in males. The proportion of imported malaria cases dropped with increasing age from age group 35 – 39 years in both genders but a slight increase was noted in age group 65 years and above. During the study period the proportion of imported cases was significantly high in 2006 at approximately 25% and majority of the cases were in Greater Tzaneen, Greater Giyani and Ba-Phalaborwa at 34% and 26% respectively.

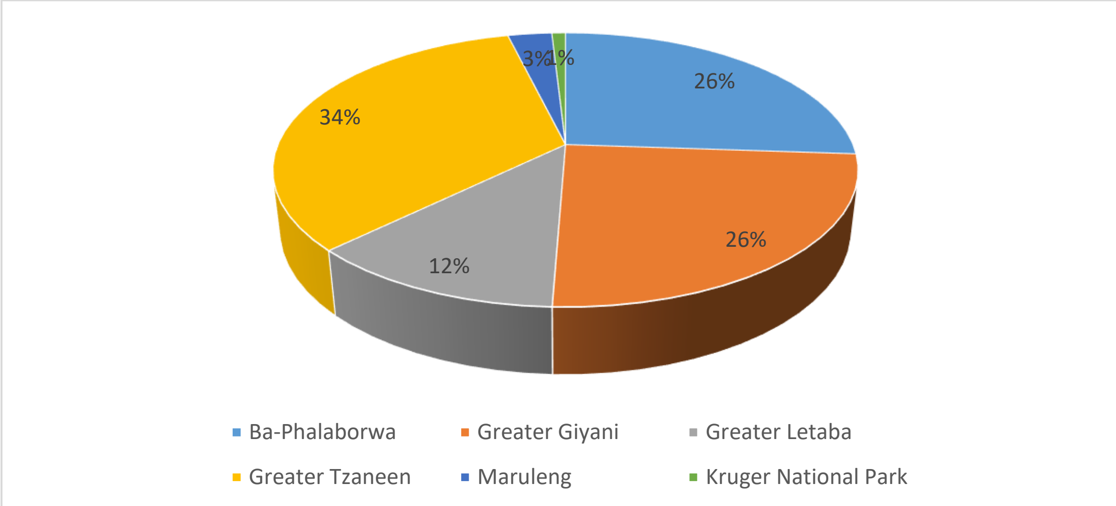

Figure 4.9: Distribution of imported malaria cases by sub-district

Figure 4.9 shows the distribution of imported malaria cases per sub district and it shows high rate of imported malaria cases in Greater Tzaneen at 34% followed by Greater Giyani at 26% and Ba-Phalaborwa at 26%. There were few imported malaria cases in Greater Letaba and Maruleng at 12% and 3% respectively. This shows that Greater Tzaneen receive more immigrants from the neighbouring African countries than the other sub districts.

