University of Ghana http://ugspace.ug.edu.gh

UNIVERSITY OF GHANA

DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT

SPATIAL ANALYSIS OF MALARIA INCIDENCE AND INTERVENTIONS IN THE BRONG AHAFO REGION

BY

ASAMOAH-PEPRAH EUGENE

(10552222)

THIS THESIS IS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF GHANA,LEGON, IN PARTIAL FULFILLMENT OF THE REQUIREMENTSFOR THE AWARD OF AN MASTER OF PHILOSOPHY DEGREE IN GEOGRAPHY AND RESOURCED DEVELOPMENT

JULY, 2017

University of Ghana http://ugspace.ug.edu.gh

DECLARATION

I, Asamoah- Peprah, Eugene, do hereby declare that this dissertation, titled "Spatial Analysis of Malaria Incidence and Interventions in the Brong Ahafo Region, is my own original research submitted to the School of Graduate Studies, University of Ghana for the degree of Masters of Philosophy in Geography and Resource Development, and that it has not been submitted neither in part nor in full for another degree in this or in any other university.

……. Date …….

ASAMOAH-PEPRAH EUGENE

(Student)

…….. Date …….

DR ALEX BARIMAH OWUSU

(Principal Supervisor)

……. Date ……

DR EBENEZER NIKOI

(Co-Supervisor)

University of Ghana http://ugspace.ug.edu.gh

DEDICATION

This piece of work is dedicated to my parents and siblings who have contributed immensely to my education.

University of Ghana http://ugspace.ug.edu.gh

ACKNOWLEDGEMENT

My ultimate thanks and acknowledgement goes to the Almighty God for his guidance, wisdom and protection throughout my work. I also offer my profound gratitude to my helpful and kind lecturers and supervisors, Dr Alex Barimah Owusu and Dr. Ebenezer Nikoi of the Department of Geography and Resource Development, University of Ghana, whom regardless of their busy schedules, have guided me throughout the work. I say thank you and may God richly bless you.

Besides, I would be ungrateful if I did not render my sincere thanks to Dr Kenneth Peprah, a lecturer at the University for Development Studies (UDS) and Bishop Edwin Ewuise Brookman, of Grace Gospel Ministries International for their kind assistance in many ways.

Finally, my grateful acknowledgement is expressed to the National Malaria Control Programme for giving me all the necessary information for the completion of this research and also to all the respondents in the Brong Ahafo Region who spared, their precious time to answer all questionnaires used for this study. I say thank you all.

University of Ghana http://ugspace.ug.edu.gh

TABLE OF CONTENTS

DECLARATION ii
DEDICATION iii
ACKNOWLEDGEMENT iv
TABLE OF CONTENTS v
LIST OF FIGURES ix
ABBREVIATIONS x
ABSTRACT xii
CHAPTER ONE: INTRODUCTION 1
1.1 Background 1
1.2 Problem Statement 6
1.3 Research Questions 9
1.4 Aim and Objectives 9
1.5 Research Hypotheses 9
1.6 Rationale of the Study 10
1.7 The Scope of the Study 10
1.8 Organization of Thesis 10
CHAPTER TWO: LITERATURE REVIEW 12
2.1 Introduction 12
2.2 Global Malaria Distribution 12
2.3 Malaria Situation in Africa 14
2.4 Malaria Situation in Ghana 15
2.5 Conditions Necessary for the Anopheles Mosquitoes Development 16
2.5.1 Temperature 17
2.5.3 Relative humidity (RH) 20
2.6 Anthropogenic Factors Affecting Malaria Transmission 21
2.7 The use of GIS Technology in Malaria Study 22
2.8 The limitations in using GIS for Malaria Research Studies 23
2.9 Malaria Control Interventions 24
2.10 Summary of literature review 26
2.11 Conceptual Framework 26
CHAPTER THREE: STUDY AREA AND METHODOLOGY 32
3.1 Introduction 32
3.2 Study Area 32

University of Ghana http://ugspace.ug.edu.gh

3.3 Research Design 35
3.4 Study Population 36
3.5 Sample Size 37
3.6 Sampling Procedure 40
3.7 Research Instruments 40
3.7.1 Questionnaire Survey 40
3.7.2 In-Depth Interviews 41
3.8 Data Collection Procedure 41
3.8.1 Map data 41
3.8.2 Secondary Sources of Data 42
3.9 Methods of Data Analysis 42
3.9.1 GIS software 42
3.9.2 Data analysis overview 42
3.9.3 Getis and Ord Gi* statistic 43
3.9.4 Ordinary Least Square 45
3.9.5 Geographically Weighted Regression 47
CHAPTER FOUR: EXAMINING THE DISTRIBUTION OF MALARIA INCIDENCE 51
4.1 Introduction 51
4.2 Perception of malaria incidence 51
4.3 Spatial patterns of malaria incidence 52
4.3 Analysis of Hotspot Distribution of Malaria Incidence 53
4.4 Result of Major Factors Influencing the Pattern of Distribution 60
CHAPTER FIVE: CORRELATION BETWEEN MALARIA INCIDENCE 64
AND INTERVENTIONS 64
5.1 Introduction 64
5.2 Malaria Control Interventions 64
5.3 Malaria Control Interventions-GWR Results 66
CHAPTER SIX: MALARIA INTERVENTIONS EXISTING IN THE STUDY REGION AND THEIR EFFECTIVENESS. 73
6.1 Introduction 73
6.2 Malaria Control Interventions in the Study Region 73
6.3 Indoor Residual Spraying (IRS) 73
6.3.1 Effectiveness of Indoor Residual Spraying (IRS) as an Intervention in the Study Region 74
6.4 Long Lasting Insecticide Nets (LLINs) 75
6.4.1 Possession of LLINs as a Malaria Control Intervention 76
6.4.2 Utilization of Long-Lasting Insecticide Net (LLINs) 76
6.5 Antimalarial drugs as malaria control intervention 77

University of Ghana http://ugspace.ug.edu.gh

6.5.1 Effectiveness of Antimalarial Drugs as an Implemented Intervention 78
6.6 Herbal medicine as malaria control intervention 79
6.6.1 Effectiveness of Herbal Medicine as Intervention Implemented in the Study Area 80
6.7 Interventions Targeting Malaria Incidence 81
6.8 Challenges of the Interventions for Malaria Control 82
6.9 Coping Strategies to Manage Malaria 83
CHAPTER SEVEN: SUMMARY, CONCLUSION AND RECOMMENDATIONS 84
7.1 Introduction 84
7.2 Summary of the Major Findings 84
7.3 Conclusion 88
7.4 Recommendations 90
REFERENCES 91
APPENDIX I: QUESTIONNAIRE 116
APPENDIX II 124

University of Ghana http://ugspace.ug.edu.gh

LIST OF TABLES

TABLES **PAGES**

Table 3.1 showing 27 administrative districts with their population.....36

Table 3.2 Sample Size by Clusters 39

Table 4. 1 Perceptions of Malaria Incidence in the districts.....51

Table 4. 2 Spatial Patterns of Malaria Incidence in the Districts.....52

Table 4. 3 Analysis of high/low clustering for different years using Getis and Ord Gi* statistics.....59

Table 4. 4 Summary of OLS result 61

Table 5. 1 Summary statistics for OLS 66

Table 6. 1 Possession of Bed nets and Malaria incidence 76

University of Ghana http://ugspace.ug.edu.gh

LIST OF FIGURES

FIGURES **PAGES**

Figure 2.1 Distribution of World Malaria....13

Figure 2.2 Map of Africa Showing Distribution of Plasmodium Falciparum Malaria....15

Figure 2. 3 Triangle of Human Ecology of disease 28

Figure 2. 4 Adapted from human ecology of malaria framework. 30

Figure 3.1 Location Map of the Study Area 34

Figure 4. 1 Malaria Hotspot 2012. 54

Figure 4. 2 Malaria Hotspot 2013. 55

Figure 4. 3 Malaria Hotspot 2014. 56

Figure 4. 4 Malaria Hotspot 2015. 57

Figure 4. 5 Malaria Hotspot 2016. 58

Figure 5. 1 Map of IRS as malaria control intervention. 68

Figure 5. 2 Map of LLINs as malaria control intervention. 69

Figure 5. 3 Map of Herbal Medicine. 70

Figure 5. 4 Map of Anti-Malarial Drug as malaria control intervention. 71

Figure 6.1 Respondents‟ perception about effectiveness about IRS....75

Figure 6. 2 Respondents perception about effectiveness of LLINs 77

Figure 6. 3 Respondents‟ perception about effectiveness of antimalarial drugs 79

Figure 6. 4 Respondents‟ perception about effective of herbal medicine....81

University of Ghana http://ugspace.ug.edu.gh

ABBREVIATIONS

ACT	Artemisinin Combination Therapy
ITN	Insecticide Treated Bed Nets
IRS	Indoor Residual Spray
IPT	Intermittent Presumptive Treatment
IPTP	Intermittent Preventive Treatment of Pregnant Woman
LLINs	Long Lasting Insecticide Nets
NMCP	National Malaria Control Programme
MDGs	Millennium Development Goals
OPD	Out-Patients Department
RBM	Roll Back Malaria
WHO	World Health Organisation
OLS	Ordinary Least Square
IDW	Inverse distance Weighted
GWR	Geographically Weighted Regression
GIS	Geographic Information System
CBO	Community-Based Organisation
NGOs	Non-Governmental Organisations
GHS	Ghana Health system

University of Ghana http://ugspace.ug.edu.gh

PHC	Primary Health Care
WLS	Weight Least Square
GIS	Geographic Information System

University of Ghana http://ugspace.ug.edu.gh

ABSTRACT

The primary objective of this study was to examine the spatial distribution of malaria incidence in the Brong Ahafo Region by using a GIS as an analytical tool.

The research employed the cluster based sampling method to solicit the views of 245 households using a questionnaire. Malaria incidence indicated a variation from one household to another and from one administration district to another. Malaria clusters were determined using Getis and Ord statistic. This cluster analysis indicated that malaria distribution, characterized by areas with high malaria incidence, called hotspot areas, with a moderate malaria incidence known as not significant and areas of low malaria known as cold spots. Malaria causing factors in the study area were also determined using Ordinary Least Square Regression. Graphs were also used to illustrate the effectiveness of implementing interventions in the Brong Ahafo Region. Malaria control interventions that were used in the study area consisted LLINs, IRS, Antimalarial drugs and Herbal medicine. The relationship between malaria incidence and interventions were assessed using Geographically Weighted Regression. The Geographically Weighted Regression proved that high malaria districts have many interventions programmes.

The study indicated that 76% of the respondents revealed that Brong Ahafo Region is an endemic area due to its internal geography which aids in the development of the mosquito. Malaria Hotspot maps from 2012-2016 were created in this study using the Getis and ord Gi*statistics. The analysis of high/low clustering for different years indicated that the concentration of clustering in 2013 with z-score of 12.0161 which was the highest. The study showed that elevation has a negative relationship with malaria incidence hence the null hypothesis was rejected. The research indicated that 79.2% of the respondent understood that malaria distribution can be controlled through effective interventions like LLINS, IRS, and

University of Ghana http://ugspace.ug.edu.gh

antimalarial and herb medicine while 20.8% assumed that clearing of the vegetation and drainage of gutters. Malaria interventions such as LLINS, IRS, antimalarial and herbal medicine found in many districts hence the null hypothesis was rejected. The study revealed that LLINS was the only intervention that recorded a positive coefficient with a t-statistic less 0.05. Based on the effectiveness of interventions, the study showed that LLINs were ranked as very strong, the IRS was ranked not effective, antimalarial was ranked with regard to the drugs that were ACTs (76%), Quinine (20%) and Amodiaquine (4%) as well as herbal medicine was ranked effective in controlling malaria.

The spatial clustering and risk maps have been used to show malaria incidence, distribution and demonstrated as an efficient tool for quick identification hot and cold spots of malaria incidence. This can provide helpful insight into the underlying means driving incidence and major factors influencing malaria in Brong Ahafo Region.

Key words: GIS, Malaria, Interventions, Brong Ahafo Region

University of Ghana http://ugspace.ug.edu.gh

CHAPTER ONE: INTRODUCTION

1.1 Background

Malaria is one of the world‟s most devastating vector-borne diseases and an important cause of morbidity and mortality in developing countries, representing a major health burden (Sachs et al., 2002; Guinovart et al., 2006; Alonso et al., 2013). Looking for causes of malaria began in the middle-ages, yet, it still exists as an important health burden. The word „Malaria‟ comes from the Italian words „mala‟ and „aria‟ meaning „bad air‟ (Carter & Mendis, 2002). Malaria is a vector-borne human parasitic disease caused by the female anopheles mosquito. It is transmitted to people through the sting of infected female anopheles mosquitoes (WHO, 2016). Risk variables like the parasite, the mosquito vector, the human host and the geographical setting are determinants that cause malaria spread. Malaria continues to be a significant parasitic disease in the world. Regardless of the birth of a Malaria Control Programme in several parts of the globe for the past decades, the influence of malaria on humans persists, particularly, in most of the tropics and subtropics (WHO, 1998; de Souza & Riley, 2002; Sachs, 2002; Sachs & Melaney, 2002; Koremomp et al., 2003).

Globally, almost 3.2 billion people live in malaria prone areas. Regardless of 100 years of malaria control, in 2014, 97 nations worldwide recorded malaria infections (WHO, 2013). In 2012, malaria occurred in 104 countries (World malaria report, 2012). In tropical and subtropical regions of the world malaria are prevalent, including parts of Africa, Asia and America. In Africa, the economic effect of malaria is estimated at $12 billion every year (Gallup & Sachs, 2001). Malaria is not pleasant for commerce; the disease is accountable for the rise in health care expenditure, reduction in productivity, and employee tendency to be away from work, which has unfavourable influence of a firm‟s image (WHO, 2011). Generally, countries in Africa lose up to 25% of revenue to malaria (WHO, 2008). The

University of Ghana http://ugspace.ug.edu.gh

financial cost involved in accessing good health care is an obstacle to the majority of people who have been infected by malaria (Egunjiobi, 1983; Baume et al., 2000; Mugisha et al., 2002; Noor et al., 2006). The emergence of the disease has led to powerful adverse relationships to the economic growth of households in the affected countries. The costs to individuals are: financial cost which reflects the unit cost of an intervention, an additional cost of travel time, time spent in the hospitals or clinics, as well as poor quality of care received from the health providers. Malaria mortality is approximately 80% among children less than five years and pregnant women in Africa (WHO, 2008). In Africa, malaria infection among pregnant women is nearly 35 million each year (WHO, 2013). The dangerous effects of malaria infection during pregnancy include maternal anaemia, intrauterine slow development, premature birth and stillbirth (McGregor, 1984; Bader et al., 2010 and Yetich et al., 2010).

Previous studies on malaria have used various designs and determinants. Some examined the correlation between socioeconomic status and malaria. In this regard, age, vulnerable individuals and disease immunity are common determinants. Specific vulnerabilities include pregnant women whose immunity has been reduced due to first or second pregnancies, young children who have not fully developed immunity against malaria and migrants from areas with no or little malaria transmission. Malaria in school children is a significant reason for absenteeism in disease prone areas. It is estimated that about 2% of children who survive cerebral malaria are likely to sustain brain damage (WHO/UNICEF, 2003). Therefore, the regular occurrence of malaria among young children can have an adverse influence on their educational success. This is a danger to human capital growth which is a major component in economic development.

One study stated that still only a handful of poor people with lower socioeconomic status budgeted and purchased Insecticide Treated Nets (ITNs), and the richer segments with higher

University of Ghana http://ugspace.ug.edu.gh

social and economic status were four and half times more likely to buy ITNs and use other control measures (Howard et al., 2003). It has been identified that the poor social and economic communities are restrained from buying bed nets, mosquito coils, repellents and insecticide sprays. The story is not same for the richer segments as expected (Ahmad, 2012). Treatment seeking behaviour of an individual infected with malaria has a relationship with the person‟s social and economic status. Another study identified that the poorest households use self-diagnosis as their means of intervention, while the less poor households usually use traditional healers and community health workers for treatment of malaria (Uzochukwu & Onwujekwe, 2004). A strong correlation exists between socioeconomic status and malaria morbidity and mortality since many lower socioeconomic households need appropriate preventive measures. Malaria, consequently, is not just a health challenge; it is an economic growth challenge. Besides the adverse impact on the economy at the national level, malaria was threatening effects on the development of tourism, investments and trade in most prone areas.

In Ghana, malaria occurrence per direct observation of patients is around three cases per baby per year. Approximately 44% of out-patients at health facilities is because of malaria and thus considered as the most important cause of hospital or clinic attendance. Malaria mortality is 25% among children less than five years; malaria causes anaemia among pregnant women and placental parasitaemia which place the mother and fetus in serious danger (GHS/NMCP, 2004). Ghana Health Service (2004) reported that malaria is the principal source of mortality in the health organization with its death rate at 17.1%. In 2008, Ghana recorded total out-patient morbidity in 5,041,025 constituting 47.4% of the total death recorded as a result of malaria (Anon., 2010). In Ghana, the National Malaria Control Programme (NMPC, 2013) reported about 11.3million cases of the outpatient malaria. The National Malaria Control Programme in Ghana aims at reducing malaria mortality and morbidity by 75% by the year

University of Ghana http://ugspace.ug.edu.gh

2015 as a way of achieving the Millennium Development Goal (MDGs). A joint report from WHO-UNICEF (2015) stated that in Ghana the malaria mortality ratio has been reduced by 60% since the emerged of the MDGs in 2000, and this is converted into 6.2 million lives protected and children being the greater number. In 2013, Brong Ahafo Region recorded 1, 357, 000 malaria cases which was the highest rate of cases in Ghana (NMCP, 2013).

Several interventions have been implemented in the form of policies and strategies to control malaria. Common control measures are categorized as an Insecticide Treated Bed Nets (ITNs), Indoor Residual Spraying (IRS), diagnosis and treatment as well as Intermittent Preventive Therapy (IPT) (WHO, 2009).

In 2009, 39 regions in the WHO African division out of 83 regions have had ITNs free of charge. The IRS, with the WHO legalized chemical like DDT continues to be one of the key interventions for lessening and breaking off malaria distribution by vector control in the environment. WHO (2009) reported that 71 regions along with 27 in the African region put into effect IRS and 17 regions reported utilizing DDT for IRS. The ITP is suggested for groups of people in regions with elevated distribution that are specifically sensitive to acquiring malaria or depressed immunity because of its occurrence, especially among pregnant women and infants. WHO (2008) reported that 35 out of the 45 regions in Africa had approved IPT for pregnant women (IPTp) as a national plan. However, no country has approved the utilizing of IPT for infants (IPTi) as national plan.

Malaria incidences in different African nations have declined owing to productive malaria resistance drugs, improvement in these drugs and major advancements in control initiatives (Protopopoff et al., 2013). Currently, the ultimate implementation processes for malaria control persist with measures to control anopheles mosquitoes. The control initiatives are aimed at every point of the spread pattern of malaria i.e. the relation between anopheles

University of Ghana http://ugspace.ug.edu.gh

mosquitoes, the parasite and the host (Gosoniu, 2008). The suggestions made by WHO (2012) on malaria control and prevention are IRS with insecticide, Long Lasting Insecticide Nets (LLINs), larvae control, preventive chemotherapy and early diagnosis and treatment. The emergence of the IRS as a malaria control by WHO in 1957 has been considered as the most effective malaria control in history (Najera, 1989). Currently, it is considered a significant instrument in controlling malaria (RBM, 2008; WHO, 2006 and WHO, 2012). The LLINs provide protection to people sleeping in order to avoid mosquito bites (WHO, 2005). This has decreased the rate at which infected mosquitoes that feed on human population, while sleeping or resting (WHO, 2008) helping to decrease malaria spread. Early diagnosis and treatment is needed to decrease mortality owing to malaria. The Artemisinin-based combination therapy (ACT) has been actively promoted by WHO for simple malaria infection. Larvae management is different from the IRS and LLINs, in spite of the efficiency of these instruments (Utzinger et al., 2001 and Gu et al., 2006). Larvae control has brought about malaria elimination in few areas of the globe (Kitron & Spielman, 1989).

In geography, there are many approaches for research work, including the use of statistics and cartography. Tools such as GIS, Remote Sensing and other Geospatial techniques have aided in solving problems of malaria epidemiology and several other diseases (Getis et al., 1992; Booman et al., 2000; Boulos, 2004; Yeshiwondim et al., 2009). Geographic Information System is a computer-based technology for capturing, storing, processing and visualizing spatial data (Booman et al., 2000). The technology has the ability to merge the attribute data of disease incidence and other attribute characteristics with images such as topographical maps, satellite images and aerial photos. Geographic Information System has been used globally in producing disease distribution maps and for examining spatial pattern in disease distribution (Cattani et al., 2001). The introduction of GIS has contributed to malaria control programmes and it is currently considered a significant instrument in the processing and

University of Ghana http://ugspace.ug.edu.gh

carrying out of plans for the programme. In determining epidemiological patterns of disease, GIS contributes supplementary ability to carry out spatial and temporal analysis of health data. The cost involved in using the GIS application still serves as a barrier to it extensive usage (Booman et al., 2000). Geographic Information System supports a geographical database comprising environmental, social and health data. These data sets support the action of analytical examination. For instance, GIS can aid in the analytical examination of contagious disease data and spatial data and at that produce instant layout of the hot spots in the region of interest (Kolivras, 2006).

Presently, malaria control and prevention programmes in Ghana involve the allocation of ITNs, IRS, and case management and prevention chemotherapy for pregnant women. However, the forms and dimension of interventions need to be based on the incidence and prevalence of disease in large populations and thus detect the source and cause of epidemics of the infectious disease occurrence. For example, maps have been acknowledged as a significant instrument for modelling malaria control programmes for years (Kleinschmidt et al., 2000 and Yeshiwondin et al., 2009). In the study region, the absence of malaria risk maps gives rise to challenges to make the best of the insufficient resources in accomplishing goals at the time of control programmes. Risk maps of the spatial distribution of malaria will be critical instruments in mediating and testing control programme.

Therefore, this study examines the geographical distribution of malaria incidence in the Brong Ahafo Region and the interventions for malaria control using a GIS approach.

1.2 Problem Statement

In spite of numerous efforts to slow down malaria incidences, it is still one of the greatest threats in Africa. About 261 million malaria incidences were reported globally in 2010 with an Africa accounting for 81%. Also, malaria kills 655,000 persons each year with 91% of the

University of Ghana http://ugspace.ug.edu.gh

morality rate from Africa (World Health Organisation, 2011). In Ghana, the National Malaria Control Programme in the first quarter of 2016 reported about 2.2 million suspected cases of malaria, which represented a 3.50% increase from the malaria incidence in 2015 (NMCP, 2016). Key causes for the high malaria incidence in Ghana are attributed to poor quality of environmental sanitation which is strengthened by fast unplanned urbanisation and climatic factors (Mwangangi et al., 2012).

Urbanization contributes to the prospect of development and growth in an area, but it is accompanied by some adverse effects. These adverse effects include weakening conditions of the health of people owing to unsanitary conditions, lack of social amenities and the need for land for building sanitation facilities. Chaplin (1999) and Songsore (2003a), indicated that the major risk confronting several developing nations undergoing urbanization is the problem of sanitation. As the population of a specific area increases, sanitation problems are elevated, leading to acceleration of infectious disease like malaria.

In Ghana, environmental problems like poor sanitation, pollution of water bodies and inappropriate disposal of waste are among the topmost problems that the country faces (Government of Ghana, 2010a). The Brong Ahafo Region is no exception from the rest of Ghana. It is faced with crucial environmental problems such as inappropriate disposal of solid and liquid waste, dirty drains and air pollution resulting from the smoke from burnt refuse. The choked drainage systems with waste and stagnant water in receptacles serve as breeding grounds for mosquitoes and hence the endemicity of malaria.

Much effort has been made by the government of Ghana and Non-Governmental Organizations in the health sector to eliminate malaria in the Brong Ahafo Region. Nonetheless, the incidence rate remains high. This has triggered the question „why is the malaria incidence still high in spite of the many interventions"? The continuous growth in

University of Ghana http://ugspace.ug.edu.gh

malaria incidence is of great concern to the people of the Brong Ahafo Region because this elevated level of malaria exacerbates poverty levels. This has resulted in loss of work hours and the high economic cost due to treatment (UNICEF, 2007). However, an examination of malaria incidence and control in the Brong Ahafo Region has not received much attention in academic research. Regional malaria studies for site specific incidences, resistance to insecticides and anti-malarial drugs, malaria hotspots and health system responses are lacking. Asante et al. (2011) studied malaria epidemiology in the Ahafo area of Ghana. The research did not address how the malaria incidence differs between districts in the whole Region. It rather assessed malaria epidemiology in special areas such as mining areas in the Brong Ahafo Region as a way to control the disease. Osei and Yibile (2015) reported the geographic pattern of malaria in the Brong Ahafo Region. In this work, the yearly geographical distribution of districts" level malaria incidence from 2008 to 2011 in the Brong Ahafo Region of Ghana was mapped. However, the research did not report on the correlation between malaria incidence and interventions. Daniel (2009) studied malaria transmission dynamics and Pyrethroid Insecticide Resistance status of anopheles Gambiae Senue Lato Gilles in two districts of the Brong Ahafo Region. This study unveiled some findings on malaria transmission that will assist in providing better malaria control. However, this research was limited in assessing the effectiveness of malaria control intervention. To fill these gaps, this current research aims at examining the spatial distribution of malaria incidence by identifying major factors facilitating conditions for mosquito breeding and will produce malaria risk maps to determine hotspot areas, which will support decision-making concerning malaria monitoring and control.

University of Ghana http://ugspace.ug.edu.gh

1.3 Research Questions

- How is malaria incidence spatially distributed in the administrative districts?
- Are there correlations between malaria incidence and intervention programmes?
- What are the malaria control interventions and their effectiveness?

1.4 Aim and Objectives

The aim of this research is to examine the spatial distribution of malaria incidence in the Brong Ahafo Region by using a geographic information system as an analytical tool.

The specific objectives of the study are to:

- Examine the spatial distribution of malaria incidence.
- Assess the correlation between malaria incidence and interventions in the study area.
- Identify malaria interventions existing in the study region and their effectiveness.

1.5 Research Hypotheses

Hypothesis 1:

H_o=High malaria incidence districts are not likely to have many intervention programmes.

H_1=High malaria incidence districts are more likely to have many intervention programmes.

Hypothesis 2:

H_o= Elevation is the main determinant of malaria incidence in the study area.

H_1= Elevation is the not main determinant of malaria incidence in the study area.

University of Ghana http://ugspace.ug.edu.gh

1.6 Rationale of the Study

The research was expected to examine the spatial distribution of malaria incidence and interventions in the study area. Likewise, information on the distribution of malaria incidence related to interventions for malaria control was sought. Data on climatic variables and on malaria transmission‟s spatio-temporal distribution from objectives 1 and 3 were used to determine malaria distribution (hot spots). Interventions such as IRS, LLINs and environmental management were related to distribution of malaria to determine if malaria transmission is low or high in these areas. The interventions were expected to greatly decrease malaria vectors with an ultimate reduction of malaria transmission using small resources and cost.

1.7 The Scope of the Study

The scope of this research was defined by the geographic area, the subject matter and the time frame. Geographically, the research was designed to cover the Brong Ahafo Region, which involves 11 health administrative districts out of the 27 districts in the region. Regarding the subject matter frame, the focus was on how to determine hot spot regions, what account for these hot spots and identify related interventions to control malaria in these hot spot areas through the application of GIS. For this research, the time frame for malaria cases is from 2012 to 2016.

