ENVIRONMENTAL DETERMINANTS OF PATTERNS AND TRENDS OF THE OCCURRENCE OF UNSTABLE MALARIA IN KERICHO DISTRICT, KENYA

By

Warkach Kipkorir Tonui
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DECLARATION

This thesis is my original work and to the best of my knowledge, it has not been presented for a degree in any other University or for any other award.

Candidate's Signature________________ Date 30th April 2008

WARKACH KIPKORIR TONUI

This thesis has been presented for examination with our approval as the appointed university supervisors

SUPERVISORS

1. DR. SAMUEL C.J. OTOR Signature____________ Date 8/5/08

   Department of Environmental Science,

   Kenyatta University.

2. PROF. EPHANTUS W. KABIRU Signature____________ Date 21/05/08

   Department of Pathology,

   Kenyatta University

DEDICATION

This thesis is dedicated to my wife Rita Chepkirui, our children, my retired father, Sergeant-major Kiptonui Chumo and my mother Tapsagah Chumo. The love, tolerance, patience and encouragement you gave me sustained me in the pursuit of this study and especially in the many long hours of my absence from your company.

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ABBREVIATIONS AND ACRONYMS

ACT	-	Artemisinin Combination Therapy
AEZ	-	Agro-Ecological Zone
AMREF	-	African Medical Research Foundation.
Asl	-	Above Sea Level
CBS	-	Central Bureau of Statistics
CDC	-	Centre for Disease Control
DDT	-	Dichlorodiphenyl Trichlorothane
DMOH	-	District Medical Officer of Health
DPHO	-	District Public Health Officer
e.g	-	examplia gratia, For or as an example
e.t.c	-	et cetera, And so on
i.e	-	id est "that is" or that is to say
GIS	-	Geographic Information Systems
GPD	-	Gross Domestic Product
GOK	-	Government of Kenya
HIS	-	Health Information Systems
ITNs	-	Impregnated Treated Nets
KDDP	-	Kericho District Development Plan
MARA	-	Malaria Risk in Africa
MOH	-	Ministry of Health
MOST	-	Ministry of Education, Science and Technology
NMCS	-	National Malaria Control Strategy

PEEM	-	Panel of Experts in Environmental Management
pH	-	Potenz of Hydrogen or Hydrogen potential $=-\log[H^{+}]$
ROK	-	Republic of Kenya
SSA	-	Sub-Saharan Africa
STDs	-	Sexually Transmitted Diseases
SWOT	-	Strengths, Weaknesses, Opportunities and Threats
TB	-	Tuberculosis
UNICEF	-	United Nation Children's Education Fund.
USA	-	United States of America
WB	-	World Bank.
WHO	-	World Health Organization

DEFINITION OF TERMS AND CONCEPTS

Admission Rate: It is an incidence rate that includes both admitted patients to hospital/clinics and those at home.

Agro-Ecologic Zone (AEZ): A classification of an area based on rainfall evapotranspiration and land potential (Jaetzoldt and Schmidt, 1983).

Change: Involves making something different in one way or another e.g. climate change, perception etc.

Death: The permanent disappearance of all forms of life at any time after birth and according to WHO death does not include still-birth or abortion.

Differential morbidity: Differences in morbidity found among various sub-populations at a particular time or between different cohorts.

Disease: A disordered condition of the body recognizable as a specific entity.

Ecology: Is the relationship of organisms to their animate and inanimate surroundings (Winslow *et al.,* 1952).

Economic Activity: Any human occupation or activity that contributes to the productive agriculture, employment etc; it provides income e.g in monetary terms.

Endemic: Implies that malaria is always present in an area and is by its very nature regular and predictable in occurrence.

Environmental Determinants: Refers to cliamatic, socio-economic and health care delivery system. They influence the occurrence, prevention and control of occurrence of malaria burdens at a household or at a community level.

Environmental Manipulation: An environment management consisting of planned activity aimed at producing temporary conditions which are not favourable to the breeding of mosquitoes in their habitats e.g. removal of vegetation or draining of water from ponds etc.

Epidemic: A mass outbreak in a population of a disease which spreads and then disappears within a relatively short period e.g. Plague in Europe in 1348-1350, Spanish Flu in 1918, malaria epidemic in North eastern province. Kenya in 1998.

Epidemic malaria: Is a term applied to describe *P. falciparum* transmission characteristics of the highland malaria in East Africa (Shanks *et al.,* 2005).

Epidemiological Factors: Include factors such as age, sex, infection rate, and vector capacity among others.

Health: A state of full physical and spiritual well-being and perfect adaptation to environmental conditions (WHO, 1998).

Household: Comprises a person or group of persons bound by the ties of kinship who normally reside together under a single roof or under several roofs within the same compound (GOK, 1981)

Hospital Beds: The number of beds and costs in a health facility. Hospital beds provide a measure of the capacity of a health facility.

Host: Human individual who harbours infected malaria parasites.

Incidence Rate (IR): Defined in epidemiology as the number of new cases of malaria during a specified period divided by the average population during the period (Hoem, 1978) or $IR = N \times \frac{k}{P}$, where N = Number of new cases of malaria beginning with a specified period. k= Constant (1000 for a common disease and 100,000 for a rare disease). P = Average number of persons exposed to the risk of contracting malaria during the period.

Incidence Rate of Malaria: The number of new cases observed during a specified period e.g. 300 cases per 10,000 population per 6 months.

Incidence Rate of Infection: The number of susceptibles being infected per unit time. The number of new malaria infections per unit time in a sub-location/division divided by the total population in the sub-location/division.

Infected: Having come into contact with malaria parasites (*Plasmodia*).

Innovation: Is a change in which something new is added to an existing phenomenon. It can also be a process of initiating something new and spreading through a social system, e.g. addition of funds to malaria control programmes, addition of hospitals or clinics, or using herbs to treat malaria, using ITNs e.t.c.

In-Patients: Number of inpatients recorded by a health facility in a year and this measures the hospital service output. The data on monthly work programmes and the increase in out-patients increases the recurrent costs e.g. costs on food, drugs etc.

Malaria Burdens: Are hospital admissions: morbidity, mortality abortion, anaemia, still birth, costs of diagnosis and treatment, disability, mental disorder, psychological effect etc.

Morbidity: The number of sick individuals e.g. due to malaria per 1000 of the total population in an area in a given time in 1 month, 2 weeks etc.

Mortality: The number of deaths due to a disease per 1000 of the total population in area in a given period.

Optimum Temperature: Is the best quantity of temperature conducive to the survival of *Plasmodia* and A. mosquitoes.

Out-patients: The number of first and subsequent outpatient visits to a health facility, it measures the hospital service.

Prevalence Rate (PR): It quantifies morbidity during a specified period. A point prevalence rate includes both old and new causes of a disease at a point in time.

Prophylaxis: A method used to prevent and control occurrence of malaria e.g taking of anti-malaria drugs.

Response: The action by *Plasmodia* or human on reply to a change in its environment.

Rigors: Are fits of shivering together with a feeling of extreme coldness.

Sign of Malaria: The way in which malaria makes its presence of occurrence known to the senses of feeling or sight.

Social Factors: Classification of household according to sex, age, education level, culture and beliefs, sleeping patterns, religion etc.

Stable malaria: Means malaria always exists in an area of low transmission.

Susceptible host: A humanbeing who will become diseased upon exposure to an infectious A. mosquito's bite.

Symptoms of malaria: A change in the normal functions of the body in a human being and caused by malaria.

Unstable malaria: Means malaria epidemic which occurs in unstable transmission zones e.g in East African highlands and in semi-arid areas and is principally a *P. falciparum* transmission. Unstable malaria in the context of highlands of East Africa is often referred to as highland malaria epidemic.

Vector: Carrier of parasites e.g. a female A. Mosquito is a carrier of *Plasmodia.*

ABSTRACT

This study investigated environmental determinants of patterns and trends of occurrences of unstable malaria burdens in Kericho district of Kenya, a formerly malaria free highland district in early 1960s but classified by Kenya government in 2001 as malaria epidemic prone district where fatal malaria epidemics have reemerged seasonally each year since 1980s and represents a leading cause of morbidity and mortality in the district. To achieve this objective patterns and trends of malaria burdens; malaria hospital admissions, morbidity and mortality, climatic elements; and households' characteristics and district health delivery system were investigated.

Secondary data on malaria burdens and climatic element were obtained from Kericho district health facilities and Kericho meteorological station respectively for the synoptic period 1988-2005. Primary households' characteristics were obtained using questionnaires from a randomly sampled households (N=301) apportioned to all four Agro-Ecological Zones (AEZs) study sites in seven administrative divisions based on 1999 national population census. Useful information on health efficiency delivery system in the district was obtained from key medical professionals respondents to questionnaires in Kericho district health facilities.

The data were analysed displayed and interpreted using statistical methods; tables, graphs, means, percentages, ranges, correlation, regression analysis and tests of significance (t-test) and Analysis of Variance (ANOVA). Tables and time series graphs, were used to study emerging patterns and trends in malaria burdens and climatic elements over time. Correlation and regression methods were used to determine the relationship between malaria burden and climatic and socio-economic data. The t-test was used to establish the significance of computed correlation coefficients between malaria morbidity and each of the household's variables.

Archview Geographic Information System (GIS) software was used to create a malaria zonation map of the distribution of incidences of malaria morbidity in the district and SWOT analysis was used to analyse the effectiveness of malaria control, prevention and management algorithms in the district.

Findings emerging from this study showed that outpatient malaria cases grew from 19643 cases in 1989 to 124408 cases in 1994 or a growth rate of 106.7% per annum and growth rate of 101.9% per annum in 1995-2002. Malaria hospital admissions grew from 10.27% per annum and a growth rate of 42.8% per annum in 1988-1994 and 1995-2002 respectively. Malaria deaths in Kericho district main hospital grew from 23 cases in 1988 to 34 in 1994, a growth rate of 6.9% per annum and in 1995-2002 malaria deaths grew from 84 to 160 cases or an annual increase of 18.1%.

Overall total 70611 malaria hospital admissions were recorded in health facilities in the district and resulted in 1476 deaths or 21 malaria deaths in every 1000 malaria admissions. Malaria hospital admissions were seasonal in patterns of occurrences with peak occurrences in June- July each year and generally malaria hospital admissions increased gradually between April and July and gradually decreased in August-September to March each year. Case fatality rates (1988-2002) ranged between 0.02% to 4.2% or 10 cases to 24 cases per 1000 malaria admissions in 1988-1990 and 2 to 21 cases per 1000 malaria admissions in1990-2002.

Trend in malaria hospital admissions was on upward trend in 1988-2002 with a growth rate of 111.13% while malaria death rate grew by 10.486% per annum and t-test revealed that trend in observed malaria hospital admissions was significant at 0.05 thus the null hypothesis stated that there was no significant difference in temporal trend discernible in occurrence of malaria morbidity in the district was rejected at 0.05 level.

The mean reporting rate by health institutions changed from 27.2% in 1999 to 67.1% in 2003 and proportion (%) of population who needed treatment for malaria and actually received it increased from 10.8% to 22% in 1999-2004 in the district.

In 1988-2005 the annual mean temperature, rainfall and relative humidity were 17.6°C,153mm and 64.6% respectively while monthly means were17.7°C, 162.3mm and 65%respectively. Results showed emerging positive trend in temperature with a change of 0.8°C but no trend in monthly values. Negative trend in mean annual rainfall was observed with change of 20mm and a negative growth of 0.78% during 1988-2005.

The regression model regarding malaria admissions produced coefficient of determination R^2=0.3052 i.e. 30.52% of the change in time accounted for 30.52% variation in malaria burdens (admissions) while time accounted for 34.79% of the variation in malaria deaths due to the disease and the t-test revealed that the difference in trends in malaria hospital admissions in 1988-1995 and 1995-2002 was significant at 0.05 level while difference in trends in malaria deaths during the same periods was significant at 0.05 levels. Thus the null hypothesis that there are no significant trends discernible in occurrence of malaria burdens and change in time in the district was rejected at 0.05 level.

Regression results revealed that change in time (1988-2002) accounted for 95.35% variation in mean annual temperature, 7.9% and 0.83% variations in mean annual rainfall and relative humidity respectively.

Results revealed that malaria morbidity correlated strongly (0.943) with frequency of visits to the nearest health facility and this value being significant at 0.05 level (2 tailed test). However malaria morbidity lowly (0.134) correlated with family size.

Malaria morbidity in a household correlated positively (0.321) with distance to the nearest health facility and this value being significant at 0.01 level (2-tailed test), positive sign implied that distance from a household influenced malaria morbidity and might have led to delay in prompt treatment of malaria thus an increase of malaria transmission in a household.

Family income correlated negatively (-0.114) with family size, a correct sign implied that a low family income was associated with a large family size. Family income correlated negatively with each of the variables maternal age and maternal education with values of 0.205 and 0.238 respectively and both values being significant at 0.01 level (2-failed test). However, family income did not have effect on malaria occurrences in a household.

GIS results created 5 malaria zones in the district based on annual malaria morbidly cases as; very high malaria zone. 10855-15029 cases, high malaria zone 7917-10834 cases, medium zone 6239-7916 cases, low zone 5367-6238 cases and least malaria zone had below 5366 malaria cases annually.

Overall 60% of respondents interviewed (N= 301) purchased anti-malaria drugs from local kiosks/shops without the prescription from qualified health personnel. Only 21.2% of all 250 medical staff in the district public health facilities received on-job training on malaria control and information technology during 2000-2005. Less than 12% of the households' respondents (N= 301) interviewed used ITNS regularly. The uncollected used plastic/polythene materials were observed in 60% of 301 households' compounds visited in 2006 where 70% of all households' respondents knew and used local herbs/plants *polyganum, Acacia-Siebariana, Cyathilaennacea, SP and Septenitrionalis* to treat malaria and more than 61% knew *Tegetes minuta* repulsed away mosquitoes.

The efficacy of anti-malaria drugs: Coartem, Helfan, Paluther and Cotexcin ranged between 50% and 80% in 1999-2005.

SWOT analysis results have revealed future strategies for effective malaria control programmes in the district. Overall strategies opportunities and strengths in malaria control exist and should be stepped up in the district to meet the long term strategies and to be in line with NMCS, 2001-2010 framework.

The study concludes that to prevent and control malaria, more malaria educational programmes, improvement of accessibility to health facilities provision of free ITNS and improvement of environmental sanitation should be stepped up as well as full implementation of malaria control programmes according to ministry of health, 2001-2010 framework.

CHAPTER ONE
INTRODUCTION

1.1 Background to the study problem

Malaria is a protozoan disease caused by parasites of genus *Plasmodium (P): P. falciparum, P. malariae, P. ovale and P. vivax* which cause malaria in humans (Mattingly, 1960; Giles, 1995; Ridley, 2002) and undergo same life cycle, one cycle in humans and the other cycle in mosquitoes. The *Plasmodia* are transmitted by *Anopheline* (A) Mosquitoes as vectors in humans, rodents, birds and monkeys. Malaria has also been reported in reptiles (Bruce-Chwatt, 1980). The life cycle of malaria parasites consists of a sexual phase in diverse strains of female A. mosquitoes and an asexual phase which multiplies in humans (Singer, 1990). There are 70 species of A. Mosquitoes that are vectors of malaria transmission in humans (Lieshout *et al.*, 2004). Figure 1.1 shows the distribution of the main vectors of malaria A. Mosquito species in Africa; *A. Arabiansis, A. gambiae, A. melas, A. merus, A. fenestus, A. pharaensis and A. sergentii transmit malaria* and currently, there are no accurate maps to show the global distribution of malaria parasites (Lieshout *et al.*, 2004). *A. gambiae* complex are the most widely spread and most efficient vectors in the world and a major cause of malaria burden in Africa (Goodman *et al.*, 2000).

Malaria occurs in the tropics, sub-tropics and temperate areas where temperature is 20°-30°C and relative humidity is 60% is essential for sporozoite development within mosquitoes (Oaks *et al.*, 1991). Worldwide, some 2 billion people (more than 40% of the world's population) live in areas where they are at risk of contracting malaria (Lieshout *et al.,* 2004). The global incidence of malaria ranges from 3 to 5 million clinical cases with a death toll ranging from 2 to 3 million (Okenu, 1999; WHO, 2001).

Malaria burden in humans has the following components: morbidity and mortality and severe forms of untreated *P. falciparum,* celebral malaria and severe anaemia which in pregnant women may cause abortion, premature delivery and low birth weight (Goodman *et al.,* 2000).

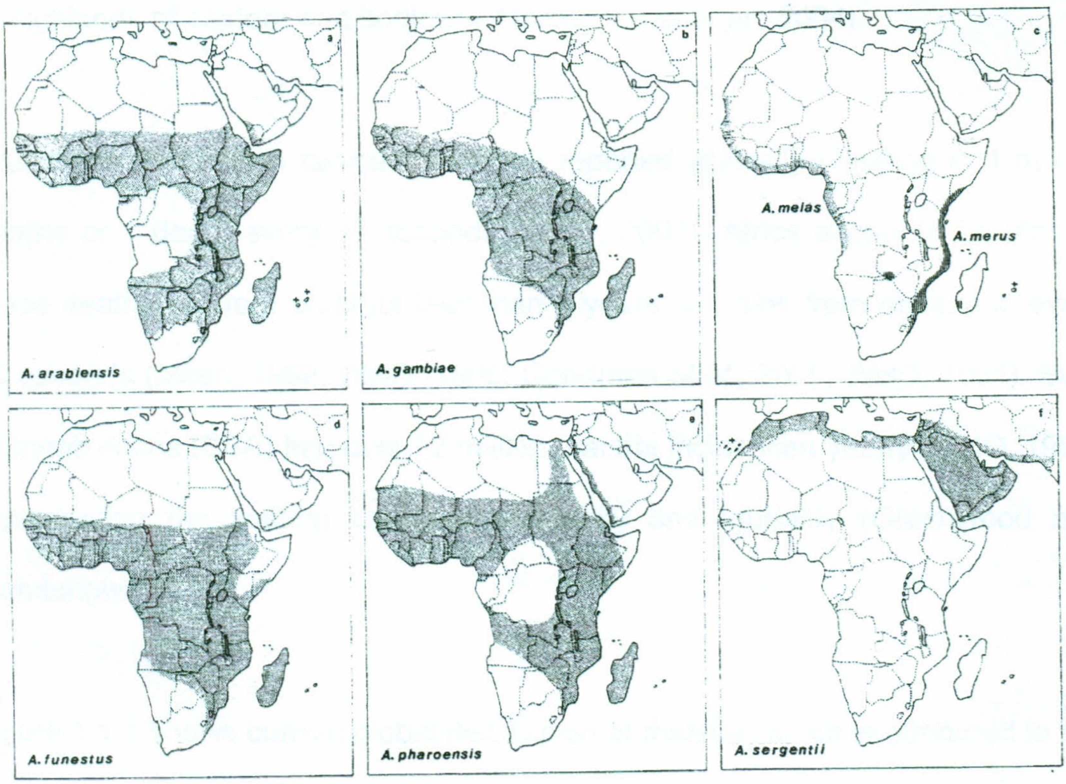


Figure 1.1: Distribution of malaria vectors; A. mosquito species in Africa. Source: WHO, 1989.

In many parts of Africa malaria is ranked as the leading cause of morbidity, disability, anaemia, still birth, mental disorders and mortality and the trend is increasing every year (Kilema and Kihamia, 1991, Goodman *et al.*, 2000) leading to an economic loss in Africa estimated to be in excess of USA dollars 2 billion per annum (Okenu, 1999). In 2001, the economic cost of malaria globally was estimated to be in excess of 4 billion USA dollars, of which Africa accounts for over 3.6 billion USA dollars (WHO, 2001) and loses USA dollars 12 billion in GDP annually (Greenwood, 2004). Malaria is the greatest economic burden for Africa. This situation calls for global concerted efforts towards control and management of the disease, particularly the recent increase in frequency of malaria epidemic in highlands of eastern and southern Africa (Worrel *et al.*, 2004).

Worldwide 500 million clinical cases are reported annually resulting in 1 million deaths or 1 death every 30 seconds (WHO, 2001). Africa accounts for 90% of these deaths where 1 child (of less than 5 years old) dies from malaria in every 20 seconds (Mash, 1992; WHO, 1996; Goodman *et al.*, 2000; WHO, 2001). Sub-Saharan Africa (SSA) has over 92 million malaria incidences yearly (WHO, 1996) representing the leading cause of morbidity and mortality (Greenwood and Mutabingwa, 2002).

Figure 1.1.1 shows current global distribution of malaria, which is attributed to the changes in social environmental factors and resistance of both the vector and malaria parasites to insecticides such as DDT and anti-malaria drugs respectively (Sachs and Malaney, 2002; Lieshout *et al.*, 2004).

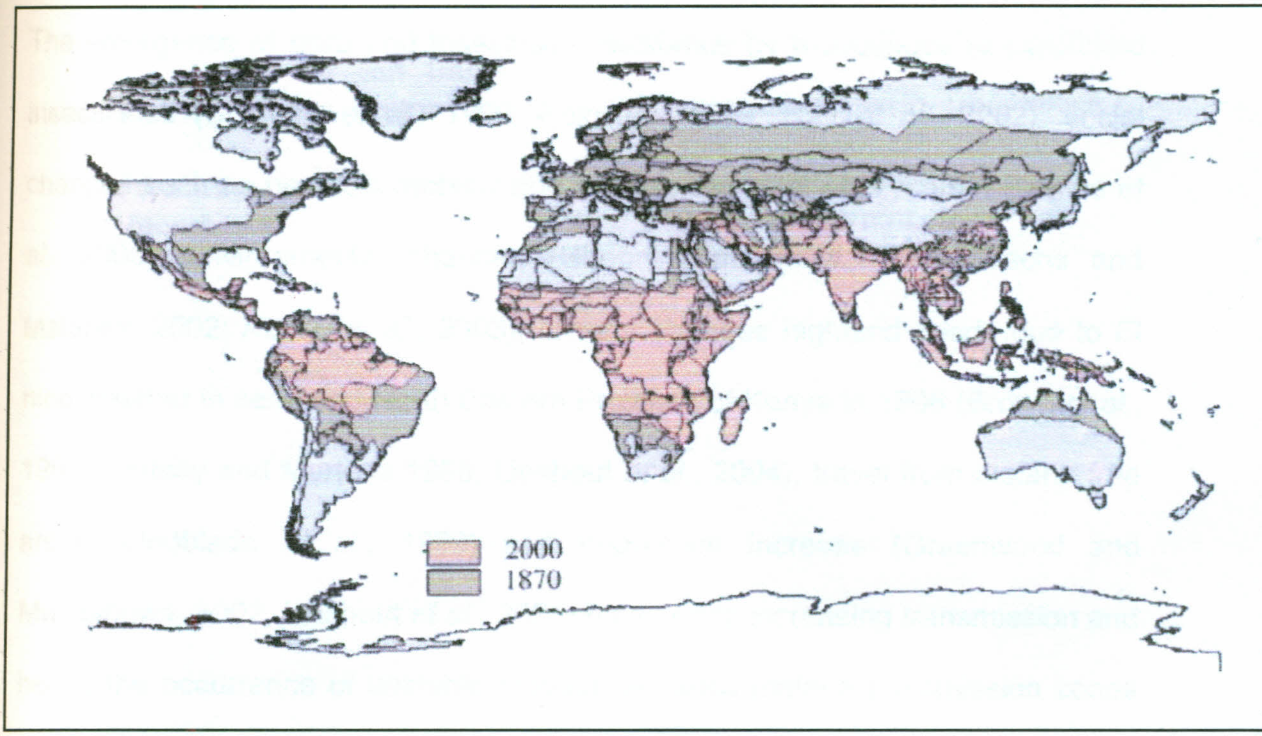


Figure 1.1.1: The current global distribution of malaria and the historical distribution

Source: WHO, 2002

The prevalence of the disease continues to increase and spread widely (Hay *et al.*, 2002). Because attempts at curtailing its the devastating effects of malaria have been punctuated with many obstacles. Although access to prompt diagnosis and adequate treatment are the basis for effective malaria control in many Sub-Saharan countries (WHO, 1993) traditional beliefs, about malaria and quality of health are major obstacles (Mwenesi *et al.,* 1995; Tanner and Vlassoff, 1998). In Kenya, malaria is a leading killer of children and adults. The number of deaths due to malaria was estimated in 2001 at 40,000 per annum (MOH, 2001).

The emergence of drug and insecticide resistance by mosquitoes to pyrethroid insecticides (Chandre *et al.,* 1999; Kokwaro, 1999; Hay *et al.*, 2002); social changes such as people's mobility due to wars etc, (Pitt *et al.*, 1998, Shanks *et al.*, 2005); environmental changes (Ghebreyesus *et al.,* 1999, Sachs and Malaney, 2002; Abeku *et al.*, 2003); climate changes highland floods due to El nino weather in semi arid North Eastern Province of Kenya in 1998 (Brown *et al.*, 1998; Lindsay and Martens 1998; Lieshout *et al.*, 2004), travel from malaria free areas (Lindblade *et al.*, 1999) and population increase (Greenwood and Mutabingwa, 2002; Lieshout *et al.,* 2004) have led to increasing transmission and hence the occurrence of unstable malaria. In Africa malaria transmission zones according to Snow *et al.,* 1999 are stable (endemic), unstable (epidemic) and unstable (non-epidemic) transmission zones, Table 1.1.