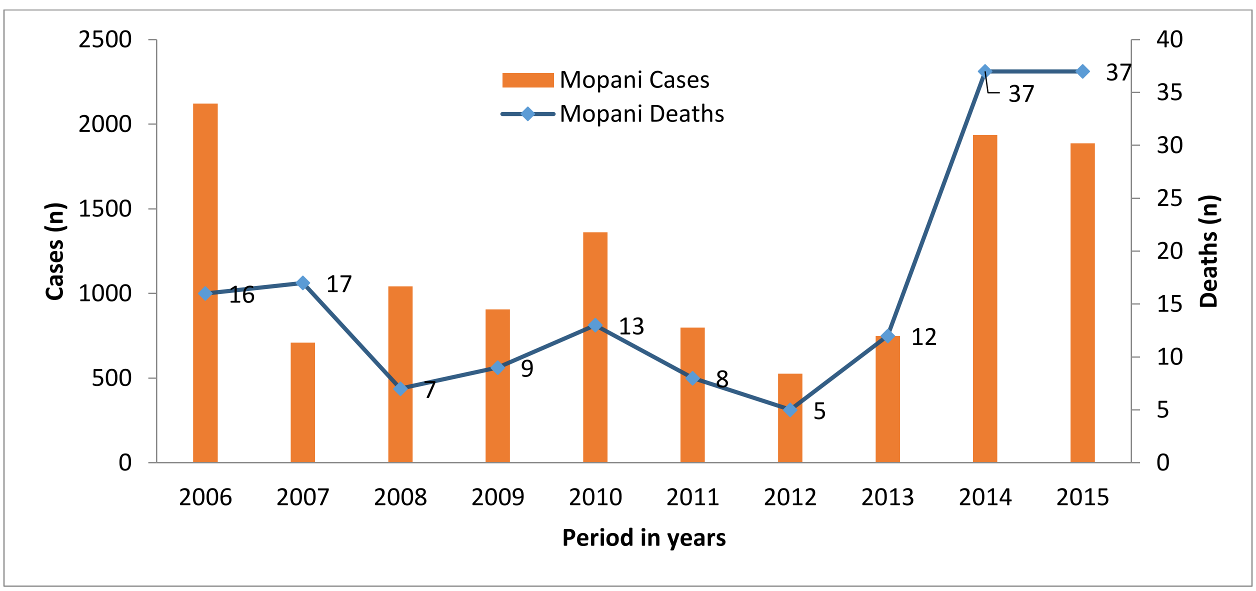

Figure 4.10: Malaria cases and deaths in Mopani district, 2006 - 2015

Figure 4.10 above illustrates the distribution of malaria cases and malaria deaths in Mopani district. For the study period there were 161 (1.3%) malaria deaths ranging from

16 deaths in 2006 to 37 deaths in 2014 and 2015. The lowest number of deaths were recorded in 2012 and the highest number of deaths were in 2014 and 2015 at 37 deaths.

Table 4.5: Malaria Case Fatality (CFR) in Mopani district, 2006 - 2015

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Mopani district	0.8	2.4	0.7	1.0	1.0	1.0	1.0	1.6	1.9	2.0
Ba-Phalaborwa	0.5	2.0	0.9	1.7	1.3	2.7	2.6	1.6	1.5	2.4
Greater Giyani	0.2	2.0	0.6	0.6	0.4	0.8	0.0	0.9	1.6	0.5
Greater Letaba	0.0	4.2	0.0	0.0	4.3	0.0	3.8	5.5	3.7	3.6
Greater Tzaneen	1.8	6.0	0.8	0.0	0.0	0.0	0.0	0.8	3.3	2.6
Maruleng	0.0	0.0	0.0	9.1	4.0	0.0	5.0	3.2	1.9	5.6
Kruger National Park	1.8	0.0	0.0	0.0	2.4	0.0	0.0	0.0		

Table 4.5 above presents the recorded Case Fatality Rates (CFR) in Mopani district during the study period. Mopani district had the highest case fatality rate in 2007, 2015, 2014 and 2013 at 2.4%, 2.0%, 1.9% and 1.6% respectively. The highest case fatality rate was recorded in Maruleng sub-district at 9.1%, 5.6%, 5.0% and 4.0% in 2009, 2010, 2012 and 2015 respectively. Greater Tzaneen sub-district had the highest case fatality rate in 2007, 2014 and 2015 at 6.0%, 3.3% and 2.6% respectively. Greater Letaba sub-district had the highest malaria case fatality in 2013, 2010, 2007, 2012, 2014 and 2015 at 5.5%, 4.3%, 4.2%, 3.8%, 3.7% and 3.6% respectively.

Chapter 5: Discussion

5.1 Introduction

South Africa has made significant progress in controlling malaria transmission over the past decade. This study was conducted mainly because malaria was one of the key targets within Goal 6 of the Millennium Development Goals (MDGs), whereby the disease needed to be halted and reversed by the year 2015. Therefore, the focus of the current study was to determine the distribution of malaria in Mopani district of Limpopo Province and furthermore suggest interventions which could be implemented to strengthen implementation of the elimination strategies. Mopani district is one of the two malaria endemic districts in Limpopo Province of South Africa (Moonasar et al., 2012) and the data for the period of 2006 to 2015 was chosen for the study as data for this period was available and verified by malaria institute in Limpopo Province.

5.2 Methodology

The methodology employed in the current study was retrospective quantitative in nature and all the reported malaria cases from Mopani district of Limpopo Province from 2006 to 2015. Similar methodology has been used in several studies to determine the annual number of cases and the annual incidence which were mapped by matching them to corresponding province- and county-level administrative units in a geographic information system (Lin et al., 2009; Cui et al., 2012; Chen et al., 2015).