1.8 Organization of Thesis

This thesis is organized into seven chapters. The first chapter presents introduction, problem statement, objectives, hypotheses, significance and scope of the study. The second chapter is the review of relevant literature. Malaria conceptual frameworks based on the literature were produced. In terms of methodology, this is captured in Chapter Three; the research links both qualitative and quantitative methods but is skewed towards a quantitative approach. The

University of Ghana http://ugspace.ug.edu.gh

chapter entails the comprehensive research design in choosing a study area, data collection and analysis, as well as methods used to address the research questions stated in the introduction.

Chapter Four treated the first research objective through the use of GIS to examine incidence distribution. Under this chapter the Getis and Ord (hot spots) were used to examine malaria hotspots in the study area. This chapter also predicts the major factors influencing the pattern of malaria distribution within the study area.

Chapter Five assesses the relationship between malaria incidence and interventions to control malaria. The use of the Ordinary Least Square tool was to produce a global model of the relationship between malaria incidence and existing intervention for malaria control. Chapter Six examines the various activities of malaria control interventions in place in the study area. It also treats the perceptions of respondents on the effectiveness of malaria control interventions, challenges and coping strategies. The final chapter of the thesis discusses the researcher‟s contributions to knowledge and future research aspiration.

University of Ghana http://ugspace.ug.edu.gh

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Africa retains a dominant share of the global malaria burden. In 2015, the region had 88% of malaria cases and 90% of malaria mortality world-wide (WHO, 2015). However, much research is required, as previous studies have centred on medical and clinical aspects and not so much on its geography.

Manifestations from the literature disclose multiple discussions that have suggested explanations between malaria, human and environment disease relationship. In this section, the thesis covered broadly the ecology of malaria where common interactions influence the disease. It encompassed the global malaria distribution, malaria situation in Africa and Ghana, conditions necessary for the anopheles mosquito development. It also covered the anthropogenic factors affecting malaria transmission, the use of GIS technology in malaria study and malaria control interventions.

2.2 Global Malaria Distribution

Malaria is one of the world‟s most devastating vector-borne diseases and an important cause of morbidity and mortality in developing countries (Sachs & Malaney, 2002; Guinovart et al., 2006; Alonso et al., 2013). Regardless of 100 years of malaria control, the malaria epidemic continues in 104 countries (World Malaria Report, 2012). Figure 2.1 depicts the global distribution of malaria in Africa, South America, and Asia. Mediterranean, South Eastern Asia and Western-Pacific are quite in malaria endemic zones. In 2011, the world recorded an estimated of about 216 million malaria cases and almost 665,000 deaths. In 2012 international funds raised for malaria control elevated from less than US$ 100 million in 2000 to US$ 1.84 billion in the same year (WHO, 2012).

University of Ghana http://ugspace.ug.edu.gh

Although the number of zones where malaria transmission happens is estimated to have declined from 1900 to 2010, with the population at risk of contracting malaria has grown from 890 million to 3,410 million globally. The areas at risk were estimated from 77 to 39 million Km² (Snow et al., 2005). The people of South-East Asia and the Western Pacific have the greatest malaria risk. The people at risk are located in rural communities in or near the forested and border zones. These happen not to be the only places where the malaria vector exists in abundance, but places where availability of health care is lacking (Snow et al., 2005). From the year 1990 to 2010 an estimated number of malaria cases a year that lived with disability (YLDs) was respectively 433 and 498 per thousand of YLDs at all ages (Vos et al., 2012). Malaria is a massive burden in the world and troubles any progressive development of the world economies (Sachs et al., 2002).

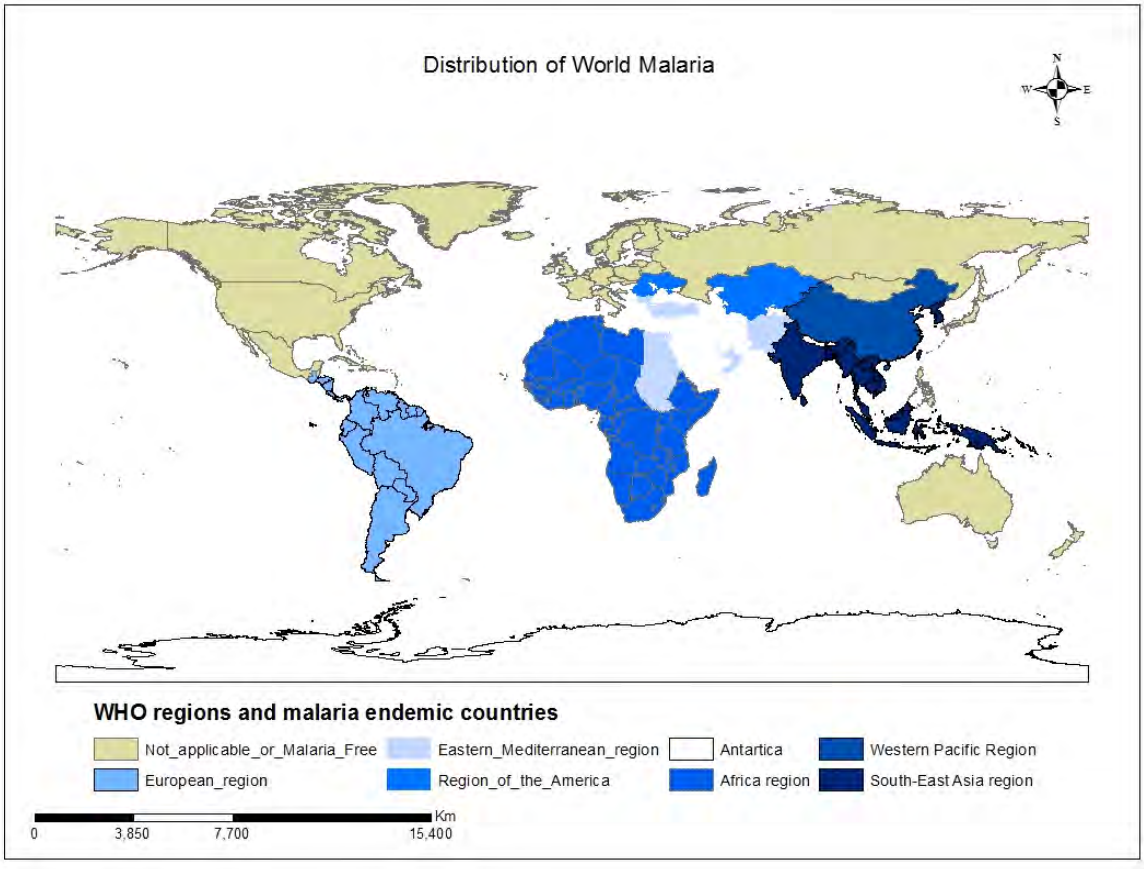


Figure 2.1 Distribution of World Malaria (Source: World Health Organization, 2012)

University of Ghana http://ugspace.ug.edu.gh

2.3 Malaria Situation in Africa

Malaria is believed to have been emerged from Africa and to have coexisted with its definitive hosts, mosquito vectors and intermediate hosts, placental mammal (Poinar, 2005). The trace of mosquitoes can be found from 30 million years ago, indicating that the mosquito vector existed before the ancient history of man (Poinar, 2005). The ancient migrants might probably have introduced the Plasmodium from Africa to other sections of the globe, a circumstance that persists as tourists and migrants today return home with malaria from prone areas (Newton & White, 1999).

Low-income nations of the globe are the most seriously affected by malaria disease (Mhalu, 2005), with the majority found in Africa (Ricci, 2012). According to Dzinjalamala (2009) nine out of ten deaths due to malaria occur in Africa. Figure 2.2 is a map of Africa depicting the nations where malaria is endemic. The uniform Plasmodium falciparum spread areas in Africa were estimated to be inhabited by 753 million people, in 2010. Regions of low, stable transmission were estimated for 228 million people and have lasted for a definite period of time at the Horn of Africa, Sudan, Kenya, upland regions of Tanzania, Rwanda, Burundi, the Democratic Republic of Congo and Madagascar. This cut across the southern part of the stable transmission region in Angola, Zambia, Botswana and South Africa. The highest transmission areas of Plasmodium falciparum are mainly West Africa and large areas of central Africa are stretching out eastwards through Mozambique and Madagascar. It embodies 327 million people at risk. Ghana is among the risk areas with the malaria incidence greater than 5% but lower than 40%.

University of Ghana http://ugspace.ug.edu.gh

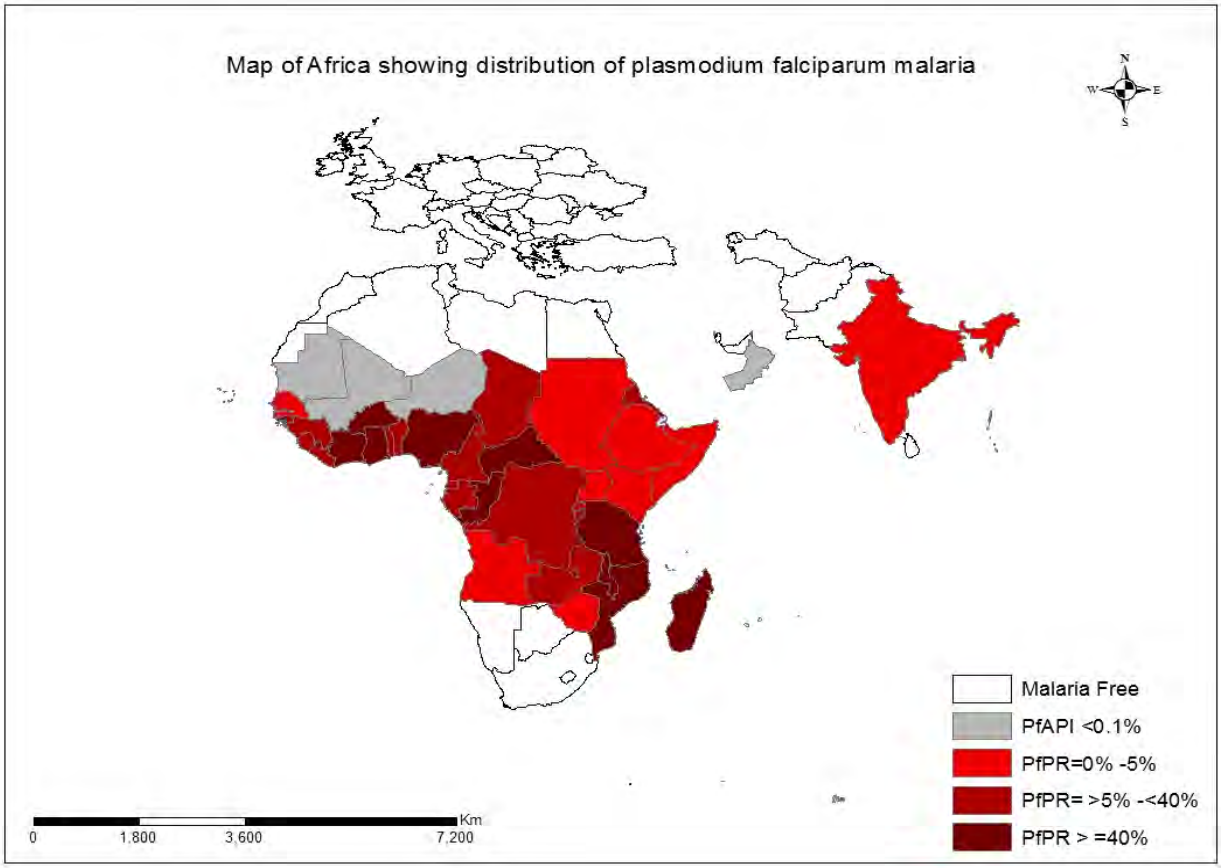


Figure 2.2 Map of Africa Showing Distribution of Plasmodium Falciparum Malaria

(Source: The Malaria Atlas Project, 2010)

2.4 Malaria Situation in Ghana

Malaria is the single most significant disease in Ghana since 1985, being partly responsible for 45% of all outpatient cases at health facilities. It also contributes to 15% of mortality every year (GHS, 2004a). In Ghana, almost all malaria cases are caused by Plasmodium falciparum, which spreads through the mosquito bite. Malaria cases have been recorded for about 36% of patients admitted to health facilities for a decade (GHS, 2004a). In 2008, Ghana recorded total outpatient morbidity of 5 041 025 constituting 47.4% of the total recorded as a result of malaria (Anon, 2010). In Ghana, the effect of malaria continues to be immense for about 323 per 1,000 cases recorded among children less than five in 2008, with insufficient proof of the reduction from 2002-2008 (WHO, 2009).

University of Ghana http://ugspace.ug.edu.gh

The effect of malaria is complex in the forest zone of Ghana (Ahmed, 1989). Owusu-Agyei (2009) conducted a research, in the Brong Ahafo Region of Ghana on epidemiology of malaria in the forest-savanna transitional zone. The study accounted for increased spread of malaria due to the environment which helps in the development of the vector. Also, the parasite at their breeding sites with the elevated humidity that continue for a long time.

The high social and economic expenditure of malaria treatment shows the need for greater success in malaria control interventions a way to reduce malaria incidences and deaths (Asante & Asenso-Okyere, 2003). Malaria control interventions have focused on the use of LLINs, IRS, drug use, case management and other vector control strategies (WHO, 2000, 2005a, 2006).

2.5 Conditions Necessary for the Anopheles Mosquitoes Development

The ability of the anopheles mosquito to exist and increase in density is as a result of suitable climatic factors (Service & Townson, 2002). Climatic factors such as rainfall, temperature and relative humidity are the significant variables for the mosquito"s development and growth but the most persistent one is temperature. According to Paaijmans et al. (2010), the humidity content from rainfall affects the malaria distribution, whereas temperature serves as the checking point for determining density level and the existence of the anopheles mosquito. It is unquestionably demonstrated that the anopheles mosquitoes are pleased to exist between 16^0C and 35^0C, while the anopheles can exist with a relative humidity as low as 50% (Macdonald, 1957; Craig et al., 1999; Service & Townson, 2002). This explains the anopheles development containing between 9 to 10 days in a period of this temperature range.

Further, Paaijmans et al. (2010) state that at a temperature between 20^0C to 25^0C associated with a 60% relative humidity, this climatic condition aids the longevity of mosquitoes to

University of Ghana http://ugspace.ug.edu.gh

elevate in density and in malaria incidence due to the increased number of days from 10 to 14. However, as low or high as temperatures between 16^0C and 35^0C and low-lying relative humidity at 50%, deaths elevate and the longevity period of mosquitoes reduces to 9 days (Craig et al., 1999). A temperature over 40^0C, the longevity estimate mark is assumed to be zero (Craig et al., 1999; Okogun et al., 2005; Fournet et al., 2010). This leads to a reduction in the density of mosquitoes, indicating a decrease in malaria occurrence. Numerous studies have analysed the interrelation between climatic factors and the Anopheles mosquito as well as significant determinants that have elevated their density, development and growth leading to possible high malaria occurrence. These studies accordingly acknowledge the necessity of research into other features such as the surroundings. And also the human being impact at a remote spatial scale and their place in the malaria climate relationship.

The intention of this research and literature review is based on identifying the twisting interrelations between the major risk variables of climate and malaria.

2.5.1 Temperature

Temperature performs an important task in the transmission process of the parasite and the mosquito‟s longevity (Brooker et al., 2004; Mordecai et al., 2013). Temperature has a crucial impact on the development and longevity of the parasite (Blanford et al., 2013). The duration of the parasite relies on temperature and different climatic determinants (Martens et al., 1995). The evolutionary process of the parasite in the mosquito is considered to stop at 16℃, and transmission at as low as 18℃, though these estimates or findings are insecure. However, a temperature higher than 22℃ is appropriate for secure transmission (Craig et al., 1999). Temperature affects the mosquito‟s existence as well. The maximum temperature for a mosquito‟s existence is within the interval of 20 ℃ and 25 ℃ (Martens et al., 1995), and malaria infection is at 25 ℃ (Mordecai et al., 2013). Also, it is established that the most

University of Ghana http://ugspace.ug.edu.gh

appropriate temperature for fast development of the mosquito vector is within an interval of 20-30℃. To some extent, increasing temperature lessens the range between the blood meals and intensifies the mosquito‟s biting rate, and hastens the growth of the parasite thereby increasing the malaria infection (Martens et al., 1995). An elevated temperature should intensify the chance of transmission because it lessens the period of time between the infection and the outbreak of the disease‟s symptoms (Reiter, 2001).

Studies have demonstrated that an extremely elevated temperature, approximately 40-42 ℃ can facilitate the death of the mosquito (Craig et al., 1999) and parasite (Dale et al., 2005). The day-to-day longevity of mosquitoes ranges from 0℃ to 40℃ (Craig et al., 1999). Low temperatures can decrease the quantity of mosquitoes in an area as a result of the extended larval period (Dale et al., 2005). Hence, temperature is regarded to be a central variable for malaria transmission (Gething et al., 2011). In Madagascar, a research by Rakotomanana et al. (2010) for a year did not ascertain a specific relation between the average monthly temperature and clinical malaria cases at a max temperature degree of 26^0C.

As reported by, Tay et al. (2012) in a study based on a population study in Kumasi in Ghana, with the geographical environment the same as in the highlands of Ethiopia. In both cases, a research on the indirect effect of the high temperature on malaria incidence over a 12 week period was measured. The research also assessed the relationship between high temperature and malaria incidence in the broad scale population. These researches varied in their findings of the influence of temperature on malaria. According to Teklehaimanot et al. (2004) a direct significant positive rise in malaria incidences came as a rise in the lowest temperature, while Tay et al. (2012) reported a direct opposite relation, namely no significant influence in an up to eight weeks period.

University of Ghana http://ugspace.ug.edu.gh

2.5.2 Rainfall

Rainfall plays a key part in malaria transmission (Kovats et al., 2001). The impact of rainfall on malaria spread is composite. The relationship that exists between malaria and rainfall patterns is well understood as the period when the temperature is not restricted or when sewage in geographical areas becomes a breed site for anopheles mosquitoes. Or in a situation where rains may bathe their breeding sites resulting in short-term break ups in their longevity and development. It is difficult to understand the preliminary subtle relation between malaria and rainfall (Hoshen & Morse, 2004; Cator et al., 2013).

Investigation of rainfall patterns has been employed to the forecast malaria epidemic. According to Shanks et al. (2002) and Teklehaimanot et al. (2004) the relation between rainfall patterns and malaria occurrence is not consistent contemporarily. The place where meaningful relations happen, the degree, chronological characteristics, minimal quantities of rainfall needed and time varies shown different results (Craig et al., 2004b; Ye et al., 2008; Oluleye & Akinbobola, 2010).

Ye et al. (2008) state that the ultimate relation between rainfall and malaria happens at a specific start of the rainfall rate and is usually associated with a temperature over 23^0C. According to Craig et al. (1999), for constant transmission of malaria to happen, rainfall pattern should be at least 80mm for a period of five months associated with a temperature estimated to be nearly 22^0C. Furthermore, Craig et al. (1999) asserted that rainfall over 80mm within a month is inadequate for any meaningful spread of malaria regardless of the degree of temperature. However, Ye et al. (2008) opposed Craig et al. (1999) argument, by stating that rainfall of 100mm within a month stimulates a meaningful spread of malaria, with a relation scale of 160mm with a temperature between 23^0C and 27^0C. Fournet et al. (2010) equally recorded that minimum rainfall pattern as 2.3mm and 200mm as maximum pattern

University of Ghana http://ugspace.ug.edu.gh

and that a temperature over 23^0C stimulates the spread of malaria throughout the year in Ouagadougou.

The results may vary, but eventually a conventional mark for a rainfall measure may over-estimate its influence at a locality. The results of Ye et al.‟s (2008) research demonstrates that below the period of time between malaria and rainfall, a conventional mark of any 10mm of rains with a maximum over 160mm, stimulate approximately a 4% malaria incidence increment below a 23^0C temperature rate.

2.5.3 Relative humidity (RH)

Relative humidity (RH) appears to have a simple impact on the growth of the parasite, however, it may influence the life cycle of the mosquito (Dale et al., 2005). The maximum relative humidity for the mosquito‟s longevity is over 60% with a temperature ranging from 20℃ and 30 ℃ (Bureau of Endemic Diseases Control of P.R. China, 1998). On the condition that the average relative humidity is over 60% (Bureau of Endemic Diseases Control of People's Republic of China, 1998) or over 80% (Bhattacharya et al., 2006), the longevity of the mosquito vector becomes shorter. In an event that the mean relative humidity is lower than 25%, mosquitoes will stop biting (Bureau of Endemic Diseases Control of People's Republic of China, 1998), the adult mosquito longevity will be significantly decreased by the low humidity (Keiser et al., 2002), hence malaria spread will be no more (Dale et al., 2005).

Numerous researches have been administered to improve the understanding of relative humidity on malaria transmission. Okogun et al. (2005) argued that an increased temperature state, relative humidity aids, to decrease scarcity of mosquitoes‟ breeding sites, by that increasing their longevity and lifetime. As stated previously, the relation between malaria and mosquito densities have been indirect. Relative humidity is an efficient forecaster of malaria occurrence in different geographical regions and its results have been fluctuating like rainfall.

University of Ghana http://ugspace.ug.edu.gh

2.6 Anthropogenic Factors Affecting Malaria Transmission

Apart from the impact of climatic conditions in malaria transmission, non-climatic determinants like human activities such as movement, environmental modification and also socioeconomic status, and vector control interventions influence malaria spread (Githeko et al., 2000; Lindsay et al., 1998; Reiter, 2001). The impacts of the non-climatic determinants influencing malaria transmission are shown below;

Keating et al. (2005) and Deressa et al. (2007) and Peters (2010) asserts that beside the farming methods, pastoral farming can display problems of the anopheles mosquito turning into the vector. Peters (2010) indicates that based on the scale of pastoral farming and the great multitude of animals available in a zone, the greater the option for the generation of blood present for the mosquito and the higher the transmission of malaria at that level.

Healthcare systems with accessibility, affordability, quality of care and efficiency with sufficient assistance in the global and national level have provided meaningful results of decreasing malaria mortality and morbidity.

Aikins et al. (1993) and Opiyo et al. (2007) state that numerous researches current in Africa demonstrate that the spread pattern of malaria is not comprehended by the people and creates a continuous space between consciousness and action (Opiyo et al., 2007). For example, Mwenesi et al. (1995) and Yadav et al. (2007) anticipate that enlightenment would elevate people‟s consciousness about the reasons of malaria spread. However, many maintain the misconception that the reason for the spread of a disease such as malaria is the act of witches and the rays from the sun.

In numerous states in the world, especially in African countries, migration of people for political, social and economic reason creates the avenue for transmission of malaria. The increased movement of fugitives and immigrants may spread malaria in free malaria zones

University of Ghana http://ugspace.ug.edu.gh

owing to the introduction of new parasites which may be resistant to treatment in these free zones. However, sometimes immigrants may have the malaria transmitted when they access these malaria zones because they have migrated from low-lying or no spread region (Giada et al., 2003).

2.7 The use of GIS Technology in Malaria Study

Tools such as GIS, Remote Sensing and Geostatistical methods have aided in solving problems of malaria epidemiology and several other disease types (Getis et al., 1992; Boulos, 2004; Yeshiwondim et al., 2009). The constituent part of a GIS contains not only a data bank, but also geographic information and a number of techniques that connect the systems as one. GIS has been explained as the branch of scientific knowledge in geographic information science (Goodchild, 1992a), which is clearly described as „research on the generic issues that surround the use of GIS technology, impede its successful implementation, or emerge from an understanding of its potential capabilities". Below are some examples of how techniques in GIS technology can be used in entering, storing, analysing and displaying digital Geo-referenced data in research work.

Thomson et al. (1997) assert that malaria mapping is based on the relationships between disease occurrence and climatic variables being natural elements which are suddenly impacted by meteorological determinants. So the connection can be employed to anticipate the malaria occurrence within localities where data are not obtainable. Wimberley et al. (2008) assessed the local and global distribution of malaria incidence in the USA. The research aimed at analysing the difference between non-spatial and spatial classic methods to determine the distribution pattern of malaria in a locality. The findings acquired demonstrated an integration of spatial dependency of the major variations in the evaluation of malaria allocation.

University of Ghana http://ugspace.ug.edu.gh

Yeshiwondim et al. (2009) conducted a study in Ethiopia assessing 543 villages comparing the global and local pattern of malaria distribution based on information acquired from six laboratories and health care centres. The findings obtained indicated a difference in malaria occurrence in a way that was based on gender and age, where the quantitative data were meaningful on ages as low as five years or more. The local cluster of disease occurred in the space that separated villages based on meaningful area intervals. Malaria risk maps were created to indicate hot zones for easy observation and location marking. Tsai et al. (2009) conducted a study in Taiwan using the spatial autocorrelation technique based on Moran's I, local Getis and Ord statistics. The researches explained and illustrated spatial clusters within regions and could locate 20 dominant reason of mortality. Basel (2008) examined the spatial trend of malaria distribution in Africa and evaluated the connection between malaria and ecological variables that differ progressively in space. Spatial autocorrelation was used to analyse the findings, which indicated a positive significant between malaria cases and ecological variables.

The process of examining and determining the correct coordinates and to coordinate the system to obtain data on unreferenced malaria cases with reference to environmental data, applying analytical approach, can aid in ascertaining the determinants that are partly responsible for malaria spread and death at distinctive geographical environment (Craig et al., 2007).

2.8 The limitations in using GIS for Malaria Research Studies

The application of GIS in developing countries like Ghana has many challenges. These limitations are different in most countries due to variation in spatial setting. Lack of awareness, lack of qualified staff and financial implications of hardware and software are

University of Ghana http://ugspace.ug.edu.gh

some of the major challenges to mention. There is much connection between these limitations.

GIS is quietly an expensive application in most developing countries. The financial implication of data collection, the monetary value of software and hardware and costs for qualified staff is over the ability of most developing countries in Africa. There are difficulties in data transfer due poor internet connection. The lack of corroboration from organizations and lack of awareness among heads of department of what GIS can aid to empower in the decision making process in Africa is demerit for the application. Hence, it is important to influence to elevate the awareness of governing bodies to convince them into allocating funds into the development of the application (Stuart et al., 2009).

2.9 Malaria Control Interventions

Malaria incidence in different African nations has declined owing to productive malaria resistant drugs, improvement in these drugs and major advancements in control initiatives (Protopopoff et al., 2013).

In recent times, the ultimate implementation processes for malaria control persist with measures to control anopheles mosquitoes. The control initiatives aim at every point of the spread pattern of malaria that is the relation between anopheles mosquitoes, the parasite and host (Gosoniu, 2008).

Mabaso et al. (2004) state that major control initiatives are put in place to decrease the relation of the human-vector connection. The decline in the longevity of the mosquito vector influences its duration to spread parasites. Delves et al. (2013) analysed the possible associations that influence measures to stop parasites being transferred from host to mosquito. Alonso et al. (2011) conducted a study in southern Africa, on IRS and LLINs

University of Ghana http://ugspace.ug.edu.gh

indicating the advantages of fundamental control initiatives of the mosquito vector in the region based on WHO suggestions (Mabaso et al., 2004).

The suggestions made by WHO emphasise an instant identification of the disease, quick treatment by the discovery and the sudden spread of the malaria occurrence. Gosoniu (2008) and Craig (2009) established that no malaria incidence, host or health care methods are uniformly allocated, and measures are required to aim at the people of the dominant risk regions in time. The initiatives for malaria control change based on the understanding of how the disease spreads and can be controlled, while the means required to measure timing conditions at risk times to assess and understand the unique environments of spread in order to accomplish the appropriate results are vital.

In reaction to the malaria, plague the World Health Organization (WHO) approved the Global Malaria Control Strategy (GMCS). The Ministry of Health initiated a general Malaria Control Action Plan (MCAP) in November 1992 after Ghana had accepted the Global Malaria Control Strategy (GMCS), with the intention to decrease the incidence of malaria and death in the country (Ahorlu et al., 1997).