Table 1.1 Malaria transmission zones, estimated deaths and clinical malaria attacks in Africa, 1995

Malaria Transmission zone	No. of malaria Deaths	No. of clinical malaria attacks (in millions)
Stable (Endemic) malaria	987,466	207
Unstable malaria (Epidemic)	128,241	13.3
Unstable (non-epidemic) malaria	1,500	0.15
South Africa	2019	0.21359
Total	1,119,226	221.7

Source: Snow *et al.* 1999

According to ministry of health, Kenya in 2001 sub-divided the country into four malaria ecological zones; endemic (stable), highland (epidemic prone), Arid (epidemic prone), and high risk (epidemic prone) zones. Endemic zone covers Coast and Nyanza provinces and highland (epidemic prone) zone covers highlands of western Kenya. Arid (epidemic prone) zone covers North-eastern province and high risk (epidemic prone) zone covers highlands of central Kenya.

In other parts of the world the occurrence of unstable malaria (epidemic) has been reported in East Africa (De Savigny *et al.*, 2004); in Brazil, Ecuador, Guyana, Panama, India, Malawi (Pickarski, 1989); Korea (Menendez, 1985); South-America (Sherwood, 1996), Tanzania (Fogh *et al.,* 1979). In Africa, the first detected case of occurrence of unstable malaria was reported in 1979 in Kenya and Tanzania (Fogh *et al.,* 1979: Campbell *et al.*, 1979). Since 1979 the occurrence of unstable malaria has intensified and expanded to formerly rare malaria highland districts of Kenya and East Africa in general (De Savigny *et al.*, 2004 and the semi-arid North-Eastern Province (Najera *et al.*, 1998; KDHS, 1998; WHO, 2000)

The occurrence of unstable malaria manifests itself in fatal episodes of epidemic proportions after heavy long rains followed by high temperatures (>25°C) since early 1990s in the highlands (Some, 1994). Historically, Chloroquine used for a long time to be the first-line treatment drug for malaria in Kenya, although other anti-malarial drugs such as Sulfadoxine/Pyrimenthamine/ Fansidar/Metakelfin are also widely used. In 1999 however, the Government of Kenya slapped a ban on the use of chloroquine as a first-line of malaria treatment due to its impotency on the parasite, P. *falciparum.* Current efforts to treat malaria involve use of new anti-malarial drugs, new drug combinations and making better use of other available drugs. Quite a number of these drugs are dispensed in informal sources including open markets, streets or villages, parks and shops and they have been estimated to account for as much as half of the anti-malarial drugs distributed in many local distributing sources (Foster, 1978)

In recent times there has been a strong advocacy for an eclectic approach for malaria control and management. This approach involves use of drugs in the treatment, use of Insecticide Impregnated Bed Nets (ITNs), proper environmental management towards vector control and a continuous search for an effective vaccine, among other approaches (Okenu, 1999; Richie and Saul, 2002).

Kurihara (1983), Luh (1979) and Luh and Zhu (1983) have shown that innovative indigenous integration techniques in the control of mosquito pest and treatment of malaria programmes forms a more effective strategy. According to these studies it has been shown that in the early long association between man and mosquitoes, our ancestors tried various ways of protecting themselves from the nuisance caused by these pests. For instance, a mixture of *Atractylodes chinensis* with seeds of *Wistaria sinensis* and realagel (Luh 1979) would kill mosquitoes instantly when burnt in a room (Luh and Zhu 1983). The burning of certain herbs e.g. *Artemisia annua SPP* and *Calamus SPP* practised in remote parts of China banished biting mosquitoes. Kurihara (1983) has also documented records that Japanese burnt cedar leaves, dried orange-rinde and *Mugwort Artemisia SPP* to produce fumigants and evening "smudges" to drive away mosquitoes. Consequently, the need for this study is to identify and document indigenous techniques and seek ways of integrating them in the control and management of malaria in the district and other malaria prone areas of Kenya and elsewhere.

1.2 Statement of the problem

In view of the above background, it is clear that malaria has expanded from stable zones into the highland districts such as Kericho district (Shanks *et al.*, 2002; Hay *et al.*, 2005) which were formally rare malaria zones, where fatal occurrences in the form of epidemic have been reported for example in 1979, 1995, 1998 etc (GOK, 1992; Khan *et al.,* 1992; Some, 1994; Najera *et al.,* 1998; Hay *et al.*, 2002; Shanks *et al.,* 2005) and is attributed to climate changes (PEEM, 1993; Brown *et al.,* 1998; Bremen, 2001; Sachs and Malaney, 2002; Greenwood and Mutabingwa 2002, Lieshout *et al.*, 2004).

The scope of the research problem is basically concerned with investigation of the environmental components climatic changes and socio-economic that underlie the patterns and trends of occurrence of unstable malaria (highland malaria epidemic) and the specification of relations between these events and the possible causal mechanisms. These are specifically defined by the following research questions:

1.3 Research questions

i. What are the emerging patterns and trends in occurances of instable malaria burdens?

ii. What are the patterns and trends of climatic elements?

iii. What is the relationship between malaria burdens and climatic elements in the district?

iv. What is the relationship between a household's characteristics and the occurances of malaria cases (morbidity) in a household?

v. Which were malaria epidemic years in the district during the surveillance period 1988-2002?

vi. What are the strategies and programmes instituted by health providers regarding malaria control in the district?

vii. What are the local iniatiatives and technologies regarding malaria control in the district?

1.4 Research objectives

The main objective of this study was to investigate environmental determinants of patterns and trends of the occurrence of unstable malaria in Kericho district of Kenya. Based on this, the specific objectives are:

i. To analyse the spatio-temporal patterns and trends of malaria burdens and climatic elements in the district.

ii. To determine the link between occurrence of unstable malaria and the physical and socio-economic environments.

iii. To model the contribution of socio-economic environment to the contribution of ocurrence of malaria morbidity at a household level.

iv. To identify and define malaria epidemic years in Kericho district during 1988-2002.

v. To map and describe the distribution of malaria morbidity in the district.

vi. To examine methods of control of occurrence of malaria burdens the district.

vii. To investigate the local communities' knowledges and perceptions regarding malaria occurrence and its control.

viii. To analyse effectiveness of management control and preventation of malaria in the district.

ix. To assess malaria strategies and programmes and status of implementations and challenges in the district.

1.5 Research hypotheses

To guide this research the following hypotheses were formulated and tested;

i. There are no significant temporal trends discernible in occurance of malaria morbidity in Kericho district

ii. There is no significant relationship between variation in occurence of malaria burdens and change in time in Kericho district.

iii. There is no significant relationship between temporal variation in occurance of malaria burden and variation in climatic change.

iv. There is no significant relationship between temporal variation in occurance of malaria and socio-economic factors

1.6 Significance of the study

Kericho district is classified as a highland malaria epidemic prone zone (MOH, 1999) where malaria has increased by 750% over a 13 year period, 1986-1998 (Shanks *et al.*, 2005) justifies the choice of the district as a study area regarding malaria.

The first significance of this research is its part as a nationwide campaign to control, eradicate and manage malaria in Kenya where it has expanded into formerly rare malaria highlands (Githeko, 1998; WHO, 1994; Snow *et al.*, 1999; Sachs and Malaney, 2002; Hay *et al.*, 2002). In 1998, WHO identified malaria as a key priority and launched the "Roll Back Malaria" Campaign aimed at the reduction of global malaria burden, initial emphasis being on high transmission areas of Africa.

The Kenya Government, through the Ministry of health (MOH, 1999) rates malaria as one of the high priority health and clinical packages, as expressed in National Health Sector Strategic Plan 1999-2004 (MOH, 1999; NMCS, 2001-2010). The main objectives of the plan was to reduce malaria morbidity and mortality by 30% as at the planned period by 2001-2010.

This study contributes knowledge of the socio-economic and physical environments that underlie the occurrence of patterns and trends of occurrence malaria burdens.

To reduce malaria burden, investigation of its patterns, trends and control from the socio-economic perspective will help efforts by the Kenya Government to reduce foreign exchange spending on purchase of anti-malarial drugs thereby promoting economic productivity, benefits and efficiency.

From this study, local innovations, beliefs and knowledge of malaria control can be incorporated into educational programmes in the district as examined because the algorithm documented and hence further research on these methods can be undertaken.

The present study is a contribution to the data base documentation for further research on malaria epidemic and general referral document for health care providers, health development programmes and the community at large.

1.7 Scope and limitation of the study

This study concentrates on occurrence of unstable malaria in Kericho district of Kenya covering an area of 2110.6 km² and falls in an epidemic malaria (unstable) prone zone (MOH, 2001; Sachs and Malaney, 2003; Shanks *et al.*, 2005). The study sites constituted four Agro-ecological zones (AEZs) loosely represented by the divisions where all populations in sampled households formed non-aetiological study target regarding malaria cases and households' characteristics and methods of control of occurrence of malaria in the households.

The study has addressed the non-aetiological issue of the principal environmental factors that determine the patterns and trends of occurrence of unstable malaria. The Patterns and Trends of occurrence of malaria burdens, anti-malaria use patterns at household level, patterns and types of anti-malaria drug distributing outlets, individual households, perceptions/beliefs and knowledge, and the district's malaria control and management programmes regarding occurrence of unstable malaria, has been addressed. However, the limitation of the study included the following:

i. Inadequacy and inaccuracy of unstable malaria morbidity and mortality data at household level
ii. Non-reporting of malaria incidences by households at the district heath facilities
iii. Non-reporting of malaria morbidity and mortality incidences by District Hospital or health centres to the Health Information Systems (HIS) during 1999-2005
iv. Lack of accurate information on anti-malaria drug use and malaria medical costs
v. Lack of sufficient climatic data in all divisions/agro-ecological zones during the surveillance period, 1988-2005.

1.8 Definition and detection of unstable or malaria epidemic

The definition, detection and control of unstable or epidemic malaria is increasingly attracting many researchers both locally and internationally. This is because epidemic malaria is on an increasing trend in tropical and sub-tropical countries, particularly in Africa where *P. falciparum* malaria is most extensive and prevalent (WHO, 2001; Sachs *et al.*, 2002) and a leading health and economic burden particularly in SSA (Goodman *et al.*, 2000)

Epidemic malaria is a term applied to describe *P. falciparum* transmission characteristics of Highlands of East Africa and the Horn of Africa (Shanks *et al.*, 2000). Though epidemic malaria has not been clearly and neatly defined, for example MacDonald (1957) defines epidemic malaria as an acute exacerbation of the disease out of proportion to the normal to which the community is subjected, and epidemics are common in zones of unstable malaria where very slight modification in any of the transmission factors may completely upset equilibrium and where the restraining influence of immunity may be negligible or absent and may therefore show a very marked geographical distribution.

The term "epidemic" is used to refer to occurance of malaria in Kenya highlands often the term is used to refer to occurrence of malaria in excess of normal (Hay *et al.*, 2002). The highlands of Kenya are defined as zones at altitude > 1600m Asl and are characterized as highland/epidemic prone zones (Garnham, 1945, 1948; Lindsay and Martens 1998; Hay *et al.*, 2002; NMCS 2001-2010).

Epidemic malaria is not only confined to highland zones but also in arid areas, e.g, North Eastern Province of Kenya where epidemic malaria occurred in 1998 during the 1997/1998 El Nino weather (Najera *et al.*, 1998). Generally, in other parts of Africa it occurs at the fringes of endemic areas mostly in arid regions of north Africa and the highlands of East Africa and the Horn of Africa (Hay *et al.*, 2001; Hay *et al.*, 2002). These are areas of unstable malaria transmission and thus unstable malaria occurrence.

In the western highlands of Kenya where Kericho district (1600-3000m Asl) is located occurrence of unstable malaria is assuming a seasonal incident of occurrence (Hay *et al.*, 2002). The government of Kenya through MOH (2001) has classified 15 districts in western Kenya as prone to malaria epidemic. These highland (>1600m Asl) districts include: Narok, Bomet, Kisii, Nyamira, Gucha, Trans Mara, Trans Nzoia, Uasin Gishu, Nandi, Kakamega, Vihiga, West Pokot and Kericho district. Eastern highland districts include Kiambu, Kirinyaga, Nyandarua, Murang'a, Thika, Maragua, Nyeri, Meru central, Nyambene and Nithi. In the Semi-arid North Eastern province: Wajir, Mandera, Isiolo and Tana river districts are also included in epidemic malaria prone zones of Kenya and have experienced severe malaria epidemic in 1997/98 following the heavy rainfall due to the El Nino event. The Samburu and Turkana districts in the North rift valley province are also included in the epidemic malaria prone zones of the country (NMCS, 2001-2010).

Kericho district is regarded as a formally malaria free zone e.g. during the period 1960-1980 (Shanks *et al.*, 2002; Hay *et al.*, 2003) and local malaria transmission was non-existent in the 19th century (Matson, 1957) and between 1960 and 1980.

Peoples' mobility due to economic activity particularly after the completion of the Uganda railway in 1901 which opened up activities such as colonial military posts the Kericho town, played a major role in the introduction and transmission of malaria in Kericho district, also after the first world war in 1918, malaria epidemic occurred in the district in 1919 due to returning local African soldiers who had been recruited to fight against the Germans in Tanganyika (Matson, 1957

The economic development e.g. the start of tea growing in 1918 in the district, movement of immune resistant people from malaria endemic Lake victoria region into the district played a major role in the transmission of malaria (Chataway, 1929; Shanks *et al.*, 2002). Consequently, malaria epidemic occurred in the district in 1928 when 1727 cases were recorded (Matson, 1957). Other malaria epidemics occurred in the district in 1931, 1932, 1934, 1937 and 1940 (Roberts, 1964). In 1939-1948 malaria epidemic in the district was a major health problem due to the returning African soldiers after the Second World War in 1945.

To detect malaria epidemic particularly in SSA which has limited resources to manage epidemics, WHO (2001) advocates the use of the methods: Simple Incidence Threshold (SIT), Disease Time Series (DTS), WHO Quartile (WQ) and Cumulative Sum (C-Sum) methods. In this study disease time series method proposed by Cullen (1984) was used identify malaria epidemic years in Kericho district during the surveillance period 1988-2002.

In this method the points in a disease time series outside 95% confidence intervals of a normal distribution are determined from the history of cases at a location. The Cullen's (1984) method uses the previous five years of data (epidemic years are arbitrarily excluded) to construct alert threshold (AT) for each month and computed as means plus 1.96 times standard deviation and this admission profile for an average year. The Alert Threshold (AT) for each month is then determined as the mean plus 1.96 times the standard deviation should capture 95% of the cases in a normally distributed data (Kirkwood, 1988). The DTS method has been used successfully in Thailand in the 1980s by Cullen (1984) to study cases of *P. Vivax* malaria. Albonico, *et al*, (1999) also used DTS method in the control of epidemic malaria in the highlands of Madagascar.

1.9 Conceptual framework

The occurrence of unstable (epidemic) malaria continues to cause theoretical and practical concern to a wide range of researchers, policy makers and health providers in both developing and developed countries of the world. The main focus of the disease is the study of underlying attributes to its occurrence transmission mechanism and strategies to prevent and control its occurrence particularly the emergence of the resistance phenomenon of malaria parasites.

A wide range of research on malaria in general exists but little research work on malaria epidemic related to anti-malaria drug resistance by malaria parasites, continue to grow and most known anti-malaria drugs no longer offer complete cure of the disease.

The emergence of malaria epidemic is attracting the attention of scientists of diverse disciplines, such as malarialogy, natural sciences, environmental sciences, statistical epidemiology, demography, economics, etc. They all aim at better understanding of the disease being the outcome of complex interrelation between the environment, the vector, and the host. This study conceptualize that the occurrence of malaria burdens is determined by the changes in climatic and socio-economic environments in a community

The better understanding of the attribute of malaria epidemic is the basis for laying a conceptual framework for its control in particular incorporating local initiative and knowledges of communities to supplement the combined therapic approaches to control its occurrence. This section presents a review of theoretical and conceptual issues in the research on malaria in Kenya and worldwide. The conceptuall framework is built around the following assumptions and hence the Basic Impact Model (BIM), Figure 1.9;

i. Climatic variation impacts and determines occurrence and transmission of unstable malaria in an Agro-ecological zone (AEZ).
ii. Household behavioural characteristics have an impact of climate variation and determine the patterns, control and transmission of unstable malaria.

Climatic Variation: The basic impact model, Kates (1985)

The Basic Impact Model (BIM) consists of three elements; climatic variation, climatic effects on human population activity, region or nation and causes impacts through population activity. Interaction model (Kates, 1985) recognizes impacts as joint products of interaction between climate and society. The impact models can be grouped into three categories; ordered impacts, multiple impacts and anthropogenic climatic impacts (Kates, 1985). These models assume direct cause effect in climate events: exposure units and impacts or consequences. Atmospheric climate events are climatic systems (Hare, 1985). This study uses temperature, humidity and rainfall as a set of atmospheric states. Agro-ecologic zones, human population and climatic events are seen to interact and produce A. mosquito and malaria parasite characteristics that cause malaria in humans and hence occurrence of malaria as evidenced by morbidity, mortality, anaemia, still birth and abortion due to the disease.

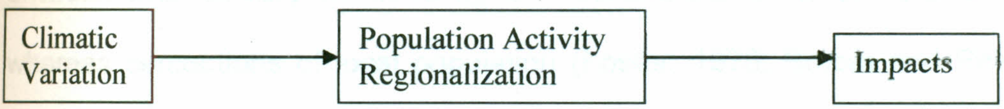


Figure 1.9: The basic impact model

Source: Kates, 1985

Human behavioural patterns and control of occurrence of malaria

Behavioural theory was developed in the 1960s (Knowles and Wareing, 1980) to explain and account for human behaviour focusing on observed patterns of behaviour such as ways of environmental preferences, evaluations and decisions effect on land use and location. On the other hand, the bio-behavioural interaction disease model focuses on disease ecology and related control programmes in a locality.

The conceptual concerns of research regarding the occurrence of unstable malaria is firstly to account and explain the patterns and trends of environmental factors that determine the occurrence of unstable malaria and secondly, determine the impact of malaria burdens on an individual, household members and community in general. Knowing the patterns and trends of environmental factors that are attributed to the occurrence of unstable malaria would enable control measures of its occurrence can be suggested so as to improve human health and thus enhance productivity and efficiency.

May (1958) conceptualized how human behaviour; social and physical environments co-vary in affecting the occurrence of a disease in humans whereas perceptions of local population (Foster, 1978; Broom and Reid, 1984) are important factors in local disease control. The environmental perception is a process by which an individual, by receiving stimuli from his/her environment through his/her senses which are filtered through his/her reason and emotions resulting in different individual humans responding differently to images or mental pictures of their environment. In turn these images form the basis of a mental model of their behaviour to their environment and, consequently, evolution of different cultures and beliefs which have influence on environmental perception (Knowles and Wareing, 1980). Different cultures produce different socio-economic, ecologic and environmental transformation such as agriculture and settlements, among others, affect the prevalence and control of occurrence of a disease such as malaria (Mwabu and Wanyoike, 1985; PEEM, 1983; Mwabu, 1991)

The bio-behavioural interaction model will be used to contextualize the occurrence of unstable malaria which has defied sophisticated technological, prophylaxis and chemotherapic control, (Campbell *et al.*, 1979; PEEM, 1993; Sherwood and Mutabingwa, 2000; Sachs and Malaney, 2002)

Figure 1.9.1 shows a conceptual framework for analyzing relationship between income and malaria prevalence economic transformation. The pre-conditioning factors of social, economic and physical environment (PRE) include socio-economic structure of any country (Herrin and Rosenfield, 1986), individual household and community characteristics; beliefs, attitudes and preferences. Household characteristics include age-sex composition, human capital-including land, working capital and housing. Community factors include physical environment, commodity structure, market, population size, structure and organization of physical and health infrastructure. All these factors determine the quality and quantity of non-health inputs. Furthermore, they determine the negative spillover effect dimension (PRD) i.e. Proximate Determinants of Health refers to Health Outputs (HEO), Non-Health Output (NHO) and Negative Spillover effects (NES).

The vectors of malaria are examples of NES and PRD and are behaviourally determined by preconditioning factors such as an individual choice to an exposure risk of malarial environment.

Transformation of Intermediate Outputs (TIO) refers to HEO, NHO and NES transformation into socio-economic outcomes (SEC) which includes incomes, savings, physical and human capital additional production of market and non-market goods, social interactions and health consumption.

The NES is perceived as an undesirable output of the interaction between PRE and PRD. An example of NES is the malaria vectors induced by an irrigation scheme or dam project construction. Managing effects of NES, e.g, morbidity and mortality due to malaria is dependent on the savings of the community, income and behavioural pattern of the community in relation to exposure to malaria.
The social welfare (SWE) of a population is assumed to depend directly on elements which constitute socio-economic outcomes (SEC).

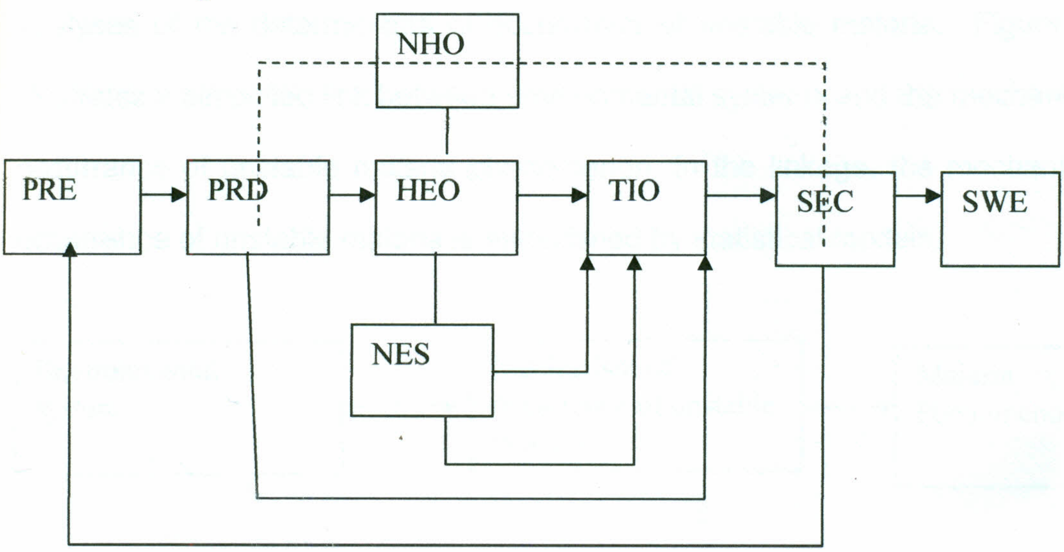


Figure 1.9.1: A conceptual framework for analyzing relationship between income and malaria prevalence at different states of economic transformation

Source: Adopted from Herrin and Rosenfield, 1986

In Figure 1.9.9 above the abbreviations indicated as specified as:

PRE - Preconditioning factors of social economic and physical environment.

PRD - Proximate determinants of health outputs non-health outputs and negative spillover effects.

HEO - Health outputs

NHO - Non-Health outputs

NES - Negative spillover effects

TIO - Transformation of intermediate output into social and economic outcomes

SEC - Social and economic outcomes

SWE - Social welfare of the population

From the above models and behavioural theory the researcher has developed conceptual and operational models, Figures 1.9.1 and 1.9.2 respectively for the analyses of the determinants of occurrence of unstable malaria. Figure 1.9.1 illustrates a simplified link between environmental systems and the mechanism of occurrence of unstable malaria phenomenon. In the linkage, the mechanism of occurrence of unstable malaria is established by statistical models.

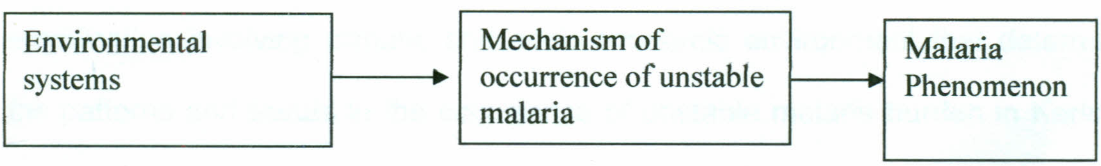


Figure 1.9.2: A simple model linking environmental systems mechanism of malaria occurrence and malaria phenomenon

Source: Author, 2007

Figure 1.9.2 shows operational model and summarizes the complex relationship between the occurrence of unstable malaria and environmental determinants. The occurrence of unstable malaria can be viewed as a complex function of the eco-system which consists of socio-economic and physical environments as displayed in Figure 1.9.3.

The complex functional link between the above environments determine the result of the occurrence of unstable malaria. Though the extreme delineation of boundary of each component may not be determined precisely, their ranges can be estimated and furthermore each component can be considered as a system in the entire eco-system.