5.3 The distribution of malaria cases and deaths per geographical area

In the current study it was found that malaria is endemic in the northeast part of the country which is Limpopo Province and this concurs with several studies (Gerritsen et al., 2008; Moonasar et al., 2012; Munhenga et al., 2014). In Limpopo Province malaria remains a major public health concern in three sub-districts of Mopani District based on the findings from the current study and these sub-districts lies in the north-eastern part of the district (Munhenga et al., 2014). Over the 10-year study period, the total number of reported malaria cases decreased slightly from 2121 cases in 2006 to 1888 cases in 2015.

The findings in the current study revealed that malaria incidence was higher in males than females which concurs with several studies (Kumar et al., 2007; Lin et al., 2009) but not in all age groups thus it is contrary to a study conducted in India were the burden of malaria was generally higher in men than women in all age groups (Kumar et al., 2007). Similar findings were from a study conducted in Ethiopia (Ruecker et al., 2014). In the current study male children were at higher risk of malaria, possibly indicating that males were associated with high exposure behaviour which concurs with a study conducted in Ethopia (Winskill et al., 2011).

Mopani District is one of the districts prone to malaria in South Africa and from the current data in this study this district has experienced malaria epidemics during the study period which concurs with report from Maharaj et al., 2013. Our findings also show that malaria in Mopani districts as part of Limpopo Province is more significantly associated with temperature as most cases were reported during the months in which temperatures are high such as October to April. As in a study conducted by Maharaj et al, seasonal focal malaria outbreaks associated with favourable climatic conditions have been reported in Mopani district (Maharaj et al., 2012).

The high-volume migration across South Africa's northern and eastern land borders places a continuing risk to non-immune border populations (Maharaj et al., 2013). Imported malaria cases (mainly from other endemic countries) were increasingly being reported in Mopani district and majority of them were males and this concurs with a study conducted in China (Lin et al., 2009. Similar to studies conducted in several countries, our findings also revealed that imported malaria are seen in children of all ages in Mopani district (Ladhani et al., 2007). The adults over the age of 15 years in the current study accounted for more than 80% of the cases which concurs with a study conducted in Yunnan Province of China (Lin et al., 2009) and the 0 – 15 years had few imported malaria cases. In the current study as in other studies (Alemu et al., 2012), *Plasmodium Falciparum* was the most common type of human malaria reported in Mopani District which is concurrent with studies elsewhere (Lin et al., 2009).

5.4 Measures which could be implemented to implement the elimination strategies and thus work through the goal of elimination by 2018

Malaria control in southern Africa (South Africa, Mozambique, and Swaziland) began in the 1980s and has shown substantial, lasting declines linked to scale-up of specific interventions (O'Meara et al., 2010). The challenged picked in the current study is that there has been a substantial increase of malaria cases and deaths during the years 2014 and 2015. This is in contrary to the international goals which were set with an aim to reduce malaria incidence by the year 2015, and begin to reverse the incidence of malaria including the reduction of malaria case incidence by 75% (Bhatt et al., 2015). This suggest that interventions which were working in the past might not be working currently and thus there is a need to look into what measure could be done to protect the communities in malaria endemic areas of Mopani district. Therefore, Mopani district proves to have missed out on this international initiative or target to reduce malaria case incidences as cases.

5.5 Conclusions

Malaria remains a serious global health burden as it is a life-threatening disease affecting the world's most under-developed countries and regions where basic healthcare infrastructure is lacking. Nonetheless, Mopani district has halved its malaria transmission for the comparison years, however the slow reduction in numbers of deaths is still a cause for concern. Despite the TLMI, reduction in malaria cases in the Limpopo Province compared to the other provinces have not been that marked. This slow reduction of cases could be due to importation of cases and secondary transmission from the neighboring countries such as Zimbabwe and Mozambique. Financial resource constraints in Zimbabwe could have contributed to slow progress of implementation of the TLMI, this issue has recently been resolved as Zimbabwe as received a 2010 Global Fund grant for Malaria.