The Government of Ghana employed the „Roll Back Malaria (RBM) Action" in 1999 and established a vital plan to assist its operation. The Ghana RBM highlights the intensification of health services by means of an alliance with the United Nations Children"s Fund (UNICEF), the United Nations Development (UNDP), the World Bank, ministries, NGOs, the private sector, as funders of research institutes to bring about treatment and preventive action to a greater extent. The aim of the initiative was to decrease malaria related incidence and death by 50% from the 2010. Eventually, the Malaria Control Strategic Plan emerged in 2008-2015, with the aim at declining malaria incidence and death by 75% by the year 2015 and as a way of achieving the Millennium Development Goals (MDGs). This objective was

University of Ghana http://ugspace.ug.edu.gh

to be attained by the means of a general health sector growth, an advanced significant investment in malaria prevention and to extend the scope of availability of malaria treatment and prevention interventions.

2.10 Summary of literature review

This study aims at a re-examination of research works on malaria; it indicates the relation between climate-malaria researches, which happens to be a subtle and complicated connection that exists between mosquitoes, malaria occurrence and meteorological determinants and the function of temperature in the general interaction processes. The results of research work reviewed previously indicate that temperature has several measurement forecasters and has proved to be more consistent in determining its connection with malaria occurrence based on the assessment of different fundamental meteorological determinants like rainfall and relative humidity.

The reviewed literature indicates that climatic factors are uniformly meaningful under other conditions of study as assessments show the temperature is self-consistent, meaningful and perhaps the master forecaster of the relationship between malaria and climate on a geographical scale and place. The question that remains challenging and to be answered is the applicable means of resolving the environmental problem of the case‟s research locality.

2.11 Conceptual Framework

Malaria in the forest regions of Ghana can be observed as an exclusive combination of environmental conditions and social reactions which is caused by ecological, political, economic and cultural circumstances. Recent methods to curb malaria demand a combination of ecological and social methods, including societies and government. These methods depict an ecological context of health (Curtis, 1996) indicated in the description of "health as a state

University of Ghana http://ugspace.ug.edu.gh

of complete physical, mental and social well-being and not merely the absence of disease or infirmity‟ (WHO, 1986). This idea of health indicates system interactions between populations and their ecosystem, specifically between economic determinants, together with physical and biological surroundings. The variables evaluated in the study were obtained from these models: The ecological model and the human ecology of disease (Meade and Emch, 2010)

An ecological paradigm portrays interaction and negotiation, serving to connect people, their conduct and their social and geographical setting through various places and a time scale. The main fundamental law of the theory is that human mutual relations and conduct in the social arena and the varied distances as their impact on health developments is rooted in individuality, insight and resources. Therefore, the degree of agreement serving to connect people and their many stages of social and artistic settings is a significant call of well being (Stokol, 1996; Butterfield & Lewis, 2002). Even though this model is effective for analysing health behaviour, it puts more stress on the social environment than the natural environment.

Numerous researches have used the ecological models in malaria study, malaria Treatment-Seeking Behaviours (TSB) and malaria Knowledge, Attitude and Practice (KAP) which are originally interested in testing how factors of development, assets and artistic impact on understanding and usage of malaria intervention work (Panter-Brick et al., 2006; Esse et al., 2008; Oresanya et al., 2008). These researches have utilised the mixed method approach in several areas, therefore being spatially accurate. Oresanya et al. (2008), evaluated the function of many features impacting the understanding of insecticide-treated bed nets (ITN) with the focus on estimating development concerning malaria in the Millennium Development Goal (MDG) and discovered that the utilisation of ITNs within an area is influenced by religion, income, education and ethnicity (Noor et al., 2003).

University of Ghana http://ugspace.ug.edu.gh

Human ecology of disease relates to the mode in which human behaviour, in its cultural and economic settings interrelates with geographical region to generate and overt disease in vulnerable people. These interrelations determine the success of the numerous determinants showing the integration of „habitat", „population" and „behaviour" (Meade & Emch 2010, p. 30).

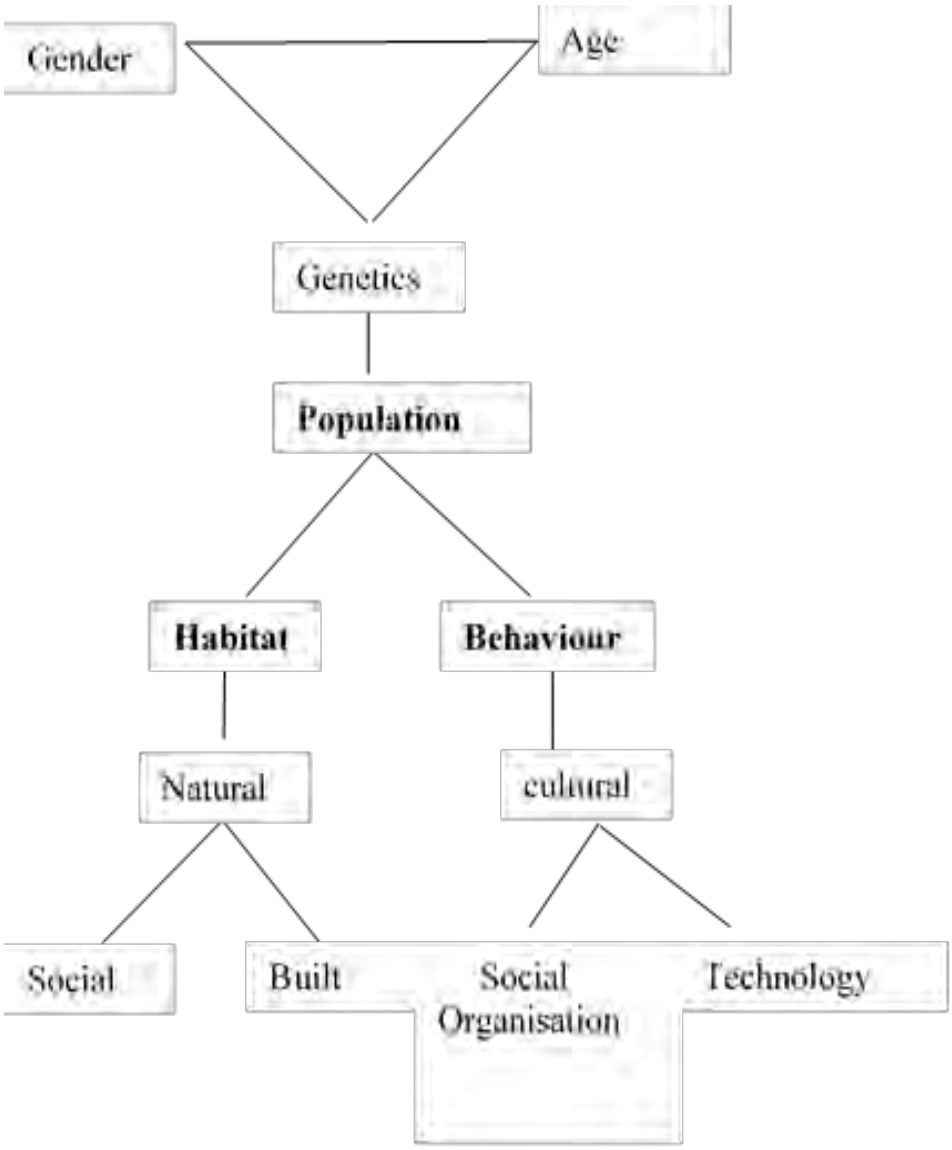


Figure 2. 3 Triangle of Human Ecology of disease (Source: Meade and Earickson, (2000).

University of Ghana http://ugspace.ug.edu.gh

According to Gatrell and Elliot (2009), habitat is „space" for the mosquito vectors and humans. Habitat is made up of physical, built and social environment. The physical environment is connected with determinants that biologically promote the growth and development of mosquito vectors like climate, soil composition, as the social, environment determinants constitute of political and social patterns like administrative government, school and health care service. The built environment determinants are housing types and workplace.

Population is associated with the special qualities of humans as natural organisms which serve as the possible host of diseases. Population"s special qualities involve genetic traits and gender, which explain the human capability to encounter varying settings and disease condition such as malaria (Meade & Emch, 2010). As stated by Agomo et al. (2009), Phillips et al. (2009) and WHO (2012a), children less than five years, pregnant women and non-immune migrants staying in geographical areas prone to malaria have been categorized as the more sensitive people. This is due to fact that pregnant woman"s immunity has been lessened as a result of the first or second pregnancies, children less than five have not developed immunity against malaria and the non-immune migrants come from areas with no or little malaria transmission. Nahum et al. (2010) assert that on a genetic basis, people without sickle cell probably suffer the effect of malaria more than the sickle cell carriers.

MacCormack (1984) and Brown et al. (1996) stated that humans as cultural creatures participate in day–to-day behaviour that changes their environment. They modify the environment to suit them through their belief systems defined by values, norms and insight by creating homes, schools, partake in cultural and religious activities, and apply new technology and so on. According to Meade and Emch (2010) these describe what is meant as behavioural variables, which explain the visible portion of human culture. They single out four ways that show that interaction exists between humans: vectors, parasites and geographical area which have health consequences. The earliest one among the four is

University of Ghana http://ugspace.ug.edu.gh

through human modification of the environment, in the process of humans creating an ecological condition, thereby generating the breeding spots of the anopheles mosquito. Secondly, partaking in unhealthy conduct. Thirdly is the process of disease diffusion in the environment and the last is based on the cultural belief systems, norms and perceptions. In a process to gain knowledge of the interrelationship between humans, diseases and the environment is by investigating and quantifying the connected determinants and thereby testing their interaction. Although, they are frequently very difficult to quantify, like Meade (1977) implies, the situation can bring about misunderstanding.

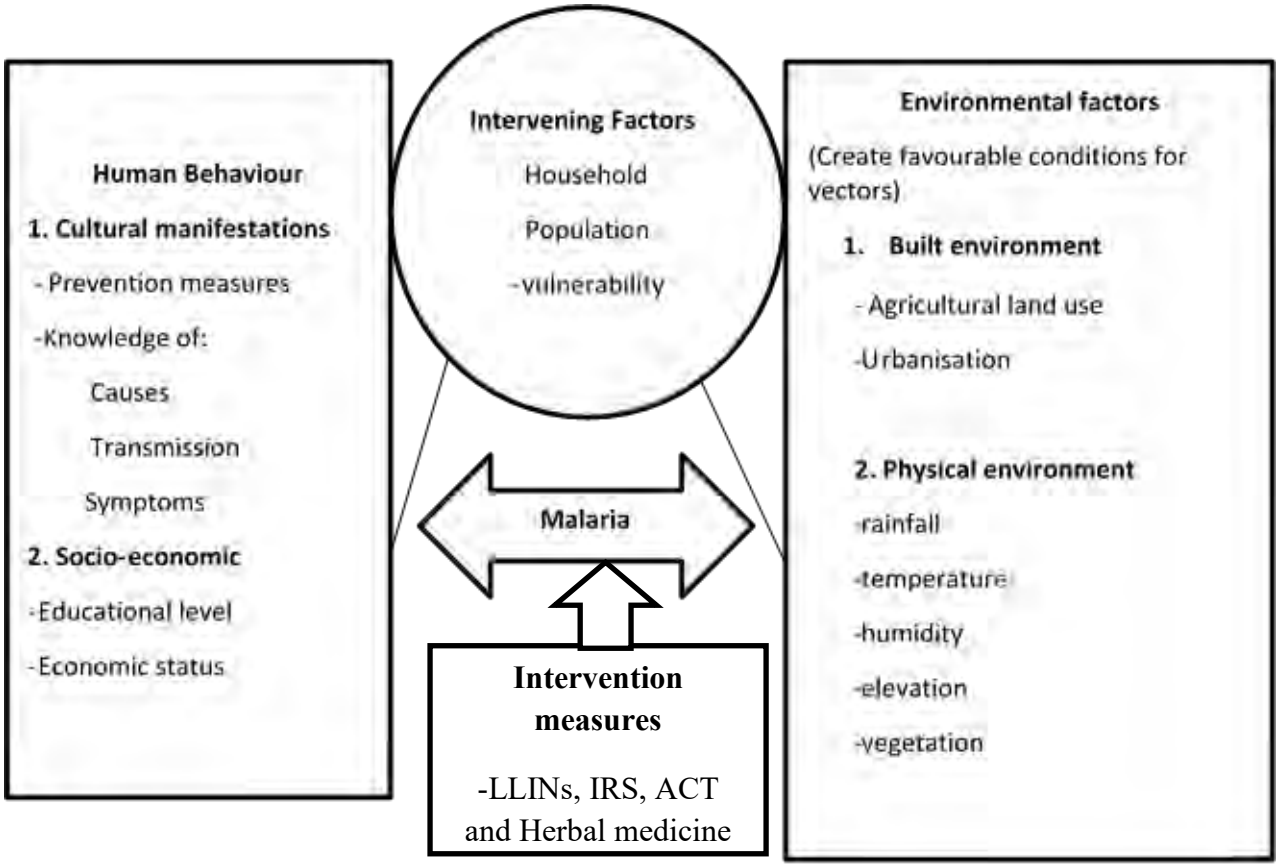


Figure 2. 4 Adapted from human ecology of malaria framework. (Source: Author, February 2017)

University of Ghana http://ugspace.ug.edu.gh

The left part of figure 2.4 shows behavioural and socioeconomic conditions. The behavioural determinants were derived from the ecological model. On the other side of the model are environmental factors related to the area to create favourable conditions for vector development. The built environment includes agricultural land use, settlement patterns, urbanization, while the physical environment involves rainfall, temperature, humidity, elevation and vegetation. The indictor in the middle of the model shows the population‟s relation with their ecosystem in one direction and the environmental conditions commanding those relations on the right side of the figure 2.4. Elevation, for instance, can affect a population‟s choice on where to construct a house. On the other hand, socioeconomic factors such as economic status may decide the type of house to construct. Culture manifestations about what causes the disease can influence one‟s access to health care as depicted on the left side of the figure 2.4. These factors relate in distinctive ways that can either strengthen or decrease the risk of malaria among populations open to similar risk factors. Based on how malaria spreads, intervention measures are put in place to help curb its spread. The intervention measures like IRS, LLINs, ACT and herbal medicine help in minimising the growth and spread of malaria parasites.

The anticipated result of this model does at best diagnose a population‟s ecological factors related to the continuous elevated malaria incidence despite the best attempts created to prevent the disease.

University of Ghana http://ugspace.ug.edu.gh

CHAPTER THREE: STUDY AREA AND METHODOLOGY

3.1 Introduction

The study seeks to portray the geographic pattern of malaria cases in the Brong Ahafo Region using administrative districts as units of analysis. This section of the study includes geographic location, data, data source, research design, study population, sample and sampling procedure, research instrument, data collection procedure and method of data analysis in order to accomplish the objectives of the research. These techniques are based on information from literature and the research environment.

3.2 Study Area

The second biggest region of the ten regions of Ghana is the Brong Ahafo Region i.e. 16.6%, with a total land zone of 39,554 sq. km. The Region is bordered to the north by the Northern Region, on the south by the Ashanti and the Western Regions, in the east by the Volta Region and in the southeast by the Eastern Region and in the west by La Côte d‟lvoire. The Brong Ahafo Region lies in the west-central part of Ghana between $0^0$15‟ E-3^0W as longitude and latitude of $8^0$45‟ N-7^0 30‟ (Ministry of Food and Agriculture, 2014).

The capital of the Brong Ahafo Region is Sunyani. The region has 27 administrative districts. The average temperature in the Region is 23.9◦C and a relative humidity of 75% per year, with the highest humidity observed during the wet months. The rainfall pattern is either moderate or massive in the southern part of the region, while the northern part registers a lower rainfall. The Region has two maximum rainfall trends, ranging from an average rainfall of 1400mm in the southern zone and 1000mm in the northern zone.

The decreased level of rainfall leads to high temperatures in the region. The increase in temperature has a great influence on the rise of anopheles mosquitoes during the moderate

University of Ghana http://ugspace.ug.edu.gh

periods of rainfalls and this is reflected in the increase in malaria incidence in the region. In the Brong Ahafo Region the dominant vegetation zones are the rain forest belt reserves to the south and southwest. The northern part shows a transition to Guinea savanna woods (GHS, 2006)

University of Ghana http://ugspace.ug.edu.gh

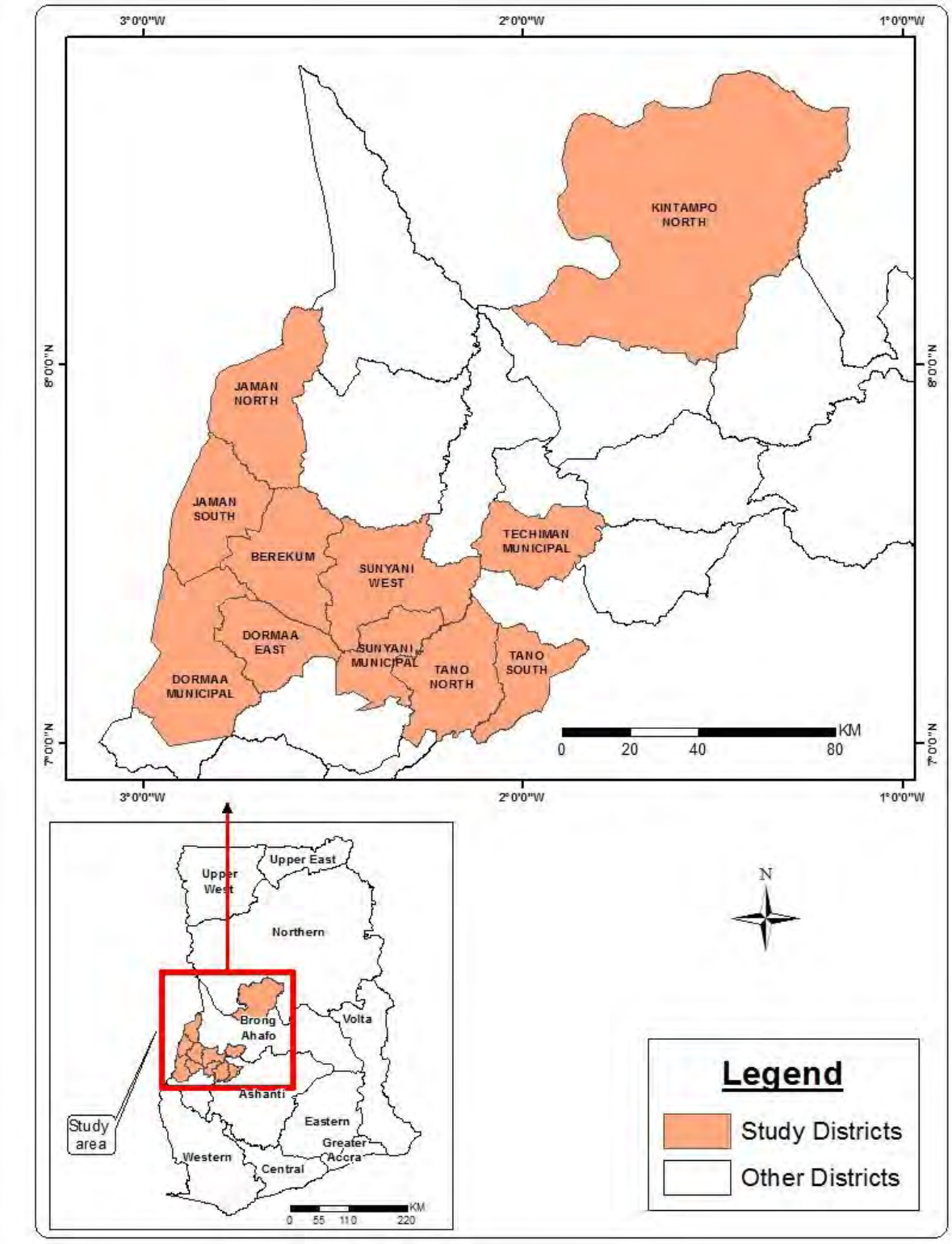


Figure 3.1 Location Map of the Study Area (Source: Author, 2017)

University of Ghana http://ugspace.ug.edu.gh

3.3 Research Design

The objective of this study was to examine the geographical distribution of malaria occurrence using cluster sampling and case study design. As stated by Bryman and Bell (2007) the case study design entails a comprehensive and intensified assessment of a sole or a handful of cases. The aim of the case study design is not to make a general statement about the conclusion, findings of different cases or of a sizable number of people, the interest lies on the cases and their diverse settings and to set a structural frame for deliberating on the development.

The mixed methods research which is termed to be the third research paradigm was employed in this study. According to Fidel (2008) mixed methods research has not been frequently used by researchers in their recent publication. Greene (2006) has indicated that philosophical assumption of the mixed method needs to enlighten in social inquiry, debating that the philosophical assumption of ontology, epistemology, objectivity and subjectivity should be much enlighten. The importance of the mixed methods research is indicated by Creswell and Plano Clark (2007), as the method with significant approaches to researchers in generating contradictory ideas and contested arguments in the research. The method gives researchers the idea to use any number of philosophical views while under the mixed method the research questions are the primary importance regardless of the philosophical worldview. For the purpose of this study, both qualitative and quantitative approaches (mixed methods) were used for data collection, analysis and presentation.

Mixing both qualitative and quantitative approaches aided in establishing that the constraints of one kind of approach are balanced by the strength of the other approach. This is based on the established fact that understanding is obtained by mixing different approaches of

University of Ghana http://ugspace.ug.edu.gh

knowledge. The quantitative method was used to measure malaria risk relationships while the qualitative method was used to capture expressive information not showed in quantitative data about beliefs, feelings and motivation that underlie behaviours. It was used to uncover trends in thought and opinions and dive deeper into malaria disease. Using a mixed method, the technique has numerous merits and demerits. The method primarily displays its effectiveness and reduces the vulnerabilities of both techniques to enrich the whole research work, except that it involves greater effort.

3.4 Study Population

The 2010 population and housing census estimate the Brong Ahafo Region‟s population to be 2,310,983, representing 9.4% of Ghana‟s population (GSS, 2010). There are 27 administrative districts in the Brong Ahafo Region. Table 3.1 contains the complete list of the administrative districts of the region and their respective population.

Table 3.1 showing 27 administrative districts with their population

Districts	Population
Asunafo South	95,580
Asunafo North	124,685
Asutifi	105,843
Dormaa Municipal	159,789
Dormaa East	50,871
Tano south	78,129
Tano North	79,973
Sunyani Municipal	123,224
Sunyani East	85,272

University of Ghana http://ugspace.ug.edu.gh

Berekum	129,628
Jaman South	92,649
Jaman North	83,059
Tain	108,386
Wenchi Municipal	89,739
Techiman Municipal	206,856
Nkoranza South	100,929
Nkoranza North	65,895
Atebubu Amantin	105,938
Sene	118,810
Pru	129,248
Kintampo South	81,000
Kintampo North	95,480

Source: Ghana statistical Service, 2010)

3.5 Sample Size

A simple equation can aid in the selection of a representative sample size. Computing for sample size, a few elements about the study population and sample needed must be determined. These are the total population of the study region, margin error, confidence level and the standard deviation. The sample for household(s) was accurately chosen from the health administration districts by applying cluster sampling probability proportional to size (PPS). The sample size was measured from 90% of people infected by malaria incidence from 2012 to 2016 in the Brong Ahafo Region, based on precision of 5% and 95% confidence interval. Utilizing the formula

University of Ghana http://ugspace.ug.edu.gh

$$npps = \frac{deff \times Z^2pq}{d^2}$$ (Source: Fisher et al.1991)

……. (Equation 1)

n = sample size population

PPs = assuming proportion estimated precision absolute desired

deff = design effect

d = precision absolute desired

p = the combined (national) estimate

q = proportional estimate

Z = Z-value for a two-sided 95% confidence interval

$$npps = \frac{2 \times 1.96^2 \times 90 \times 8}{5^2}$$

$$= 5531.905/25$$

npps = 221.27616

To have non-response and accept only, a 90% response rate of the sample was adjusted as below:

$$n = 221.27616/0.9 = 245.9$$

Formula for measuring the population to sample per cluster in a PPS survey

$$\text{Number to sample per cluster} = \frac{npps}{m}$$

245/11 =22..... (Equation 2)

University of Ghana http://ugspace.ug.edu.gh

Where m is the number of cluster

The sample size for the study was 245 units. The act of picking households, nurses and other health was to gain their views on malaria incidence and intervention. The sample size used for the study was 245 for questionnaire administration, and the sample shares were established upon the number of households in each cluster proportionately.

Table 3.2 Sample Size by Clusters

Districts(clusters)	Sample share	Households
Berekum Municipal	13	2,227
Sunyani Municipal	25	4,156
Sunyani West	24	3,961
Dormaa Municipal	6	1,384
Dormaa East	19	3,121
Jaman North	23	3,783
Jaman South	19	3,134
Tano South	24	4,004
Techiman Municipal	17	2,849
Wenchi Municipal	12	873
Kintampo Municipal	63	2,010
Total	245	39,818

(Source: Author, 2017)

University of Ghana http://ugspace.ug.edu.gh

3.6 Sampling Procedure

Multistage cluster sampling was utilized to choose respondents from households to whom the questionnaire was administered. The application of the multistage cluster sampling was divided into two (2) stages in this study.

In the first stage, in order to select equal proportions from each household, the ratio of units from target districts were selected. The target districts were eleven. The total number of households in the 11 districts was computed in Table 3.2. The eleven (11) districts were selected because they were districts with much available secondary data for the study. In order to determine the sample share for each district, the household ratio was divided by the total population multiplied by the sample size.

In the second stage, random selection of household within the 11 clusters like household is chosen randomly within each cluster using the simple random sampling. The sampling interval is calculated as the number of households in the study area is divided by the number of cluster needed. The first house was randomly chosen and ascribed a number R, then the next house to be selected was the "R + ith" house. The interval was then added repeatedly until the desired sample was needed.

3.7 Research Instruments

Research instruments used to gather data included questionnaire and in-depth interview.

3.7.1 Questionnaire Survey

The questionnaire administration is the most important study tool that was used to gather household data. A total of 245 structured questionnaires with open and closed ended questions were administered in the study area. The quantitative data was used in the descriptive statistically analysis. The questionnaire contained questions pertaining to section

University of Ghana http://ugspace.ug.edu.gh

A which is the demographic characteristics of the study. The section B discussed questions relating to the spatial distribution of malaria incidence. The section C discussed questions pertaining to the correlation between malaria incidence and interventions. The section D discussed questions relating to interventions and their effectiveness. (See appendix I)

3.7.2 In-Depth Interviews

An in-depth interview with malaria control policy makers at the district level was carried out. The research employed a semi structured interview approach for an in-depth interview. The interview guide contained issues on malaria distribution (incidence), control processes, action plans, results and problems of the malaria control process. The in-depth interview was employed to treat transcription and interpretation of data administered from the study area. It was used to ask questions in order to obtain insightful information regard perceptions, attitude and coping strategies.

The in-depth interviews were conducted at Dormaa East, Jaman South, Sunyani Municipalities and at the national level of Malaria Control Programme in Accra. The in-depth interviews were conducted in these areas because the respondents were willing to work with and had time for the researcher. A total of two interviewees each were used at the above mentioned districts and two at national malaria control at Accra. The interviewees were selected purposively.

3.8 Data Collection Procedure

3.8.1 Map data

GIS polygon map of the Brong Ahafo Region was created by the researcher. Data for creating the map was obtained from the University of Ghana, Geographic Information System (GIS) laboratory.