This research considers occurrence of unstable malaria expressed by morbidity and mortality rates, prevalence and endemicity, to be influenced by socio-econimic, physical environments, health care system and mosquito type.

May (1958), broad concepts approach of determining the dynamic co variation in human behaviour and physical environments was adopted in this study with modification involving climatic and socio-economic environment that determine the patterns and trends in the occurrence of unstable malaria burden in Kericho district of Kenya.

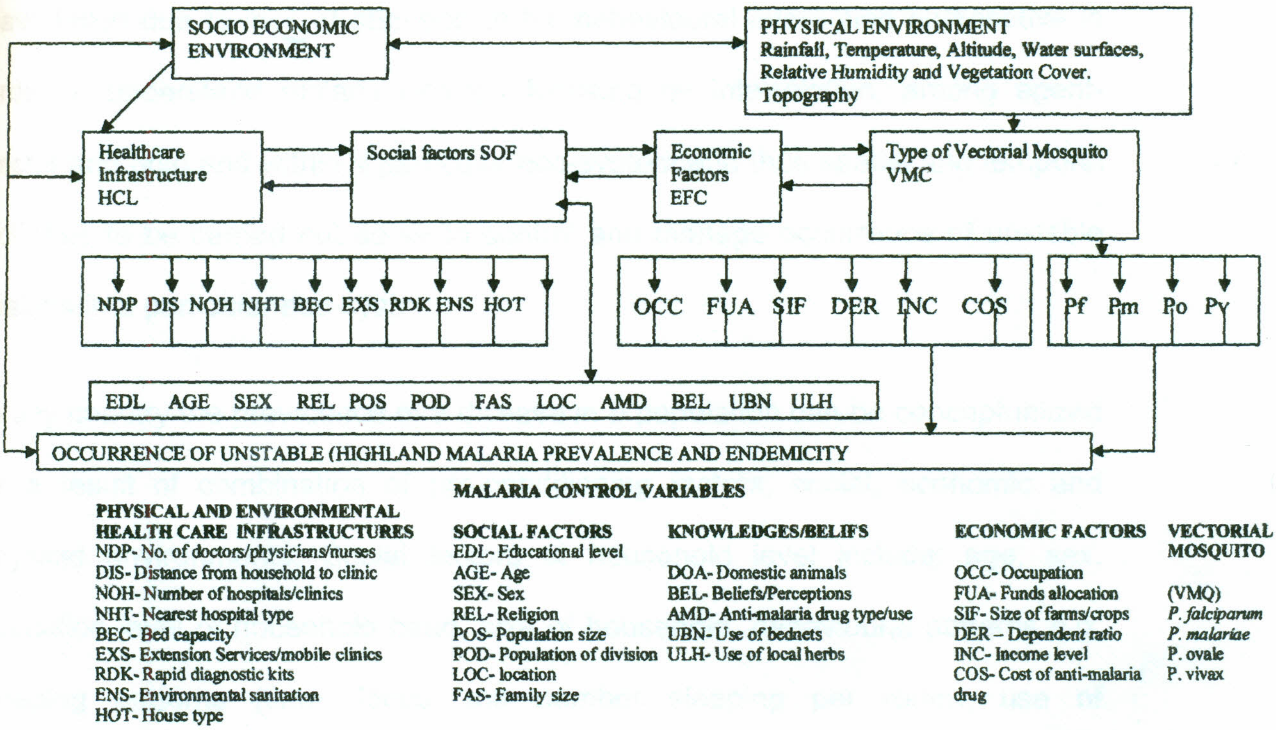


Figure 1.9.3: Operational model for analyzing environmental determinants of occurrence of unstable malaria and its control

Source: Author, 2007

The occurrence of unstable malaria can be understood from the perspective of the eco-systems behaviour involving interdependence of its different components. In this system, dynamic changes in the inputs influence the system's behaviour and the spatial and temporal relationship the outcome of the environment which determines the occurrence of unstable malaria. The magnitude of occurrence of unstable malaria is influenced by the government, non-governmental organizations, health care providers and community participation. Etkin (1991) has shown that many malaria control programmes have failed due to lack of attention to bio-behavioural interaction perspective in order to understand malaria ecology focusing on interrelation, among agent-vector and host and within a particular eco-system and thus spatial and temporal activities to be carried out so as to control and manage occurrence of unstable malaria in a particular eco-system.

In any country the prevalence of a disease in a population can be conceptualized as a result of combination of pre-conditioning factors; social, economic and physical environments. Social factors at household level include: age, sex, education level of household head, size of household, behavioural patterns e.g. sleeping patterns (time, locus, the number sleeping per room), use of impregnated bed nets, beliefs/knowledges, clothes and blankets. The social organization e.g. gender, sex status in social organization of household vary among human communities e.g. clothing pattern and risk patterns such as mobility inspired by religious or occupation may affect malaria transmission thus occurrence of unstable malaria.

Education achievement of a household broadens an individual's perception of improving quality of life leading to a desire for better housing, for example by appreciating and recognizing the need for better hygiene and also broadening of ones access to income generation.

Beliefs and people's perceptions about a disease influence the treatment and prevention of a disease (Mwenesi *et al.*, 1995; Tanner and Vlassoff, 1998). Economic factors include; income, savings, occupation, farm size, crops grown domestic animals (proximity, type and their numbers). The economic factor such as income measured in terms of money is needed by a household to pay for education cost, construction of a house, transport (access to a health facility), hiring of labour, and purchase of anti-malaria drugs and impregnated bed nets, among others.

The physical environmental factors include house type structure, vegetation, swamps, water-surfaces surrounding the household, rainfall, temperature, humidity, access to a health centre (communication/distance to the lowest cost-health facility), etc. The house type and vegetation determine the suitability of A. Mosquitoes, hiding and resting sites. Water surfaces offer breeding sites for mosquitoes whereas climatic factors (rainfall, temperature regimes and humidity) affect the geographic distribution and abundance of A. Mosquitoes, and thus the transmission and hence the occurrence of unstable malaria (Githeko et al, 2000; Brown *et al.*, 1998; Bremen, 2001; Sachs and Malaney, 2002).

Economic Activities

Due to favourable climate; good rainfall regime between 1150mm and 1400mm annually, and distribution in relation to potential evaporation rates of between 100mm and 150mm monthly rainfall and air temperature minimum of 13°C-14°C with optimum range between 18°C and 30°C and the soil mean temperature of

20ºC monthly, fertile soils and the topography and human population factor, agriculture and livestock keeping and forestry are the most important economic activities in the district. The cash crops grown include tea in Belgut, Ainamoi, Sigowet and pyrethrum in Kipkelion and Londiani divisions. Tea is grown by small-scale farmers and in large plantations; flower culture production are common.

Since tea production is a labour intensive and is a continuous activity throughout the year, both abundant unskilled and skilled labour force is constantly required, the latter is readily available from the neighbouring districts thus a constant inter districts migration/mobility of people which influence transmission of malaria in the district.

The food crops grown in the district include maize, potatoes, beans and vegetables. These crops are widely grown in all parts of the district for local consumption and for sale to other districts of the country. Livestock keeping is another important economic activity in the district, where goats, sheep and cattle are kept.

The forest products contribute significantly to the district's income through sales of timber for construction works and also as fuel apart from their role in prevention of soil erosion, medicinal use as well as their beauty value.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses malaria transmission modes and ecology, diagnosis, symptoms and manifestation, the state of research on the occurrence of malaria burden and specifically in the world, in Africa, Sub-Saharan Africa (SSA) and in Kericho district of Kenya. The patterns and trends underlying climate and socio-economic environments of its occurrences impacts and control of its occurrence are reviewed as follows:

Malaria transmission modes, host, vector and ecology

Malaria transmission is expressed by incidence and prevalence rates of infection which quantifies morbidity rate (Anderson and May, 1992) and mortality rates and are core indicators of prevalence and endemicity of occurrence of malaria.

The *Plasmodia (P)* is transmitted to a female mosquito from an infected human host during its blood meal intake. The *Plasmodia* once in a female mosquito is a sexual phase of development whereas multiplication of *Plasmodia* in human host is asexual phase of development (Singer, 1990).
The genus *A. gambiae* complex species of female A. mosquito is the most predominant in SSA (Goodman *et al.*, 2000; Akhwale *et al.*, 2004) and is the main agent of malaria parasite transmission (Greenwood and Mutabingwa, 2002). The unstable malaria manifestation include severe *P. falciparum,* high

fevers, headaches, vomiting, anaemia, abortion, still birth and death in non-immune susceptibles (McGregor, 1987; Shililu, 1998; Sachs and Malaney, 2002).

Methods of diagnosis of the presence of malaria parasites, symptoms and manifestation of malaria

The clinical and microscopic methods have been widely used as the methods for the diagnosis of the presence of malaria. Clinical method mostly used in rural malaria endemic areas (where malaria is considered a normal occurrence) and where laboratory facilities are non-existent uses clinical signs and symptoms which are associated with malaria fever, often accompanied by chills, sweating, anorexia, headaches, vomiting and general malaise for uncomplicated malaria, the manifestations such as drowsiness with prostration together with severe manifestations such severe anaemia, celebral malaria, still birth, abortion etc. The symptoms of malaria include fever, chills, headaches and muscle aches, develop 6-8 days after being bitten by infected female A. mosquito or as late as several months after departure from malarious area (WHO, 1998, Allan, et al., 1998) and can kill infected humans within 72 hours if not correctly diagnosed and treated. The clinical approach is quite cheap to perform e.g. it does not require laboratory or skilled personnel if confined to malaria endemic areas but unfortunately symptoms of malaria resemble those of other febrile illnesses (WHO, 2000).

Details of use and advantages of both microscopic method and rapid diagnostic tests (RDTS) are discussed in Payne (1988) and WHO (1998). The distribution of these equipment in Kericho district health facilities was assessed so as to evaluate efficiency of diagnosis of malaria in the district.

Global distribution of malaria transmission

Based on the levels of malaria transmission high intense, moderate, low and sporadic transmission zones can be distinguished (WHO, 2000) and different classifications have been used to describe and display world's malaria transmission patterns as; stable (endemic) malaria and unstable (epidemic) malaria (Snow *et al.*, 1999, WHO, 2000).

Stable malaria transimission zones imply that malaria is endemic and occurs every year and seasonal variation in transmission intensity exist depending on climatic conditions (Goodman *et al.*, 2000; WHO, 2001; Sachs and Malaney, 2002; Lieshout *et al.*, 2004).

According to Barendregt *et al.*, (1996) the malaria transmission patterns in Sub-saharan Africa (SSA) is classified as, intense, stable and perennial. Details of global statistics and distribution of malaria transmission zones generalized as; high, moderate, low and epidemic malaria transmission zones are fully discussed in WHO (1998) and WHO (2000). However malaria transmission zones and occurances of malaria epidemic in kenya is discussed as follows:

Malaria Transmission Zones and Malaria Burdens in Kenya

The distribution and characteristics of malaria transmission zones (i) stable (Hyper-Endemic Zone), (ii) stable (Holo-Endemic zone) and unstable (Epidemic

Zones) based on malaria intensity are contained in the works of; Masinde and Krogstad, 1994; McElroy *et al.,* (1994), Shililu (1998), Malakooti et al., (1998) and Shanks *et al.,* (2005). ,

Generally malaria, in Kenya is the leading killer of children and adults and constitutes a major health and economic problem. MOH (2002-2010) contributing to a loss of 170 million working days per annum due to disease and thus a major contributor of poverty in the country.

Furthermore, MOH (2001) reported that about 1600 expectant women are likely to develop severe anaemia and another 2500 are likely to deliver Low Birth Weight (LBW) due to malaria and the number of deaths per annum due to the disease was estimated at 40,000 children i.e. 70-90 children deaths daily due to malaria. This is a big concern to the government of Kenya and other health stakeholders.

Occurrence of unstable or epidemic malaria in Kenya

The first cases of occurrence of unstable malaria or malaria epidemic in Kenya attributed to chloroquine resistance by the malaria parasites and was first reported in 1992 in East African countries (Kenya and Tanzania) by Khan *et al.,* 1979; Fogh *et al.*, 1979; Campbell *et al.,* 1979), and since then it has spread to many highland districts and is blamed on combined anti-malaria drug resistance, socio-economic and environmental changes (Githeko, 1998; Kokwaro, 1999; Shanks *et al.*, 2005).

In Kenya, the unstable malaria transmission zone lies in the Kenya highlands at an altitude of 1700-2800m Asl and in the arid and semi-arid areas of the country (Garnham, 1945; Garnham, 1948; Lindsay and Martens, 1998; Hay *et al.*, 2002). The occurrence of unstable (highland) malaria has been reported in these areas in recent years; in Uasin Gishu in 1990 (Some, 1994), Trans-Nzoia, Kakamega, Kiambu and Nyandarua districts in 1989, 1992, 1995 (GOK, 1989; Khan *et al.*, 1992) and in Kericho, Bomet and Bureti districts in 1995, (GOK, 1995; KDDP, 1997-2001); Trans Mara, Gucha, Kisii districts in 1996, 1997, 1998, (Hay *et al.*, 2002; Allan, 1998; Akhwale *et al.*, 2004) and in semi-arid North eastern province in 1998 (Najera *et al.*, 1998). These areas were formerly rare malaria zones and free of malaria infections (Some, 1994).

Heavy monthly rainfall (>150mm) followed by high monthly temperatures (>20°C-30°C) create suitable sites for the abundance of A. mosquitoes (Shanks *et al.*, 2002), Further communities in these areas have little acquired immunity and all age groups of the population are affected by the lethal *P. falciparum* which is most predominant in these areas and have developed resistance to chloroquine and most anti-malaria drugs (Campbell *et al.,* 1989; Peters, 1990; KDHS, 1998; Kokwaro; 1999; WHO, 2001; Lieshout *et al.*, 2004).

The relationship between anti-malaria drug resistance by the malaria parasites, socio-economic and environmental changes contributing to the upsurge in the occurrence of unstable malaria in the diverse highlands has hardly been understood (Goodman *et al.,* 2000; Lieshout *et al.*, 2004) and thus the need investigate patterns and trends of environmental determinants of its occcurrance so as to provide frameworks for the disease control.

2.2 The underlying socio-economic factor as determinant factor in occurrence of unstable malaria

The relationship between occurrence of unstable malaria and socio-economic environment has drawn interest to a number of researchers worldwide. The social environment includes social human behavioural patterns such as; cultures, perceptions/beliefs, knowledges about malaria, and its prevention and control. The economic environmental factor influences the prevention and control of occurrence of malaria and can decrease or increase its transmission.

Few studies exist that relate economic development of a country/region and the occurrence and transmission of malaria (Mwabu, 1991) and hardly any research has been undertaken to relate economic characteristics of a households and the occurrence of malaria.

May (1958) generalizes that all major killer diseases are associated with socio-economic status of a community. Whether or not such a generalization can hold for what we have referred to as a subtle combination of social economic and cultural characteristics is yet to be verified.

May (1958) studied the behavioural patterns of communities in relation to the presence of a disease and he concluded that social behaviour of humans together with physical environments affect the presence of a disease in a community. In other studies by Ross (1978), Curtin (1989), Barlow (1991) and Etkin (1991) on the behavioural patterns of humans in relation to occurrence of malaria, it is established that the behavioural social patterns such as age, gender, health status , proximity to domestic animals (type and number), sleeping patterns (time, locus, use of nets, blankets, number of persons per room), daily activities, religion, mobility, etc, affect the transmission of malaria in a household/community.

2.3 The relationship between social changes, economic level and malaria burdens

Greenwood and Mutabingwa (2002) and Shanks *et al.* (2005) reported that in Africa social (wars and civil disturbance, travel and population increase) and economic factors have led to an increase in malaria transmission and hence malaria burdens in SSA. Wars have led to the problem of malaria transmission in refugee population, just as migration from malaria free areas to malaria endemic areas for work. However, Lieshout *et al.*, (2004) contend that relation between socio-economic and malaria is not neatly defined at global level and no suitable indicator for socio-economic development constrains global statistical analysis, hence the need to attempt such analysis at district level.

Miller *et al.* (1994) concluded that malaria mortality in Africa remains high because of poverty in the region and hence limited access to treatment. Sachs and Malaney (2002) studied the relationship between poverty and malaria and concluded that there exists a strong correlation between the disease and poverty in SSA; a comparison of income in malarious and non-malarious countries in 1995 indicated that the average GDP (adjusted to give parity of purchasing power) in malarious countries was USA 62 dollars, compared with USA dollars 8,268 in countries without intensive malaria (Gallup and Sachs, 2001).

Sachs and Malaney (2002) studied global distribution as per capita income and malaria transmission and found a strong correlation between poverty in SSA and malaria transmission. Poverty promotes malaria transmission which limits economic growth which is mostly related to climatic condition in much of SSA.

Mwabu (1991) studied total cultivated acreage of cassava to total family size and total number of malaria cases over a period of 3 months involving a typical Kenya setting and they found out that malaria had no statistical significance effect on cassava production or the acreage cultivated.

Shanks *et al.* (2005) studied malaria in Kericho district, tea estates study sites and they found that malaria reemerged in the 1980s and that the renewed epidemic malaria coincided with the emergence of chloroquine resistant *P. falciparum.* The same study also identified meteorological changes, population movements, degradation of health services and changes in A. mosquitoe-vector populations have contributed to the reemergence of malaria in the district and specifically chloroquine resistance has led to the increase of highland malaria resulting to increase in death rates of hospitalized malaria patients in the tea plantations in the district since 1990. Other studies relating malaria epidemic to temperature and rainfall influences on increase of malaria include works of Shanks *et al*., (2002); Hay *et al*., (2002) and Hay(2000). However there has been no significant changes in trends regarding rainfall and temperature in trends in the Kenya highlands (Thomas, 2004; Small *et al*., 2003; Zhou et al., 2005). For this reason other environmental determinants need to be investigated to link it to the increase in malaria burdens in Kericho district.

2.4 Cultures/perceptions and knowledges as determinant factors in occurrence of unstable malaria.

The perceptions of local populations (Foster, 1978; Broom and Reid 1984) are important factors in a local disease prevention and treatment and hence the occurrence of a disease, has been given emphasis, e.g, by WHO (1978) regarding equitable distribution, preventions and application of appropriate technology.

The people's cultures/perceptions and knowledges regarding occurrence of diseases such as unstable malaria vary in different human societies worldwide. Regarding people's change of perceptions, Onadeko *et al.,* (1986) have argued that young people are known to be amenable to instructions and change, but it is extremely difficult to change perceptions of older people whose ideas about issues are already fixed.

On issues of diseases, Foster (1978) and Broom and Reid (1984) concluded that patterns of people's perceptions are important factors in local disease prevention and treatment and specifically on malaria issue. Mwenesi *et al.,* (1995); and Tanner and Vlassoff (1998) contented that the majority of malaria episodes among African countries is influenced by traditional beliefs about occurrence and treatment of the disease. The beliefs can influence treatment hence transmission and control of its occurrence.

The control and management of occurrence of malaria in many countries of Africa has failed because of socio-cultural variables this is because firstly different individuals perceive their environment differently (Knowles and Wareing 1980) and secondly because bio-behavioural interaction model is not addressed (Etkin, 1991) and Gilbert (1989) has shown the influence of environmental perception by socio-economic, cultural, political and social characteristics of an individual and thus the control of the dieseae be addressed. Luh (1979), Lhu and Zhu (1983) and Kurihara (1983) have demonstrated that indigenous knowledges and innovation techniques in control of mosquito pests and treatment of malaria are effective control strategies.

The Chinese herb *Antemisia annua* also known as ginghao in China has been used for treatment of malaria in China for many years, and has active component artemisin or ginghosu in Chinese which has been isolated and classified by Chinese scientists and demonstrated its safety and effectiveness in clearing parasitaemia and malaria related manifestations (WHO, 1993; Rugemalila *et al*., 2000). The local indigenous innovations and anti-malaria herbs in Kericho district have not been documented.

2.5 The underlying physical environmental changes as determinant factor in occurrence of unstable malaria

Physical environmental changes such as temperature, rainfall, relative humidity, altitude, topography of the land, water surfaces and vegetation affect the transmission of malaria and rainfall changes and water bodies attribute to the relative abundance of A. mosquitoes e.g. *A. funestus* which breed in water bodies with a large shading cover whereas A. *gambiae* breed in open sunlit water bodies (Malima, 1999).

Giles *et al.* (1993); WHO (1998); Gallup and Sachs (2001); Lieshout *et al*., (2004) have studied the relationship between temperature, malaria parasites development and malaria transmission and have demonstrated that malaria parasites are transmitted to a female *A.* Mosquito from an infected human host during its blood meal intake. Within a female Mosquito, the malaria parasites must undergo a life-cycle change before being infectious. The period change the malaria parasites undergo between the blood meal intake by the A. Mosquito through a life cycle and being infectious increases as the ambient temperature (17-34°C) declines.

Lieshout *et al.*, (2004) have shown that the distribution and seasonal transmission of malaria is affected by climate because both vector and parasite are sensitive to temperature and rainfall. Lindsay and Berley (1966) content that a rise in temperature from 19ºC to 21ºC shortens the genotrophic cycle of A. mosquitoes from 4 to 3 days and increases the vectorial capacity of the mosquito. Nega (1989) studied the influence of temperature factor in transmission and hence occurrence of malaria in Ethiopian highlands lying at altitude of 1500-2000m Asl and mean monthly temperature of 20ºC. He established that malaria endemicity under these conditions is low and unstable and malaria occurs as an epidemic with high mortality rates due to lack of communal immunity.

Githeko and Ndegwa (2001) studied the occurrence of malaria in the highlands (above 1300m, Asl) of Kenya and concluded that temperature regimes above 16.8ºC has led to the upsurge of unstable malaria in the Kenya highland districts.

Giles *et al.* (1993), Bremen, (2001) and Sachs and Malaney (2002) have demonstrated and concluded that rainfall and relative humidity are predominant factors that explain the geographical distribution of malaria. Rainfall causes the presence of stagnant water which under hot conditions (20-30ºC) are favourable breeding environments for A. mosquitoes and vectorial capacity (Lyimo *et al.*,1991; PEEM, 1993; Craig *et al.*,1999; MARA, 1999; Lieshout *et al.*,2004).

Najera *et al.,* (1998) reported that the high rainfall due to El Nino weather of 1997/98 in Semi-Arid North Eastern Province of Kenya caused the outbreak of fatal malaria epidemic in that area.

Nega (1991) studied some characteristics of malaria transmission in Ethiopia and concluded that malaria epidemic depends mainly on rainfall regime in the range of 400-2400mm per annum and mean temperature of 20°C monthly so that in such areas malaria endemicity is low and unstable. He also concluded that in lowlands below 1500m Asl. where humidity is high, 70-80%, mean temperatures of 20-30°C and rainfall ranging between 100-900mm annually, malaria is endemic and its transmission is highly seasonal.

Environmental changes such as clearing of forests for agricultural use, dam construction, irrigation projects, floods as associated with El Nino weather e.g. in Kenya in 1997/98 are associated with increased malaria transmission is supported by Malakooti *et al.*, (1998). The development of projects involving water harnessing affect transmission of vector-borne diseases for example the construction of dams such as Aswan in Egypt, Kariba in Zambia, Akosombo in Ghana (Hunter *et al.*,1993) and in Northern Ethiopia (Ghebreyesus *et al.*, 1990), rubber plantation in Thailand (Gomes *et al.,* 1998) have led to an increase in malaria transmission and intensity.

2.6 Immunity and anti-malaria drug resistance determinant factors in occurrence of unstable malaria

Mollineaux and Grammiccia (1980), Shililu *et al*., (1996); McElroy *et al.,* (1994) and Miller *et al*., (2002) have observed that repeated infection of the same human individual in endemic areas provides partial protection against malaria and the risk of developing a clinical disease.

The emergence and rapid spreading of multi-drug resistant strains of *P. falciparum* and generally severe malaria parasites have developed resistance mechanism against anti-malarial drugs for example in 1979 Kenya and Tanzania were the first East African countries where chloroquine (CQ) resistance was first reported (Campbell *et.al.,* 1979; Fogh *et al*., 1979) and resistance phenomenon to other anti-malaria drugs e.g Amodiaquine (AM) and Sulfadoxine/Pyrimethamine (SP), has increased (WHO, 1996; WHO, 1998; Kokwaro, 1999, Msangeni and Chomba, 2000).

2.7 Review of statistical modelling of infectious diseases

On statistical modelling, Willems (1989) concluded that deducing a good model from data involves system identification (system theory) and approximate theory, both of which have application in many branches of science. Since occurrence of malaria is viewed as dynamical spatio-temporal dependent event, both deterministic and stochastic models can be applied to identify and describe its distribution within an ecosystem which generates data for the occurrence thus modelling it.

Literature on dynamics of parasitic infection is extensive. Most of the literature is about the transmission of parasites from human host to another human (Bailey, 1957; Anderson and May, 1979a), postulated that an epidemic behaviour depends on the contact between susceptible human host and another infectious human, is a significant factor in mathematical epidemiology and is referred to as "mass action" principle which was translated to a continuous time model by Ross (1908, 1911, 1916 and 1919; cited in Anderson and May, 1992) in which the mathematical dynamism of malaria transmission is fully articulated.