5.6 Recommendations

South Africa has targeted to eliminate malaria by the year 2018. Therefore, constant monitoring of malaria morbidity and mortality trends in affected sub-populations such as Mopani district of Limpopo Province is recommended as this is crucial in guiding and refining control interventions. The reorientation of the malaria control program in Mopani district is needed to improve implementation of public health interventions to prevent morbidity and mortality. Thus taking a malaria control program from the control phases through to elimination in Mopani district needs an emphasis on completeness and timeliness of activities in order to reduce malaria infections and interrupt transmission.

5.7 Contributions of the study and implications for health care

The study has contributed valuable information which could be used to understand how malaria transmission is occurring in Mopani district with an ultimate aim to develop and strengthen malaria control programme. As malaria transmission is the leading public health problem, the study identified high risk areas or villages within Mopani district with high transmission rates and the vectors causing the disease in those areas. The findings were used to better understand the spatial distribution of malaria and determine the effective targeted control strategies to eliminate malaria in the district.

5.8 Limitations of the study

The current study relied on secondary data and the major limitation was that the data related to climate change and humidity including rain fall patterns were not available to complement the analysis of the spatial distribution of malaria cases in the study area.

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Appendix A: Ethical clearance from University of Limpopo Research Ethics Committee

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING: 05 July 2016

PROJECT NUMBER: TREC/81/2016: PG

PROJECT:

Title:	Spatial distribution of Malaria cases in Mopani District, Limpopo Province, South Africa: 2006-2015
Researcher:	Ms GG Machimana
Supervisor:	Dr E Maimela
Co-Supervisor:	Prof L Skaal
School:	Health Care Sciences
Degree:	Masters in Public Health

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**

ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding solutions for Africa

Appendix B: Request letter to Limpopo Department of Health to conduct the study

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

Ethics Committee

University of Limpopo (Turfloop Campus)

Private Bag X1106

SOVENGA

0727

Dear Sir/ Madam

SUBJECT: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

1. I am a student at the University of Limpopo South Africa, School of Health Sciences, doing Masters in Public Health. I am about to determine the distribution of malaria cases and deaths per geographical area over 10 years as my research topic. This study will help to define populations at risk of developing malaria in Mopani District.

2. I will conduct the study using quantitative cohort retrospective method using records available at the malaria institute programmes for 2006 to 2015. Research findings will be reported and made available to the Department. It is my wish to publish the study after completion. I will be happy if my request is acknowledged.

Yours Sincerely

____

Machimana Gabaza Gloria

Student number: 201518636

____

Supervisor: Dr E Maimela

____

Co- Supervisor: Prof L Skaal

Appendix C: Permission from Limpopo Provincial Department of Health to conduct the study

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH

Enquiries: Latif Shamila (015 293 6650) Ref:4/2/2

Machimana GG
University of Limpopo
Private Bag X 1106
Sovenga
0727

Greetings,

RE: Spatial distribution of Malaria cases in Mopani District, Limpopo Province, South Africa : 2006-2015

The above matter refers.

1. Permission to conduct the above mentioned study is hereby granted.
2. Kindly be informed that:-
   - Research must be loaded on the NHRD site (http://nhrd.hst.org.za) by the researcher.
   - Further arrangement should be made with the targeted institutions, after consultation with the District Executive Manager.
   - In the course of your study there should be no action that disrupts the services.
   - After completion of the study, it is mandatory that the findings should be submitted to the Department to serve as a resource.
   - The researcher should be prepared to assist in the interpretation and implementation of the study recommendation where possible.
   - The above approval is valid for a 3 year period.
   - If the proposal has been amended, a new approval should be sought from the Department of Health.
   - Kindly note, that the Department can withdraw the approval at any time.

Your cooperation will be highly appreciated.

Head of Department

15/09/2016

Date

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

APPENDIX D: DATA COLLECTION TOOL

Data collection tool to determine distribution of malaria cases in Mopani district		
Patient Unique ID		
Age in years		
Gender	Male	Female
Sub-district name		
Village name		
Health facility name		
Health facility level		
Year reported		
Month reported		
Epidemiologic week reported		
Laboratory confirmation	Confirmed	Suspected
Type of malaria		
Origin of infection	Local transmission	Imported case
Outcome	Alive	Deceased