University of Ghana http://ugspace.ug.edu.gh

3.8.2 Secondary Sources of Data

Secondary data used by this research were received from Ghana health service under the District Health Information Management System (DHIMS) and Policy Planning Monitoring and Evaluation (PPME). The emergence of DHIMS into the health institution has led to significance control of the challenges with data collection service. The data were collected from DHIMS on choosing districts of the Brong Ahafo Region. The results of microscopic diagnosis were confirmed from malaria OPD cases from 2012-2016. The population size of each district was obtained from the Population and Housing Census at the regional statistical service office at Sunyani.

Climate data were acquired from Ghana Meteorological Agency at the regional office in Sunyani. This research concentrates on meteorological factors that are relevant to malaria distribution. Malaria incidence is the dependent variable, while rainfall, temperature and humidity are climatic independent variables. The rest of independent variables include elevation, vegetation, educational level, urbanization and economic status within the Brong Ahafo Region.

3.9 Methods of Data Analysis

3.9.1 GIS software

GIS data were assembled and evaluated using the Arcmap 10.4 software [Environmental System Research Institute (ESRI)]. This software allows data concerning environmental and social features of a region to be mapped and examined close to areas and shape features of geographic attributes.

3.9.2 Data analysis overview

These spatial statistical tools were used to aid in understanding the geography of malaria in the Brong Ahafo Region because everything happens in space and time. These tools also deal

University of Ghana http://ugspace.ug.edu.gh

with the complex data sets which GIS deals with all the time. Getis and Ord Gi* statistics were used to ascertain the extent to which geographical distribution of malaria occurs in the Brong Ahafo Region. A Geographically Weighted Regression was employed to explain the relationship between malaria incidence and interventions. This aids identification of malaria control interventions and their effectiveness in the area. Ordinary Least Square was used for examination of the major factors in the malaria distribution in the study region.

3.9.3 Getis and Ord Gi* statistic

The Getis and Ord Gi* statistic technique was used to measure hot spot features in the dataset. The results z-scores and p-values indicate where features with either high or low values cluster spatially. The high or low values of the spatial collection showed z-score and p-value of the outcome. This technique assesses each attribute within the space of surrounding attributes. To have a hot spot that is statistically significant, there should be high value of the attribute with a high value of neighbouring attribute. The Getis and Ord Gi* test statistic is given by:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad \text{..... (Equation}$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

3) ..... (Equation

4)

University of Ghana http://ugspace.ug.edu.gh

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}$$

……. (Equation 5)

Source: (Getis and Ord, 1992)

Getis and Ord Gi* statistics shows a significant positive z score; the greater the z score, the more concentrated the clustering of high values (hot spots). A significant negative z score, the lower the Z score, the more concentrated the clustering of low values (Cold spot). Local Getis and Ord Gi* Statistic are based on Z score (Getis and Ord, 1992).

Clustering malaria incidence provides understanding about the spatial pattern of malaria incidence data as long as the malaria incidence is expected to be heterogeneous at every district level. In ArcGIS, the hotspot analysis was used to ascertain clusters, as malaria incidence was used as the input field per district from 2012 to 2016.

University of Ghana http://ugspace.ug.edu.gh

3.9.4 Ordinary Least Square

Geographically Weighted Regression (GWR) is not a remedy for all regression difficulties as it is not considered as an instinctive choice in all regression modelling operations. The OLS is a default regression model found fit for this analysis.

This part provides a general explanation of the evaluation process between malaria incidence and intervention in the Brong Ahafo Region. The likely appropriate variables for malaria forecasting were evaluated through the process of a collinearity analysis. The correlation between malaria incidence and its major causing factors is evaluated using the OLS.

Collinearity refers to the correlation between independent variables. It normally happens when several independent variables are integrated in the regression model. The presence of collinearity influences its model evaluation and the explanation of the result(s). Collinearity does not influence the goodness-of-fit; it creates a situation in evaluating the specific results of each explanatory variable.

The Variance Inflation Factor (VIF) analysis is seen as the result of collinearity. The VIF is defined as VIF = 1/ (1-R^2j), where R^2j= multiple relationship of the variable Xj. The VIF influences collinearity on the accuracy of values. The VIF indicates how collinearity makes the coefficient values likely to change (Freund & Littell, 2008). It shows how inflated the variance of the coefficient becomes and what might happen to a given variable when such a variable does not relate to other variables in the model. Collinearity becomes difficult to understand when the VIF exceeds the value of 10 which shows the VIF is greater than 1 (one).

The regression model was applied for the correlated reason of explaining and evaluating the relationship between the dependent (malaria incidence) and independent variables (LLINS,

University of Ghana http://ugspace.ug.edu.gh

IRS, antimalarial drug and herbal medicine) and achieved a precise prediction value of the dependent variable for future development. A regression model equation is shown as

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \qquad \text{for } i=1 \ldots n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(Equation 6)}$$

In this linear equation y_i is the dependent variable (malaria incidence) and i is the location (study area) while Xi is the independent variables (LLINS, IRS, antimalarial drug and herbal medicine), ε_i stands for the error, β_0 and β_1 are elements which are to be evaluated to indicate t0hat the value is reduced to achieve n observation in the dataset. The term $\hat{y}_i$ is the fitted estimation for the "i" observations which predict "i" estimation for X. The formulae $(y_i - \hat{y}_i)$ is considered as the residual for the "i" observation. The residual should be considered as autonomous and look exactly the same as the normal distribution with means of zero. Normally, the model is applicable to the process called the Ordinary Least Square. A multiple linear regression model equation is indicated as:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_m x_{mi} + \varepsilon_i \qquad \text{for } i=1 \ldots n \quad \ldots\ldots\ldots\ldots\ldots\text{(Equation 7)}$$

Where the forecast of the dependent variable is achieved through a linear integration of the independent variable. The OLS statistical function is

$$\hat{\beta} = (X^T X)^{-1} X^T y \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 8)}$$

where $\hat{\beta}$ stand for the vector of the evaluated parameter, X is the model that comprises the value of the independent variables and its column, "y", is the vector of observed estimations and $(X^T X)^{-1}$ is the other side of the variance and covariance design.

The power of the model to repeat the observed y values is by calculation through the goodness of fit. This is properly shown by the R^2 value which operates from 0 to 1 as well as

University of Ghana http://ugspace.ug.edu.gh

calculates the correlation of variation in the observed y that is determined by the variation in the design.

3.9.5 Geographically Weighted Regression

The Geographically Weighted Regression (GWR) is a significant tool used to investigate geographic variables. The fundamental concept of the GWR is that elements can be measured at any place in the study area when assigned a dependent variable, and collection of independent variables which can be used to quantify an area whose position is determined. Interpreting Tobler"s knowledge on proximity and correlation indicates that in evaluating parameters for a model at a specific area, the closest views should have the higher weight than distanced views. In the GWR, the dependent variable is y and the collection of the independent variables as X_k, $k=1...m$. For all the n views in the dataset to be quantified for its location is based on the correct coordinate system. The equation for GWR interpreting the OLS regression model is intended to be:

$$y_i(\mathbf{u}) = \beta_{0i}(\mathbf{u}) + \beta_{1i}(\mathbf{u})x_{1i} + \beta_{2i}(\mathbf{u})x_{2i} + ... + \beta_{mi}(\mathbf{u})x_{mi} \quad \text{.....(Equation 9)}$$

The term $\beta_{0i}(\mathbf{u})$ shows that the variable explains a correlation in the area u and is precise to such area. A declaration is made in advance for the dependent variable in the case that calculations for the independent variables are known at the area "u". Generally, the areas where the variables were evaluated indicate where the dataset was acquired. The term "u" is used to indicate some general location in the study area. Usually the term "u" stands for the vector of coordinates calculated in a projected coordinated system (universal transverse Mercator) or a geographic coordinate system (World Geodetic System 1984). In this study, the geographic coordinate system was used in measuring the "u".

University of Ghana http://ugspace.ug.edu.gh

The calculation of the GWR is the same as that of Weight Least Square (WLS). The global model was stated previous only that the weights are put into a specific area „u" similar to other views in the data and therefore fluctuate for all areas. The formula has this format:

$$\hat{\beta}(\mathbf{u}) = (X^T W(\mathbf{u}) X)^{-1} X^T W(\mathbf{u}) y \quad \text{..... (Equation 10)}$$

Where

W (**u**) = square matrix of weights similar to location u

$X^T W(\mathbf{u})$ X = geographically weighted variance-covariance matrix

y= dependent variable

The weights themselves are computed from a weighting scheme that is also known as a *kernel*. A number of kernels are possible: a typical one has a Gaussian shape:

I. Kernel

Kernel is the weighted blueprint for calculating weights. There are several kinds of the kernels, The Gaussian shape is considered as one of them and with this formula:

$$w_i(\mathbf{u}) = e^{-0.5\left(d_i(\mathbf{u})/h\right)^2} \quad \text{..... (Equation 11)}$$

Where $w_i(\mathbf{u})$ is the geographical weight of the *i* views in the data similar to the area u, $d_i(\mathbf{u})$ is the distance between "i" views and the area "u" and "h" is a measure called the bandwidth. The distances between "i" views and the area "u" are usually Euclidean distances. The bandwidth in the kernel is given in a clear way as are the coordinates used in the dataset. As the weight of the bandwidth increases, the local GWR model gets closer to the global OLS model.

University of Ghana http://ugspace.ug.edu.gh

Other kernel types, except the Gaussian, can be applied in the GWR, despite the fact that in a pattern. It usually means really small, since the kernel type is similar to Gaussian. In relation to determining the goodness of fit of the model, the selection of a bandwidth is much more significant than the geometry of the kernel. A fixed bandwidth is used when data points are logical and regularly distanced in the study area

In this study the adaptive bandwidth was used in determining the kernel type. The best way of achieving the adaptive bandwidth requirement is to select the kernel that permits similar data points for all measurements. The adaptive bandwidth is generally achieved by categorizing the distance of the data points from those of the study area. However, if the data points are not regularly distanced but clustered in the study area. It is usually worth having to permit the adaptive kernel to fit the unevenness, either by elevating the extent of the data points which are dispersed or reduce the extent of the data points which are compact.

II. Bandwidth Method

The Bandwidth method is made up of three methods in the GWR; these are the Akaike Information Criterion (AICc), the Cross Validation (CV) and the BANDWIDTH COEFFICIENT. The AICc and CV are automatic methods that are applied to discover the bandwidth that delivers a good forecast. The bandwidth coefficient is based on the requirements of a bandwidth. The AICc method brings to light the bandwidth that reduces the AICc values, while the CV detects a bandwidth that reduces the CV score.

The study made use of the AICc to determine the prediction where the AICc was used to measure the difference between the observed and the fitted values, as well as the error of the model. The error of the GWR model is determined not only by the number of variables used,

University of Ghana http://ugspace.ug.edu.gh

but also which bandwidth used as well. The relationship between the bandwidth and the error of the model is the logic for choosing AICc for the study.

University of Ghana http://ugspace.ug.edu.gh

CHAPTER FOUR: EXAMINING THE DISTRIBUTION OF MALARIA INCIDENCE

4.1 Introduction

In this chapter, the methods for data analysis are shown in conformity with the first objective of the study, which is the examination of malaria incidence distribution. A malaria incidence map was confirmed with 245 points collected from the study area supported by malaria cases from 2012 to 2016.

4.2 Perception of malaria incidence

Table 4.1 shows that malaria is endemic in about 76% of the 245 study points or locations. Only 24% reported no malaria incidence in the last 4 weeks prior to the data collection. The study indicated that 76% of the respondents revealed that Brong Ahafo Region is an endemic area due to its internal geography which aids in the development of the mosquito.

Table 4. 1 Perceptions of Malaria Incidence in the districts

Perceptions about malaria incidence	Malaria among respondent	Percentage (%)
Yes	185	76
No	60	24
Total	245	100

(Source: Field Data, 2017)

An informant from district malaria control office at Sunyani municipality revealed that *"people in the community know that malaria is acquired through mosquito sting and also some people lack knowledge about the breeding sites suitable for mosquito such as solid*

University of Ghana http://ugspace.ug.edu.gh

waste, wetlands, dry holes, with clear stagnant water and vegetation". This is one reason that justifies why Brong Ahafo Region is highly endemic.

Some respondents indicated that poverty is the cause of malaria and likewise malaria is the cause of poverty. It was further stated that due to poverty families are not able to provide good and nutritious foods as well as protective clothing and purchase mosquito nets and repellent sprays that could prevent a mosquito sting.

4.3 Spatial patterns of malaria incidence

The examination of the spatial pattern of malaria incidence indicated that Techiman and Sunyani Municipalities had the highest burden of 91% and 88% respectively. The reason for the high malaria incidence in Techiman Municipal, particularly, was a result of the unplanned settlement pattern in the district. This was indicated by 91% out of the 20 respondents in an interview. It was followed by Tano South (82%), Jaman North (70%), Sunyani West (67%) Wenchi (60%), Dormaa (55%), Jaman South (53%), Berekum (47%), Kintampo (41%) and Dormaa East Municipalities (40%).

Table 4. 2 Spatial Patterns of Malaria Incidence in the Districts

Cluster	Yes	No
	Percentage (%)	Percentage (%)
Sunyani Municipal	88	12
Berekum Municipal	47	53
Techiman Municipal	91	9
Tano South	82	18

University of Ghana http://ugspace.ug.edu.gh

Dormaa Municipal	55	45
Jaman South	53	47
Kintampo North	41	59
Jaman North	70	30
Sunyani West	67	33
Wenchi	60	40
Dormaa East	40	60

(Source: Health Data from Districts Health Information Management System, 2017)

Some respondents revealed that malaria has become regular disease that is likely to happen with elevate levels of rainfall and rise in temperature. They believed that these major factors influencing malaria spread cannot be stopped. A male respondent from Techiman Municipality notes that *"malaria is seen as regular disease nowadays and elevating unlike the past. People are no longer worried about malaria in the municipality due to death cases related to malaria. He further stated that malaria is a deathly disease due to the frequent death of people in the municipality".* Some respondents further added that malaria is regarded to be very common that when one dies, they feel another death case will be shortly heard of. This account indicated that malaria is a never ending story.

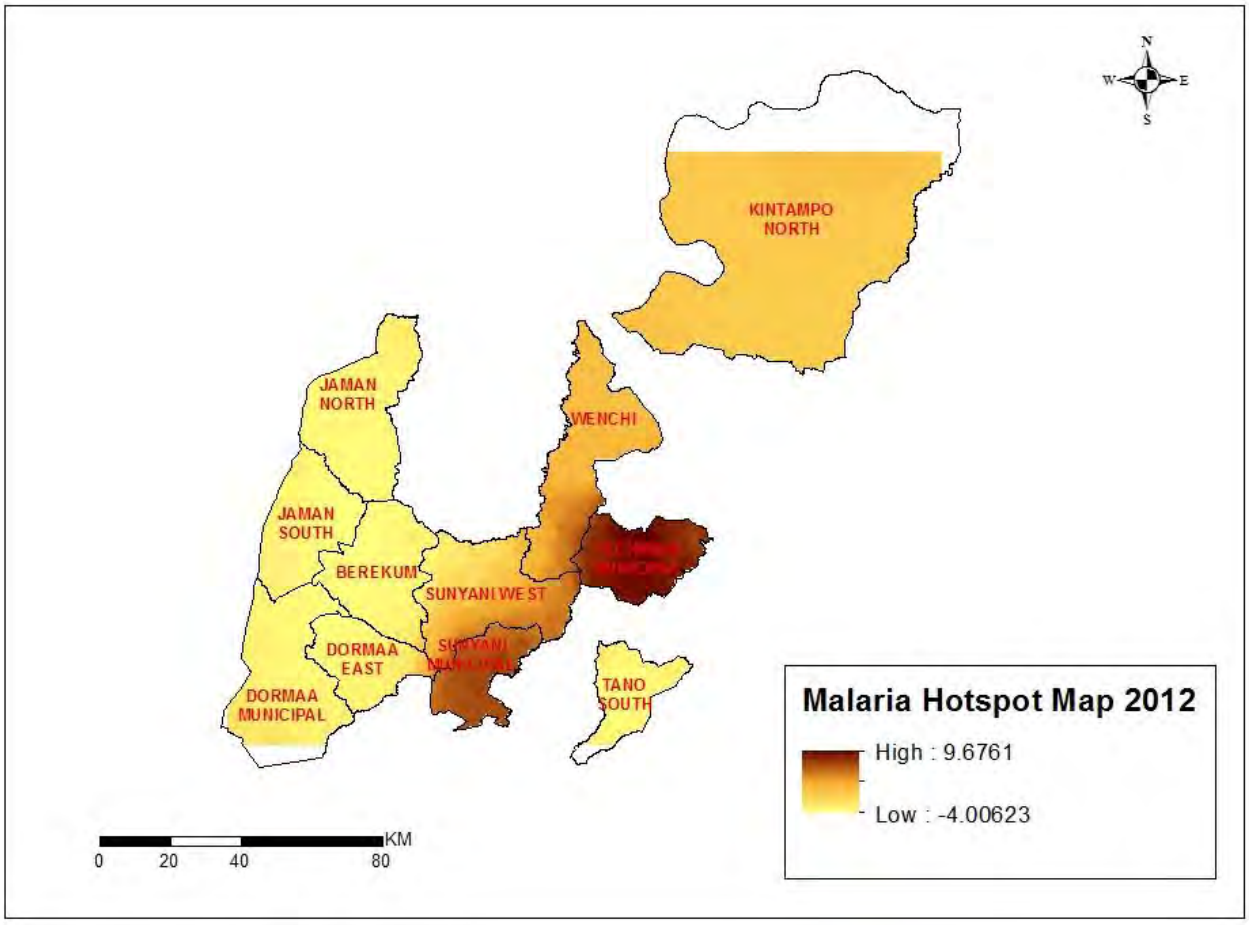
4.3 Analysis of Hotspot Distribution of Malaria Incidence

Getis and ord Gi* statistics are local indicators of spatial autocorrelation, which apply spatial neighbouring assumption to discover the clusters of geographic phenomena (Getis and Ord 1992). Malaria data from 2012-2016 were used in the Getis and ord Gi* statistics analysis obtained from the study area.

University of Ghana http://ugspace.ug.edu.gh

Getis and ord Gi* statistically pinpoint the significant local clustering of high (hot spots) or low (cold spots) of malaria incidence in the Brong Ahafo Region. A high (hot spots) means positive z score values (in brown colour) that confirm areas with high malaria incidence, while a low (cold spots) represent negative z score values (in yellow colour) showing areas with low malaria incidence. These maps depict clear spatial patterns of malaria incidence that were mostly spread in the western, eastern and south- eastern part of the Brong Ahafo Region from 2012 to 2016, while most of these areas are found to be urban or peri-urban. The statistically significant hot spots and cold spots of malaria incidence in the Brong Ahafo Region follow:

Figure 4. 1 Malaria Hotspot 2012. (Source: Field Data, 2017)



University of Ghana http://ugspace.ug.edu.gh

Figure 4.1 shows hotspots in 2012, in the Sunyani and Techiman Municipalities and small sections of the Wenchi Municipality and Sunyani West Districts while the cold spots are in the Dormaa East, Berekum, Jaman North, Jaman South, Kintampo North.

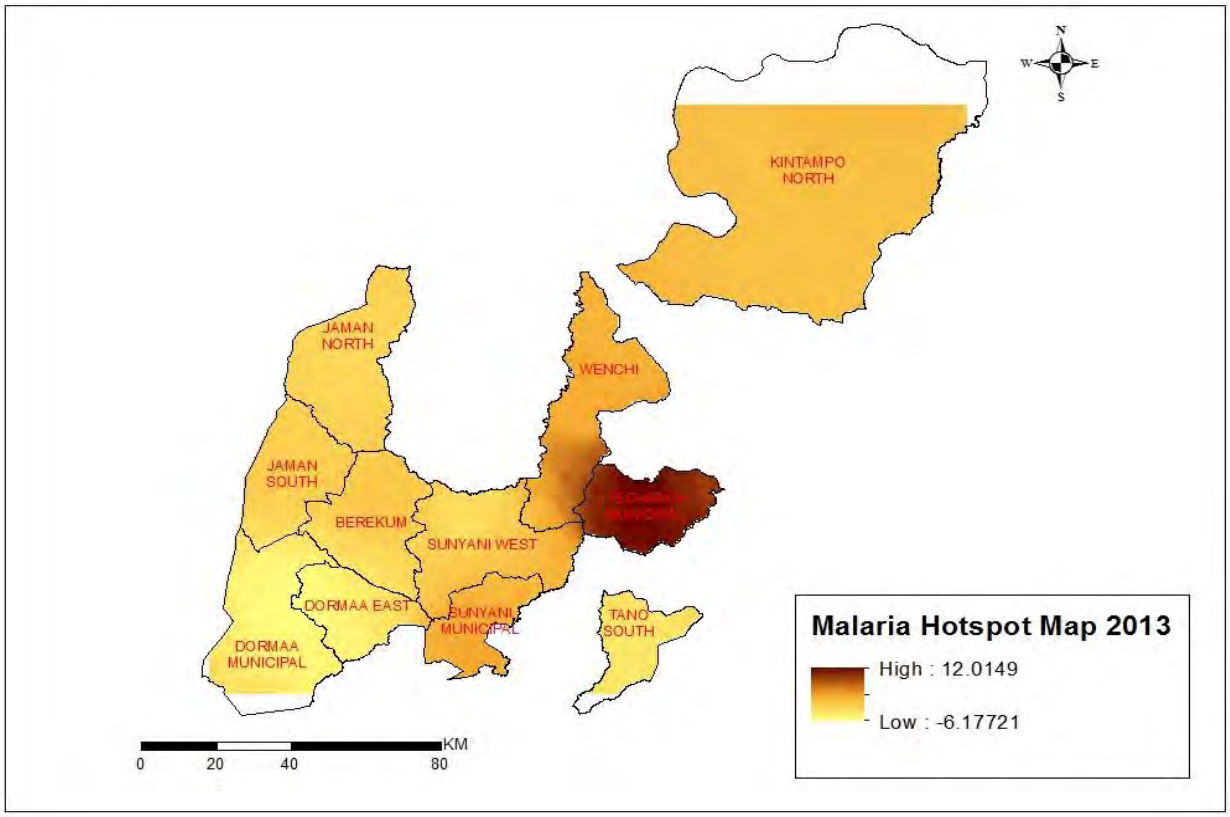


Figure 4. 2 Malaria Hotspot 2013. (Source: Field Data, 2017)

Figure 4.2 portrays hotspots in 2013, the risk map created in such instances highlight areas of high risk that needs to be identified so as to tailor major interventions and monitoring activities. According to the map above, spatial distribution of malaria incidence is high in Techiman Municipal. The malaria incidence indicates cold spots in Dormaa East, Berekum, Jaman North, Jaman South, Kintampo North, Sunyani, Wenchi, Dormaa Municipalities and Sunyani West.

University of Ghana http://ugspace.ug.edu.gh

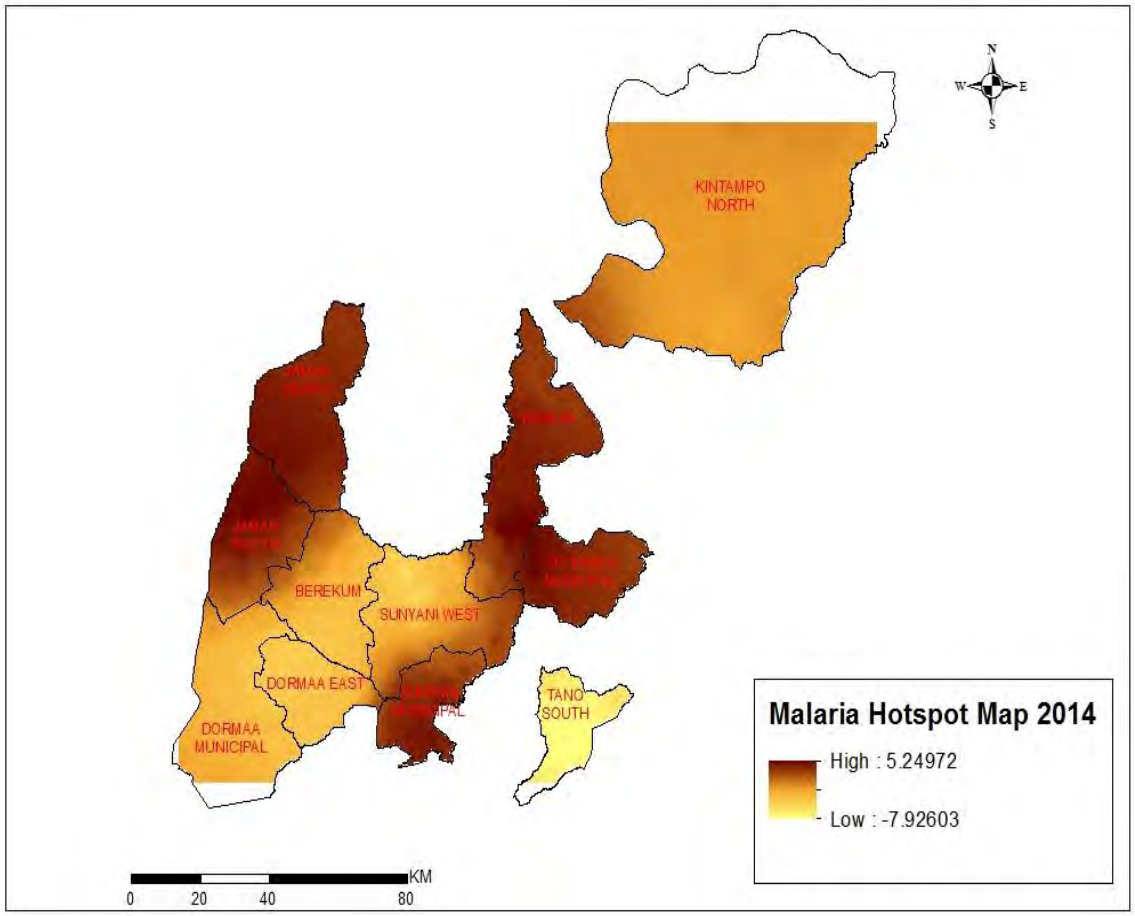


Figure 4. 3 Malaria Hotspot 2014. (**Source: Field Data, 2017**)

In 2014, Sunyani and Techiman Municipality continued to exhibit a high malaria incidence. Jaman South, Jaman North and the Wenchi Municipality recorded higher malaria incidences than in the previous years (see figure 4.3).