In 1974, Hethcote (1974) noted that much work remains to be done on infectious disease modelling involving geographic spread, age structured groups of human population, several human hosts, constant infective periods, non-latent periods, control and the need to test them using empirical data in order to draw conclusions about a disease characteristics within a geographic region. These characteristics- location, dependent infection rates and epidemic velocity have been reported by Murray and Cliff (1977), Cliff and Haggatt (1982).

On statistical modelling of infectious diseases such as malaria epidemic Becker (1989) stresses that a simple statistical model is an approximate representation of the spread of a real epidemic and that if statistical test indicates that the model does not provide efficacy and adequacy in describing some epidemic data then the model should be modified for the intended application.

One of the most important aspects of the modelling process is to be able to use the model if possible to predict the course of future events (Malkevitch and Meyer 1974).

The occurrence of a disease such as malaria epidemic appears due to environmental changes which are approximately time dependent and generally its occurrence is due to chance factors; it is plausible to choose stochastic time dependent models as opposed to deterministic models which are exact cause-effect models to describe and model the incidences of occurrences of unstable malaria.

Multiple regression models have been extensively used in analysis of data from several sources. In modelling, model parameter estimation, model diagnostic check and prediction have been used for estimating health related outcomes (Hakulinen et al., 1986a: Bulatao and Stephens 1992). Further linear regression model and locally weighted scatter plot smooth (LOWESS) methods have been used to determine trends of water resources (Helsel and Hirsch 2002). Hakulinen *et al*., (1986a); Bulatao and Stephens (1992) used multiple regression models in estimating and predicting age sex mortality rates by cause specific for the whole world.

Becker (1989) concluded that time series methods can be used to determine whether incidence data for an infectious disease in some periods exhibit high incidence occurrence at regular intervals and autocorrelation and spectral analyses are used for both endemic diseases.

Hay et al., (2002) used time series graphs to analyse malaria occurrences in Western highlands of Kenya study sites, Kilgoris, Kisii and Tabaka for the period 1981-2002, 1989-2000 and 1981-2000 respectively. Their findings showed that malaria epidemics occurred seasonally defined as 2 years in all the study sites and epidemic years were 1994 and 1998 for Kilgoris 1996 and 1997 for Kisii and 1997 and 1996 for Tabaka and malaria epidemics have been increasingly in the highlands (Linablade et al., 2000) and influenced by both socio-economic and climatic changes (Sachs and Malaney, 2002).

Models that combine socio-economic, political and physical environmental factors linked to malaria transmission at household level, is still lacking in SSA (Mwabu, *et al.*, 1991; Goodman *et al.*, 2000; Greenwood and Mutabingwa, 2002) so as to address the outcome of the disease (Etkin, 1991) and hence to seek stragegies for its control.

2.8 Global impacts of malaria distribution

The specific impacts of malaria burdens on; population growth rate, medical costs, productiveness and land use and children's development, school attendance, performance and cognitive skills are presented below

Impact of malaria burdens on population

The increasing pattern of malaria transmission in malaria prone areas of the world (WHO, 2001) implies an increase in disease burdens, morbidity and mortality rates and hence a reduction in population growth rate in these areas. The estimated global 300-500 million new clinical cases of malaria annually (WHO, 1998; Goodman, *et al*, 2000) of which 90% distributed in SSA means that SSA alone records between 270—450 million new cases of malaria annually and resulting in about 1.8 million deaths due to the disease annually.

In general as evidence can show malaria burdens have impoverished many poor tropical developing countries mostly in SSA where the income per GDP for example in 1995 was less than 2000 USA dollars (Gallup and Sachs, 2001). Malaria transmission intensity is high and endemic and (WHO, 2001) continues to impoverish these countries. Table 2.8 below shows global distribution of per capita Gross Domestic Product (GDP) in 1995 adjusted for the purchasing power.

Table 2.8: Global distribution of GDP in 1995 for selected countries

No. Categories	Countries	GDP (In USA dollars)
1.	North America, Western Europe (except Spain, Portugal and Greece) Japan, Australia, New Zealand	16,000-31,100
2.	Spain	10,000-16,999
3.	Libya, South Africa, Gabon, Saudi Arabia, Brazil, Argentina, Venezuela, Mexico, Turkey and S.W. Africa, Iran	5,000-9,999
4.	Russia, China, most of CIS, Egypt, Israel, Jordan, Syria, Peru, Indonesia, Thailand	2,000-4,999
5.	SSA, India, Pakistan, Mongolia, Afghanistan, Sri Lanka	450-1999

Source: Compiled by the Author, 2007 from Gallup and Sachs, 2001

From Table 2.7 above, North America, Western Europe, Japan, Australia and New Zealand located in temperate areas with very low risk of malaria transmission are generally countries with highest per capita GDP (1600-31,100 U.S.A dollars). The Sub-tropical countries with low malaria transmission and well managed malaria programmes are moderately rich countries; category 2 and some countries in categories 3 and 4 had per capita GDP; 5,000-16,999 USA dollars whereas the tropical developing countries with high intensity of malaria transmission rates are malaria endemic regions where *P.falciparum* is predominant; the group consists of very poor countries majority of which are in SSA. These countries had the lowest per capita GDP, 450-1999 USA dollars in 1995 and recorded growth rate per capita GDP of only 0.4% per annum compared to the average growth rate of 2.3% per annum in other countries in 1965-1990 (Gallup and Sachs, 2001).

2.9 Impacts of malaria on socio-economic status of a household or a country

Globally, the impact of malaria burdens on development was estimated at around 800 million USA dollars in 1987 (WHO, 1993). In 1995 this figure was estimated at 1.8 billion USA dollars (WHO, 1996) and in 1999 it was estimated to be in excess of 2 billion USA dollars (Okenu, 1999; Greenwood and Mutabingwa, 2002). In 2004 the economic cost of malaria was estimated to be in excess of 4 billion USA dollars, Africa contributing an estimated value in excess of 3.6 billion USA dollars of the global estimate.

In SSA, no attempt has been made to estimate the overall public expenditure on malaria prevention and treatment (Goodman *et al.,* 2000) and where available are estimates on specific preventive expenditures. Goodman *et al.,* (2000) however contends that the number of patients seeking care for inspected malaria treatment and the estimates of the unit cost of treatment implies huge public expenditure on malaria.

Goodman *et al.* (2000) concluded that very few studies involving SSA on the unit costs of treatment of malaria is available. However, they studied economic impact of malaria in Malawi and estimated the average recurrent cost per outpatient visit for suspected malaria as 0.96 USA dollars. This was in a mission and government health facility. Kirigia *et al.* (1998) investigated the cost of treating an inpatient for severe malaria and found it to cost 35 USA dollars per admission in a Kenyan district hospital. The same study also revealed that 150% of the annual recurrent costs of inpatient care in Kilifi district hospital were used by paediatric malaria admissions whereas 9% of the annual recurrent costs were used by the paedriatric malaria admissions in a neighbouring Malindi sub-district hospital. This indicated that most of the costs were incurred by the Kenyan government.

Data on the impact of malaria on households in SSA countries is inadequate or lacking and most existing studies have concentrated on urban areas (Goodman *et al.,* 2000). Apparently this is not representative of the reality of the malaria impact on household expenditures on malaria prevention, diagnosis, and treatment because the majority of the population (over 80%) in SSA live in rural areas.

Mills (1998), using household study from selected SSA countries estimated monthly per capita expenditure in 1995 on Malaria treatment to range between 0.39 USA dollars to 3.84 USA dollars per person which works out as an equivalent of an estimated range of 1.79 USA dollars to 2.5 USA dollars per household in urban areas. Majority of over 60% of the population in SSA live below poverty line of less than 1 USA dollar per day (WHO, 2000). This calls for urgent poverty eradication by the SSA governments. One way is to put efforts on malaria control, for example by free medical care for the poor, a policy which, for example was implemented by the Kenyan government and was expecetd to be effective as from 2004.

The new methods of prevention and control of malaria in childhood and in pregnant women is the use of Insecticide Treated Nets (ITNs) and residual spraying of houses and rooms. Large-scale use of ITNs in reducing infant mortality has been found to be very effective and has been shown to be cost-effective, (Goodman *et al.*, 2000).

The impact of malaria on land use in SSA does not exist (Goodman *et al.*, 2000), however Mwabu and Wanyoike (1985) studied agricultural land use patterns in relation to changing malaria conditions in many Kenyan districts. The study related the total cultivated acreage of cassava to the total family size and the total incidences of malaria episodes in households in three months. They concluded that the prevalence of malaria had no statistically significant effect on cassava production nor the acreage of the cultivated land. This is explained by the fact that households involved hired labour to cushion the effects of malaria on household income and household contribution effort when a malaria incidence beset a family member.

The Inter-Regional Economic Network (IREN, 2004) a research and Educational organization reported that 17 million work days were lost due to malaria in Kenya in 2001, which implies a substantial income loss nationally. The free medical services to be provided by the Kenyan government, effective from July 2004 enabled the majority of the Kenyan population to access medical services and hence a long term positive effect on the country's economic growth.

A number of studies in Kenya and other countries of SSA countries have shown that a substantial number of school days are lost due to occurrence of malaria besides its effect of malaria on children's performance and cognitive skills development.

Leighton and Foster (1993) studied impacts of malaria in Kenyan and Nigerian typical primary schools and secondary schools based mostly on group discussion. In the study, the Kenya Primary School pupils were estimated to contract and become sick of malaria and as a result 20 days of abseinteeism in school for each pupil annually and 11% out of Kenya's 186 school days annually whereas each secondary school student lost an average of 8 school days annually.

2.10 General methods of prevention and control of occurrence of malaria

To prevent and control the occurrence of malaria WHO, (1998); Goodman *et al.* (2000) and WHO, (2003) advocate control and prevention methods including, treatment, use of DDT, residual spraying, environmental sanitation, application of insecticides and avoiding contact with mosquitoes among others.

Prompt treatment of malaria immediately the disease has been positively diagnosed by clinical microscopic or Rapid Diagnostic Tests (RDTs) is an effective method. Treatment is done by intravenous injection of anti-malaria drugs or use in tablet form of anti-malaria drugs as prescribed by qualified health personnel.

The anti-malaria drugs affect and kills *Plasmodia* in human blood stream but however, *Plasmodia* in the central nervous system are not affected and reappear again in the blood stream. Chemical prophylaxis involves a process of taking up of drugs to prevent malaria. The anti-malaria drugs kills *plasmodia* and are useful for fieldworkers, soldiers, tourists etc.

However, automative chemoprophylaxis method in vector control is not currently implemented in SSA (Goodman *et al.*, 2000). In recent times (WHO, 2003)) has classified and recommended Artemisinin based combination therapies (ACT) as the standard treatment of malaria to replace the ineffective Chloroquine (CQ) and Sulphurdoxine pyrimethamine (SP) drugs in the treatment of malaria.

In the above programme the allocated total fund for malaria control in Africa was USA dollars 38.5 million for CQ and SP drugs and USA dollars 16.1 million for ACT. The CQ and SP resistance level in East Africa has reached 64% and 45% respectively, in 2003, WHO recommended that CQ and SP drug use be stopped because their resistance have surpassed the 25% level it recommends and therefore should be replaced by ACT and *artimisinin* based drugs such as coartem, which has been recommended and is being used in Kenya.

The resistance phenomenon of malaria causing parasites and mosquito vector is attributed to socio-economic and socio-cultural patterns, perceptions, knowledges, anti-malaria drug use, refugees, wars and conflicts, settlements and physical environmental factors which have combined to reinforce the upsurge and transmission of malaria epidemic (Kokwaro, 1999; Sachs and Malaney, 2002; Greenwood and Mutabingwa, 2002).

Figure 2.10 below summarizes the different modes of the general prevention and control methods of vector-borne diseases. These include vector control, environmental management of vectors, environmental control, chemotherapy and behavioural control.

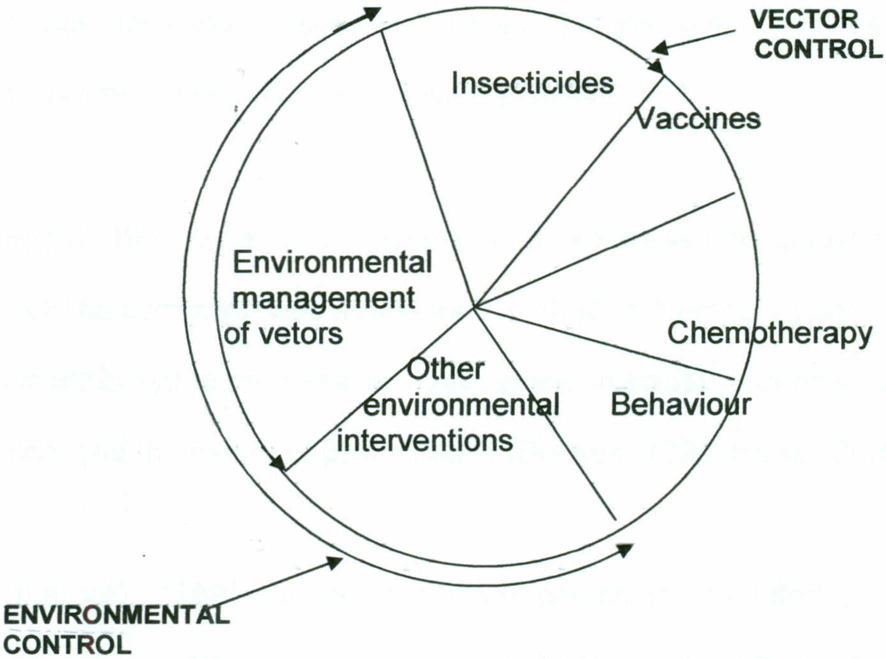


Figure 2.10: Modes of control of vector-borne diseases

Source: Bradley, 1990 (PEEM, 1993)

Following the above general modes of control of vector-borne diseases, the following specific prevention and control methods are presented as follows.

Control of occurrence of malaria

Use of DDT.

The systematic malaria control started after the discovery of the malaria parasite in the 1880's. The mosquito was found to be the vector of malaria and this led to the control strategies and with the discovery during the Second World War of the powerful insecticide DDT and malaria eradication programme was launched by WHO during the 1955 and 1969 and campaign involved spraying inside homes with residual insecticide DDT and use of quinine. There is evidence to show that this mathods achieved success in southern Europe, north America and some parts the former Soviet union, Sri Lanka and India.

At the end of 1969 malaria transmission in these areas was virtually eradicated after which the campaign was abandoned in 1969. in Europe equally, absence of malaria is attributed to progressive improvement in social, economic, agricultural, educational and the nature of public health (Dobson, 1994; Reiter, 2000).

During the 1955-1969 malaria eradication campaign, no effort was made to control malaria in SSA (Greenwood and Mutabingwa, 2002). The situation continued up to the early 1990s such that malaria has been on the increase in the region. The increase is apparently accounted for by socio-economic, drug resistance by malaria parasite, insecticide resistance by the vector mosquito and climatic changes (Brown *et al.*, 1998; Greenwood and Mutabingwa, 2002).

WHO, (1998) "Roll Back Malaria" (RBM) initiative raised a number of issues regarding malaria control programmes and a set of targets including the achievement of 60% access to effective prompt treatment, protection during pregnancy, use of ITNs or other vector control measures for risk groups in high malaria transmission zones in SSA by 2005 and global reduction of morbidity from malaria by 50% by the year 2010. Following the above WHO's initiative, the few developments in methods of malaria control constitute: avoiding contact with the vector A. Mosquito, prompt diagnosis and treatment, improving environmental sanitation, enhancing malaria education programmes, and involving local communities in malaria control programmes. The development of malaria vaccine is viewed to be the most feasible cost-effective method (Targett, 1995) and is still a challenge and clinical trials are being undertaken (Richie and Saul, 2002).

Avoiding contact with vector A. mosquito: Use of ITNs

The methods used in avoiding contact with vector mosquito include the use of Impregnated treated Nets (ITNs), use of repellants and insecticide coils to drive away mosquitoes.

The use of ITNs is receiving a wide popularity in malaria endemic tropical countries due to cost-effectiveness and particularly reduction of malaria economic burden specifically at national level. There is a reduction in hospital admissions and fund allocations by the governments of these countries in malaria control programmes. At household level the use of ITNs reduces household expenditures on purchase of anti-malaria drugs and thus a saving at the household level and thus a reduction in poverty at the household level in areas where malaria risk is highest.

The success of use of ITNs, in terms of risks in mortality and morbidity in children has received wide attention and publicity. Lengler *et al.* (1996).

The success in the use of ITNs is due to the reliance on the chemotherapic and chemophrophylis aspects of malaria control intervention.

The synthetic pytheroid insecticides are being developed and on trial stages by WHO's Pesticide Evaluation Scheme (WHOPES) whose main objective is to study the properties of the products and their impact on vector mosquito or pest population. WHO (1995) set the objectives of WHOPES programme to include, acceptability, safety, dose (formulation) application, residual effects on different surfaces, efficiency of pytheroid in different ecological settings, resistance assessment and cost-effectiveness of the several synthetic pytheroid insecticides.

The analyses of several insecticides; DDT, malathion, deltamethrin, lambda-cyhalothrin and pyrethroids are still being used in SSA (WHO, 1994) while the use of pyrethroids increased (Curtis 1994; Chavasse and Yap, 1997), however Mosquitoes resistant to pyrethrum has been reported.

In residual spraying using the insecticides the resting places of A. mosquitoes; indoor walls and ceilings, using a hand held compression sprayer and is effective against the mosquitoes while they are resting before or after feeding (Goodman, *et al.*, 2000). The impact of infant mortality reduction by residual spraying has been conducted in several parts of the world, e.g. in Flora Island of Indonesia in 1997-1998 using bifenthrin and the results showed a strong efficiency on different surfaces, the residual effectiveness lasted for 4 months after spraying (Kizinza, 2000).

Molineaux (1985) studied the impact of infant mortality reduction from spraying trials in Pare Taveta (Tanzania), Kisumu (Kenya) and Garki (Nigeria) and the results in the reduction in the infant mortality rate were as follows: 51%, 41%, and between 47% and 59% for Pare Taveta (Tanzania), Kisumu (Kenya) and Garki (Nigeria) respectively.

In another study in Gujarat state (India) conducted by (Yadava *et al.*, 1996) where cyfluthrin WP insecticide was sprayed indoor during day and the resting, density of A. Culieifacies changed from 37.3 (before spraying) to 6.9 and 4.4 after spraying or a reduction of 88% and 92% respectively.
The duration and effectiveness of residual spraying depends on the surface wall of a house, insecticide and the dosage used and general one round of spraying per annum is satisfactory where malaria occurrence is seasonal.

The cost of residual spraying in SSA per house in SSA late 1990's has been estimated in the range of 3.71 to 8.93 USA dollars (Curtis et al., 1998) which translates to about Kenya shillings 259.70 to 625.10 at exchange rate of Kenya Shillings 70 to 1 USA dollars in 2007. This is cost – effective in view of the fact that effectiveness of the methods last was about six months.

The price of a bed net (ITN) locally and imported has been estimated at the range of USA dollars 4 (Kenya shillings 280) to 11.39 USA dollars or Kenya shillings 797.30 at exchange rate of Kenya shillings 70 to 1USA dollar (Binka et al., 1997)

CHAPTER THREE
MATERIALS AND METHODS

3.1. The study area: Location and size

Kericho district, Figure 3.1 covering area of 2111.6km^2 is one of the 19 districts of the Rift Valley province of Kenya and a leading economic unit of the country. It had a population of 468,493 in 1999 (CBS, 1999) growth rate of 3.18% per annum. The district lies between longitudes 35^0 02'E and 35^0 40' E and between equator and latitude 0^o 23's at an altitude between 1600 m and 3000 m Asl. It is bordered by the districts; Nandi to the north, Koibatek to the north – east, Nakuru to the east, Bureti to the south and Nyamira to the south-west, Nyando, Rachuonyo and Kisumu districts to the west. Nyando, Rachuonyo and Kisumu districts lie at altitude 1110m-1490m Asl are malaria endemic areas thus predisposes Kericho district to vulnerability to malaria transmission due to peoples inter-districts mobility.

Kericho district was divided in 2006 into 7 adminstrative dividions, 42 locations and 115 sub locations and a projected population of 536,863 in 2005 at growth rate of 3.18% (CBS, 1999) Kericho district main hospital was chosen as a study site because it is the main referral hospital in the district and receives health facilities in the district and such data are available. Kericho meteorological station within Kericho district headquarters is only 1.5 km from Kericho district main hospital collects meteorological data routinely and such data are available.

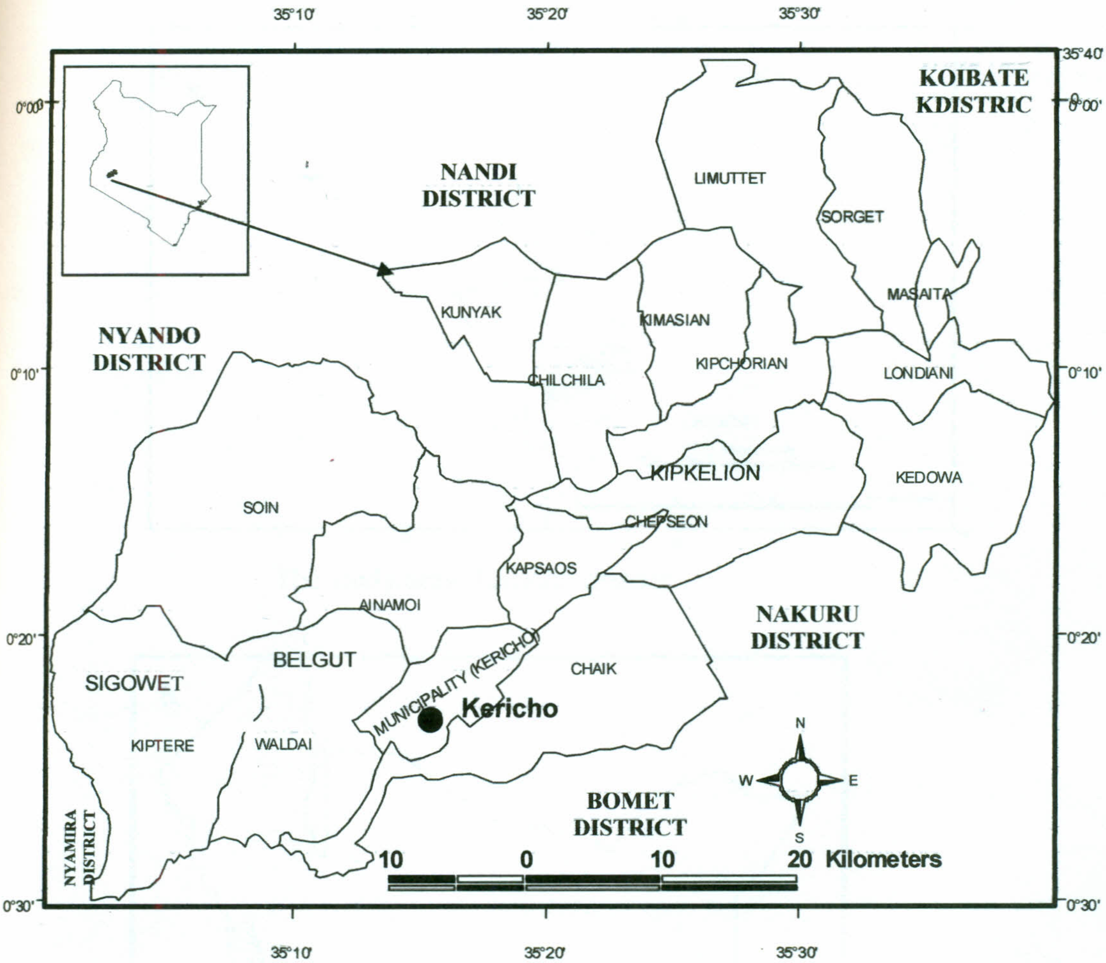
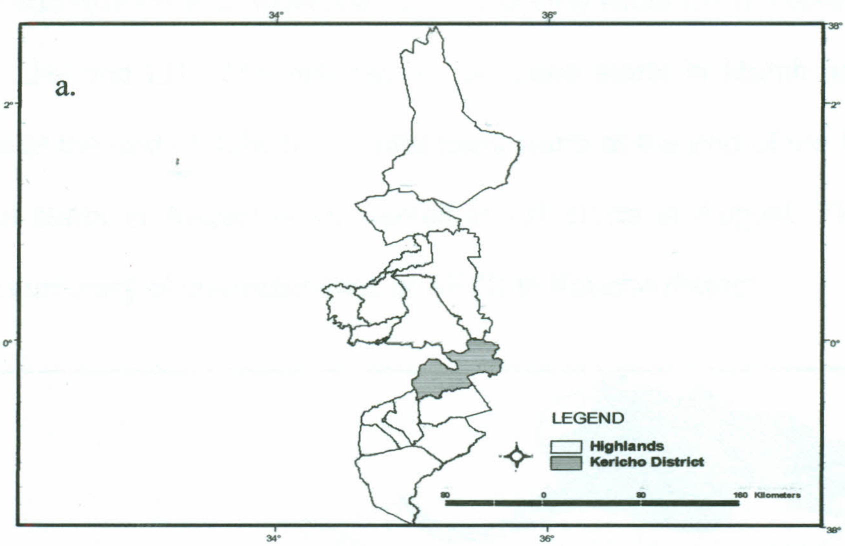


Figure 3.1 Location of Kericho district

Source: Modified form KDDP, 1997-2001

Kericho district, Figure 3.1 was identified by Kenya government, MOH (2001) as one of the districts in highlands of western Kenya, Figure 3.1.1prone to malaria epidemics. The district contains four Agro-Ecological Zones (Based on moisture supply and temperature); the Upper highland (UH), Lower highland (LH), Upper midland (UM), and Lower midland (LM) according to Jaezoldt and Schmidt, (1993), Figure 3.1.2.



The study area: Kericho district

Figure 3.1.1: Malaria epidemic prone districts in Kenya western highlands
Source: Adapted and modified from MOH, 2001-2010

The UH is sub-divided into sub-zones UH_1 and UH_2 while LH is sub-divided into sub-zones LH_1 and LH_2. The first rain in UH zone starts in March and second rains starts at the end of July. In UM first rains starts at the end of the March and the second starts in August while rainfall in LM starts in August. Figure 3.1.2 shows the summary of characteristics of AEZS in Kericho district

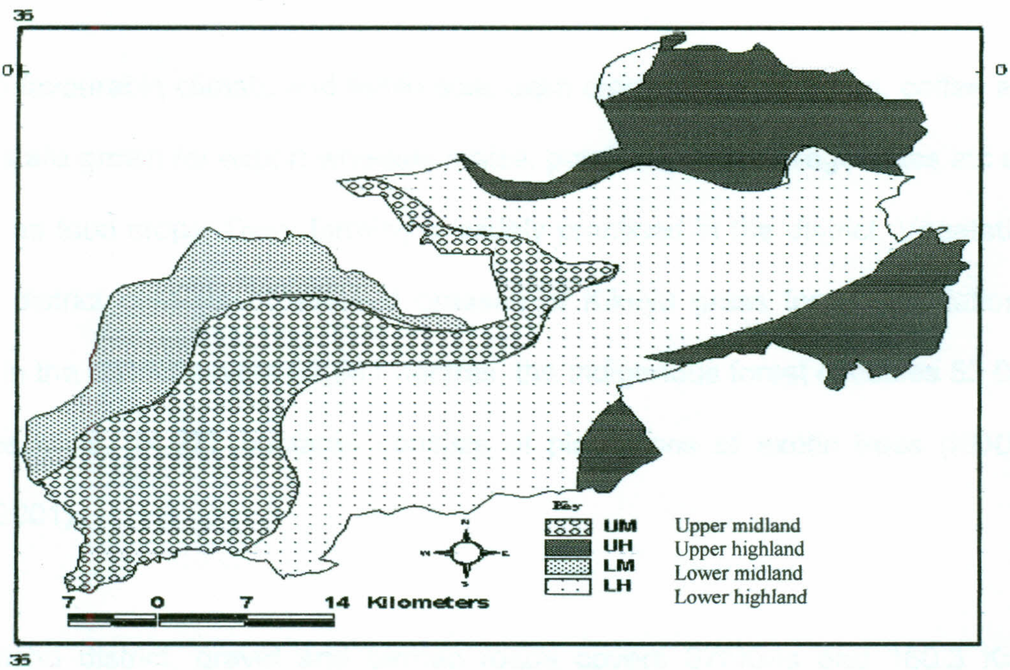


Figure 3.1.2: Distribution of agro-ecological zones in Kericho district

Source: Adapted and modified from KDDP, 1997-2001 and Jaetzoldt R and Schmidt H, 1983.

Two types of soils, loam and clay soils are found in the district. Loam soil which covers about 25% of agricultural land area in the district (KDDP, 1997-2001), is well drained with high organic content and acidic with a *ph* of 5. Clay soil occupy 47% of the district agricultural land area and mostily distributed in Kipkelion, Ainamoi and parts of Londiani division. They are deep, dark, reddish brown and well drained and are of moderate fertility containing acidic humic top soil. Yearly rainfall in the district ranges between 1700mm and 2020 mm or a mean yearly of 1860mm. Temperature ranges between 16^{0}C and 20^{0}C. The mean temperature in 1991-1995 was 17.8^{o}C (KDDP, 1997-2001).

Due to favourable climate and fertile soils cash crops, tea, pyrethrum, coffee and flowers are grown for export whereas maize, potatoes, beans, vegetables etc are grown as food crops. Dairy farming is widely practiced in the district. Vegetation in the district consists of different grasses of Kikuyu grass forest vegetations, forest in the district covers 67,941 hectres, the indigenous forest occupies 53,004 hectres while, 14,937 hectares consists of plantations of exotic trees (KDDP, 1997-2001).

In Kericho district, gravel and tarmac roads covers 675Kms and 160.3 Kms respectively (KDDP 1997-2001). These roads are not uniformly distributed in the district. However they serve all major urban centres. Most roads system in the district are seasonal and are inaccessible to motorists during wet seasons implying that communication in the district is an obstacle to prompt accessibility to immediate medical services during wet seasons. The location, patterns and trends of climatic elements, communication and socio-economic factors combine to influence patterns and trends of occurrences of malaria burdens and transmission in the district.

Table 3.1 below summarizes the characteristics of the Agro-Ecological Zonation of the District.

Table 3.1 Characteristics of the agro-ecological zones in Kericho district

AEZ (Area)	AEZ Sub-Zones	Altitude (in m) Asl	Average Yearly Temperature (°C)	Average Yearly Rainfall (mm)	Rainfall Months 1st/2nd	Division
UH: Upper Highland 660Km^2	UH$_1$: Sheep Dairy	2350-2800	15.8 – 18.1	1300-1700 1100-1300	March June June/July	Londiani
	UH$_2$: Pyrethrum Wheat	2350-2600	15.8-18.1		March/June/July	Londiani Kipkelion
LH Lower Highland (1085 Km^2)	LH$_3$: Wheat Maize Barley	1900-2350	18.4-15.8	1150-1300 1200-1500	February/July	Kipkelion
	LH$_2$: Wheat Maize Pyrethrum	1900-2350	18.5-15.8	1400-1800 1400-1800	February/July	Kipkelion Chilchila
	LH$_1$: Tea Dairy	1800-2350	18.7-15.7		February/July	Sosiot Belgut
	LH$_0$: Forest	2100-2300	17.2-16.0		February/July	Belgut
UM Upper Midland (595 Km^2)	UM$_3$: Marginal Coffee	1550-2000	20.5-17.8	1150-1300 1150-1500	March/July	Ainamoi Chilchila
	UM$_2$: Coffee	1650-1950	19.8-18.1	1400-1600	March/July	Ainamoi
	UM$_1$: Coffee	1800-1900	19.0-18.4	1750-2000	March/July	Belgut
	Tea	2300-2450	16.5-15.7		March/July	Belgut
	UM$_0$: Forest					Kipkelion
LM Lower Midland (176 Km^2)	LM$_2$: Coffee Cotton	1650-1950	19.4-18.1	1150-1500	February/July	Ainamoi
	LM: Cotton	1500-2000	20.5-17.5	1150-1300	February/July	

Source: Compiled and computed by the Author, 2006 based on: Jaetzoldt and Schmidt, 1983, Kericho district agriculture office statistics, 2006.

To answer the research questions stated in section 1.3 chapter one, data on occurrence of unstable malaria burdens; hospital malaria admissions, morbidity, mortality and anti-malaria drug, traditional innovations/beliefs and knowledges regarding malaria and malaria control programmes in the district, climatic elements; rainfall, temperature and relative humidity were collected and analysed. The types, sources and methods of data collection and sampling of respondents are outlined as follows:

3.2 Types, sources and methods of data collection and sampling of respondents

Two types of data sources namely secondary and primary, were used. The secondary sources included official and non-official health records whereas primary sources involved field work which was used to collect household socio-economic data.

Secondary sources

The following were the sources used, and type of data collected for analysis.

Kericho district main hospital: The monthly and yearly malaria statistics (1988-2005); Hospital malaria summaries: Outpatient, inpatient, filter clinics, casualty, special clinics, child health, family planning maternity, operations and special services were collected.

Information from district hospital, ati-malaria drug, food, stationary and personnel.

Ministry of health (MOH): Summary reports for Kericho district on personnel details during 2001-2005. District out-patient malaria morbidity and mortality statistics, summary of disease category at public health facilities, such as dispensaries, health clinics, malaria control programmes in the district during 1990-2005.

Central bureau of statistics: Kericho statistics office: Population data for the 1989, 1999 national population census were obtained.

Meteorological Station: Climate data: rainfall, temperature and relative humidity for the surveillance period 1988-2005, were collected.

Primary sources: Fieldwork data

The source of primary data (field data) was the response of households in AEZs and District medical officer to prepared questionnaires regarding the issue of occurrence of unstable malaria for each of these categories of respondents as described below:

Household questionnaires

The household questionnaires were designed to obtain: household socio-economic factors, beliefs/perceptions and knowledges, traditional malaria control measures, anti-malaria drug use patterns and episodes of malaria burdens in households in AEZS, use of ITNs, sleeping patterns etc.

District medical health officer (DMHO)

The Questionnaires for DMHO was designed to obtain the data on: anti-malaria drug schedules, costs of treatment of malaria overtime, malaria control programmes in the district and anti-malarial drug resistance to highland malaria.

3.3 Pilot study

The Questionnaires prepared were tested in the field by the researcher in the months of July and August. Forty households; six households in each AEZ were selected randomly to serve as pilot study so that the improvement of the questionnaires could be facilitated for the entire field study. From the pilot study it was found that the response from the households was quite good to the extend that only few corrections of wordings and questions were effected.

3.4 Training of research assistant

One research assistant was trained by the researcher on how to administer questionnaires and the ethics regarding the questioning of respondents, after which the assistant with the researcher undertook the field study.

3.5 Sampling of respondents and sample size

The residents of the four AEZs in Kericho district constituted the target population. Purposively, in the first stage, Kericho district, a subset of the highland districts in Western Kenya highlands was chosen followed by the selection of a random sample of 300 out of 98,867 households according to 1999 national population census (CBS, 1999). Also all the seven administrative divisions of the district were chosen purposively, each to represent the district and a sub-location to represent a division in each AEZ.

Using stratified sampling method, the 300 households were apportioned to each division according to the proportion of households in each division to the total number of 98,867 households in the district according to 1999 national population census (CBS, 1999), and accordingly, the sampled household sizes were chosen randomly from each division. The household heads formed respondents to prepared questionnaires.

The District Public Health Officer (DPHO) was also interviewed to obtain information on the general status of public health in the district. Also interviewed was the District medical health officer (DMHO) to obtain information on general district health system function of the district main hospital problems of expericned by the district health delivery system, health incords, general common diseases reported in the district's health system, general patterns of malaria burdens, medical staff structure and distribution in the district's health facilities, highland malaria episodes of occurrences and distribution costs of diagnosis and treatment of malaria status of efficiency of anti-malaria drugs over time, malaria control programmes, opportunities and challenges of malaria control programmes.

The clinical officers, nurses and supporting staff were also to obtain general information on work load allocation, on-job training on new approaches of malaria management and control, training on communication skills compouter related aspect general working condition in a health facility social welfare schemes rewards etc.

Table 3.5 below shows a summary of sample size tabulation of the sample sizes of households interviewed in each division. Furthermore, the table shows the distribution of AEZs in the district, range of altitudes of the divisions, temperature, rainfall, number of households and population distribution in each division.

Table 3.5: Sample size tabulation: Kericho district Agro-Ecological Zones

Division	AEZ	Altitude (M) Asl range	Range of Annual Temp. (°C)	Range of Rainfall Reliability		No. of Locations	No. of Sub-Locations	No. of Households	No. of Households interviewed	Population Size	Projected Population
				1st Rain	2nd Rain						
Ainamoi	LH UH LM	1550-2350	16-20.5	1200-1500	550-950	6	15	28,181	86	119,696	137,165
Belgut	LM UM	1550-2000	17-18.7	1400-1500	650-850	6	16	22,942	70	100,326	114,967
Kipkelion	UH LH	1850-2800	17.8-19.0	1150-1300	450-650	9	22	12,049	37	64,447	73,886
Chilchila	LH	1850	17.0-19.0	1100-1300	400-650	5	10	6,927	21	36,963	42,380
Londiani	UH	2800	16.0-18.7	550-950	430-600	7	14	11,674	35	59,441	68,115
Soin	LM	1550	18.0-20.0	1150-1300	280-390	6	23	5,389	16	26,793	29,557
Sigowet	UM	1550-2000	18.0-21.0	1150-1500	420-520	4	15	11,805	36	61,776	70,793
TOTAL						42	115	98,867	301	468,493	536,863

Source: Compiled and computed by Author, 2007, from: Jaetzoldt R and Schmidt H, 1983; CBS, 1999; KDDP, 1997-2001; Kericho district population office statistics, 1999-2005 and Kericho meteorological station statistics, 1988-2006.

3.6 Methods of data processing and analyses

The data collection instrument, questionnaires were edited and data from secondary sources to ensure their completeness. Summary tables were used for recording data and for further analyses using statistical methods, SWOT analysis and GIS discussed as follows:

3.6.1 Statistical analysis

Because of long computations involving large masses of data computer packages Statistical Package for Social Science (SPSS) and Excel 2003 were used.

3.6.2. Computation of indices for malaria burdens and climate elements

The indices, totals, means, moving, percentages, case fatality rates regarding malaria burdens were computed and depicted using tables, time graphs, pie charts and maps. The distribution of monthly and yearly totals and means of climatic elements; temperature, rainfall and relative humidity distribution were also computed and displayed using tables and time graphs to show their seasonal and yearly patterns and trends and t-test was used to compare the sample means for two sample periods 1988-1995 and 1995-2002 regarding malaria burden and climatic elements and to draw conclusions on the trends of these events over time.

3.6.3 Summarization and dispersion of quantitative data

The mean, median and modes are common methods of summarization of a set of quantintative data (Lwanga, 1974) and measure the central tendency for a set of data whereas the range, variance and standard deviation are measures of dispersion of a set of data (Lwanga, 1974; Webster, 1992). In this thesis the means of malaria burdens, climatic elements and some socio-economic data were computed to summarize them.

The mean ($\overline{X}$) of a set of quantitative data is computed according to the formula (Lwanga, 1974:52)

$$\overline{X} = \frac{\sum X}{n} = X_1 + X_2 + ... + X_n \text{ ....(1)}$$

Where,

$\overline{X}$ = Mean value

$\sum$ = Summation sign

X = Value of observed cases

N = Number of observations

3.6.4 Time series graphs

The temporal patterns and trends in the occurrences of malaria burdens and change in climatic elements were displayed using time series graph for the period 1988-2005. In this thesis time series components, seasonal (monthly) variation and trend of malaria and climatic data were displayed by time series graphs for the period 1988-2002. However, the other components of a time series, cyclical variation and irregular or random variation (Webster, 1992) were not analysed in this thesis.

Data on malaria burdens and climatic elements were tabulated and corresponding time graph drawn to show seasonal variations and trends. The five-year moving average of that data were computed to smoother the year to year variation and to establish the existence of trends in these data. Trend lines that fitted the points of the scatter diagrams were plotted. This enabled the description of the nature of the emerging patterns and trends of the emerging pattern and trend of these events. The least square method (LSM) was used to compute the trend line. The use of LSM is to obtain ideal position at which the sum of squares of the differences of the individuals observed values from the line is at the absolute minimum (Hammond and McCullagah, 1978). The equation of trend line has two estimates the Y – Intercept (b_0) and regression coefficient (b_1) or the slope. The significance of the trend line was determined by the use of the student t-test to determine the significant differences in trends between two selected periods, 1988-1995 and 1995-2002 was determined. According to Gregory (1971) and Webster (1992) the t-value is computed as;

$$t_{computed} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad \text{.......(4)}$$

Where, $\bar{X}_1 \, and \, \bar{X}_2$ are sample means for the periods, 1988-1995 and 1995-2002

$S_1^2 and S_2^2$ are standard deviations for the two sample period.

n is the number of observations.

Trend or secular trend is a long term movement of a variable over an extended period of time. In the extended period of time a phenomenon can grow or decline due to the complex external forces that can affect a time series.

Seasonal variation

This is a variation that reoccur each year at specific intervals or about the same time due to the change in the seasons.

3.6.5 Correlation analysis

Correlation analysis is a statistical technique used to determine the strength and direction of relationship between two sets of data (Webster, 1992). Two variables are associated if the distribution of one is affected by values of the other variable. A linear association between two variables.

In this study correlation was used to determine the magnitude and direction of association between variables; malaria burdens and selected climatic and socio-economic variables.

To determine the association between two variables, Pearson product moment correlation coefficient is used to get a correlation coefficient (r) which is an index and ranges in values between -1 and +1. When r is +1 or -1 or close to these values, the closer is the relationship between the two variables and when r=0, the less is close is the relationship between the two variables. A positive r value is interpreted to mean that an increase in the value of one value is associated with an increase in the values of the other variable i.e t he two variables increase in the same direction and vice versa when r is a negative value. When r=1 or r=-1, indicate perfect positive and negative association between two variables. A value of r=0 indicates the existence of no correlation between two variables.

To compute the bivariate correlation coefficient r among variables Y_i and X_i the following formula is used

$$r_{yx} = \frac{N\sum X_i^* Y_i - \left(\sum X_i\right)\left(\sum Y_i\right)}{\sqrt{\left(N\sum X_i^2 - \left(\sum X_i^2\right)\right)\left(N\sum Y_i^2 - \left(\sum Y_i^2\right)\right)}} \quad \text{...(5)}$$

Where

r_{yx} = correction coefficient between Y and X

N = number of observations

Y and X are variables

* Stands for a multiplication operation (computer programme)

The zero order correlation coefficient were computed to determine the extend and nature of association among variables, malaria cases (morbidity) and socio-economic factors in households. Under the null hypothesis the p=0 (the population correlation coefficient estimated by r) the correlation coefficient is related to student distribution for small sample size (n<30) by the expression

$$t = r\sqrt{\left\{(n-2)/\left(1-r^2\right)\right\}} \quad \text{..(6)}$$

Where t= t-test, statistic, n = number of pairs of data studied which is a t distribution with degrees of freedom (df) = n-2. This is a means of testing a null hypothesis by using the above computations and referring to t values from t-tables with df = n-2 for comparison so that if the t computed value > t value from t table, then the correlation between the two variables is high. The t test above was conducted to determine if or not the correlation coefficient obtained was a chance occurrence.

3.6.6 Regression analysis

Regression model is a quantitative expression which links dependent and independent variables. Regression model seeks to determine if variable tend to more in the same direction or opposite directions (Webster, 1992). Regression model also seeks to determine the amount of change in a dependent variable that can be accounted for by a change in the independent variables (Gregory, 1971; Webster, 1992). Both dependent and independent variables must be measured on an interval scale. To use a regression model the following conditions must be satisfied (Johnstone, 1980, Webster, 1992):

i) Linearity: Data set must be linear if not the data can be the transformed into linear by expressing the variables in their common logarithms.

ii) Normality: The study variables particularly the condition distributions of the residuals, should have a normal distribution the distribution are the value of $\left(Y_i - \hat{Y}\right)^2$ for every value of X

iii) Means of conditional distribution. For every value of X the mean of the residual , $\sum\left(Y - \hat{Y}\right) = 0$

iv) Autocorrelation: the value of each observation on X independent variable must be independent of all the values of all other independent variables, when this condition is not satisfied there, will be a problem of multicollinearity among the variables. This means they are measuring the same effect.

v) Lack of measurement error.

Both dependent and independent variables must be measured without an error, otherwise the regression equation coefficients will be biased.

Two regression models can be distinguished, simple linear and multiple linear regression models.

Simple linear regression model is an expression linking two variables Y and X and expressed as (Webster, 1992)

$$Y_i = \beta_0 + \beta_1 X_i + \ell_i \text{ ....} (7)$$

Where

Y_i = dependent variable

X_i = independent variables

$\beta_0 = Y - \text{intercept}$

β_1 = slope or regression coefficient

ℓ_i = error term of stochastic or distribution

Using the sample data the intercept b_o and b_1 the estimate for population parameter β_0 and β_1 can be computed as follows:

$$b_0 = \frac{(\sum Y_i)(\sum X_i^2) - (\sum X_i)(\sum X_i Y_i)}{N\sum X_i^2 - (\sum X_i)^2} \quad \text{.........(8)}$$

Where:

b_o = y – intercept

N = number of observations

Y and X are variables (depended and independent respectively)

$$b_1 = \frac{N\sum X_i Y_i - (\sum X_i)(\sum Y_i)}{N\sum X_1^2 - (\sum X_i^2)^2} \quad \text{.........(9)}$$

Coefficient of Determination, r^2

Coefficient of determination r^2 measures the total deviation of Y that is explined by the sample linear regression model developed and computed as follows:

$$r^2 = \frac{Explained Variation}{Total Variation} = \frac{\sum\left(\hat{Y} - \bar{Y}\right)^2}{\sum\left(Y_i - \bar{Y}\right)^2} \quad \text{.........(10)}$$

Where,

$\hat{Y}$ = estimated Y values from estimated line

$\bar{Y}$ = mean of Y values

The values of r^2 ranges between 0 and 1 and r^2 is multiplied by 100 to show the amount of variation (%) in the dependent variables that is associated with variation in the independend (X) variable i.e. the % percentage that the model explains of the change in Y.

The unexplained variance represent the error term e_i is the square root of the error sum of squares i.e

$$\sqrt{\frac{\sum\left(Y_i-\bar{Y}\right)^2}{n-1}} \qquad (11)$$

Expression 11 is used for small sample size (n<30)

Simple linear regression was used in this study to determine the variation in occurance of malaria burdens and climatic elements as associated with passing of time, 1988 -2002 and 1998 and 2005. A mulitiple linear regression model shows a relation between one dependent variable (Y) and more than one independent variables (X) is expressed byformula 12. below;

$$Y=b_0+b_1x_1+b_2X_2+\ldots+b_nX_n+e \qquad (12)$$

Where

Y= Dependent

b_0 = Y-intercept

b_1 b_2 .....b_n = Partial regression coefficients

X_1 X_2....X_n = Independent variables

n= maximum number of variables

e= error term

The b_1 b_2.... b_n represents the change in the dependent variable Y, for each unit change in the independent variable (X) and the coefficient of determination R^2 measures the strength of the relationship between Y and independent variables (X_1 X_2....X_n) and is computed using the formula 13 (Webster, 1992)

$$R^2 = \frac{n\left[b_0\sum Y + b_1\sum X_1Y + b_2\sum X_2Y + ... + b_K\sum X_kY\right] - \left(\sum Y\right)^2}{n\sum Y^2 - \left(\sum Y\right)^2} \quad ....(13)$$

The range of values of R^2 lies between 0 and 1 and is multiplied by 100 to give the percentage amount of variation in the dependent variable that is accounted for by all the independent variables. The error term is interpreted in the same way as was done in simple linear regression model and a test of significance can also be performed in the same way as in simple linear regression model.

Regression model was used in this thesis to determine the relationship between occurrences of malaria cases in a household and selected household's characteristic and is of the form.

$Y = a + b_i \, HOC$ ....(14)

Where

Y= Malaria cases (morbidity) in a household

a= Y-intercept

b = Patial regression coefficients, i = 1, 2,...

HOC = Household's characteristics

The regression models were run using each of the selected independent (explanatory) selected variables specified in model 14 above. In the first stage zero order correlation coefficients were computed and then forward stepping multiple regression analysis to determine the contribution of each explanatory (independent) variable influence the variation in the occurrence of malaria in a household. The zero order correlation was used to determine whether the independent variables were highly correlated hence the problem of multicollinearity. The forward stepping procedure is used in retaining only variables that are significant in the regression model and the SPSS programme has the ability for the selection of significant variables in the regression model. The selection of significant variables by SPSS programme in the regression model uses criteria of the number of cases involved, the number of number of variables being studied and the nature of correlation among the independent variables. The SPSS programme computed the F-value that sets the limits at which an independent variable will either be entered or removed from the regression model. An independent variable is entered if its F- value and removed if the F-value is less than the computed removed value.

3.6.7 SWOT analysis

SWOT is an acronym for words strengths, weaknesses, opportunities and threats. The SWOT analysis technique is used as a diagnostic analysis regarding the control measures of the occurrence of malaria burdens with respect to national community goal targets, achievements and failures of the control measures of the disease burdens. SWOT analysis can be applied to many situations at varying scales for an organization or country to achieve their set goals (Boseman and Phatak, 1989)

Strengths refer to internal capacities of an organization that promote the set objectives of an organization in a competitive environment. Weaknesses are internal disadvantages that restrict the achievement of the set objectives by an organization.