University of Ghana http://ugspace.ug.edu.gh

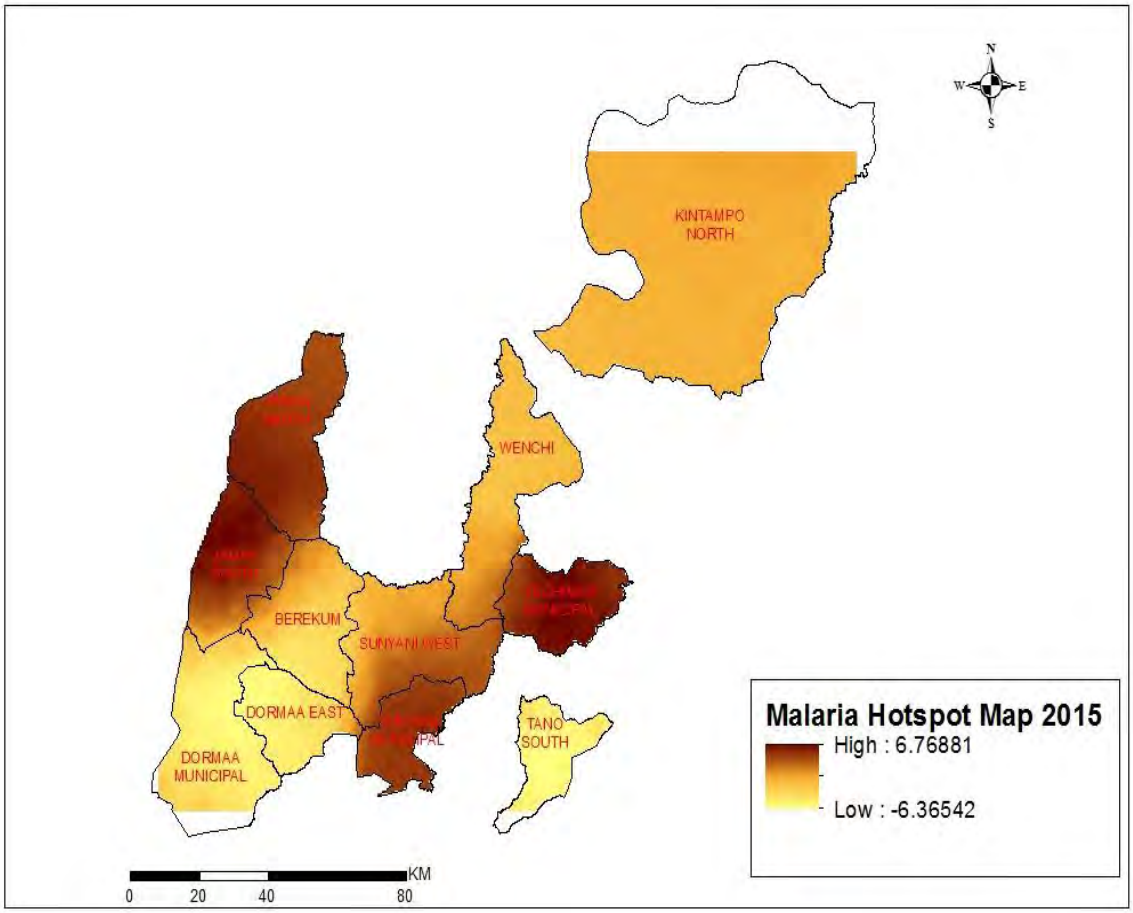


Figure 4. 4 Malaria Hotspot 2015. (Source: Field Data, 2017)

In 2015, Jaman South and Jaman North have become a malaria endemic area and indicated as a hotspot. The Techiman and Sunyani Municipalities maintained its high malaria incidence as a hotspot. There is some reduction in the case of the Sunyani West.

University of Ghana http://ugspace.ug.edu.gh

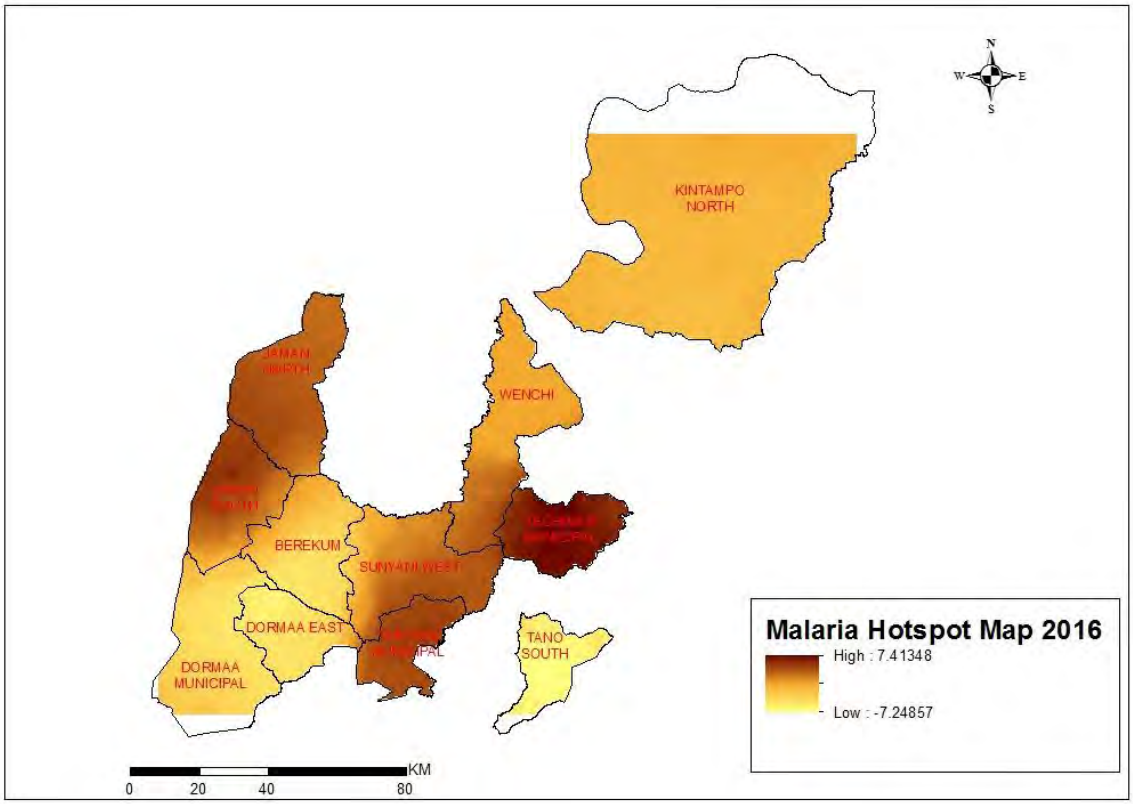


Figure 4. 5 Malaria Hotspot 2016. (Source: Field Data, 2017)

In 2016, Jaman South, Jaman North, Sunyani and Techiman Municipalities maintained their high malaria incidence shown as hot spots. Sunyani West had regained its previous hotspot indication.

The Getis and ord Gi* statistics were computed for a yearly malaria incidence from the health data, producing z-score and p-value demonstrating the level of clustering. The spatial weight explains the neighbourhood search for each selected district and with the proximity of areas anticipated to have the same values. The observed values were correlated with the expected to show whether by chance the levels of malaria clustering were higher or lower than the expected values. The z score and p-values for each year present the probability that they were not produced randomly. A small p-value indicates that there is randomness in the spatial

University of Ghana http://ugspace.ug.edu.gh

pattern produced. The values of z score connected with Getis and ord Gi* statistic indicate that the concentration of a clustering increase from z score of 9.3240 in 2012 to 12.0161 in 2013, however, shows a reduction in clustering the years after. The highest of Getis and Ord Gi* statistic value was validated at 0.009 in 2013; while the lowest was examined in 2014 (see Table 4.3).

Table 4. 3 Analysis of high/low clustering for different years using Getis and Ord Gi* statistics

Year	Observed	Expected	Variance	Z-score	P-value
2012	0.00574	0.00320	0.000002	9.3240	<0.01
2013	0.00963	0.00320	0.000017	12.0161	<0.01
2014	0.00422	0.00320	0.00002	5.25119	<0.01
2015	0.00523	0.00320	0.00004	6.76985	<0.01
2016	0.00552	0.00320	0.00003	7.41459	<0.01

(Source: Health Data from Districts Health Information Management System, 2017)

The analysis of high/low clustering for different years as indicated in Table 4.3 demonstrates a connection with the maps above. The research indicates the spatial and temporal aspects of malaria disease in the Brong Ahafo Region, employing the GIS technique and a spatial statistical analysis, which permit for the calculation of the degree of clustering of malaria incidence. Such techniques have been employed to examine the spatial clustering of cholera causing factors in Kumasi, Ghana (Jerry, 2012) and malaria epidemiology in the Amansie West District (Larri, 2011).

University of Ghana http://ugspace.ug.edu.gh

4.4 Result of Major Factors Influencing the Pattern of Distribution

Table 4.4 indicates OLS regression result of the major factors that the influence malaria incidence in the study area. The ordinary least square model, in this study was executed based on the formula below:

$$Yi=Bo + B1Xi +B2Ui +B3Hi +B4Ai +B5Ti +B6Vi - B7Eai + B8Ebi - B9Zi - B10Ki\ldots\ldots\ldots \text{ (Equation 12)}$$

Where Y is the malaria incidence, X is rainfall, U is urbanization, H is humidity, A is agricultural land use, T is temperature, V is vegetation, Ea is educational level, Eb is elevation, E is economic status, and I is district subscript.

Urbanization was shown to be a significant factor in malaria incidence in the Brong Ahafo Region. This result affirms with the result of Norri, (2004) which indicates that attaining knowledge about how the environmental variables effect the distribution of mosquitoes is significant in disease ecology. This is because the anthropogenic changes in climate and landscape (urbanization) are influencing the disease distribution. According to Johnson et al., (2008) and Steiger et al., (2012), environmental features influence mosquito spread widely since each mosquito vector has certain habitat demand which differ widely between connected vectors (Becker et al., 2010).

University of Ghana http://ugspace.ug.edu.gh

Table 4. 4 Summary of OLS result

Variables	Coefficient	t-statistics
Intercept	1022.562089	0.532609
Rainfall	145.881628	1.260164
Urbanisation	41.235771	0.046831*
Humidity	56.135971	0.116851
Agricultural land use	82.781629	0.918725
Temperature	811.008119	1.0884293
Vegetation	-144.782509	-0.45850
Educational level	305.827614	0.878824
Elevation	-213.341645	-1.370851
Economic status	-14.793022	1.729483

(Source: Field Data, 2017)

The study indicates that vegetation recorded negative coefficient as a factor of malaria incidence. This result differs from earlier findings which show that vegetation is positively linked with malaria incidence (Sharma, 1996; Mbooera & Kitua, 2001). The urban and peri-urban nature is the probable reason in this specific case. Human settlements in urban areas show limited or no vegetation. Vegetation cover is mainly grouped as either natural or artificial habitats of the mosquito and shows that microclimate conditions make up temperature and humidity. These conditions create vegetation cover favourable for the mosquito to rest, breed and shelter and have the possible influence on the behaviour of the mosquito (Pavlovsky, 1966; Clements, 1999; Matthys et al., 2006a).

Contrary to the respondents‟ expectation, temperature showed a positive correlation with malaria. Walsh et al. (1993) indicate that high temperature may elevate the progress at which

University of Ghana http://ugspace.ug.edu.gh

mosquitoes fully grow the rate of their blood feeding and the parasite obtained as well as the process of early development of the parasite within the mosquito. However, this is supported by data from the Brong Ahafo Region.

The study showed a positive correlation between urbanisation and malaria incidence. The presence of solid and liquid waste generation and disposal created places for mosquitoes to breed. Environmental factor were the likely major factors behind the world intensification of malaria spread (Hay et al., 2004 and Gething et al., 2010). These factors usually happen at the same time as the socio-economic development and land use change (Bradley, 1996). Hay et al. (2005) and Tatem et al. (2008) state that urbanisation is one major factor of this development that causes malaria spread.

Also, educational level, agricultural land use and humidity were positively related to malaria incidence at district levels in the Brong Ahafo Region. It is necessary for further studies to use panel data with more control variables to examine factors that may be correlated with malaria incidence in the Brong Ahafo Region.

The model indicates that elevation has a negative relationship with malaria incidence in the study area. The null hypothesis stated that elevation was the main factor of malaria incidence distribution. However, the results, with a negative coefficient of (-213.341645), showed that elevation was not the main factor that influences malaria incidence distribution This means there was a negative correlation between elevation and malaria incidence distribution in the Brong Ahafo Region. Hence the null hypothesis is rejected.

The study demonstrates that there is negative relationship between malaria incidence and economic status. According to Sachs and Melany (2002), malaria is constantly considered as a disease of the poor. This proposition contradicts the conjecture that poverty threatens the

University of Ghana http://ugspace.ug.edu.gh

management strategies that could aid poor people to lessen their exposure to malaria (Yanda et al., 2006).

University of Ghana http://ugspace.ug.edu.gh

CHAPTER FIVE: CORRELATION BETWEEN MALARIA INCIDENCE AND INTERVENTIONS

5.1 Introduction

The chapter assesses the correlation between malaria distribution and interventions used in the study area. The interventions for malaria control were provided by responses from respondents in the questionnaire as were interventions recommended by the NMCP. These interventions were LLINS, IRS and drug use. The correlation was analysed using the Geographically Weighted Regression (GWR).

5.2 Malaria Control Interventions

The malaria incidence data were obtained from the District Health Information Management System (DHIMS) and Policy Planning, Monitoring and Evaluation (PPME) of Ghana Health Services (GHS). The data were based on five years outpatient malaria incidence in the eleven districts of the study area.

The data on interventions for malaria control came two fold from respondents in the questionnaire and from National Malaria Control Programme (NMCP). The interventions included LLINs, IRS, Herbal medicine and Drug Use. The impact of IRS for malaria control and prevention prior to the elimination period by WHO (1957), facilitated the entrance of IRS to be the most important malaria control in history during the elimination period (Najera, 1989) and currently considered as a significant instrument (WHO, 2012; RBM, 2008 and WHO, 2006). According to WHO (2005) LLINS intervention provides protection to people sleeping in order to avoid mosquito bites. This has decreased the ratio at which infected mosquitoes feed on the human population while sleeping or taking a rest as well as it decreases malaria spread (WHO, 2008). Early diagnosis and treatment is needed to decrease difficult incidences and mortality owing to malaria. The OLS regression indicated that the

University of Ghana http://ugspace.ug.edu.gh

four variables were used in the statistical evaluation. These variables were identified as the LLINs, IRS, anti-malarial drug and herbal medicine. The outcomes of the investigations for spatial autocorrelation and diagnostic for spatial dependence produced a clustered pattern of significance. The significance of the malaria distribution‟s relationship with intervention is determined by the coefficient of the OLS.

Malaria Control Intervention-OLS Model Results

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

$$y_i\ \varepsilon_i\ \beta_0\ \beta_1\ \hat{y}_i\ (y_i - \hat{y}_i)\ y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_m x_{mi} + \varepsilon_i\ \hat{\beta} = (X^T X)^{-1} X^T y$$

$$\hat{\beta}\ (X^T X)^{-1}\ y_i(\mathbf{u}) = \beta_{0i}(\mathbf{u}) + \beta_{1i}(\mathbf{u}) x_{1i} + \beta_{2i}(\mathbf{u}) x_{2i} + \ldots + \beta_{mi}(\mathbf{u}) x_{mi}$$

$$\hat{\beta}(\mathbf{u}) = (X^T W(\mathbf{u}) X)^{-1} X^T W(\mathbf{u}) y\ w_i(\mathbf{u}) = e^{-0.5\left(d_i(\mathbf{u})/h\right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 13)}$$

The results from Table 5.1 show that antimalarial drugs have negative relationships with malaria incidence. The LLINs was shown to be a significant intervention for malaria control in the Brong Ahafo Region. It also showed that the IRS has a negative relationship with malaria incidence. This contradicts that of Tukei et al.‟s (2017) study which indicates IRS has relationship with a significant reduction in malaria in Northern Uganda. Herbal medicine was negatively related to malaria control in the Brong Ahafo Region.

With a VIF score of 2.22, collinearity was not an issue. The value of Jarque-Bera statistics show that the residual does not show normal distribution. However, the global Moran‟s index for spatial autocorrelation tests also indicate that model residuals were significantly biased, $p < 0.004$

University of Ghana http://ugspace.ug.edu.gh

Table 5. 1 Summary statistics for OLS

Variables	Coefficient	t-statistics
Intercept	2083.506460	0.000002*
Antimalarial drug	-59.243866	0.224189
LLINS	-95.862814	0.029797*
Herbal Medicine	-60.539122	0.098601
IRS	55.094057	0.151189

(Source: Field Data, 2017)

Malaria = 2083.506_0-$59.244X_1$-$95.862814X_2$-$60.539122X_3$+$55.094057X_4$ …… (Equation 14)

Where X_o=Y intercept

X_1= Anti-malarial drug

X_2= IRS

X_3= Herbal medicine

X_4= LLINS

5.3 Malaria Control Interventions-GWR Results

Test for GWR to examine whether the data as a whole shows the relationship between malaria distribution and interventions to control malaria against the null hypothesis that high malaria incidence districts are not likely to have many intervention programmes.

University of Ghana http://ugspace.ug.edu.gh

Here, interventions for malaria control have been identified to show the relationship with malaria distribution. At this point the question GWR will be permitted to answer is assessing the relationship between malaria distribution and intervention to control malaria across the study area. However, the OLS model was confirmed to show non-stationarity, hence the GWR is recommended to improve upon the OLS model.

The GWR model in this study was executed based on the formula below:

Malaria incidence(i)=Bio - B(i1)AMD(i) - B(i2)IRS(I)- B(i3)HM(i) + B(i4)LLINS(i)

…..……. (Equation 15)

Where B coefficient are interventions express as AMD is antimalarial drug, IRS is Insecticide Residual Spraying, HM is Herbal Medicine and LLINS is Long-Lasting Insecticide Nets. The GWR model with Adaptive Kernel and AICc Bandwidth was chosen to produce the AICc and the R^2 as indicated in Table 5.2. Correlating the fit of the OLS, which is the global model and GWR which is the local model, the result of the global OLS indicated that the adjusted R^2 was 0.05 with the analysis operated with 245 malaria incidence datasets. The adjusted R^2 for the local GWR was 0.22 with a bandwidth of 245 which shows that there has been further enhanced through the use of the local modelling technique. The recommended coefficient of the model fit AICc was 3859.877 for the OLS, while the local model, that is the GWR, produced 3818.811412. The GWR could interpret 88% of the total variation of the model.

University of Ghana http://ugspace.ug.edu.gh

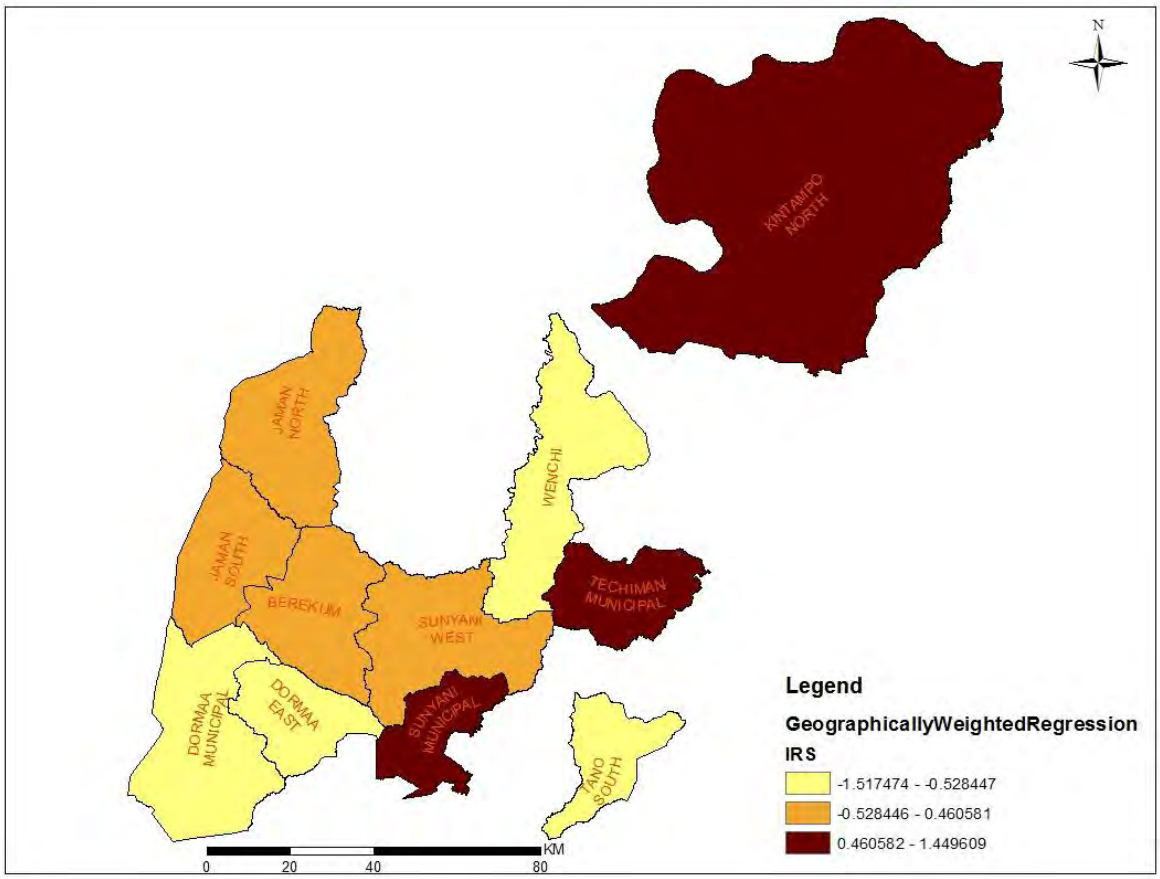


Figure 5. 1 Map of IRS as malaria control intervention. (Source: Field Data, 2017)

The geographic account of the local regression coefficient, (a) LLINS, (b) Herbal medicine, (c) Anti-malarial drugs, (d) IRS based on measurement of GWR model is depicted in Figure 5.1 and shows that the IRS regression coefficient was positive in Kintampo North, Sunyani and Techiman Municipalities while, negative in Dormaa East, Berekum, Jaman North, Jaman South, Wenchi Municipality, and Dormaa Municipality

University of Ghana http://ugspace.ug.edu.gh

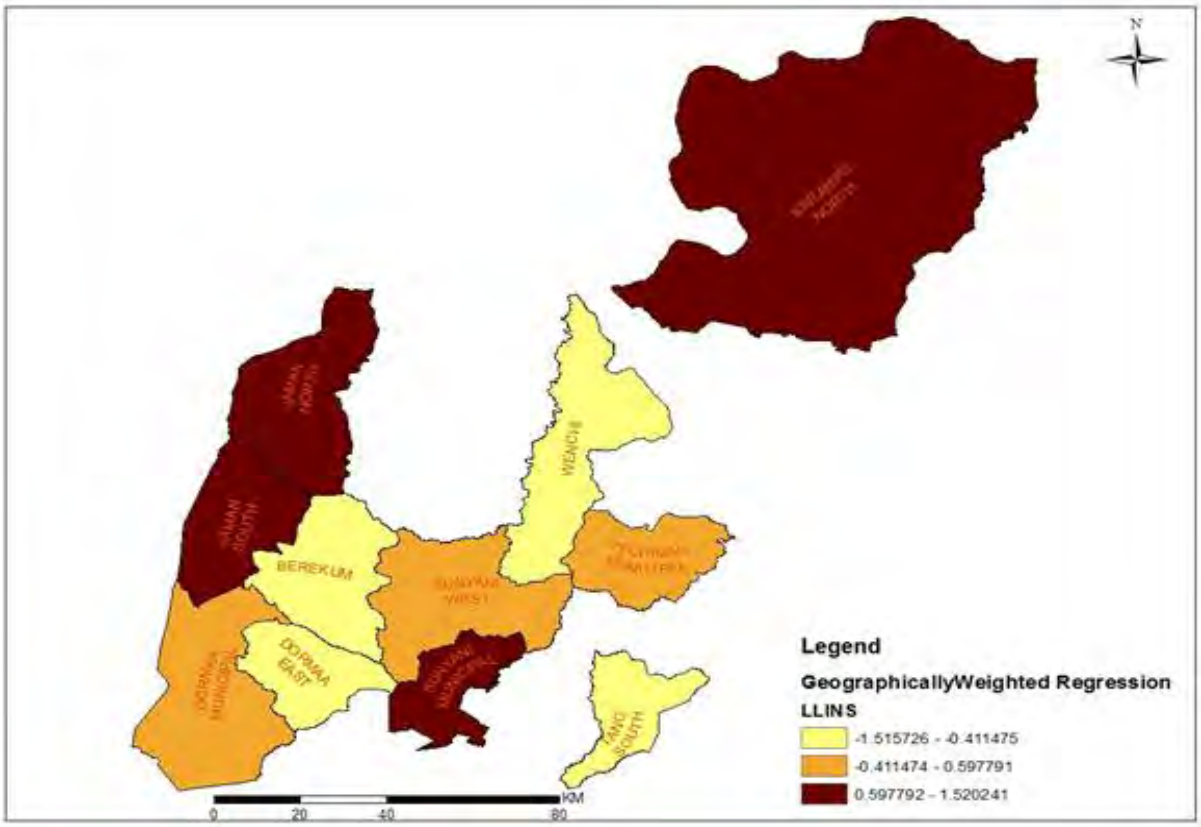


Figure 5. 2 Map of LLINs as malaria control intervention. (Source: Field Data, 2017)

Figure 5.2 represents the regression coefficient of LLINs, which shows a positive coefficient in Kintampo North, Jaman North, Jaman South and Sunyani Municipality. Other districts, such as Dormaa East, Berekum, Tano south, Wenchi Municipality, Techiman Municipality and Dormaa Municipality had negative coefficients.

University of Ghana http://ugspace.ug.edu.gh

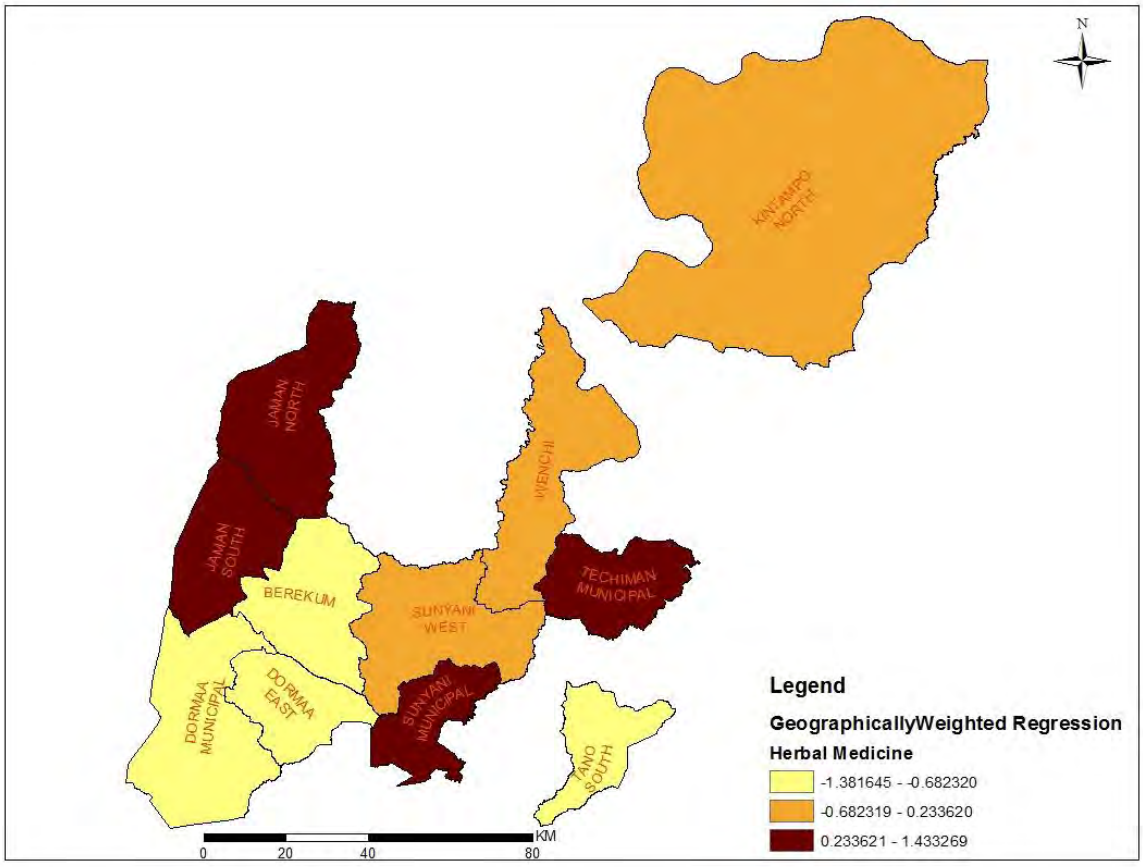


Figure 5. 3 Map of Herbal Medicine. (Source: Field Data, 2017)

The herbal medicine coefficients as shown in Figure 5.3 were negative in most area districts in the Brong Ahafo Region. Higher coefficients of herbal coefficients were distributed in Jaman North, Jaman South, Sunyani and Techiman Municipalities. There were lower coefficients in Dormaa East, Berekum, Tano South, Sunyani West, Kintampo Municipality, Wenchi Municipality and Dormaa Municipality.

University of Ghana http://ugspace.ug.edu.gh

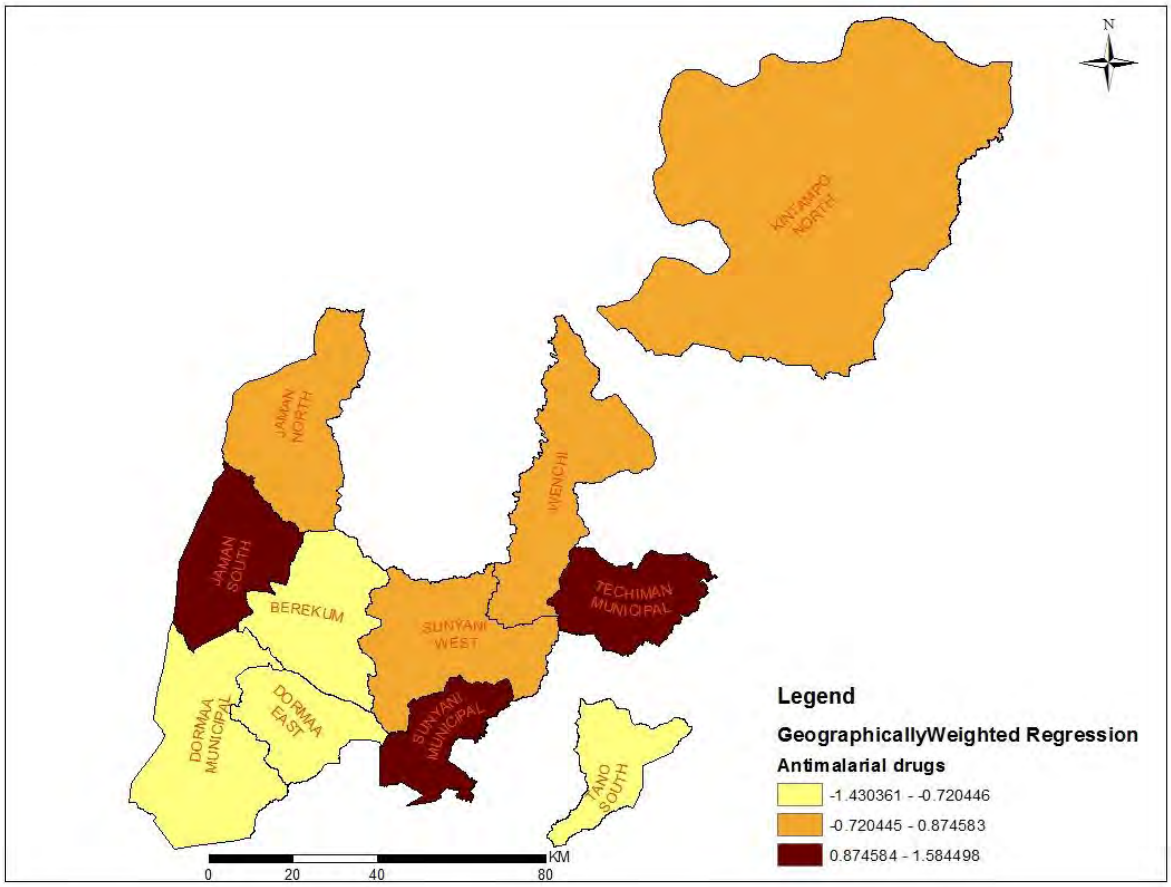


Figure 5. 4 Map of Anti-Malarial Drug as malaria control intervention.

(Source: Field Data, 2017)

Figure 5.4 indicates the validation of the non-stationarity of the Anti-malarial drugs coefficient. The map of the local coefficient of the Anti-malarial drugs showed that Jaman south, Techiman and Sunyani Municipalities had the higher coefficients. Lower coefficients were recorded by Dormaa East, Berekum, Jaman North, Sunyani West, Tano South, Kintampo North, Wenchi Municipal and Dormaa Municipality. The null hypothesis of this study is that high malaria incidence districts are not likely to have many intervention programmes. However, high incidence districts like Techiman Municipality, Sunyani Municipality, Sunyani West, Kintampo North, Jaman south and Jaman North had malaria control intervention programmes such as LLINS, Herbal medicine, Anti-malarial drugs and

University of Ghana http://ugspace.ug.edu.gh

IRS. Hence the null hypothesis that high malaria incidence districts are not likely to have many intervention programmes is rejected.

This research gave an additional validation that there was a non-stationary correlation between malaria distribution and intervention for malaria control in the Brong Ahafo Region. It is evident that the Sunyani Municipality recorded a positive coefficient for all the interventions. Therefore, the findings showed that a geographic interplay between malaria distribution and interventions has an effect on malaria distribution.

This thesis draws on the theoretical construct of human ecology of disease as initially argued as interplay between humans and their environment which leads to the spread or prevention of disease (Butterfield and Lewis, 2002). Hence, it is based on organization of malaria incidence in space which borders on the concept of human ecology of diseases. In this context, malaria is commonly regarded as urban disease (Klinkenberg et al., 2005). It is argued that urban dwellers have higher disposable incomes as well as better medical facilities and services (Deressa et al., 2007). However, in Africa urbanization has come the opposite due to incidence on urban poverty, urban blight and slums. Human interactions with the natural and built environment have generated wastes which are not properly managed leading to hygiene and sanitation problems. Malaria parasites take advantage of the conducive environmental conditions to multiply. The relationship which ensues between the urban human population and stinging mosquitoes that transmit malaria is a problem of this study. The international community has focused attention on malaria intervention in urban areas (WHO, 2012a). This warrants assessment of outcome of the targeted interventions on the incidence of malaria. Furthermore, the thesis considers the effectiveness of the interventions as another criteria area for investigation

University of Ghana http://ugspace.ug.edu.gh

CHAPTER SIX: MALARIA INTERVENTIONS EXISTING IN THE STUDY REGION AND THEIR EFFECTIVENESS.

6.1 Introduction

The theme of the last aspect of the analytical chapter relates to the fourth objective of the study, which deals with the malaria interventions existing in the districts and their effectiveness. The analysis in this section is based on the use of tables and charts to show variation between variables.

6.2 Malaria Control Interventions in the Study Region

Distinctive approaches to malaria control interventions have been in place in the Brong Ahafo Region to control the disease. These approaches for malaria control have regularly been changed through time as ways to enhance their effectiveness. The respondents mentioned that there are several interventions through which malaria can be controlled, however, emphasis was laid mostly on LLINS, IRS, anti-malarial drugs and herbal medicine in the study region. Much emphasis was laid on above mention interventions because they were interventions commonly used in the study area.

6.3 Indoor Residual Spraying (IRS)

Indoor residual spraying is a highly effective malaria control intervention which involves spraying the interior walls of the house using insecticides to kill the mosquito vectors (WHO, 2009). The WHO advocates that spraying of mosquitoes should be done at least once each year in endemic areas as a way to reduce mosquitoes. The spraying is mostly done using chemical such Dichloro-Diphenyl-Trichloroethane (DDT). The IRS kills mosquitoes usually when the vector has had a blood meal and is taking a rest indoors. This signifies that the IRS can only have an effect on the mosquito vector after an infectious bite, but not before. Hence, the IRS is not an effective way to control malaria transmission (NetMark USAID, 2007).

University of Ghana http://ugspace.ug.edu.gh

6.3.1 Effectiveness of Indoor Residual Spraying (IRS) as an Intervention in the Study Region

The result of the research showed that the utilization of IRS as an intervention in controlling malaria incidence in the study area was generally less significant, however, the intervention was supposed to produce good results without costing a lot of money. The findings showed that just 18% of the household were discovered to spray their house sometimes.

The reason for low usage of the IRS was attributed to the high cost of the residual sprays. It was indicated 82% of the respondent had not embraced IRS. However, the respondents conceived it was a fruitful intervention for controlling and preventing malaria incidence. The IRS is a good control intervention for protection of areas such a refugee camp, migrants and military personnel (WHO, 2013). The National Policy for Vector Control by National Malaria Control Programme (NMCP) in April 2007 included IRS as a component of malaria control intervention. The IRS was introduced to the account of the effective implementation process at Obuasi in the Ashanti region of Ghana in 2005. The implementation process led to an intense reduction of malaria incidence from 7000 to 1000 reported OPD cases annually (NMCP Annual Report, 2008).

The respondents were asked to rank the effectiveness of the IRS based on these statements: Very effective, Effective, Not effective and Undecided and their opinion is shown in the chart. Figure 6.2 shows that the IRS was “Not effective” in the study region.

University of Ghana http://ugspace.ug.edu.gh

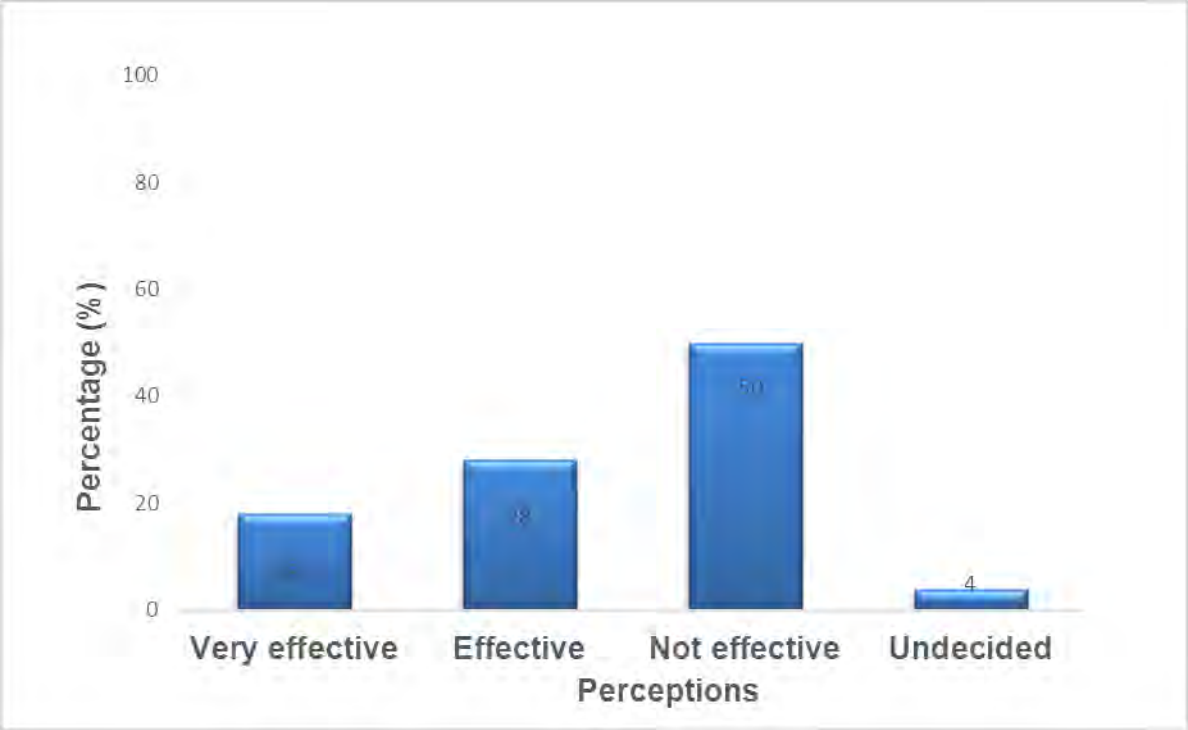


Figure 6.1 Respondents' perception about effectiveness about IRS (Source: Field Report 2017)

6.4 Long Lasting Insecticide Nets (LLINs)

The LLINs is one of the effective interventions of controlling malaria in the Brong Ahafo region. In 2010, the NMCP and other development partners introduced the „catch-up" approach of carrying out the free mass distribution campaign with the aims of accomplishing universal coverage of LLINs in all the regions of Ghana by 2012 (NMCP, 2010).

The LLINs have the capability to prevent frequent bites of mosquito provided that they are correctly used (WHO, 2005). In 2012, mass distribution of LLINs was done in the Brong Ahafo Region and total of 1,457,399 nets were distributed in the region (NMCP, 2015). Each bed net was to accommodate an average of 1.8 persons which means at least two people. This indicates that the mass distribution of LLINs to households may not be adequate to fight malaria occurrence (WHO, 2004).

University of Ghana http://ugspace.ug.edu.gh

6.4.1 Possession of LLINs as a Malaria Control Intervention

The results in the ownership of bed net showed 84% of the respondents owned some kind of a bed net. In spite of the high percentage of household ownership of bed net, a remarkable number of households (16%) do not have any kind of bed net (see Table 6.1). The difference between those who owned a bed net and those who do not was a single aspect that weakened the effectiveness of malaria intervention in the study region. It was revealed from the results, that the LLINs were the common bed nets possessed by many respondents. One of the National Malaria Control Programme informants in Sunyani Municipal stated that "LLINs *is an effective way to curb malaria transmission in endemic areas and that the LLINs should be considered a public good for all people living in malaria endemic areas"*.

Table 6. 1 Possession of Bed nets and Malaria incidence

Bed net Possession and Malaria Prevalence (N=245)	Frequency	Percentage (%)
Yes	205	84
No	40	16
Total	245	100

(Source: Field Data, 2017)

6.4.2 Utilization of Long-Lasting Insecticide Net (LLINs)

Based on the findings, it was revealed that in spite of the report about LLINs, not every household had acquired LLINs. The LLINs accommodate at least two individuals. Hence, some household members are not accommodated under LLINs. A National Malaria Control Programme informant stated that "*our reports indicate that LLINs is used by at least two*

University of Ghana http://ugspace.ug.edu.gh

persons in a household. Most households have more than two members. Hence, we conclude that there are other household members not covered by LLINs".

The respondents were requested to rank the effectiveness of the LLINs after assessing the use of the LLINs. The effectiveness of the LLINs was ranked based on these statements: very effective, effective, not effective and undecided as shown in Figure 6.2.

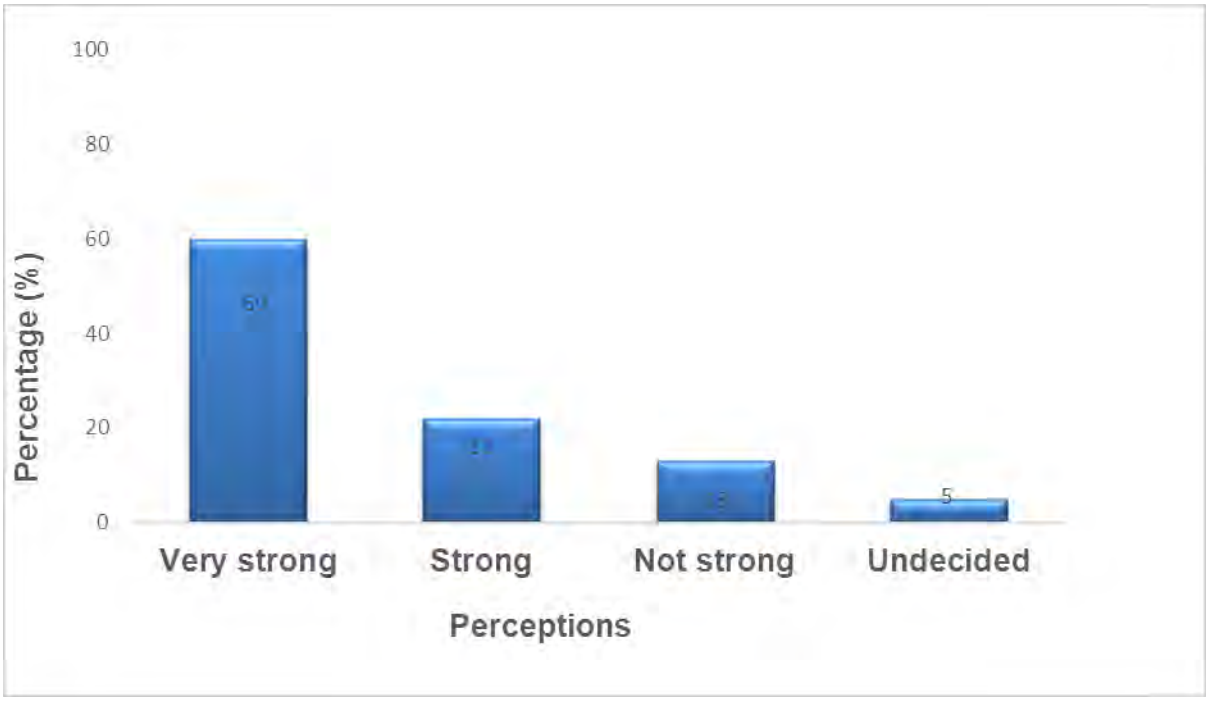


Figure 6. 2 Respondents perception about effectiveness of LLINs (Source: Field Report 2017)

6.5 Antimalarial drugs as malaria control intervention

There are different drugs which are mostly used in treating malaria. In most cases, these drugs are prescribed to be taken on daily basis by those infected with malaria disease. In endemic areas like the Brong Ahafo Region, prophylactic drugs are used full-time by people infected with malaria because such people have some level of immunity to fight the parasites. The use of prophylactic drugs is normally restrained/confined to children under five years,

University of Ghana http://ugspace.ug.edu.gh

pregnant women and travellers to malaria endemic regions, since these people/categories have little or no immunity to fight the malaria parasite (WHO, 2009).

The use of quinine as a prophylactic to fight malaria dates back to the seventeenth century. Quinine is still used today in treating chloroquine resistant Plasmodium falciparum. In the twentieth century, there have been other effective prophylactic drugs such as quinacrine, chloroquine, and primaquine to reduce usage of quinine (Toovey, 2004).

Currently there have been modern drugs such as mefloquine (Lariam) (Jacquerioz, 2009), and the combination of atovaquone and proguanil hydrochloride (Malarone) in treating malaria. One‟s choice of drug in the study region is based on drugs that can kill the parasite and its side-effects.

6.5.1 Effectiveness of Antimalarial Drugs as an Implemented Intervention

The research also showed that both private and public health providers in the study area administered antimalarial drugs. It was indicated that three different types of antimalarial drugs were mostly administered in both private and public clinics in the study. These antimalarial drugs were ACT, Quinine and Amodiaquine.

The study indicated that 76% of the respondents had accepted ACT as an effective malaria control. In 2005, the Ministry of Health, Ghana established series of actions to achieve the result of utilizing ACT based on WHO recommendations (GHS, 2004). It was revealed that quinine represented 20%, while Amodiaquine represented 4%, which showed that respondents had not embraced quinine and Amodiaquine in the study region. Amodiaquine was first recommended for uncomplicated malaria incidences in any country suffering from resistance to monotherapy (GHS, 2004). Figure 6.3 shows views on effectiveness of each antimalarial drug in the study area.

University of Ghana http://ugspace.ug.edu.gh

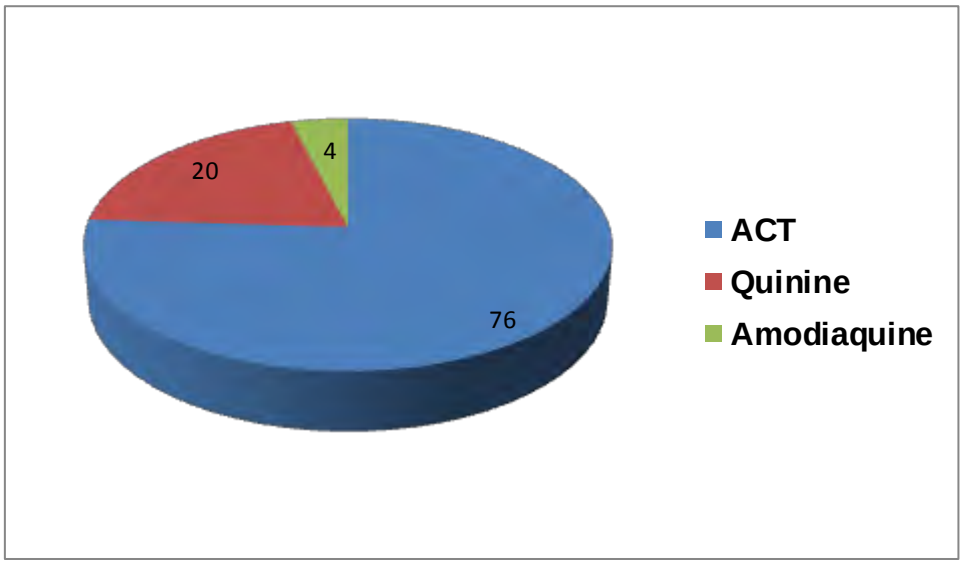


Figure 6. 3 Respondents' perception about effectiveness of antimalarial drugs (Source: Field Data, 2017)

6.6 Herbal medicine as malaria control intervention

As malaria remains one of the deadly disease and its resistance to modern medicine is causing people to feel danger. However, the poor cannot afford the modern medicine or lack access to modern medical facilities. Hence, herbal medicine could be the significant way to control malaria. Lucas (2010, p. 76) indicates that herbal medicine is „the use of plant products to treat or prevent a disease". There are different types of herbs that are used for medicinal purposes. These may include leaves, flowers, stems, roots, seeds, and berries (Woolf, 2003).

Herbal medicine is affordable and accessible, as they are made from local plants cut from the forest or in homes. In Africa, for primary health care, about 80% of the population applies herb medicine (WHO, 2002a; Mensah, 2008). Herbal medicine is used in treating 60% of children with high fever emanating from malaria in Ghana, Mali, Nigeria and Zambia (Darko, 2009; Okigbo & Mmeka, 2006; WHO, 2003a; WHO, 2003b; Abbiw et al., 2002).

University of Ghana http://ugspace.ug.edu.gh

6.6.1 Effectiveness of Herbal Medicine as Intervention Implemented in the Study Area

The findings of the research indicated that the use of herbal medicine as an intervention in controlling malaria in the study region was generally significant.

A key informant from Dormaa East district stated that "*despite the fact that herbs used by local people are likely to be effective in controlling malaria, the herbs are likely to result in other health effect*. It was further indicated by some respondents in the Dormaa East District that *an herb like neem tree (Azadirachta Indica) has the ability to control pests in the farm. Hence, the possible damage to human life, particularly, when taken for a long period to treat malaria should not be underestimated".* In Ghana, for primary health care, about 70% to 75% of the people use herb medicine (WHO, 2001; Abbiw et al., 2002). Yeboah (2000) indicates that traditional health services cannot solve all health situations in Ghana. While some herbs may be regarded as healthy, they may have critical side effects (IUPAC, 2008).

Respondents revealed that the location is one element which affects the choice of herbal medicine in controlling malaria in the study area. It was indicated that people staying in urban areas normally prefer using the orthodox means of intervention (LLINs, IRS and anti-malarial drugs). People living in rural areas in the same district prefer the traditional means of intervention such as herbal medicine. Respondents living in rural areas of the study region also stated that they use the orthodox means of intervention (LLINs, IRS and antimalarial drugs), however, they still drink herbal medicine to aid their body get rid of the malaria parasites.

The effectiveness of the herbal medicine was ranked based on these statements: Very effective, Effective, Not Effective and Undecided. Figure 6.4 show that the usage, herbal medicine was Effective in the study region.

University of Ghana http://ugspace.ug.edu.gh

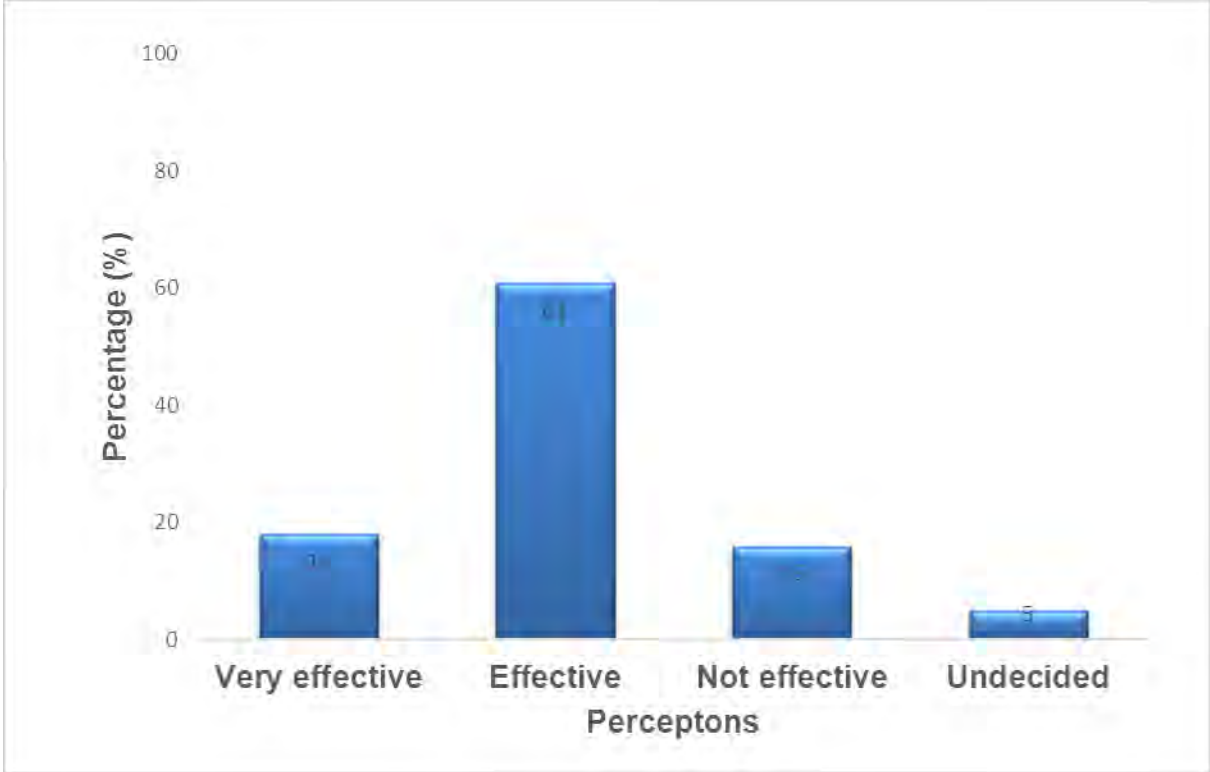


Figure 6. 4 Respondents' perception about effective of herbal medicine (Source: Field Data, 2017)

6.7 Interventions Targeting Malaria Incidence

The research established that 79.2% of the respondents understood that malaria distribution in the study region can be controlled despite other respondents had other thoughts. However, the other respondents (20.8%) assumed that clearing of the vegetation and draining of gutters was the greatest interventions of controlling malaria incidence. Moreover, the use of LLINs, IRS, anti-malaria drugs and herbal medicine were interventions that were significantly noted. The respondents stated that the LLINs was the ultimate intervention of control malaria incidence.

According to Lipowsky et al., (1992), another school of thought have tried to establish the key factors of effective malaria control. It was indicated that understanding human perceptions of malaria and factors that affect these perception should be the key way of finding a significant intervention for malaria control throughout the world. Several factors do

University of Ghana http://ugspace.ug.edu.gh

influence the treatment seeking behaviour among malaria patients. Asenso-Okyere et al., (1997a), indicated that the cost of malaria treatment has a direct and indirect effect on household. The direct cost stated as the cost of mediation and transport while the indirect cost becomes the time wasted.