Opportunities are external forces events, etc to enhance an organization that might create problems for an organization to achieve its goals. However, strengths and weaknesses can be controlled by the by an organization but threats cannot be controlled by an organization. In summary SWOT analysis is a framework on which decisions and actions are based so that if implemented can enable an organization to achieve its set goals because it provides the following:

i) Development of a profile for an organization programme
ii) Framework to assess the present and future strategies
iii) Control mechanism of the necessary information on weaknesses strengths opportunities and threats that an organization faces
iv) Reality of an organization's programme.

To conduct a SWOT analysis a SWOT matrix, Table 3.3. The matrix enables the matching of its elements to produce a SWOT matrix of strategies. To construct a SWOT matrix the following steps are necessary:

i) A matrix consisting of three rows and three columns are drawn
ii) The cells (boxes) are labeled to show strengths opportunities and threats

iii) List all opportunities, threats, strengths and weaknesses

iv) The strengths and opportunities are matched and results recorded

v) The weaknesses and opportunities are matched results recorded

vi) The strengths and threats are matched and results recorded

vii) The weaknesses and threats are matched and results recorded

Table 3.3: A SWOT matrix

Internal Factors / External Factors	STRENGTHS (S) List all strengths	WEAKNESSES (S) List all weaknesses
OPPORTUNITIES (O) List all opportunities	SO strategies (maxi-maxi) Strengths are used to take advantage of opportunities	WO strategies (Mini-maxi) Overcome weaknesses by taking advantage of opportunities
THREATS (T) List all threats	ST strengths (maxi-mini) Use strengths to avoid threats	WT strategies (mini-mini) Maximize weaknesses and avoid threats

Using the above matrix it is then possible to make strategies to realize the objectives of an organization or programme

3.6.8 Geographic information system (GIS)

GIS is an acronym for Geographic Information System, is a computer based system for capture, entry, storage, display, manaupulation, analysis and output of data which is organized according to location i.e. geographical data. GIS uses Global Resource Information Data Base (GRID). The GRID has been used to model the environmental factors that contribute to the transmission of diseases.

In 1987 GRID was used to investigate the environmental factors that limit the range of East Coast Fever (ECF), a cattle disease which is transmitted by a vector, the brown tick is common and widespread in SSA where it is responsible for the deaths of most cattle in the region. The GRID centres are Geneva and Nairobi among other centres. These centres have a number of microcomputers to be assessed at national or personal computers for data acquisition and mapping. GIS can be used to identify, classify and create environmental map which shows all areas of a region which are conducive for the survival of disease-vector that causes transmission of a disease in both animals and humans. In the context of malaria burden morbidity, the arc view GIS computer package was used in this research to create environmentally suitable map in Kericho district with the same range of malaria incidences of occurrence.

The above methods were used to analyse malaria burdens and climatic data collected in the district for the synoptic period 1988-2005 specifically patterns and trends of changes in these events were anlysed using tables, time graphs while correlation and regression analyses were used to determine the relationship between malaria morbidity at household level and household characteristics whereas SWOT and GIS methods were used to analyse effectiveness of malaria control programmes and mapping of incidences of occurrences of malaria respectively in the district.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents results of the analysis of patterns and trends of the occurrence of malaria burdens and climatic elements during the surveillance periods 1988-2002 and 1998-2005 in Kericho district. In the first stage data on these variables are described using tables, means, graphs and later statistical analyses, t-test and F-tests on these data are presented. In the second stage empirical relationship between malaria burdens and climatic changes are addressed. In this chapter the research questions stated earlier in section 1.3 are answered and the hypotheses stated in section 1.4 are tested and thus the objectives stated in 1.5 are achieved.

4.2 Patterns and trends of malaria burdens and climatic elements and their empirical relationships

4.2.1 Patterns and trends occurrence of malaria burdens

To present changes in occurrences of malaria burdens the following components of diseases burdens were used in this thesis:

i) Malaria hospital admissions

ii) Malaria morbidity cases

iii) Malaria outpatient cases

iv) Deaths due to malaria

v) Case fatality rates computed as the number of deaths due to malaria divided by total malaria admissions.

Tables 4.2.1.1, 4.2.1.2 and 4.2.1.3 show the patterns and trends of malaria burdens in Kericho district.

Table 4.2.1.2: Pattern and trend of malaria morbidity, Kericho district, 1998-2005

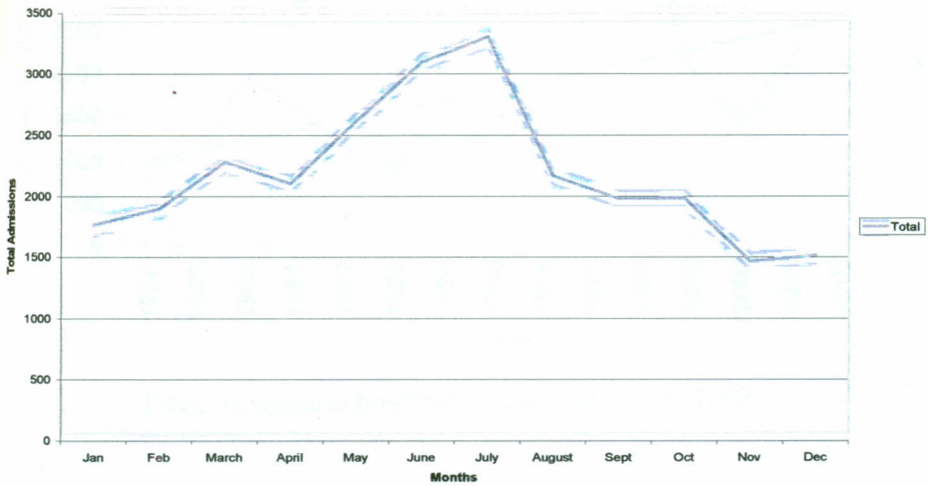
Month	1998	1999	2000	2001	2002	2003	2004	2005	Average
January	1951	4005	2765	4834	4262	9833	6593	9544	5473.4
February	3974	2766	3338	4801	4507	10818	6688	9226	5764.8
March	2587	3683	4112	7547	3202	11339	8205	7514	6023.6
April	6318	3147	4168	3387	3932	7030	7701	6318	5250.1
May	5493	5537	7283	3337	5425	6696	10248	10078	6762.1
June	5000	6489	6290	5188	18080	14688	16656	9028	10177.4
July	4155	8591	3354	5643	23616	18712	15158	12184	11426.6
August	1753	4738	4296	5124	11923	8285	8355	11357	6978.9
September	3071	2236	3916	4528	4996	5706	7491	10807	5343.9
October	4057	2766	3461	4451	4321	6716	7150	8212	5141.8
November	2314	2663	2899	3990	2704	4237	6215	5837	3857.4
December	4126	1870	2878	3046	3617	5196	6344	4203	3909.5
Total	44799	48491	48756	55876	90585	109256	106804	104308	
Mean	3733.25	4040.92	4063	4656.33	7548.75	9104.67	8900.33	8692.33	

Table 4.2.1.3: Trend of malaria burdens, Kericho district main hospital,1988-2002

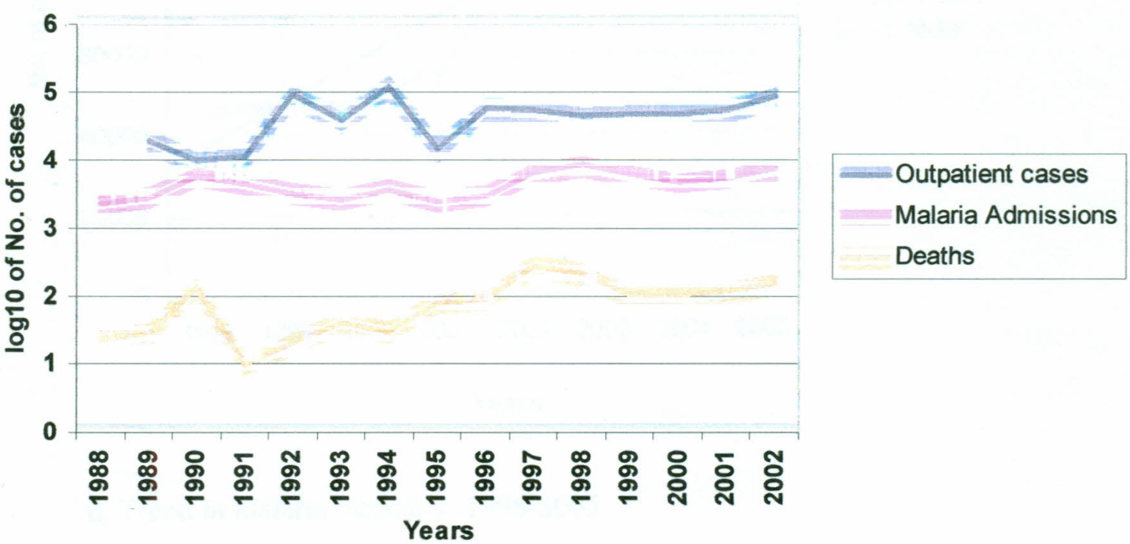
Year	Outpatient malaria morbidity	Malaria admissions	Malaria deaths	Case fatality rates per 1000
1988		2425	23	9.5
1989	19643	2839	28	9.8
1990	10014	5707	135	23.6
1991	11240	3172	18	2.2
1992	93232	2298	21	6.5
1993	40792	1672	48	16.1
1994	124408	3228	43	8.4
1995	114408	2134	84	34.3
1996	60158	2146	91	29.4
1997	53775	7155	290	42.3
1998	44808	8424	215	25.2
1999	49667	6340	109	17.2
2000	48491	4822	119	24.7
2001	55875	5680	176	30.9
2002	87853	7791	16	13.6
Total	714364	70611	1476	293.7
Mean	51026	4707.4	98.4	19.58

Source: Computation by Author, 2007 based on data from Kericho district main hospital statistics, 1998-2002

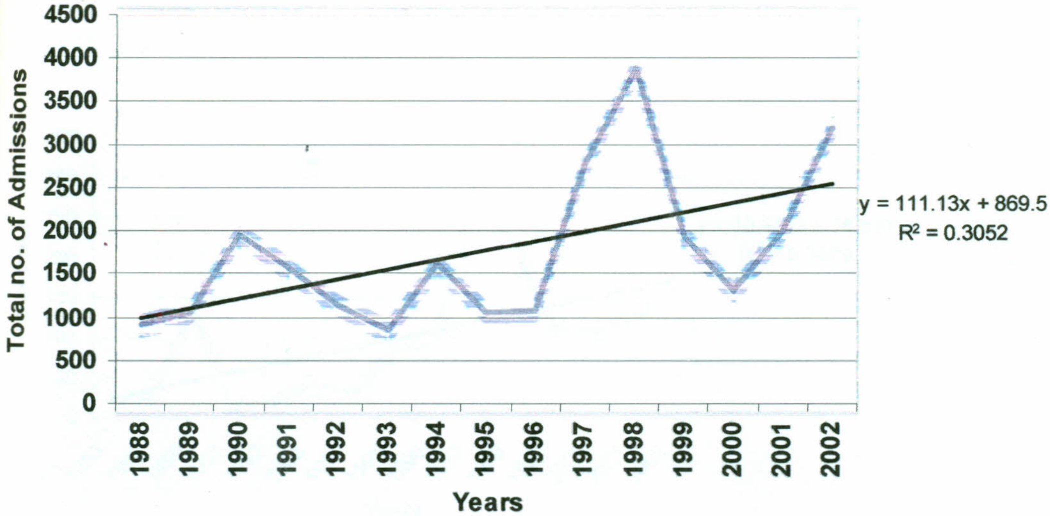
Using the above data, Figure 4.2.1.1 was drawn to show overall emerging changes in malaria burdens over time.



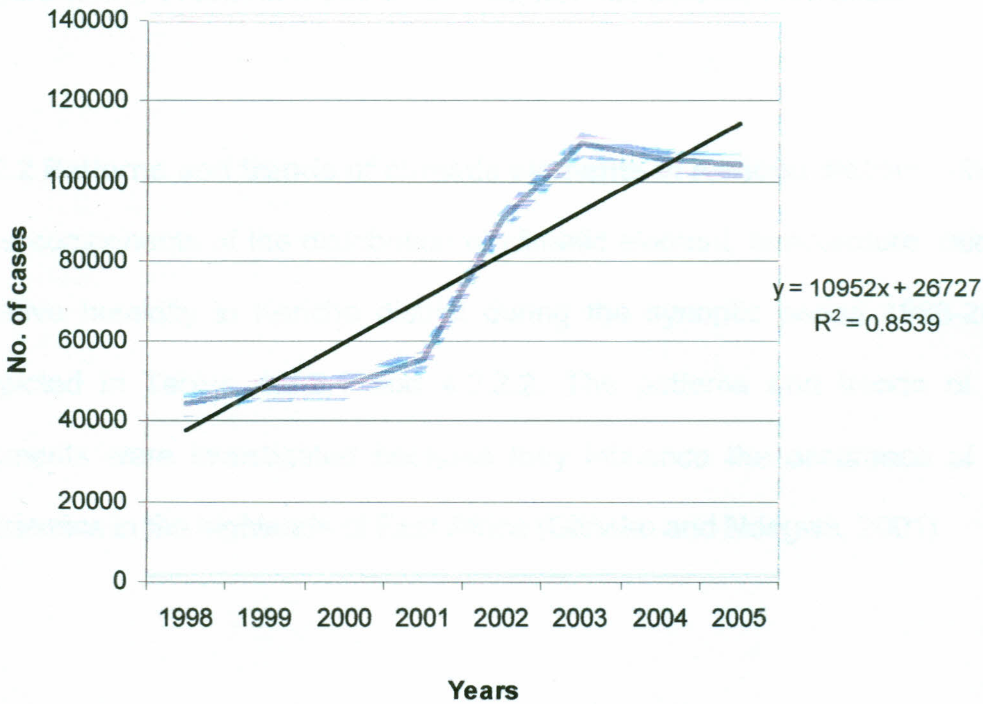
a. Pattern of malaria hospital admissions, Kericho district main hospital, 1988-2002



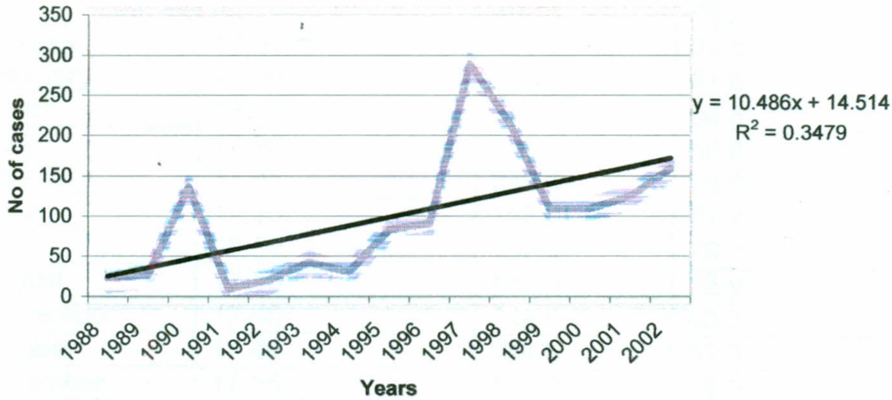
b. Trends of malaria burdens, 1988-2002



c. Trend in malaria hospital admissions, 1988-2002



d. Trend in malaria mobidity, 1998-2005



e Trend of malaria deaths, 1988-2002

Figure 4.2.1.1 Trends of malaria burdens, Kericho district, 1988-2005.

4.2.2 Patterns and trends of climatic elements in Kericho district, 1988-2005

The components of the distribution of climatic element, temperature, rainfall and relative humidity in Kericho district during the synoptic period 1988-2005 are depicted in Tables 4.2.2.1 and 4.2.2.2. The patterns and trends of climatic elements were investigated because they influence the occurance of malaria epidemics in the highlands of East Africa (Githeko and Ndegwa, 2001)

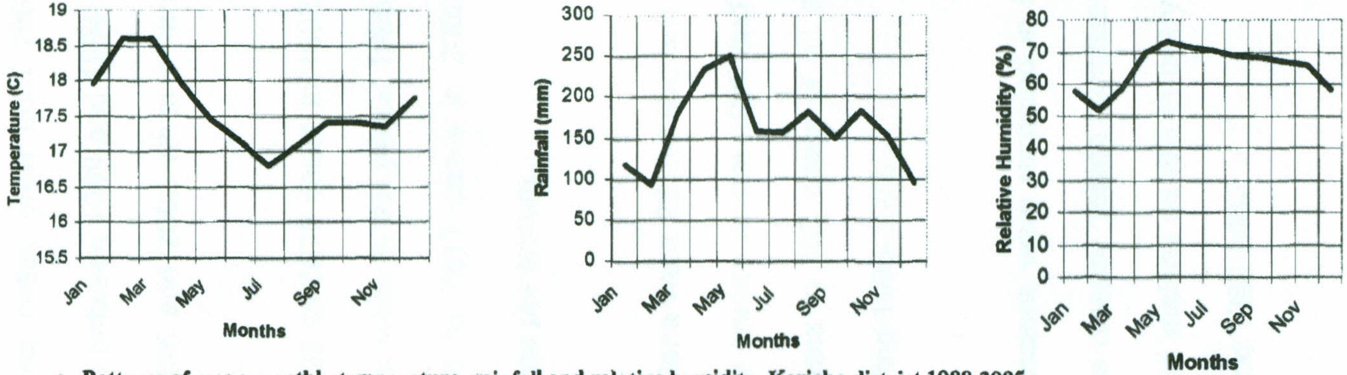
Table 4.2.2.1: Patterns of mean monthly temperature, rainfall and relative humidity: Kericho district, 1988-2005.

Month	Temperature (°C)	Rainfall (mm)	Relative Humidity (%)
January	17.95	117.7	57.6
February	18.60	93.2	51.5
March	18.60	179.0	58.6
April	17.95	232.5	69.8
May	17.45	249.9	73.3
June	17.15	157.7	71.2
July	16.80	157.3	70.1
August	17.10	182.3	68.9
September	17.40	148.9	68.2
October	17.40	184.3	67.0
November	17.35	153.2	66.0
December	17.75	95.8	57.9
Mean	17.6	162.7	65.0

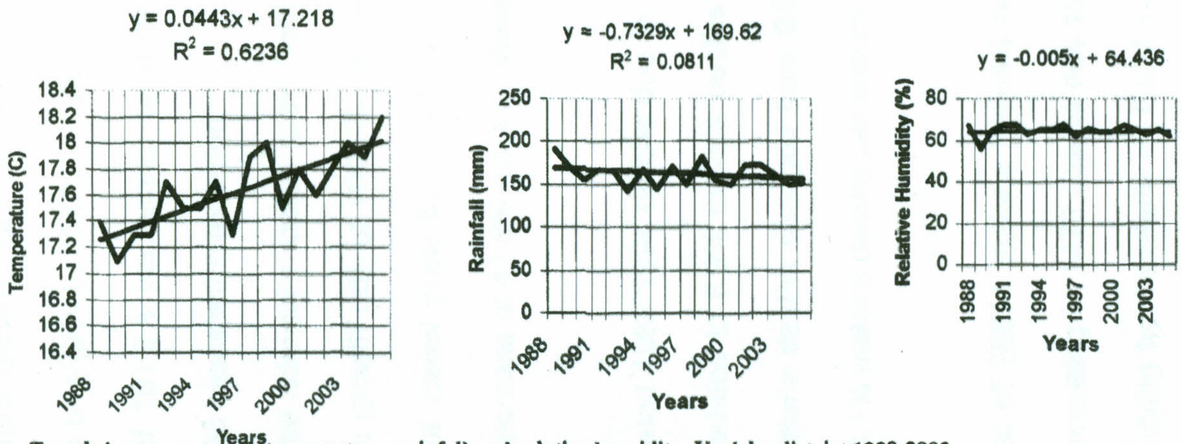
Table 4.2.2.2: Trends of climatic elements, Kericho district in 1988-2005.

Year	Mean Annual Temperature (°C)	Mean Annual Rainfall (mm)	Mean Annual Relative Humidity (%)
1988	17.4	192.4	67.1
1989	17.1	171.8	55.7
1990	17.3	155.3	65.1
1991	17.3	167.9	66.8
1992	17.7	166.5	67.4
1993	17.5	142.2	62.7
1994	17.5	167.1	64.8
1995	17.7	144.4	65.0
1996	17.3	171.6	67.4
1997	17.9	149.8	62.1
1998	18.0	182.0	65.5
1999	17.5	155.0	63.9
2000	17.8	150.0	63.9
2001	17.6	173.9	67.2
2002	17.8	174.1	64.8
2003	18.0	162.0	62.9
2004	17.9	150.0	65.1
2005	18.2	151.8	61.6
Total	317.5	2927.8	1159
Mean	17.6	162.7	64.4

Using the above data, Figure 4.2.2.1 was drawn to show their emerging patterns and trends with passage of time.



a. **Patterns of mean monthly temperature, rainfall and relative humidity, Kericho district 1988-2005.**



b. **Trends in mean annual, temperature, rainfall and relative humidity, Kericho district 1988-2002**

Figure 4.2.2.1: Patterns and trends of climatic elements, Kericho district, 1988-2005

Source: Author, 2007 based on data from Appendices 6 and 7

From the above results patterns and trends in malaria burdens; outpatients, malaria hospital admissions, malaria deaths and fatality rates, and morbidity were on upward growth. The outpatient malaria cases grew from 19643 to 124408 cases or a growth of 106.7% per annum between 1989 and 1994 and a growth rate of 101.9% per annum between 1995 and 2002 when a range of 14408 to 87853 cases were recorded

Malaria hospital admission cases grew from 2425 to 3670 cases in 1988-1994 representing a growth rate of 10.27% per annum while in the period 1995-2002 the number of cases grew from 2449 in 1995 to 7811 cases in 2002. this represent an increase of 42.8% malaria admissions per annum.

During the period 1988-1994 deaths due to malaria were 23 in 1988 and 31 in 1994 this translates to 6.9% malaria deaths per annum and in 1995 and 2002 number of malaria deaths changed from 84 cases to 160 cases or an annual increase of 18.1% malaria deaths per annum during 1995-2002.

Overall a total of 70611 malaria hospital admissions were recorded in health facilities and resulting in 1476 deaths due to the disease which translates to a probability of dying from malaria as 0.021 i.e. 21 malaria deaths in every 1000 malaria hospital admission cases during the period 1988-2002.

The occurrence of malaria cases followed seasonal patterns of climatic elements, Figures 4.2.1.1a and 4.2.2.1a, for example increase in malaria cases occurred between January-March and April and July each year when temperature, rainfall and relative humidity ranged for January – March between 17.95 and 18.6, 93.2 and 179mm and 51.5 and 58.6% respectively and for April-July ranged between, 16.8 and 73.3% respectively. The peak occurance of malaria hospital admission occurred between April and July when mean temperature, rainfall and relative humidity were 17.4^{0}C, 165.6mm and 67.5% respectively the least yearly malaria hospital admission cases occurred in November each year when mean temperature, rainfall and relative humidity were 17.35^{0}C, 153.2mm and 66% respectively.

From Figures 4.2.1.1c-e and 4.2.2.1 b it is clear that there is and upward trend in cases of malaria hospital admissions, malaria morbidity, malaria death and temperature in Kericho district. They grow at the rates of 111.13%, 109.52% 10.486% and 0.0443% per annum respectively whereas downward trends in mean annual rainfall and relative humidity growing negativity at 0.7329% and 0.005% respectively. These are revealed by the coefficients of simple regression models of these event. Furthermore simple regressions models for malaria hospital admission, malaria morbidity and malaria deaths produced coefficients of determinations (R^2) of 0.3052, 0.8539 and 0.3479 implying that time (1988-2005) accounted for 30.52%, 85.39% and 34.79% of the temporal variations observed in the malaria admissions, malaria morbidity and malaria deaths respectively whereas time accounted for 62.36% and 8.11% of the temporal variations observed in mean annual temperature and rainfall respectively. The t-test revealed that the trend observed in the number of malaria hospital admissions is significant Table 4.2.2.3 at 0.05 level of significance thus the null hypothesis that there is no significant difference in the temporal trend of occurrence malaria burden admission in Kericho district is rejected. This indicates that the difference that has been observed in the trend in the number of malaria hospital admission cases is significant.

Table 4.2.2.3: Results of t-test for two sample periods for the number of malaria hospital admissions-Kericho district main hospital, 1988-2002.

Period	Sample mean	Sample standard deviation
1988-1995	2934.375	1238.539
1995-2002	5561.15	2398.934
Computed t value	2.7523	
Degrees of freedom	7	
Critical t value (exact approximated)at: 0.05 level	2.4	

Source: Author 2007

The computed t-value 2.7523 is greater than t critical value 2.4 at 0.05 level of significance implying their difference in the means of two sample periods,1988-1995 and 1995-2002 is significant. Thus the null hypothesis that there is no significant temporal trends discernible in occurrence of malaria morbidity in Kericho district is rejected at 0.05 level.

Table 4.2.2.4 Results of t-test for two sample periods for malaria deaths, Kericho district main hospital, 1988-2002

Period	Sample mean	Sample standard deviation
1988-1995	50	40.55
1995-2002	132.5	85.95
Computed t value	2.68	
Degrees of freedom	7	
Critical t value (exact approximated) at 0.05 level	2.365	

Source: Author, 2007

The results depicted in Table 4.2.2.4, shows that the computed t-value of 2.68 is greater than t-critical value of 2.365 at 0.05 level. This implies that at 0.05 level there is a significant difference in mean malaria deaths for two sample periods 1988-1995 and 1995-2002. Thus at 0.05 the trend that has been observed is significant.

Table 4.2.2.5: Results of t-test for two sample periods for mean annual temperature, Kericho district, 1988-2002

Period	Sample mean	Sample standard deviation
1988-1995	17.44	0.207
1995-2002	17.7	0.2267
Computed t value	2.4065	
Degrees of freedom	7	
Critical t value (exact approximated) at: 0.05 level	3.2447	

Source: Author, 2007

The results revealed by Table 4.2.2.5 above shows that the computed t-value of 2.4065 is less than critical t-value of 3.2447 at 0.05 level. This implies that at 0.05 level there is no significant difference in the mean annual temperature for the two sample periods 1988-1995 and 1995-2002.

Table 4.2.2.6: Results of t-test for two sample periods for mean annual rainfall, Kericho district, 1988-2002

Period	Sample mean	Sample standard deviation
1988-1995	163.45	16.17
1995-2002	162.6	14.29
Computed t value	0.13	
Degrees of freedom	7	
Critical t value (exact approximated) at 0.05 level	2.4	

Source: Author, 2007

From the results shown in Table 4.2.2.6 the computed t-value of 0.13 is less than t-critical value at 0.05 levels respectively. This implies that there was no significant difference in the mean annual rainfall for the two sample periods 1988-1995 and 1995-2002 this implies that there was no trend in annual mean rainfall during these period.

Table 4.2.2.7: Results of t-test for two sample periods for the annual mean relative humidity, Kericho district, 1988-2002

Period	Sample mean	Sample standard deviation
1988-1995	64.325	3.809
1995-2002	64.975	1.761
Computed t value	0.78	
Degrees of freedom	7	
Critical t value (exact approximated) at 0.05 level	2.4	

Source: Author, 2007

The above results shows that t computed value, 0.78 is less than t-critical values of 2.4 at 0.05 level of significance. This implies that there was no significant difference in mean annual relative humidity for the two sample periods 1988-1995 and 1995-2002.

Results depicted in Tables 4.2.2.6 and 4.2.2.7 have revealed that both trends in mean annual rainfall and mean annual relative humidity are not significant at and 0.05 significant level during the sample periods 1988-1995 and 1995-2002.

The above results reveal that trends observed in malaria hospital admissions and malaria deaths are statistically significant at 0.05 level leads to the rejection of the null hypothesis which states that there is no significant temporal trends in occurrence of malaria burdens in Kericho district.

Table 4.2.2.7: Results of t-test for two sample periods for the annual mean relative humidity, Kericho district, 1988-2002

Period	Sample mean	Sample standard deviation
1988-1995	64.325	3.809
1995-2002	64.975	1.761
Computed t value	0.78	
Degrees of freedom	7	
Critical t value (exact approximated) at 0.05 level	2.4	

Source: Author, 2007

The above results shows that t computed value, 0.78 is less than t-critical values of 2.4 at 0.05 level of significance. This implies that there was no significant difference in mean annual relative humidity for the two sample periods 1988-1995 and 1995-2002.

Results depicted in Tables 4.2.2.6 and 4.2.2.7 have revealed that both trends in mean annual rainfall and mean annual relative humidity are not significant at and 0.05 significant level during the sample periods 1988-1995 and 1995-2002.

The above results reveal that trends observed in malaria hospital admissions and malaria deaths are statistically significant at 0.05 level leads to the rejection of the null hypothesis which states that there is no significant temporal trends in occurrence of malaria burdens in Kericho district.

The above results of simple regression models reveal that time explains a substantial occurrence of malaria morbidity and this leads to the rejection of null hypothesis stated earlier that there is no significant relationship between variation in occurrence of malaria burdens and change in time in Kericho district. Simple regression models above have been used to assess the relationship between time and occurrence of malaria burdens. Furthermore, the above results have revealed that time also accounted for a substantial proportion of variation in annual mean temperature hence the null hypothesis stated earlier that there is no significant relationship between occurrence of malaria burdens and climate change in rejected at 0.05 level of significance.

Because socio-economic environments influence the occurrences of malaria cases in a household as revealed by literature review in chapter two the socio-economic characteristics, malaria cases and interventions in household in Kericho district is addressed and presented as follows:

4.3 Empirical relationship between occurrences of malaria cases in a household and a household's characteristics

Based on literature review and own consideration the data appendix 14 on the following household's variables were studied regarding randomly chosen sample of 194 households in seven administrative divisions in Kericho district in 2006. The dependent variable was chosen as the number of malaria occurrences (cases) or malaria morbidity in a household (2-4 weeks before administering a questionnaire, Appendix 1) and the idependent variables hypothesized to influence the occurrence of malaria (morbidity) in a household are shown in Table 4.3.1 below.

Tables 4.3.1: Definitions of a household's variables, Kericho district, in 2006.

No	Variables	Description
1	M	Mobiditry, number of malaria cases
2	FAS	Family size, number of family members
3	FAI	Family income in Kenya shillings (countinuous variable)
4	MAG	Maternal age, expressed in years (continuous variables)
5	MED	Maternal education, expressed as the number of years of formal education (continuous variable)
6	DHF	Distance to the nearest low cost helath facility expressed in Kilometer (continuous variable)
7	VHC	*Number of visits to the nearest health facility*

Source: Author, 2007

Table 4.3.2: Descriptive statistics. Results summary sample (N=194)

Variable	Minimum	Maximum	Mean	Standard deviation
Family malaria				
Malaria cases (morbidity), M	0	3	1.268	0.619
Family size (FAS)	2	12	5.366	1.870
Family income (FAI)	1500	4500	2750	1650
Maternal age (MAG)	20	69	44.5	9.13
Maternal education (MED)	0	12	3.64	1.03
Distance to nearest health facility (DHF)	0.1	12	3.50	2.24
Number of visits to health facility (VHC)	0	3	1.24	0.64

Source: Computation by Author, 2007, based on data displayed in Appendix 14

From the above results the mean age of mothers interviewed was 44.5 years minimum was 20 years and a maximum of 69 years. The mean family size was 5.4 and a minimum and maximum of 2 and 12 respectively, However, majority of women worked in family farms averaging between 2 acres and 10 acres and cash crops tea and sugar cane were grown while maize, beans, vegetables and potatoes were widely grown as food crops and surplus for sale. Livestock, dairy cattle for a household's consumption and surplus for sale were common economic activities practised in the district in 2006.

The average household's income monthly in tea growing areas of Belgut, Ainamoi and Sigowet divisions ranged between minimum of Kenya shillings (Kshs) 1,500 or 0.67 USA dollars daily and a maximum of Kshs. 4,500 or about 2 US dollars daily (at exchange rate of Kshs. 75 to 1 USA dollar in 2006). In non – tea growing areas of Kipkelion Londian, Soin and Chilchila divisions the average household's income monthly ranged between Kshs. 1500 and Kshs. 2300 or about 0.6 to 1 USA dollar daily.

The lowest level of material education was zero i.e. no year of formal schooling and the highest was above 12 years of formal schooling. The mean maternal education level was 3.6 years i.e. about 4 years of primary education.

The mean distance to the lowest cost health facility ranged between 0.1 kilometers and 12 kilometers and majority of low cost health facilities were Government health facilities. The number of visits to the health facility ranged between 0 and 3 visits per household and mean occurrences of malaria (cases) morbidity per household was one in an average household's family size of 5.4 which translates to probability of occurance of a malaria case of 0.14. Used uncollected plastic/polythene materials were observed scattered in majority of households' compounds.

Majority of households' 60% respondents interviewed said the residual spraying method was very effective in controlling mosquitoes. However malaria education programmes at location level were minimal (<2 visits by Government health providers per annum.)

Correlation and regression analyses were used to analyse household's data depicted in Appendix 14. In the first stage Pearson's bivariate correlation coefficients between household's variables were computed to determine the strength and direction of relationship between a pair of household's variables and results are presented in Table 4.3.3. In the second stage regressions were run involving all household's variables specified in Table 4.3.1 above

Table 4.3.3: Pearson's bivariate correlation coefficients, sample, (N=194), 2006

Variable	Malaria cases (M)	Family size (FAS)	Family income (FAI)	Maternal age (MAG)	Maternal education (MED)	Distance to the nearest health facility(DHF)	No of visits to health (VHC)
Malaria cases	1	0.134	0.027	0.183(*)	0.004	0.321(**)	0.943(*)
Family size (FAS)	0.134	1	-0.114	0.494(**)	0.309(**)	0.258(**)	0.055
Familly income (FAI)	0.027	-0.114	1	0.205(**)	0.238(**)	-0.013	0.021
Maternal age (MAG)	0.183(*)	0.494(**)	0.205(**)	1	-0.401(**)	0.111	0.169(*)
Maternal education (MED)	0.004	-0.309(**)	0.238(**)	-0.401(**)	1	-0.125	-0.010
Distance to nearest health facility (DHF)	0.321(**)	0.256(**)	-0.013	0.111	-0.125	1	0.276(**)
Number of visits to health facility (VHC)	0.943(**)	0.055	0.021	0.169	-0.010	0.276(**)	1

*Correlation is significant at the 0.05 level (2-tailed)
**correlation is significant at the 0.01 level (2-tailed)

Source: Author, 2007, based on data from field studies in the district, Appendix 14

The above results have revealed that malaria cases in a household is highly correlated with the frequency of households visits to the nearest low cost health facilities (0.943) and significant at 0.05 level in a 2 – tailed test. However malaria cases is lowly correlated with family size (0.134). The correlation between occurrences of malaria cases in a household and distance to the health facility is 0.321 and significant at 0.01 level in a 2- tailed test. The positive sign implies that distance of health centre from a household influences control of malaria morbidity in a household i.e. distance from a household to a health facility may lead to delay in prompt diagnosis and treatment of the disease thus increase malaria transmission in a household and hence increased malaria cases in a household.

Family income and family size are correlated negatively (-0.114) with a correct sign implying that low family income was associated whith a high family size. Maternal education correlated negatively (-0.309) and significant at 0.10 level with family size implying that the longer the time mothers spend in schooling the smaller family they are likely to have. Further, family income correlated positively with each of the variables; maternal age and maternal education with values of 0.205 and 0.238 respectively and both values being significant at 0.001 level in a 2-tailed test. However, family income did not have effect on malaria occurrences in a household or effect on the number of visits to a health facility by a household member.

The regression analysis results showing relationship between malaria morbidity cases in sampled households (N=194) and their characteristics are summarized in Tables 4.3.4 and 4.3.5.

Table 4.3.4: Regression analysis results summary, sample (N=194)

	Coefficient	Standard error	t-ratio	p-value	95% confidence interval	
Family size (FAS)	-0.007	0.015	-0.27	0.791	-0.061	0.047
Maternal age (MAG)	0.015	0.006	2.50	0.013	0.003	0.027
Maternal education (MED)	0.083	0.048	1.74	0.084	0.011	0.177
Distance to health facility (DHF)	0.089	0.019	4.57	0.000	0.050	0.127
Family income (FAI)	-0.028	0.043	-0.65	0.518	-0.113	0.057
Constant	0.109	0.335	0.33	0.744	-0.552	0.771

Table 4.3.5: Regression results summary, sample (N=194)

Source	Sum of squares (SS)	Degrees of freedom (df) $F(5,188) = 6.18$	Mean square MS
Model	10.46	52.092	Prob F = 0.000
Residual	63.6	188.34	$R^2 = 0.141$
Total	74.06	193.38	Adjusted $R^2 = 0.118$
			Root mean square error=0.582

Source: Computation by Author 2007, based on cross-sectional data displayed in Appendix 14.

The above results have revealed that multiple regression model linking malaria morbidity and explanatory variables is of the form:

$M=0.109 - 0.007\ FAS + 0.015\ MAG + 0.083\ MED + 0.089DHF - 0.028FAI$...(1)

Based on t-ratio values, the significanct explanatory variables retained in model 1 above are MAG and DHF thus model 2 below which links malaria cases (morbidity) in a household and these variables.

$M = 0.109 + 0.015\ MAG + 0.089DHF$ ....(2)

The coefficient of determination R^2 = 0.118 implies that the multiple regression model predicted only 11.8% of malaria cases in a household hence 88.2% predictors are not included in the model. The poor prediction of malaria cases of occurrence may be attributed to the cross-sectional data obtained. The F calculated value of 6.18 is larger than F-critical values of 2.30 and 3.22 at 0.05 and 0.01 levels respectively hence there is a significance difference in relationship between temporal variation in occurrence of malaria cases and soco-economic factors. Thus the null hypothesis stated earlier in section 1.4, that there is no significant relationship between temporal variation in occurrences of malaria cases and socio-economic factors is rejected.

4.4 Identification and detection of malaria epidemics in Kericho district.

The Cullen (1984) epidemic detection technique was used in this study because it is more sensitive than other epidemic techniques such as WHO (2001) and Cumulative sum techniques (Hay *et al.*, 2002). Moreover, Cullen technique is cheap and recommended for use in developing countries (WHO, 2001)

The data required for the Cullen technique were yearly and monthly paediatric hospital malaria admissions depicted in Appendix 2 for the surveillance period 1988-2002 and the previous 5 year (1998-2002) paediatric malaria admissions data Table 4.4.1 were used to construct Alert Threshold (AT) for each month determined as: AT = mean +1.96 times standard deviation, which should capture 95% of malaria admission cases in a normally distributed data (Kirkwood, 1988).

When AT is exceeded (i.e points outside 95% confidence interval of a normal distribution of the disease data) an epidemic alert is triggered. Figures 4.4.1 and 4.4.2 show pattern and trend of paedriatic malaria hospital admissions in Kericho district main hospital during the surveillance period 1988 - 2002

Table 4.4.1 Pattern and trend of alert threshold (AT) of paediatric malaria hospital admissions, Kericho district main hospital, 1998-2002.

Month	1998	1999	2000	2001	2002	Total	Mean	Alert Threshold (AT)
Jan	245	79	19	174	209	726	145.2	428.6
Feb	350	92	180	194	124	940	188	471.4
March	376	73	130	264	135	978	195.6	479.0
April	432	91	124	185	148	980	196	479.4
May	415	300	118	141	141	1115	223	506.4
June	398	379	130	206	597	1710	342	625.4
July	411	251	74	177	878	1791	358.2	641.6
August	212	142	78	128	299	859	171.8	455.2
September	252	100	82	179	218	831	166.2	449.6
October	399	158	110	154	123	944	188.8	472.2
November	125	135	104	89	95	548	109.6	393.0
December	140	140	92	174	160	706	141.2	424.6
Total	3755	1920	1301	2064	3167			
Mean	312.9	161.7	103.4	172.1	260.6			

Source: Author, 2007 based on data displayed in appendix 2

Results from Table 4.4.1 and Appendix 2 have revealed that 12 months during the surveillance period, 1998-2002 were epidemic and the pattern and trend of paediatric hospital malaria admissions in Kericho district main hospital is shown in Figures 4.4.1 and 4.4.2

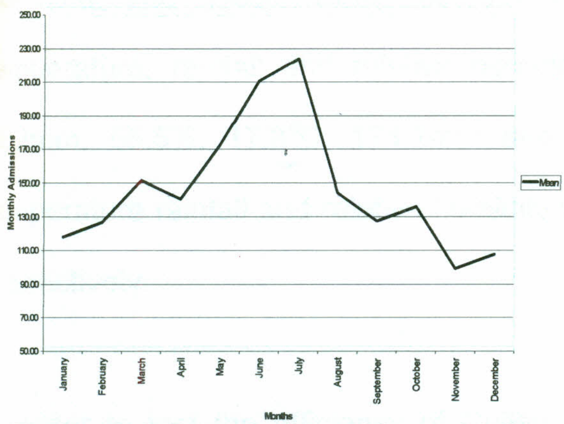


Figure 4.4.1: Pattern of monthly paedriatic malaria hospital admissions, 1988-2002

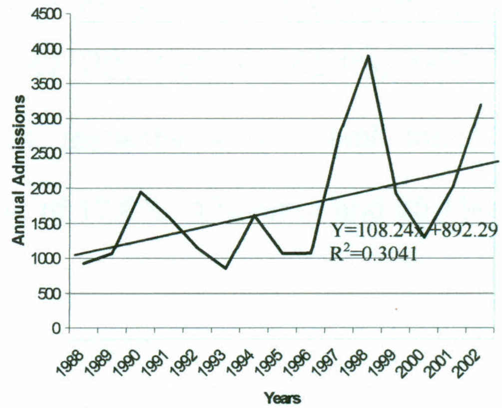


Figure 4.4.2: Trend of annual paedriatic malaria hospital admissions, 1988-2002

From Figure 4.4.1 the pattern of paedriatic malaria admission was seasonal in occurance each year during 1988-2003, with peak of over 3360 malaria admission in July, when the temperature, rainfall and relative humidity was 16.8^{o} C, 157.3 mm and 70.1% respectively. Generally malaria admission increased between January and March and between April and July and then decreased rapidily between the end of July and September but increased to over 2030 cases in October when the mean monthly temperature, rainfall and relative humidity were 17.4^{o}C, 184.3 mm and 67% respectively and overall the trend in paedriatic malaria hospital admission was on upward trend during 1988-2002, Figure 4.4.2 which grew at 108.34% per annum and R^2=0.3041 i.e. time accounted for 30.41% of variation in paedriatic malaria hospital admissions.

The years with exceptionally high cases of paediatric malaria hospital admissions in Kericho district main hospital was defined as 3. These correspond to malaria epidemic years in Kericho district during the surveillance period 1988-2002 which were 1990, 1998, and 2002. when 2048, 3755 and 3187 cases respectively were admitted and these were the years with corresponding mean annual temperature, rainfall and relative humidity of 17.3°C, 1.55mm, 65.1%, 18°C, 182mm, 65.5%, 17.8°C, 174.1mm and 64.8% respectively or overall mean temperature rainfall and relative humidity values of 17.6°C, 170.4mm and 65.1% respectively.

In order to test the efficiency of Cullen technique in identification of highland malaria epidemic as 3, paediatric hospital malaria admissions were used to compute skewness coefficient so as to determine asymmetric distribution of such data around their mean and also to test for normality of such data. To normalize i.e. reduce skewness of admissions data $\log_{10}$transformation of these data were determined. The skewness coefficient for untransformed and transformed paediatric hospital malaria admissions were computed as 0.3138 and 0.2776 respectively, thus asymmetric distribution in paedriatic malaria admission data during 1988-2002. Table 4.4.2 shows summary of descriptive statistics results.

Table 4.4.2: Descriptive and skewness coefficient for paediatric malaria hospital admissions, Kericho district main hospital, 1988-2002.

Statistic	Value	Log_{10}transformed admission
Mean	203.7700	2.2262
Minimum	19.0000	1.2788
Maximum	878.0000	2.9435
Sum	12226.0000	133.5700
Count	180.0000	180.0000
Standard deviation	142.6720	0.2680
Standard error	92.4360	0.1654
Skewdness statistic	0.3138	0.2776

Source: Computed by Author, 2007 based on data shown in Appendix 2.

4.5 Modelling of malaria morbidity with geographic information system (GIS)

This section presents the results of modelling of occurrences of malaria morbidity with a GIS. The spatial distribution of occurrences of malaria morbidity during the period 1999-2006 in the divisions of Kericho district is displayed in Appendix 3 Using the lowest and the highest incidences of occurrences of the disease and also yearly means of occurrences, a distribution map, Figure 4.5 was created by GIS.

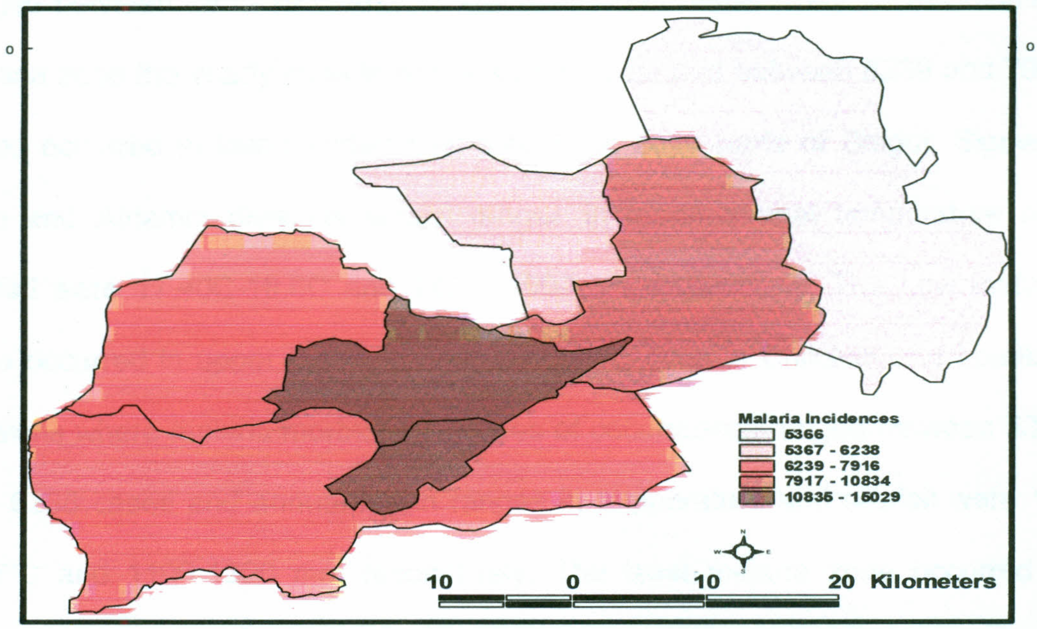


Figure 4.5: Map of distribution of occurrences of unstable malaria morbidity. Kericho district, 1999-2006

Source: Author, 2007 based on data depictd in Appendix 11

Figure 4.5 above shows areas with the same range of distribution of occurrences of unstable malaria. Accordingly five malaria zones were created by GIS as, highest, high, medium, low and least malaria zones.

Highest malaria zone had annual range of 10835 - 15029 malaria morbidity cases of occurrences in the lower highland (LH) of Kipkelion and Ainamoi division where ranges in annual mean temperature and rainfall were 17°C– 18°C and 1200-1500 mm respectively. In high malaria zone yearly occurrences of malaria morbidity ranged between 7917-10834 cases occurred mostly in upper highland and upper midland agro-ecological zones and covered parts of Kipkelion, Chilchila and Soin divisions where mean temperature and rainfall ranged between 18°C-19°C and 1300mm-1600mm respectively. In the medium malaria zone the yearly malaria morbidity cases ranged between 6239 and 7916 cases occurred in lower midland agro-ecologic zone parts of Belgut, Sigowet, Soin and Ainamoi divisions where ranges in mean annual temperature and rainfall were 17.40C-18.6C and 1400 -1600mm respectively. The Low malaria zone occurred in upper highland agro-ecological zone in Chilchila and Londiani divisions where malaria morbidity episodes of occurrences ranged between 5367 and 6238 cases and annual mean ranges in temperature and rainfall were 16-18.7°C and 1100-1300 mm respectively. The least malaria zone occurred in higher part of upper highland agro-ecologic zones in Londiani and Chilchila divisions where annual mean ranges in temperature and rainfall were 16-18°C and 550 - 950 mm respectively where mean yearly malaria morbidity cases were 5366.

Most of malaria cases in all agro-ecologic zones occurred seasonally each year between the months of May-July ie. mostly after long rainy season followed by high temperature above 17°C

CHAPTER FIVE

CONTROL OF OCCURRENCE OF UNSTABLE MALARIA IN KERICHO DISTRICT

5.1 Background to malaria control programmes in Kenya

Due to failure of vertical mosquito control programmes, particularly the global failure to control and eradicate mosquito vector using insecticides such as DDT in the 1960s and 1970s, the 38th WHO Assembly in 1985 adopted and resolved that malaria control programmes had to be developed as an integral part of Primary Health Care (PHC) systems at the district level (WHO, 1986). Since then, this has continued to be implemented in Kenya, for the purpose of improving the health of the people of Kenya which is a major contribution to development through the impact on productivity.

Since the 1970s, 1980s and through 1990s and in the 21st century, there has been a general upsurge in global malaria transmission particularly in poorer developing tropical countries (WHO 2001; Sachs 2002; Malaney, 2002; Lieshout *et al.*, 2004). The upsurge in malaria transmission is blamed on resistance of vector mosquitoes to insecticides, malaria parasites resistance to known anti-malaria drugs such as chloroquine, sulfadoxine pyremethamine etc, social factors e.g. political, wars and refugees, environmental changes especially temperature and rainfall changes, economic factors e.g. development projects such as settlements and irrigation.