6.8 Challenges of the Interventions for Malaria Control

Possible challenges of effective malaria control interventions from the respondents were poor sanitation, inadequate basic information on malaria, fake drugs, high cost of anti-malaria drugs and herbal medicine, low rate of LLINs and other bed nets as well as fake medical practitioners. Likewise, the respondents added that the bad attitude of individuals on many occasions failing to complete a full dosage of malaria drugs can suddenly increase the resistance of the parasite to the anti-malaria drugs.

A key informant from NMCP in the Jaman North district stated that "*insufficient funds influence the entire implementation plans for malaria control interventions as well as affect their means to increase the existing interventions appropriately"*. The official at NMCP, particularly pointed out that "*we have best action plans to control malaria however we are not capable to rise adequate funds to increase the LLINS distribution and completely implement the IRS"*. The officials of NMCP at the district level also revealed that malaria control is combined with the Primary Healthcare (PHC) in Ghana. However, the officials stated that malaria control has not fully operated well in association with PHC which has led to an unproductive workforce at the local level. The health sector in malaria endemic areas is usually charged with malaria control intervention as a way of measuring the control (WHO, 2008 However, there are numerous conditions why malaria still remains a key health problem (http: malariajournal.com, 2008). According to the World Malaria Report (2008), the

University of Ghana http://ugspace.ug.edu.gh

conditions of not being able to convince policy maker is a key challenge for vector control intervention.

6.9 Coping Strategies to Manage Malaria

Coping strategies are described as blueprints used by households to reduce the cause of a problem. As a result of the high malaria incidence indicated in the study region, respondents were required to provide their coping techniques to help control malaria.

Some respondents at Techiman Municipality stated that "*wearing long slit and a pair of trousers to avoid bites at night especially, closing windows and doors, burning of orange peels, and clearing of the environment were the techniques they have developed on their own to curb malaria incidence"*. Other respondents also indicated that the Community-Based Organisations (CBOs), National Sanitation Day (NSD) and NGOs act as agency that aid in the cleaning of the environment as well as giving health education to respondents.

University of Ghana http://ugspace.ug.edu.gh

CHAPTER SEVEN: SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter draws conclusions on the geographic account of malaria incidence and intervention in the Brong Ahafo Region. It consists of summaries of findings based on the key analytical themes, thus providing answers to the research questions. Both the conclusion and the recommendations address identified problems.

7.2 Summary of the Major Findings

This section of the research provides a summary of the major findings with reference to the objectives outline for the study.

I. Spatial distribution of Malaria Incidence; Following what other scholars have established about malaria incidence in malaria endemic areas, the thesis established that the Brong Ahafo Region had a high malaria incidence. The research had 76% of the respondents who revealed that their districts were malaria endemic as a result of poor sanitation. However, 76% of the respondents added that they have had malaria in the past 4 weeks, while 24% of the respondents had not reported to be sick during the same period. The demand to examine the spatial distribution of malaria incidence in the study area stimulated the use of hotspot analyses (Getis and Ord Gi* statistics) using malaria incidence on a yearly basis as the input field. The output of the hot spot analyses produced hot spot maps of malaria incidence from 2012-2016 which indicated clusters in the study area with hot zones noted as significant clusters of high values being positive and cold

University of Ghana http://ugspace.ug.edu.gh

zones as significant clusters of low values being negative. Figure 4.1 shows hotspots in 2012, in the Sunyani and Techiman Municipalities and small sections of the Wenchi Municipality and Sunyani West Districts while the cold spots are in the Dormaa East, Berekum, Jaman North, Jaman South, Kintampo North. Figure 4.2 portrays hotspots in 2013, in Techiman Municipal and in some tracts in Sunyani and in the Wenchi Municipalities. Dormaa East, Berekum, Jaman North, Jaman South, Kintampo North, Dormaa Municipality and Sunyani West indicate cold spots. In 2014, Sunyani and Techiman Municipality continued to exhibit a high malaria incidence. Jaman South, Jaman North and the Wenchi Municipality recorded higher malaria incidences than in the previous years (See figure 4.3). In 2015, Jaman South and Jaman North have become a malaria endemic area and indicated as a hotspot. The Techiman and Sunyani Municipalities maintained its high malaria incidence as a hotspot. There is some reduction in the case of the Sunyani West (See figure 4.4). In 2016, Jaman South, Jaman North, Sunyani and Techiman Municipalities maintained their high malaria incidence shown as hot spots. Sunyani West had regained its previous hotspot indication (See figure 4.5).

II. The regression model was applied for the correlated reason of explaining and evaluating the relationship between the dependent (malaria incidence) and independent variables (rainfall, temperature, humidity, elevation, vegetation educational level, economic status, agricultural land use and urbanization). The study indicated that urbanization was the likely factor to cause malaria incidence based on the strength of the coefficient. The model demonstrated that there was no relationship between elevation and malaria incidence which means that elevation was not a major factor influencing malaria incidence distribution in the study area. The null hypothesis stated that elevation was the main factor of malaria incidence

University of Ghana http://ugspace.ug.edu.gh

distribution. However, the result showed that elevation was not the main factor that influences malaria incidence distribution. The null hypothesis was rejected.

III. The interventions for malaria control were provided by the responses from the questionnaire as well as interventions recommended by the NMCP. These interventions were Long Last Insecticide Nets (LLINs), Insecticide Residual Spraying (IRS) and Drug Use. The correlation was analysed using the Geographically Weighted Regression (GWR). The malaria incidence data were obtained from the National Malaria Control Programme (NMCP) of Ghana Health Services (GHS). The data were based on the five years‟ outpatient malaria incidence in the eleven districts of the study area. A thin line is drawn between OLS and GWR in assessing the relationship between the malaria and interventions. The Geographically Weighted Regression (GWR) is not a remedy for all regression difficulties nor considered instinctively as the preferable choice in all regression modelling operations. The OLS is a default regression model found fit for this analysis. A negative coefficient states that there is an inverse relationship between distribution and interventions while a positive coefficient indicates that a relationship exists between the malaria distribution and intervention. The result indicated that anti-malarial drugs, IRS and herbal medicine recorded low negative coefficients with t-statistics greater than 0.05 which imply that anti-malarial drug, IRS and herbal medicine as interventions had a negative relationship in controlling malaria distribution. The LLINs was the only intervention that recorded a positive coefficient with t-statistic less 0.05 showing that LLINs has a direct relationship with malaria distribution in the study area. Therefore, the OLS model was confirmed to be non-stationary, hence the GWR is recommended to improve upon the OLS model. The GWR regression model

University of Ghana http://ugspace.ug.edu.gh

showed that LLINs had correlation with malaria incidence in more than two districts which indicates that the intervention was positive. Antimalarial drugs and IRS were significant in Kintampo North, Jaman South, Techiman and Sunyani Municipalities. The herbal medicine coefficients were negative in most districts in the study region except in Jaman South, Jaman North, Techiman and Sunyani Municipalities. This asked for a rejection of the null hypothesis that high malaria incidence districts are not likely to have many intervention programmes rather than high malaria incidence districts are likely to have many intervention programmes.

IV. There is some evidence to support a view that interventions implemented have been effective in controlling malaria in the study region. Many of the respondents stated the LLINS was the ultimate intervention for controlling malaria incidence. Further interviews with the officials of the National Malaria Control Programme in Accra indicated that the LLINS is an effective way to curb malaria transmission in endemic areas and that the LLINS should be considered a public good for all people living in malaria endemic areas. The results of the research showed that the utilization of IRS as an intervention in controlling the malaria incidence in the study area was generally less significant. The reason for low usage of the IRS was attributed to the high cost of the residual sprays. The research also demonstrated that both private and public health providers in the study area administered anti-malarial drugs. It was indicated that three different types of antimalarial drugs were mostly administered in both private and public clinics. These anti-malarial drugs were ACTs, Quinine and Amodiaquine. The findings of the research indicated that the use of herbal medicine as an intervention in controlling malaria in the study region was generally significant. Some respondents believed that even

University of Ghana http://ugspace.ug.edu.gh

though herbs used by the local people are likely to be effective in controlling malaria, the herbs are likely to result in other health problems. It was further indicated by respondents that on the assumption that a particular herb like neem tree has the ability to control insects on farmlands then the herbs should not be discounted to have an adverse effect, particularly on human health, when taken for a long period as malaria medication. The respondents indicated that possible challenges of effective malaria control interventions were poor sanitation, inadequate basic information on malaria, fake drugs, high cost of antimalarial drugs, low rate of LLINS and the use of other bed nets among households and fake medical practitioners. The respondents revealed their coping strategies against malaria. These were the wearing of long slits and pairs of trousers to avoid bites at night, especially, closing windows and doors, burning of orange peel, and clearing of the environment of weeds and waste.

7.3 Conclusion

This study sets out to examine the spatial distribution of malaria incidence in the Brong Ahafo Region by using a Geographic Information System (GIS) as an analytical tool. The result of this research indicates that malaria incidence in the Brong Ahafo Region demonstrated a spatial pattern not only on some meteorological variables, but also on socioeconomic factors such as agricultural land use and urbanisation. The OLS was performed under the null hypothesis that elevation has a negative relationship with the malaria incidence in the study area. Hence the null hypothesis was rejected.

The incidences of malaria in the study region were significantly clustered showing hotspot in 2012, the Sunyani and Techiman Municipalities and small sections of the Wenchi Municipality and Sunyani West Districts while the cold spots are in the Dormaa East,

University of Ghana http://ugspace.ug.edu.gh

Berekum, Jaman North, Jaman South, Kintampo North. It also portrayed hotspots in 2013, in Techiman Municipal and in some tracts in Sunyani and in the Wenchi Municipalities. Dormaa East, Berekum, Jaman North, Jaman South, Kintampo North, Dormaa Municipality and Sunyani West indicate cold spots. In 2014, Sunyani and Techiman Municipality continued to show high malaria incidence. Jaman South, Jaman North and the Wenchi Municipality recorded higher malaria incidences than in the previous years. In 2015, Jaman South and Jaman North have become a malaria endemic area and indicated as a hot spot. In 2016, Jaman South, Jaman North, Sunyani and Techiman Municipalities maintained their high malaria incidence shown as hot spots.

The correlation between malaria incidence and interventions were analysed using GWR. The control interventions included LLINs, IRS, ACT and herbal medicine. The analysis showed that LLINs had correlation with malaria incidence in more than two districts which indicates that the intervention was positive. Antimalarial drugs and IRS were significant in Kintampo North, Jaman South, Techiman and Sunyani Municipalities. The herbal medicine coefficients were negative in most districts in the study region except in Jaman South, Jaman North, Techiman and Sunyani Municipalities. The GWR was performed under the null hypothesis that high malaria incidence districts are not likely to have many intervention programmes. Hence the null hypothesis was rejected because high malaria incidence districts have many intervention programmes like LLINS, IRS, Herbal medicine and Antimalarial drugs.

The result of malaria control interventions and their effectiveness indicated that LLINS was the only malaria intervention that had a positive coefficient because it was revealed that LLINS was the effective way to curb malaria transmission in endemic area like Brong Ahafo Region. However, interventions like antimalarial drugs, herbal medicine and IRS recorded low negative coefficient due to cost of the residual sprays and antimalarial drugs. It also

University of Ghana http://ugspace.ug.edu.gh

indicated that the location is one element that affects one choice for herbal medicine in controlling malaria.

7.4 Recommendations

The study findings revealed that there were hotspot zones in the study area. In order to reduce the negative effects that follow, the following measures should be taken into consideration.

- Malaria clusters were detected in the study area and the single difference between the cold, not significant and hot spots were analysed. There is the need for further study to analyse the causes underlying each of the detected hotspots in order to identify special intervention measures. Therefore, the detected locations of clustered areas whose lives are at risk of malaria need more attention from the government of Ghana and other organizations.

- The result of this study demonstrates that lack of difference between malaria protected and unprotected people. There is a need to further study on human education and behaviour in malaria to assess the underlying factors because they might influence the use of malaria control measures. Therefore, the WHO and other organizations is needed to address the problem of malaria protected and unprotected people who deserves well-tailored information education and communication.

- The continuity of effectiveness of malaria interventions in controlling malaria, especially in a hot spot, needs vigilant monitoring of the National Malaria Control Programme in Ghana. The government of Ghana needs to give the due attention to the poor, distant and inaccessible households in the effort of malaria intervention programmes such as LLINs distribution.

University of Ghana http://ugspace.ug.edu.gh

REFERENCES

Anon. (2010). The Health Sector in Ghana-Fact and Figures. Accra, Ghana: Ghana Health Service, 47 pp.

Alonso, P. L., & Tanner, M. (2013). Public health challenges and prospects for malaria Control and elimination. Nature medicine. 19(2): 150-155.

Ahmed K. (1989). Epidemiology of malaria in Ghana. Ghana Med J 23:190–196.

Asante FA & Asenso-Okyere K., 2003.Economic burden of malaria in Ghana.Technical report submitted to the World Health Organization (WHO), Africa Regional Office (AFRO) University of Ghana,Legon

Aikins, M. K., Pickering, H., Alonso, P. L., D'Alessandro, U., Lindsay, S. W., Todd, J. and Greenwood, B. M. (1993) 'A malaria control trial using insecticide-treated bed nets and targeted chemoprophylaxis in a rural area of The Gambia, west Africa', Trans Soc Trop Med Hyg, 87(Suppl 2), pp. 25 - 30

Alonso Pl, Brown G, Arevalo-Herrera M, Binka F, Chitnis C, Collins F, Doumbo OK,Greenwood B, Hall BF, Levine MM, Mendis K, Newman R. D, Plowe CV Rodriguez M.H Sinden R., Slutsker L & Tanner M. (2011) A research agenda to underpin malaria eradication. PLoS Medicine, 8, e1000406

Abbiw, D., Agbovie, T., Akuetteh, B., Amponsah, K., Dennis, F., Ekpeh, P., Gillet, H., Ofosuhene- Djan, W., and Owusu-Afriyie, G. (2002). Conservation and Sustainable Use of Medicinal Plants in Ghana: Conservation Report. (Accessed from http//www.unepwcmc.org/species/plants/ghana/pdfs/ Conservation_report.pdf on 15 May 2010).

University of Ghana http://ugspace.ug.edu.gh

Ahorlu, C. K., Dunyo, S. K., Afari, E. A., Koram, K. A., & Nkrumah, F. K. (1997). Malaria-related beliefs and behaviour in southern Ghana: Implications for treatment, prevention and control. Tropical Medicine and International Health, 2, 488–499. http://dx.doi.org/10.1111/tmi.1997.2.issue-5

Asante K.P., Charles Z., Dominic B.D., CharlesB., George A., Antwi-Dadzi Y., Martin A., Tudhum K., David D., Seeba A., Christine M.,Kwenbena B., Chris B., Gray K.Seth O.A,(2011) malaria epidemioliogy in Ahafo area Ghana, http/wwwmalariajournal.com/10 January 2011.

Ahmad, Y.M (2012). Environmental sanitation and incidence of malaria control in Gusau Metropolis Zamfara state. Msc Dissertation submitted to Dept of Sociology UDUS.Unpublished

.Asenso-Okyere K., Osei-Akoto I., Anum A. (1997a): Willingness to pay for health Insurance in a developing economy. A pilot study of the informal sector of Ghana using contingent valuation. Health Policy Vol 42(3):223-237.

Agomo, C. O., Oyibo, W. A., Anorlu, R. I. and Agomo, P. U. (2009) 'Prevalence of malaria in pregnant women in Lagos, South-West Nigeria', Korean Journal of Parasitology, 47(2), pp. 179-183.

Becker, N. D. *et al. Mosquitoes and their control* 2nd edn, Springer Verlag (Berlin Heidelberg, Germany 2010).

Baume, C., Helitzer, D. and Kachur, S. P. (2000) 'Patterns of care for childhood malaria in Zambia', Social science & medicine, 51(10), pp. 1491-1503.

Bader E, Alhaj AM, Hussan AA, Adam I. Malaria and stillbirth in Omdurman Maternity

University of Ghana http://ugspace.ug.edu.gh

Hospital Sudan. Int J Gynaecol Obstet. 2010; 109:144–6.

Boulos, M. N. (2004), Towards Evidence-based, GIS-driven National Spatial Health Information Infrastructure and Surveillance Services in the United Kingdom, International Journal of Health Geographics,Vol. 3, No. 1, pp 1-10

Basel, P. (2008). Development of Bayesian geostatistical models with applications in Malaria Epidemiology, Malaria Journal, vol. 9:4-6.

Butterfield, R. M. and Lewis, M. A. (2002) 'Health-Related Social Influence: A Social Ecological Perspective on Tactic Use', Journal of Social and Personal Relationships,19(4), pp.505-526.

Brown, P. J., Inhorn, M. C. and Smith, D. J. (1996) 'Disease, ecology, and human behavior', in Sargent, C. F. and Johnson, T. M. (eds.) Medical Anthropology: Contemporary Theory and Methods. pp. 183-218.

Bryman, A. and Bell, E. (2007) Business Research Methods, 2nd ed., Oxford: Oxford University Press.

Bhattacharya, S. Sharma, C., Dhiman, R., et al. (2006). Climate change and malaria in India. Current Science. 90: 369-375.

Booman, M., Durrheim, D., Grange, K., et al. (2000). Using a geographic information System to plan a malaria control programme in South Africa. Bulletin of the World Health Organization. 78(12): 1438-1444.

Brooker, S., Clarke, S., Njagi, J., et al. (2004). Spatial clustering of malaria and associated risk factors during an epidemic in a highland area of western Kenya. Tropical

University of Ghana http://ugspace.ug.edu.gh

Medicine & International Health. 9(7):757-766.

Bureau of Endemic diseases Control of People's Republic of China. (1998). Manual of Malaria Control: People's Health Publishing Company

Bradley D.Newbold C.I WarrellD.A (1996) Malaria In Oxford Textbook of Medicine,eds weatherall, D J.Leding , J.G.C and Warell D.A Oxford : Oxford University Press 835- 863

Blanford J., Blanford S., Crane R., Mann M., Paaijmans K., Schreiber K., Thomas M. (2013). Implications of temperature variation for malaria parasite development across Africa. Scientific Reports. 3:1-11.

Craig, M. , Sharp, B., Mabaso, M., et al. (2007). Developing a spatial-statistical model and map of historical malaria prevalence in Botswana using a staged variable Selection Procedure. International Journal of Health Geographics. 6:44

Curtis, C. F. 1996. Impregnated bednets, malaria control and child mortality in Africa. Trop. Med. Int. Health 1:137-138

Carter R., Mendis K.N (2002). Evolutionary and historical aspects of the burden of malaria. Clin microbiol: 564-94.

Clements, A. 1999. The biology of mosquitoes. Volume 2. New York CABI Publ.

Cattani P, Jannin J, Lucas P. Sleeping sickness surveillance: an essential step towards elimination. Trop Med Int Health. 2001; 6:348–361.

Craig, M. H., Kleinschmidt, I., Nawn, J. B., Le Sueur, D. and Sharp, B. L. (2004b) Exploring 30 years of malaria case data in KwaZulu-Natal, South Africa: part

University of Ghana http://ugspace.ug.edu.gh

I. The impact of climatic factors', Trop Med Int Health, 9(12), pp. 1247-57.

Craig, M. H., Snow, R. W. and Le Sueur, D. (1999) 'A climate-based distribution model of malaria transmission in sub-Saharan Africa', Parasitology today, 15(3), pp. 10

Cator, L. J., Thomas, S., Paaijmans, K. P., Ravishankaran, S., Justin, J. A., Mathai, M. T., Read, F., Thomas, M. B. and Eapen, A. (2013) 'Characterizing microclimate in urban malaria transmission settings: a case study from Chennai, India', Malaria Journal, 12(1), p. 84

Craig MH (2009) The temporal and spatial distribution of malaria in Africa, with emphasis on southern Africa. PhD thesis, University of Basel, Switzerland.

Chaplin, S. E. (1999). Cities, Sewers and Poverty: India‟s Politics of Sanitation, Environment and Urbanization, 11 (1), 145–158.

Creswell, J.W, Plano Clark, V.L (2007).Designing and conducting mixed methods research thousand oaks, CA: sage

Daniel H., (2009)Malaria transmission dynamics and pyrethroid insecticide resistance statue of anopheles gambiae senu lato gilles in two districts of brong Ahafo, Ghana. Kwame Nkrumah University of Science and Technology for Doctor of Philosophy (Ph.D.) Degree in Biological Sciences.

Darko, I.N. (2009). Ghanaian Indigenous Health Practices: The Use of Herbs. Unpublished MA Thesis presented to Department of Sociology and Equity Studies in Education. Ontario Institute for Studies in Education, University of Toronto.

University of Ghana http://ugspace.ug.edu.gh

Dale, P., Sipe, N., Anto, S., et al. (2005a). Malaria in Indonesia: a summary of recent research into its environmental relationships. Southeast Asian Journal of Tropical Medicine and Public Health. 36(1): 1-13.

De Souza J. B. and Riley E. M. (2002). Cerebral Malaria: The Contribution of Studies in Animal Models to Our Understanding of Immunopathogenesis. Microbes and Injection, 4, 291- 300.

Deressa, W., Ali, A. and Berhane, Y. (2007) 'Household and socioeconomic factors associated with childhood febrile illnesses and treatment seeking behaviour in an area of epidemic malaria in rural Ethiopia', Transactions of the Royal Society of Tropical Medicine and Hygiene, 101(9), pp. 939-947.

Delves MJ, Ruecker A, Straschil U, Lelievre J, Marques S, Lopez-Barragan Mj, Herreros E & Sinden Re (2013) Male and female P. falciparum mature gametocytes show different responses to antimalarial drugs. Antimicrobial Agents and Chemotherapy

Dzinjalamal A, F. 2009. Epidemiology of malaria in Malawi. In: Guebbels, E. & Bowie, C. (eds.) Epidemiology of Malawi. Division of Community Health: University of Malawi College of Medicine.

Egunjiobi, I. (1983) 'Factors influencing the utilisation of hospitals a case study of the northern part of Oyo State, Nigeria', Social Science and Medicine, 17, pp. 585 – 589.

University of Ghana http://ugspace.ug.edu.gh

Esse, C., Utzinger, J., Tschannen, A., Raso, G., Pfeiffer, C., Granado, S., Koudou, B., N'Goran, E., Cisse, G., Girardin, O., Tanner, M. and Obrist, B. (2008) 'Social and cultural aspects of 'malaria' and its control in central Cote d'Ivoire', Malaria Journal, 7(1), p. 224

Fisher A.A., Laing J. E., Stoeckel J.E and Townsend J.W (1991). Handbook for Family Planning Operations Research Design 2nd ed. p43. Population Council. New York, USA Available on: www.popcouncil.org

Fidel, R. (2008) Are we there yet? Mixed methods research in library and information Science. Library and information science research,30 265-272

Fournet, F., Cussac, M., Ouari, A., Meyer, P.-E., Toé, H. K., Gouagna, L.-C. and Dabiré, R. K. (2010) 'Diversity in anopheline larval habitats and adult composition during the dry and wet seasons in Ouagadougou (Burkina Faso)', Malaria journal, 9(1), p. 78.

Gallup, J.L. & Sachs, J.D. (2001), The economic burden of malaria. American Journal of Tropical Medicine and Hygiene, 64(1, 2) S, pp 85-96.

Guinovart. C, Navia, M.,Tanner M. et al 2006. Malaria burden of disease. Current molecular medicine 6(2), 137.

Gething PW, Van Boeckel T, Smith DL, Guerra CA, Patil AP, Snow RW, Hay SI: Modelling the global constraints of temperature on transmission of *Plasmodium falciparum* and *P. vivax*. Parasit Vectors. 2011, 4: 92-10.1186/1756-3305-4-92.

Greene, J. (2006). Towards a methodology of mixed methods social inquiry, research in the schools, 13 (1) 39-98

University of Ghana http://ugspace.ug.edu.gh

Githeko, A., Lindsay, S., Confalonieri, U., et al. (2000). Climate change and vectorborne diseases: a regional analysis. Bulletin of the World Health Organization. 78(9): 1136- 1147

Gu W, Regens JL, Beier JC, Novak RJ. Source reduction of mosquito larval habitats has unexpected consequences on malaria transmission. PNAS. 2006; 103 (46):17560–17563.

Gosoniu L (2008) Development of Bayesian geostatistical models with applications in malaria epidemiology. PhD thesis, University of Basel, Switzerland

Getis, A. and Ord, J. (1992).The Analysis of Spatial Association by Use of Distance Statistics. Geographical Analysis 24(3):189-206.

GHS, 2011‟‟ Technical and Response Plan Human Pandemic Influenza (2005-2006)

Gatrell, A. C. and Elliott, S. J. (2009) Geographies of health: an introduction. John Wiley & Sons.

Gething, P. W., Smith, D. L., Patil, A. P., Tatem, A. J., Snow, R. W. and Hay, S. I. (2010) 'Climate change and the global malaria recession', Nature, 465(7296), pp. 342-345.

Government of Ghana. (2010a). National Environmental Sanitation Strategy and Action Plan. Accra: Environmental Health and Sanitation Directorate, Ministry of Local Government and Rural Development.

GHS (2004a). Annual Report. GHS, Ashanti Region.

GNA, NMCP, (2013) Availabile:www.ghananews.org/health/Ghana Accessed August 4, 2013 Ghana Health Service (2004) Antimalarial drugs Policy for Ghana, GHS, Accra.

University of Ghana http://ugspace.ug.edu.gh

GHS, NMCP (2015) Annual Report, long-lasting insecticide nets. Available at http//: www.ghanahealthservice.org, accessed 24 February 2016.

GHS, NMCP, (2004) Antimalaria Drug Policy for Ghana, http//:www.ghanahealthservice.org, Accessed March 2007, 2nd revised version, p.35.

GHS, NMCP (2010) Annual Report, long-lasting insecticide nets, GHS, Accra

Ghana Statistical Service, Population and Housing Census Report, (2010)

GoodchildMF.1986.Spatial autocorrelation. Norwich: GeoBooks.

Giada, S De Groeve, T Ehrlich, D and solide P.2003 Can satellite images provide useful information on refugee camp? Int J. Rem sens, 24:4249-4250

GHS (2006) Ghana Health Service, regional health directorate brong Ahafo region performance review report 2006

Hoshen, M. and Morse, A. (2004) 'A weather-driven model of malaria transmission', Malaria Journal, 3(1), p. 32

Howard, N., Chandramohan, D., Freeman, T., Shafi, A., Rafi, M., Enayatullah, S., & Rowland, M. (2003). Socio-economic factors associated with the purchasing of insecticide-treated nets in Afghanistan and their implications for social marketing. Tropical medicine & international health : TM & IH, 8(12), 1043–50. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14641838

Hay SI, Noor AM, Nelson A, Tatem AJ (2005) The accuracy of human population maps for public health application. Tropical Medicine & International Health 10: 1073-

University of Ghana http://ugspace.ug.edu.gh

1086. 86.

Hay SI, Guerra CA, Tatem AJ, Noor AM, Snow RW (2004) The global distribution and population at risk of malaria: past, present and future. Lancet Infectious Disease 4:327-336

IUPAC (2008). Protocols on Safety, fficacy, Standardiation, and Documentation of Herbal Medicine (IPC Technical Report). Pure and applied Chemistry, vol. 80, no. 10, PP: 21952230

Jerry, A.A-Ya (2012) spatial statistics of epidemiology data: Spatial analysis and mapping of cholera causing factors in Kumasi, Ghana. Available at http//: www.itcnl>msc>gfm>assamas. Accessed (March 2012)

Johnson, M. F., Gomez, A. & Pinedo-Vasquez, M. Land use and mosquito diversity in the Peruvian Amazon. *J. Med. Entomol.* **45**, 1023–1030 (2008).

Jacquerioz F.A, Croft A.M. Drugs For Prevention Malaria in Traveller.Cochrane Database Syst. Rev. 2009 doi: 10.1002/14651858.CDOO6491.Pub2 [PubMed] [crossRef]

Korenromp, E. L., Williams, R G., Gouws, E., Dye, C. and Snow, R. W. (2003).Measurement of Trends in Childhood Malaria Mortality in Africa: Assessment of Progress towards Targets Based on Verbal Autopsy. Lancet, 3, 349-358.

University of Ghana http://ugspace.ug.edu.gh

Keiser, J., Utzinger, J., & Singer, B. (2002). The potential of intermittent irrigation for increasing rice yields, lowering water consumption, reducing methane emissions, and controlling malaria in African rice fields. Journal of the American Mosquito Control Association.18(4): 329

Kovats, R., Campbell-Lendrum, D., McMichel, A., et al. (2001). Early effects of climate change: do they include changes in vector-borne disease? Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 356(1411): 1057- 1068.

Kitron U, Spielman A. Suppression of Transmission of Malaria Through Source Reduction: Antianopheline Measures Applied in Israel, the United States, and Italy. Clin Infect Dis. 1989;11(3):391-406.

Kleinschmidt I, Bagayoko M, Clarke GPY, Craig M, Le Sueur D, A spatial statistical approach to malaria mapping. International Journal of Epidemiology. 2000; 29: 355-361

Kolivras KN., 2006. Mosquito habitat and dengue risk potential in Hawaii: a conceptual framework and GIS application. Professional Geographer, 58(2): 139-154

Keating, J., Macintyre, K., Mbogo, C. M., Githure, J. I. and Beier, J. C. (2005) 'Self-reported malaria and mosquito avoidance in relation to household risk factors in a Kenyan coastal city', Journal of biosocial science, 37(6), pp. 761-771.

Klinkenberg, E., McCall, P. J., Hastings, I. M., Wilson, M. D., Amerasinghe, F. P. and Donnelly, M. J. (2005) 'Malaria and irrigated crops, Accra, Ghana', Emerging Infectious Diseases, 11(8), pp. 1290-1293.

University of Ghana http://ugspace.ug.edu.gh

Lucas, G.N. (2010). „Herbal Medicine and Children.“ Sri Lanka Journal of Child Health, vol.39, pp. 76-78

Lipowsky R, Kroeger A, Vazquez M. L. (1992) Sociomedical aspects of malaria control in Colombia. Journal of Social Science and Medicine, vol 34, pp625-637.

Larri P.B (2011) spatial statistics of epidemiology data: Spatial Analysis of Malaria Epidemiology in the Amansie West District. Available at http//:www.irknust.edu.gh>bitstream, accessed April 2011

Lindsay, S., & Martens W. (1998). Malaria in the African highlands: past, present and future. Bulletin of the World Health Organization. 1: 33-45.

Mitchell, Andy. The ESRI Guide to GIS Analysis, Volume 2. ESRI Press, 2005

Mwangangi , J. Midega S.Kadindi et al (2012), Mosquito species abundance and diversity in Malinda, Kenya and their potential implication in pathogen transmission Parasitology Research Vol.110pp. 61-71.

Ministry of food and agriculture (2014)Regional Diaries: Brong Ahafo Region of Ghana. Available at htpp://www.mofa.gov.gh/site/page_id=644 (Accessed 13-August, 2015)

Mugisha, F., Kouyate, B., Gbangou, A. and Sauerborn, R. (2002) 'Examining out-ofpocket expenditure on health care in Nouna, Burkina Faso: Implications for health policy', Tropical Medicine and International Health, 7(2), pp. 187-196.

University of Ghana http://ugspace.ug.edu.gh

McGregor IA. Epidemiology, malaria and pregnancy. Am J Trop Med Hyg. 1984;33:517–25.

Mensah, C.M. (2008). Accessibility to and Utilization of Primary Health Care in Ga, Dangme East and Dangme West Districts of the Greater Accra Region. 17th Intra-College Seminar, CASS, KNUST, Great Hall Conference Room, March 19

Meade, M. S. and Emch, M. (2010) Medical Geography. 3rd Edition edn. New York: The Guilford Press.

Macdonald, G. (1957) 'The epidemiology and control of malaria', The Epidemiology and Control of Malaria

Mwenesi, H., Harpham, T. and Snow, R. W. (1995) 'Child malaria treatment practices among Mothers in Kenya', Social Science & Medicine, 40(9), pp. 1271-1277 64

Mabaso MIH, Brian S & Christian L (2004) Historical review of malaria in southern Africa with emphasis on the use of indoor residual house spraying. Tropical Medicine and International Health 9, 846-856

Meade, M. S. (1977) 'Medical Geography as Human Ecology: The Dimension of Population Movement', Geographical Review, 67(4), pp. 379-393.

Matthys, N'Goran, E. K., Kone, M., Koudou, B. G., Vounatsou, P., Cisse, G., Tschannen, A. B., Tanner, M. and Utzinger, J. (2006a) 'Urban agricultural land use and characterization of mosquito larval habitats in a medium-sized town of Cote d'Ivoire', Journal of Vector Ecology, 31(2), pp. 319-333.

University of Ghana http://ugspace.ug.edu.gh

Martens, W, Niessen, L.W, Rotmans et al., (1995) Potential impact of global climate change on malaria risk. Environmental Health Perspectives. 103(5):458

Mordecai,E, Paaijmans,K, Johnson, L, et al., (2013) Optimal temperature for malaria transmission is dramatically lower than previously predicated ecology letters. 16(1):22-30.

MacCormack, C. P. (1984) 'Human ecology and behaviour in malaria control in tropical Africa', Bull World Health Organ, 62 Suppl, pp. 81-7.

Mhalu, F. S. 2005. Burden of diseases in poor resource countries: meeting the challenges of Combating HIV/AIDS, tuberculosis and malaria. Tanzan Health Res Bull, 2005, 179- 84.

Mbooera, L.E.G. and A.Y. Kitua, 2001. Malaria epidemics in Tanzania: An overview. Afr. Health Sci., 8:17-23.

Noor, A. M., Amin, A. A., Gething, P. W., Atkinson, P. M., Hay, S. I. and Snow, R. W. (2006) 'Modelling distances travelled to government health services in Kenya', Tropical Medicine and International Health, 11(2), pp. 188-196

Najera JA. Malaria and the work of WHO. Bull World Health Organ. 1989;67(3):229-243.

Norris, D. E. Mosquito-borne diseases as a consequence of land use change. *EcoHealth* **1**, 19–24 (2004).

University of Ghana http://ugspace.ug.edu.gh

Nahum, A., Erhart, A., Maye, A., Ahounou, D., van Overmeit, C., Menten, J., van Loen, H.,Akogbeto, M., Coosemans, M., Massougbodji, A. and D'Alessandro, U. (2010) 'Malaria Incidence and Prevalence Among Children Living in a Peri-Urban Area on the Coast of Benin, West Africa: A Longitudinal Study', American Journal of Tropical Medicine and Hygiene, 83(3), pp. 465-473.

Noor, A. M., Zurovac, D., Hay, S. I., Ochola, S. A. and Snow, R. W. (2003) 'Defining equity in physical access to clinical services using geographical information systems as part of malaria planning and monitoring in Kenya', Tropical Medicine and International Health, 8(10), pp. 917-926.

Newton P, White N., 1999. Malaria: new developments in treatment and prevention. Annual Review of Medicine 50:179-192.

Netmark USAID (2007), Available at http://www.netmarkafricaafrica.org, Accessed 21 may 2007.

NMCP. (2016). National Malaria Control Programme, Annual Report 2015,Ghana Health Service.

Okigbo, R.N. and Mmea, .C. (2006). An Appraisal of Phytomedicine in frica. KMITL Science and Technology Journal, vol. 6, no.2, pp. 83-94.

Okogun, G. R. A., Anosike, J. C., Okere, A. N. and Nwoke, B. E. B. (2005) 'Ecology of mosquitoes of Midwestern Nigeria', Journal of vector borne diseases, 42(1), p.1.

Oluleye, A. and Akinbobola, A. (2010) 'Malaria and pneumonia occurrence in Lagos, Nigeria: Role of temperature and rainfall', African Journal of Environmental Science and Technology, 4(8), pp. 506-516.

University of Ghana http://ugspace.ug.edu.gh

Opiyo, P., Mukabana, W. R., Kiche, I., Mathenge, E., Killeen, G. F. and Fillinger, U. (2007) 'An exploratory study of community factors relevant for participatory malaria control on Rusinga Island, western Kenya', Malar J, 6, p. 48.

Owusu-Agyei S, Asante KP, Adjuik M, Adjei G, Awini E, Adams M, Newton S, Dosoo D, Dery D, Agyeman-Budu A, Gyapong J, Greenwood B, Chandramohan D: Epidemiology of malaria in the forest-savanna transitional zone of Ghana. Malaria J 2009, 8:220.

Osei FB and Yibile MM. Geographic Patterns of Malaria in the Brong Ahafo Region of Ghana. Austin J Public Health Epidemiol. 2015; 2(2): 1020

Oresanya, O., Hoshen, M. and Sofola, O. (2008) 'Utilization of insecticide-treated nets by under- five children in Nigeria: Assessing progress towards the Abuja targets', Malaria Journal, 7(1), p. 145.

Protopopoff N, Matowo J, Malima R, Kavishe R, Kaaya R, Wright A, West PA, Kleinschmidt I, Kisinza W, Mosha FW & Rowland M (2013) High level of resistance in the mosquito Anopheles gambiae to pyrethroid insecticides and reduced susceptibility to bendiocarb in north-western Tanzania. Malaria Journal, 12,149.

Paaijmans, K. P., Blanford, S., Bell, A. S., Blanford, J. I., Read, A. F. and Thomas, M. B. (2010) 'Influence of climate on malaria transmission depends on daily temperature variation', Proceedings of the National Academy of Sciences, 107(34), pp. 1513515139.

University of Ghana http://ugspace.ug.edu.gh

Peters, G. (2010) 'Malaria in Sri Lanka: A Geomedical Analysis1', in Akhtar, R., Dutt, A. K. and Wadhwa, V. (eds.) Malaria in South Asia. Springer Netherlands, pp. 43

Phillips, Bassett, P., Zeki, S., Newman, S. and Pasvol, G. (2009) 'Risk factors for severe disease in adults with falciparum malaria', Clin Infect Dis, 48(7), pp. 871-8.

Panter-Brick, C., Clarke, S. E., Lomas, H., Pinder, M. and Lindsay, S. W. (2006) 'Culturally compelling strategies for behaviour change: A social ecology model and case study in malaria prevention', Social Science & Medicine, 62(11), pp. 2810-2825.

Pavlovsky, E. N. (1966) Natural Nidality of Transmissible Diseases: With Special Reference to the Landscape Epidemiology of Zooanthroponoses. Translated by Plous Jr, F. K. Urbana and London: University of Illinois

Poinar, G., Jr. (2005). Plasmodium dominicana n. sp. (Plasmodiidae: Haemospororida) from Tertiary Dominican amber. Syst Parasitol 61, 47-52.

RBM. The Global Malaria Action Plan: Roll Back Malaria Partnership;2008.

Reiter, P. (2001). Climate change and mosquito-borne diseases. Environmental Health Perspectives. 109(Suppl 1): 141-161.

Rakotomanana, F., Ratovonjato, J., Randremanana, R. V., Randrianasolo, L., Raherinjafy, R., Rudant, J.-P. and Richard, V. (2010) 'Geographical and environmental approaches to urban malaria in Antananarivo (Madagascar)', BMC Infectious Diseases, 10, p.173.

University of Ghana http://ugspace.ug.edu.gh

Ricci, F. 2012. Social implications of malaria and their relationships with poverty. Mediterranean journal of hematology and infectious diseases.

Sachs, J.D & Melaney, P. (2002) The Economic and Social Burden of Malaria. , Nature, 415680-685..,

Sharma RS, Sharma GK, Dhillon GPS. Epidemiology and Control of Malaria in India. Government of India Ministry of Health & Family welfare NMEP (Directorate General of Health Service). 1996

Service and Townson, H. (2002) 'The Anopheles vector', in Warrell, D. A. and Gilles, H. M. (eds.) Essential Malariology. Fourth edition edn. London: Arnold, p. pp. 59 to 84.

Steiger, D. M. *et al.* Effects of landscape disturbance on mosquito community composition in tropical Australia. *J. Vector Ecol.* **37**, 69–76 (2012).

Songsore, J. (2003a). Towards a Better Understanding of Urban Change: Urbanization, National Development and Inequality in Ghana, Accra: Ghana Universities Press.

Stuart, Neil, Moss,,Duncan, Hodgart, Robert,and Radikonyana, Paul, 2009 Making GISWork in Developing countries: Views from practitioners in Africa Institute of Geography,University of Edinbury, Scotland, UK.Published by RICS,ISBN: 978-1-84219-475-7

Stokol, D. (1996) 'Translating Socio Ecological Theory into Guidelines for Community Health Promotion', American Journal of Health Promotion 10, pp. 282-298.

Snow, R., Guerra, C., Noor, A., et al. (2005). The global distribution of clinical

University of Ghana http://ugspace.ug.edu.gh

episodes of Plasmodium falciparum malaria. Nature. 434(7030): 214-217.

Teklehaimanot, H. D., Lipsitch, M., Teklehaimanot, A. and Schwartz, J. (2004) 'Weather-based prediction of Plasmodium falciparum malaria in epidemic-prone regions of Ethiopia I. Patterns of lagged weather effects reflect biological mechanisms', Malaria Journal.

Toovey S, (2004) The miraculous fever tree. The cure that changed the world. Travel Med Infect Dis. 2(2):109-10 [accessed 10th May, 2010]

Thomson, M. C., Connor, S. J., Milligan, P. and Flasse, S. P. (1997) 'Mapping malaria risk in Africa: What can satellite data contribute?', Parasitology Today, 13(8), pp. 313-318.

Tsai, P., Men-Lung, L., Chien-Min, C. and Cheng-Hwang ,P. (2009). Spatial autocorrelation analysis of health care hotspots in Taiwan in 2006; BioMed Central Ltd

Tukei B. B., Beke A., and Lamadrid- Figueroa H. (2017): Assessing the effect of Indoor Residual Spraying (IRS) on malaria morbidity in Northern Uganda: Before and After study; BioMed Central Ltd

The Malaria Atlas Project. 2010. The spatial distribution of Plasmodium falciparum malaria stratified by endemicity class map in 2010 in Africa+ [Online]. Available http://www.map.ox.ac.uk/browseresources/endemicity/Pf_class/africa-plus/ [Accessed September 09 2014]

Tatem AJ, Guerra CA, Kabaria CW, Noor AM, Hay SI (2008) Human population, urban settlement patterns and their impact on Plasmodium falciparum malaria endemicity. Malaria Journal

University of Ghana http://ugspace.ug.edu.gh

Tay, S. C. K., Danuor, S. K., Mensah, D. C., Acheampong, G., Abruquah, H. H., Morse, A., Caminade, C., Badu, K., Tompkins, A. and Hassan, H. A. (2012) 'Climate Variability and Malaria Incidence in Peri-urban, Urban and Rural Communities Around Kumasi, Ghana: A Case Study at Three Health Facilities; Emena, Atonsu and Akropong', International Journal of Parasitology Research, ISSN, 4(2), pp. 83-89.

Uzochukwu, B. S., and Onwujekwe, O. E. (2004). Socio-economic differences and health seeking behavior for the diagnosis and treatment of malaria: a case study of four local government areas operating the Bamako initiative programme in south-east Nigeria. International journal for equity in health, 3(1), 6. doi:10.1186/1475-9276-3-6

Utzinger J, Tozan Y, Singer BH. Efficacy and cost-effectiveness of environmental management for malaria control. Trop Med Int. Health. 2001;6(9):677- 687. Treatment Guidelines and artemisinin monotherapies. Geneva: World Health Organization;2006.

UNICEF. 2007. UNICEF GHANA Fact sheet, MALARIA

Vos, T., Flaxman, A., Naghavi, M., et al. (2013). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 380(9859): 2163-2196.

WHO. WHO Evidence Review Group: Intermittent Preventive Treatment of malaria in pregnancy (IPTp) with Sulfadoxine-Pyrimethamine (SP). Geneva: World Health Organization;2012

WHO (1998) Fact sheet No. 94, revised. World Health Organization Geneva.\\'\\'\V.gigers.com/matthias/malaria/quellen.htm

University of Ghana http://ugspace.ug.edu.gh

WHO (2003a). Traditional Medicine. World Health Organization Fact Sheet No 134, May 2003. (Accessed from http://www.who.int/mediacentre/factsheets/2003/fs134/en/ on 11 August 2010).

WHO (2003b). "Traditional Medicine". Fifty-Sixth World Health Assembly, Provisional agenda item 14.10. Geneva: World Health Organization Press (Accessed from http://whqlibdoc.who.int/ wha/2003/WHA56_31.pdf on 15 July 2010).

World Health Organization (2013). The Africa Summit on Roll Back Malaria.

WHO/CDS/RBM/2000 17. Geneva: World Health Organization

WHO (2005): Malaria Control Today: Current WHO recommendations (working document).

WHO (2000) Roll Back Malaria initiative in the African Region: monitoring and evaluation guidelines

Malaria journal 2008, malariajournal.com/content/Page 9 of 10

WHO (2008).World Health Organization 8.Available from:http://www.who.int/malaria/wmr2008/malaria2008.pdf, Yeshiwondem, A., Sucharita, G. ,Afework, T. and Hrishikesh, P. (2009). Spatial analysis of malaria incidence at the village level in areas with unstable transmission in Ethiopia, International Journal of Health Geographics ,vol. 8, can be found online at: http://www.ij-health geographics.com.

World Health Organization:Global Malaria Programme (2012). World malaria organization world malaria day(2012) [online]http//www.who.int/mediacentre/news/release/2012/malaria_20120442/en

University of Ghana http://ugspace.ug.edu.gh

Accessed on April 5, 2013.

World health organistion: global malaria programmme (2011). World malaria report, world Health Organisation

World Malaria Report. (2005). Global malaria situation. In: World Malaria Report /WMR/. [http://rbm.wmr 2005/htm/1-1.htm].

WHO. Expert Committee on Malaria, sixth report. Geneva: World Health Organization;1957

WHO. Indoor residual spraying. Use of indoor residual spraying for scaling up global malaria control and elimination. WHO Position Statement: World Health Organization;2006.

WHO. Global plan for insecticide resistance management in malaria vectors: World Health Organization;2012

WHO: World Health Organization, World Malaria Report 2009

World Health Organization: Global Malaria Programme. (2012). World malaria report. World Health Organization

WHO (2004): Strategic framework for malaria prevention and control during pregnancy in the African Region. World Health Organisation, Geneva; 2004 AFR/MAL/04/01[accessed 18th May, 2009.

WHO, (2000), World Health Organization WHO Economic cost of malaria is many more times higher than previously estimated. WHO /28 25 2000 [accessed 8th May, 2009]

University of Ghana http://ugspace.ug.edu.gh

Wimberly, M., Adam, D., and Michael, J. (2008). Enhanced spatial Model for predicting the geographic distributions of tick-borne pathogens. International Journal of Health Geographic‟s, 7 (15): 4-6.

WHO/ UNICEF. (2003). The Africa Malaria report 2003. Geneva

WHO (2011). WHO Global Malaria Programme: World Malaria report (2011). Geneva, Switzerland

WHO, (2001). Legal Status of Traditional Medicine and Complementary/Alternative Medicine, A Worldwide Review, pp. 26

WHO (2012a) World Malaria Report 2012. Switzerland.

WHO (2012).World malaria report 2011 fact sheet. Geneva

WHO: Global malaria program, website hptt://www.who.int/malaria (2009)

World Health Organization (2006): WHO guidelines for the treatment of malaria, World Health Organization.

WHO: World Malaria Report. 2010, Geneva: World Health Organization

WHO: World Malaria Report. (2016), Geneva: World wealth Origanization

WHO: World Malaria Report. 2008, Geneva: World Health Organization

World Health Organisation. (1986), The Ottawa chsrter for Health Promotion.Adopted at the First International Conference on Health Promotion, Ottawa, 21st November 1986-WHO/HPR/HEP/95.1

World Health Organisation. (2015), Global malaria progress and challenge in 2016.Adapted from Nigeria centre for disease control. (www.ncdc.gov.ng)

University of Ghana http://ugspace.ug.edu.gh

WHO-UNICEF, (2015), Achieving the malaria MDG target: reversy the incidence of malaria 2010-2015:published on 17th September 2015.

World Health Organisation. (2013), Malaria control in complex emergencies: an inter-agency field handbook.Second edition.Geneva,2013

WHO (2002a). Traditional Medicine Strategy 2002-2005. Geneva: World Health Organization Press. [http://whqlibdoc.who.int/hq/2002/WHO_EDM_TRM_2002.1.pdf], (accessed 11August 2011).

Woolf,(2003). Herbal remedies and children o they wor re they harmful Pediatrics, vol. 112, no. 1, pp. 240-6.

Walsh, J.F., D.H. Molyneux and M.H. Birley, 1993. Deforestation: effects on vector-borne disease. Parasitology, 106(Suppl): 55-75.

Yatich NJ, Funkhouser E, Ehiri JE, Agbenyega T, Stiles JK, Rayner JC, et al. Malaria, intestinal helminths and other risk factors for stillbirth in Ghana. Infect Dis Obstet Gynecol.2010;2010:350763.

Yeshiwondim AK, Gopal S, Hailemariam AT, Dengela DO, Patel HP. Spatial analysis of malaria incidence at the village level in areas with unstable transmission in Ethiopia.International Journal of Health Geographics. 2009; 8: 5.

Yadav, S. P., Kalundha, R. K. and Sharma, R. C. (2007) 'Sociocultural factors and malaria in the desert part of Rajasthan, India', Journal of Vector Borne Diseases, 44(3), p. 205.

University of Ghana http://ugspace.ug.edu.gh

Ye, Y., Osman, S., Kouyate, B. and Sauerborn, R. (2008) Environmental Factors and Malaria Transmission Risk: Modelling the Risk in a Holoendemic Area of Burkina Faso. Surrey: Ashgate Publishing Limited.

Yanda, P., S. Wandiga, R. Kangalawe, M. Opondo, D. Olago, A. Githeko and T. Downs, 2006. Adaptation to Climate Change/Variability-Induced Highland Malaria and Cholera in the Lake Victoria Region. AIACC Working Paper No 43

Yeboah, T. (2000). Improving the Provision of Traditional health Knowledge for Rural Communities in Ghana. ealth Libraries Review, vol. 17, no.4, pp. 203-208.

University of Ghana http://ugspace.ug.edu.gh

APPENDIX I: QUESTIONNAIRE

UNIVERSITY OF GHANA, LEGON

DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT

RESEARCH CONDUCTED ON GEOGRAPHIC ACCOUNT OF MALARIA INCIDENCE AND INTERVENTIONS IN THE BRONG AHAFO REGION, A GIS APPROACH. I AM SEEKING FOR YOUR ASSIST TO ACHIEVE THIS GOAL. THIS IS PURELY AN ACADEMIC WORK AND YOU ARE FULLY ASSURED OF THE CONFIDENTIALITY OF YOUR RESPONSES. THANK YOU

Do you have a preference for written or verbal consent? (Mark choice, signature required for written consent)

1. Written consent……. 2. Verbal consent……..

Part A: cluster code…… Location: GPS code……..

Please thick or indicate the correct response.

Section A: Socio-Demographic Characteristics of Respondents

1. Gender of respondent (1) Male [ ] (2) Female [ ]

2. Age of respondent……

3. Level of education……..

4. Occupation……

University of Ghana http://ugspace.ug.edu.gh

Section B: Spatial distribution of malaria incidence

1. At what month of the year do you or members of your household experience malaria most frequently? Please rank them

January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

2. List 10 things in the level of importance that causes malaria in your community?

1…….. 6……

2…….. 7……...

3…… 8……

4…… 9…….

5…… 10…….

University of Ghana http://ugspace.ug.edu.gh

3. How often do people get malaria in your family within a year?

(1) 2 weeks (2) 4 weeks (3) 4 months (4) 8 months

4. How often do people get malaria in your community?

……

5. In your view will you consider your community to be malaria endemic?

(1) Yes (2) no

If yes why?

……..

If No, why?

…….

6. Which of these factors below will you consider to be most important contributor of malaria in your community? Please rank them.

General environmental factors	Rank
Temperature	
Humidity	
Elevation	
Rainfall	
Vegetation	

University of Ghana http://ugspace.ug.edu.gh

7. Which of these factors below will you consider to be most important contributor of malaria in your community? Please rank them.

Human factors	Rank
Urbanization	
Educational level	
Agricultural land use	
Economic status	

8. Rank the month or months you notice a lot of mosquitoes in your area?

Months	Rank
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

University of Ghana http://ugspace.ug.edu.gh

Section C: Correlation of malaria incidence and intervention

9. What malaria interventions programmes and methods are been implemented in your community?

Interventions	Method used

10. How will you grade the performance of the intervention for malaria control?

interventions	Excellent	Very Good	Good	Average	Poor

11. Who implemented the interventions?

……

University of Ghana http://ugspace.ug.edu.gh

12. How long has the interventions been implemented?

……

13. Have the implemented interventions reduced the occurrence of malaria in your area?

Yes [ ] No [ ]

14. How do you rank the effectiveness of the interventions in your community?

1. Very strong [ ] 2. Strong [ ] 3. Not strong [ ] 4. Undecided [ ]

15. Do areas with high malaria incidence have many interventions programmes?

Yes [ ] no [ ]

(a) If yes, state them

…….

…….

…….

(b) If no, why

……

……

……

16. Are people in areas of high malaria incidence receiving the interventions in your community?

Yes [ ] No [ ]

University of Ghana http://ugspace.ug.edu.gh

17. Do you do indoor residual spraying?

Yes [ ] No [ ]

Section D: Interventions and their effectiveness

18. If you do rank the effectiveness of indoor in the control of malaria?

1. Very strong [ ] 2. Strong [ ] 3. Not strong [ ] 4. Undecided [ ]

19. Who sprayed the house?

1. Government worker/program [ ]

2. Private company [ ]

3. Household member [ ]

4. Other, specify……

5. Don,,t know [ ]

20. Do you use bed net in your community?

Yes [ ] No [ ]

21. If you do rank the effectiveness of bed net in the control of malaria?

1. Very strong [ ] 2. Strong [ ] 3.Not strong [ ] 4. Undecided [ ]

22. What type of net do you use or own?

1. ITN [ ] 2. LLIN [ ] 3.Untreated net [ ] 4. Don,,t know [ ]

23. What coping strategies have you adopted on your own to manage malaria?

……

University of Ghana http://ugspace.ug.edu.gh

……

……

……

24. What are some of the challenges of the interventions for malaria control?

……

……

……

……

……

University of Ghana http://ugspace.ug.edu.gh

APPENDIX II

In-depth interview

Interviewer:…….……

Date:……..

District:……..……...

Interviewee:……..

Position:……..

1. What is malaria and what causes it in your area?

2. What is the age group that is more infected by malaria?

3. What is the gender that is more infected by malaria?

4. What are control measures that are used in your areas?

5. What are most used control measures?

6. What are some of the challenges of the interventions for malaria control?

7. What coping strategies have you adopted on your own to manage malaria?

8. Do you think the various ways of malaria control have brought about reduction of the disease?

9. How effective is the treatment you give?