As a result of increased world's malaria transmission situation, WHO in 1998 launched a "Roll Back Malaria" (RBM) campaign to control malaria transmission starting with high malaria transmission zones particularly in SSA. The following issues were emphasized and were to be adopted regarding malaria control;

Regarding Kenya, the government has continually put malaria as a top health priority e.g. in MOH (2001) and the objectives of malaria control are stated in section 1.2 and to be implemented by the ministry of health inline with WHO (1986) resolution, of malaria control as an integral part of PHC at the district level where all the control operations are based and under the guidelines of ministry of health.

The WHO (1986) resolution emphasized that each district should actively detect malaria cases and provide prompt treatment to develop feasible malaria control algorithm for each district and specifically to involve local communities in the district in such programmes. Also emphasized in WHO (1986) assembly resolution was to utilize locally developed and appropriate malaria control techniques taking into account socio-economic and behavioural factors of the communities within each district in each country.

5.2 Unstable malaria control variables

Selected variables studied regarding the effectiveness and control of malaria burdens in the district include: change of disease burdens over time the distribution of health facilities, the number of reporting health instutions utilization of health services, local community acces to health services materials control programmes, health education, on-job-training of health personnels, local initiatives and technology of malaria control and use of ITNS. These are presented as follows.

5.3 Change of malaria burdens: Hospital admissions, malaria deaths and fatality rates in Kericho district, 1988-2002

The Kenya government over the years has emphasized the need for providing health service to the whole Kenyan population. This is expressed in GOK's development plan of 1970-1974 which emphasized that better health is a major contribution to development of the country through its impact on productivity and receptiveness. The same plan set a precedent supported continuously by the 1979-1983, 1983-1988, etc development plans.

The Kenya government's ultimate goal is to promote health for all its population by development of faster health services using efficient and appropriate developed methods and strategies that are in line with WHO (1986), WHO (1998) and WHO (2001), and based at district level. The shift to PHC approach incorporates maternal and child health, family planning control of communicable and vector-borne diseases such as malaria.

To address the issue of malaria control in Kericho district, malaria burdens: malaria hospital admissions, deaths and fatality rates in the district during the period 1989-2002 were obtained from Kericho district main hospital records and estimated by reviewing the incidences of occurrences of unstable malaria episodes. This is because such episodes of occurrences is an important indicator of the effectiveness of health programmes and malaria control programmes at the district level (Vaugh and Morrow, 1991).

Table 5.1: Malaria burdens in Kericho district main hospital, 1988-2002.

Year	<5 year old Admissions	>5 year old Admissions	< 5 year old deaths	< 5 year old death rates %	< 5 year old cases fatality rates per 1000	> 5 year old deaths	> 5 year old death rates %	> 5 year old Fatality rates per 1000
1988	926	1499	12	1.3	12.96	11	0.73	7.34
1989	1088	1751	7	0.6	6.43	21	1.20	11.99
1990	2048	3659	58	2.8	28.32	77	2.10	21.04
1991	1586	1586	2	0.1	1.26	16	1.01	10.09
1992	1149	1149	8	0.7	6.96	13	1.13	11.31
1993	836	836	24	2.9	28.71	22	2.63	26.32
1994	1614	1614	19	1.2	11.77	12	0.74	7.43
1995	1067	1394	38	3.6	35.61	46	3.30	33.00
1996	1073	2020	42	3.9	39.14	49	2.43	24.26
1997	2779	4376	117	4.2	42.10	173	3.95	39.53
1998	3755	4669	71	1.9	18.91	144	3.08	30.84
1999	1920	4420	44	2.3	22.92	63	1.43	14.25
2000	1301	3521	41	3.2	31.51	74	2.10	21.02
2001	2064	3616	90	4.4	43.60	86	2.38	23.78
2002	3167	4624	90	2.8	28.42	16	0.35	3.46
Total	26373	40734	663	35.9	358.62	837	28.56	285.66
Means	1758.2	2715.6	44.2	2.39	23.91	54.87	1.9	19.04

Source: Computed by Author, 2007 based on data from Appendix 2

The emerging changes in the trend of malaria hospital admissions for both under 5 and above 5 years old malaria patients in Kericho district main hospital during the period 1988-2002 is shown in Figure 5.1.

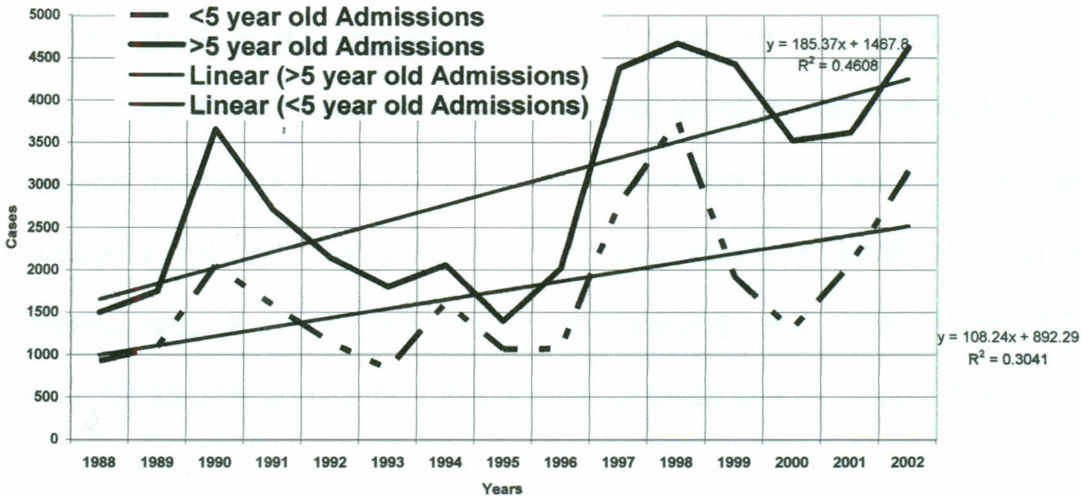


Figure 5.1: Changes in malaria hospital admissions, 1988-2002

The total malaria burdens; malaria hospital admissions, death rates and fatality rates per 1000 due to malaria for <5years and >5 year old, malaria patients were computed and presented in Table 5.2. and displayed in Figure 5.2 to show the emerging changes of these burdens over time which were generally on increasing positive trend during the period 1988-2002. Simple regression of paedriatic malaria hospital admissions and above 5 years old patients grew by 108.24% per annum and 185.37 per annum respectively and time accounting for 30.41% and 46.08% of the variation in these from burdens respectively during 1988-2002.

From Table 5.1 above, the general number of hospital malaria admissions in Kericho district main hospital increased from 926 cases in 1988 to 3167 cases in 2002 for under 5 year old malaria patients and 836 cases in 1993 to 4634 cases in 2002 for above 5 year old malaria patients. The case fatality rates ranged between 2.2 to 42.3 per 1000 during 1991-1997 a range of 1000 per annum during a range 1991-2002 and percentage death rate due to malaria changed from 0.6 to 4.2% per annum. For <5 year old malaria patients which constituted 40% of the total hospital malaria admissions during 1988-2002 and the general paedriatic malaria deaths and fatality rates were on a upward (positive) trends. They grew by 9.1684% and 2.2282% per annum respectively and time (1988-2002) accounting for 43.08% and 42.74% respectively of these events, Figure 5.2

Table 5.2: Malaria death rates and fatality rates per 1000 in Kericho district main hospital, 1988-2002

Year	Total Malaria Admissions	Total Malaria Deaths	% Death Rates	Malaria case Fatality Rates per 1000
1988	2425	23	1.0	9.5
1989	2839	28	1.0	9.8
1990	5707	135	2.4	23.6
1991	3172	18	0.6	2.2
1992	2298	21	0.9	6.5
1993	1672	48	2.9	16.1
1994	3228	43	1.3	8.4
1995	2134	84	3.9	34.3
1996	2146	91	14.2	29.4
1997	7155	290	4.1	42.3
1998	8424	215	2.6	25.2
1999	6340	109	1.7	17.2
2000	4822	119	2.5	24.7
2001	5680	176	3.1	30.9
2002	7791	16	1.4	13.6
Total	70611	1416	43.6	293.7

Source: Compiled and computed by Author, 2007 based on data displayed in Appendix 2

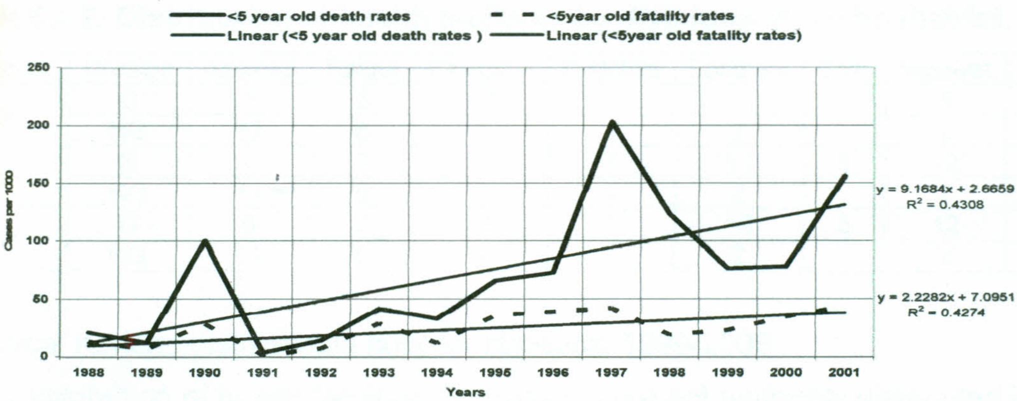


Figure 5.2: Trends in paediratic death due to malaria and fatality rates, 1988-2002

5.4 Distribution of health facilities.

As a measure of the effectiveness of district health system (DHS) in the district, this study considered the distribution of health facilities in the divisions of the district as an important component effectiveness of DHS effectiveness. Tables 5.4.1 and 5.4.2 characteristics of divisions 2000-2005. The area population densities of a divisions in relation to the number and distribution of health facilities available is an indicator of the effectiveness of a district health system.

Table 5.4.1: Distribution of projected population and health facilities in Kericho district in 2005.

	Population	Area(Km^2)	Density	Hospitals	Sub-District Hospitals	Dispensaries And Health Centres	Total
Ainamoi	119,696	302	398	1		6	7
Belgut	100,325	290	345			7	7
Kipkelion	64,477	315.9	204			11	11
Chilchila	36,983	172	315			7	7
Londiani	59,441	531.5	112		1	10	11
Soin	25,793	291.2	89			5	5
Sigowet	61,778	207.1	298			12	12
Total	468,493	2109.7	1759	1	1	58	60

Table 5.4.2: Distribution of health facilities by divisions, Kericho district, 2005-2006.

Year	Division	Ainamoi	Belgut	Kipkelion	Chilchila	Londiani	Soin	Sigowet	Total
2004	G	7	5	10	5	8	5	8	48
	NG	12	8	3	1	2		2	28
2005	G	7	7	11	7	10	5	12	59
	NG	11	8	3	1	2		2	27
2006	G	6	7	11	7	10	5	12	58
	NG	11	8	3	1	2		2	27

Source: Kericho district main hospital statistics, 1999-2006

The distribution of health facilities by division were not uniformly distributed in the district, Tables 5.4.1 and 5.4.2. During the period 2004-2006 Sigowet division had the largest number of health centres, 14 serving a projected population of 70,793 in 2005 (Table 5.4.3 in a total area of 207.1 Km^2 this translates to a population of 5057 per health facility. Soin division had the least number of health centres and a projected population of 29,557 in 2005 or a population 5911 per health facility in an area of 291.2 Km^2. Kipkelion division covering an area of 315 Km^2 and a projected population of 73886 in 2005 had 16 health facilities. From the above data the overall average population per health facility in the district was 6316 in 2005 against a total average of 5528 malaria hospital admissions yearly.

Table 5.4.3: Population projections by divisions of Kericho district, 1999-2005.

Division	1999	2000	2001	2002	2003	2004	2005
Sigowet	61,778	63,404	65,072	66,785	68,542	70,346	70,793
Belgut	100,325	100,965	105,675	108,456	111,310	114,239	114,967
Soin	25,793	26,472	27,168	27,883	28,617	29,370	29,557
Ainamoi	119,696	122,846	126,079	129,397	29,370	136,297	37,165
Chilchila	36983	37,956	38,955	39,980	41,032	42,112	42,380
Kipkelion	64,477	66,174	67,915	69,703	71,537	73,419	73,886
Londiani	59,441	61,005	62,611	64,258	65,949	67,685	68,115
Total	468,493	478,822	493,475	506,462	519,789	533,468	536,863

Source: Kericho district population office statistics, 1999-2005.

The Government hospitals and clinics/dispensaries are low cost health facilities. Kericho district main hospital is a government run hospital and serves as the main referral hospital in the district and is located in the district headquarters in Kericho town with a mean distance of 80 kilometres from any health facility in the district.

The means of transport in the district in 2006 were buses, mini-buses and registered public service vehicles (PSV) owned by private individuals. Other means of transport include private motor cars, bicycles, lorries and by foot which serve the community in accessing health facilities in the district. Belgut, parts of Ainamoi, Sigowet and Soin divisions were fairly served by road network hence a better accessibilty to health facilities in these divisions, whereas remote parts of Londiani, Chilchila and Kipkelion were poorly served by road network thus inefficiency in delivery of health services to the communities in the areas.

5.5 The number of reporting health institutions and the number of existing health institutions in Kericho district, 1999-2003

To analyze and show the trend in Reporting Rate (RR%), the number of reporting health institutions and the number of existing health institutions in Kericho district over time are shown in Table 5.5

In this study the number of reporting health institutions was considered a vital component of communication to Health Information Systems (HIS), MOH etc and enhanced the formulation of strategies to control and prevent malaria and is in line with WHO (1986) and MOH (2001-2010) malaria control and prevention strategies in Kenya. The distribution and reporting of health facilities in the district in this study was considered as an indicator of the efficiency of health facilities in relation to prompt diagnosis and treatment of malaria.

The reporting rate (RR) and number of existing health institutions, on monthly and yearly basis, were computed, Table 5.5, and Figure 5.5 shows the seasonal patterns with an increase in reporting rate between June and October.

However, the yearly mean growth in reporting rate (RR) was 27.2% to 67.1% in 1999 and 2003 respectively and the mean number of existing health institutions in the district in 2006 was 85, Table 5.5c; the mean number of reporting institutions was about 60% and the overall mean reporting rate over the whole period was 44.9%. This implies that 55% of the health institutions were not reporting to HIS. This is an indication of improved efficiency in the services of the health institutions hence effective control of malaria in the district. Furthermore this reflects the effectiveness of MOH health policies and guidelines regarding health services in the district.

Table 5.5: Number of reporting health institutions and number of existing health institutions, Kericho district, 1999-2003.

(a) Number of reporting institutions

Year	Jan	Feb	Mar	Apr	May	Jun	july	Aug	Sept	Oct	Nov	Dec
1999	22	14	18	16	27	12	18	21	16	16	16	16
2000	22	22	28	26	26	24	21	29	27	27	27	32
2001	28	30	34	25	28	26	26	28	38	29	29	35
2002	37	39	35	35	33	36	37	28	44	44	29	44
2003	40	43	44	51	55	57	51	50	60	50	47	60

(b) Number of existing institutions in Kericho district, 1999-2003.

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1999	62	62	62	62	62	62	61	61	62	62	62	62
2000	62	62	62	62	62	62	62	62	62	63	63	68
2001	68	63	64	25	28	26	63	63	64	64	64	74
2002	72	80	80	80	85	84	84	85	84	84	84	84
2003	76	76	76	76	76	76	76	76	76	76	76	76

(c) Reporting Rate (RR*) % to health facilities in Kericho district, 1999-2003.

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Average
1999	35.5	22.5	29.0	25.8	27.4	19.4	29.0	34.4	26.2	25.8	26.0	25.8	27.2
2000	35.5	36.0	45.2	41.9	41.3	38.7	33.5	40.3	46.8	42.9	39.7	47.0	40.7
2001	41.1	48.0	53.1	39.1	43.1	19.4	41.2	39.7	59.0	53.1	45.3	47.3	44.1
2002	51.3	49.0	43.8	40.0	40.0	43.0	44.0	48.0	49.0	49.0	34.5	52.4	45.3
2003	52.6	57.0	58.0	57.0	72.5	68.0	67.0	75.0	66.0	79.0	63.2	79.6	67.1
Average	25.2	42.5	45.8	40.7	44.9	37.6	42.9	47.5	49.4	50.0	41.7	50.4	

The computation of reporting rate, RR* is computed according to the relation:

$$RR^* = \frac{No.\ of\ reporting\ institutions}{No.\ of\ existing\ institutions} \times 100\%$$

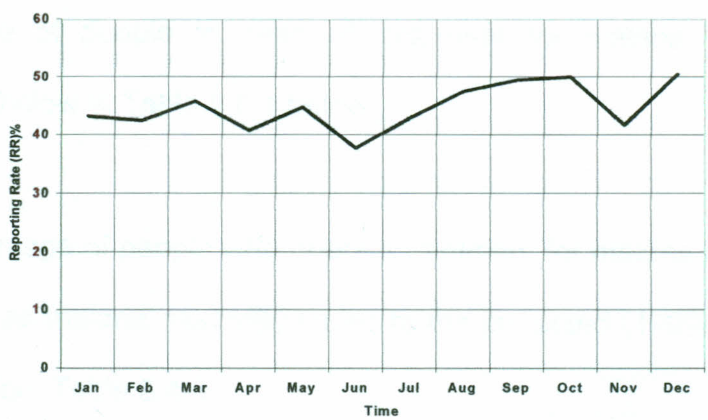


Figure 5.5: Pattern of reporting rate by health institutions in Kericho district, 1999-2003.

Source: Compiled and computed by Author, 2007 based on data from Kericho district main hospital statistics, 1999-2003.

From Figure 5.5, the pattern of reporting rate by health institution increased during the monthes of February – March, April-May, June-October and

November – December whereas reporting rate declined in months of March – April, May-June and October – November each year during 1988-2003. High reporting rate above 45% occurred in March, May, August, October and December while lowest reporting rate was in June each year during 1999-2003. This scenario implies that reporting rate by health institution was not consistent.

5.6 Utilization of health services in the district with respect to malaria burdens

Utilization of health services in relation to malaria was estimated based on the projected population, Table 5.4.3 by divisions of Kericho district and the number (morbidity cases) of people who needed treatment for malaria and actually received it are displayed in Appendices 3 and 4. Based on these data the yearly percentage of people in need of treatment for malaria wer computed and displayed below in Table 5.6.1 below:

The percentage of people who needed treatment for malaria in each division was computed as malaria morbidity cases to the projected (1999-2005) population in each division, Table 5.4.3.

Table 5.6.2: Proportion (%) of people who needed treatment for malaria by divisions of Kericho district, 1999-2005.

Year	Sigowet	Belgut	Soin	Ainamoi	Chilchila	Kipkelion	Londiani
1999	12.47	4.98	21.10	5.79	16.77	8.78	5.69
2000	14.34	5.63	30.31	7.84	17.38	13.65	5.46
2001	10.83	3.91	26.60	8.03	12.42	11.84	4.48
2002	20.69	17.28	34.61	15.06	21.09	26.89	10.30
2003	27.32	12.31	37.95	21.82	22.20	24.94	12.63
2004	21.49	12.18	44.79	18.49	16.21	20.00	14.94
2005	4.95	2.37	6.34	3.54	3.79	2.54	3.65
Total	112.09	58.66	201.7	80.57	109.86	108.64	57.15
Means	16	8.3	28.9	11.5	15.7	15.5	8.2

Source: Author, 2007 based on data shown in Appendices 3 and 11

Results depicted in Table 5.6.1 and pie chart, Figure 5.6 show that a mean proportion of 14.87% or 1491 people per 100,000 per annum needed and actually received treatment for malarial in all divisions of the district. Soin and Sigowet divisions recorded overall mean of 28.9% and 16% respectively whereas Londiani and Belgut divisions recorded the least demand for treatment for malaria, 8.2% and 8.3% respectively during the surveillance period 1999-2005.

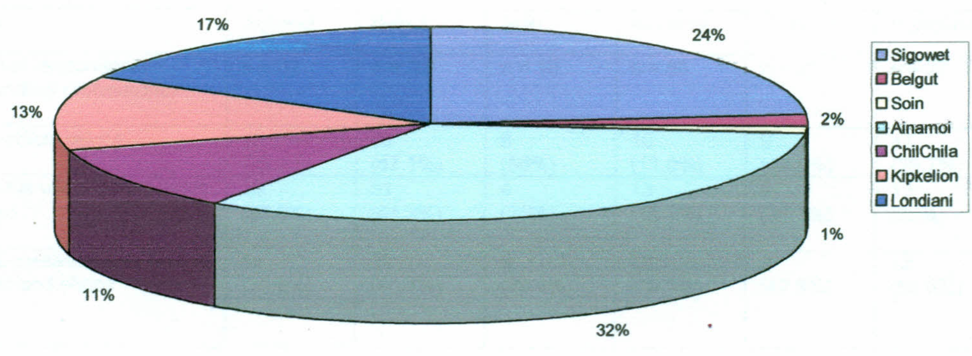


Figure 5.6: Proportions (%) of people who needed treatment for malaria by divisions in Kericho district, 1999-2005.

Source: Author, 2007

Overall, the number of people who needed and actually received medical care in health institutons was low in all divisions during 1999-2005, rainging from 2.37% in Belgut (1999) to 44.49% in Soin in 2004. Soin and Londiani divisions had the highest (28.9%) and lowest (8.2%) respectively of people who needed malaria treatment or medical care during the period 1999-2005.

5.7 Coverage: Local community access to medical professional advice on sourcing and use of anti-malaria drugs.

The results expressed as percentage of people in households in divisions, Appendix 12, who received professional medical advice on use of appropriate sources and types of anti-malaria drugs were presented in Table 5.7.1. Each respondent was asked to mention the sources of advice sought on type of malaria drugs where to obtain and how to use them. The proportions (%) of the respondents using professional advice were computed.

Table 5.7.1: Use of professional advice by the local community in Kericho district sample (N=301)

Response	Sigowet	Belgut	Soin	Ainamoi	Chilchila	Kipkelion	Londiani
Proportion of respondents seeking medical professional advice	n = 36	n = 70	n = 16	n = 86	n = 21	n = 37	n = 35
General medical advice	13 (36.1%)	33 (47.1%)	8 (50%)	10 (11.6%)	9 (42.9%)	11 (29.7%)	21 (60%)
Advice on the use of appropriate drug/source	10 (27.8%)	31 (44.3%)	4 (25%)	13 (15.1%)	8 (38.1%)	10 (29%)	9 (25.7%)
Use of anti-malaria drugs from local kiosks and shops	14 (38.9%)	32 (45.7%)	5 (29.4%)	30 (35.3%)	9 (42.9%)	12 (56.8%)	20 (57%)

Source: Author, 2007 based on field studies in Kericho district in 2006.

The above results show that the proportion of people in the district who sought medical professional advices on the use of anti-malaria drugs ranged between 11%-57% and about 40% purchased anti-malaria drugs from local Kiosks/Shops without the advice of medical health professionals. Majority of local communities in Kericho district (65%) did not seek general professional medical advice. The above results suggest that, the sources, types of anti-malarial drugs and their use might have contributed to resistance phenomenon of malaria parasites to most of anti-malaria drugs and hence an increase in malaria transmission hence increase in the trends of malaria burdens in the district.

5.8 Malaria control programmes in Kericho district, 1999-2006

Malaria control programmes at the district level under the guidelines of WHO (1986), MOH (2001) and NMCS (2001-2010) is an important measure of the efficiency of DHS in relation to the control of occurrence and transmission of the disease. The types and yearly malaria control programmes in the district overtime is summarized in Table 5.8.

The data depicted in Table 5.8 below shows that the effectiveness of anti-malaria drugs ranged from 18% to 80% for chloroquine/Sulfadoxine pyrimethamine (SP) and ACT respectively during 1999-2006. Use of Chloroquine and Fansidar were stopped in 1999 (MOH, 2001) and the new and current effective drugs are ACT, Coartem, Artemisinin, Helfan and Paluther their efficiency ranging between 40% and 80% or an average of 60% effectiveness.

Table 5.8: Control of malaria programmes in Kericho district, 1999-2006.

Year	Type of control programme	Anti-malaria Drug in use	Effectiveness %
1999	Prophylactic indoor residual spraying ITNs	Sulfadoxine/pyrimethamine Quinine Chloroquine Fansidar Amodiaquine	18 45 18 18 20
2000	Indoor Spraying Health Talk ITNs	Amodiaquine Quinine Fansidar	20 45 18 60
2001	Indoor residual spraying prophylactic ITNs Health Talk	Quinine Amodiaquine Coartem	45 30 50 66 30
2002	Indoor residual spraying prophylactic ITNs	Quinine Coartem Amodiaquine	45 50 20 70
2003	Indoor residual spraying prophylactic Health Talks ITNs	Quinine Coartem Artemisin ACT	45 50
2004	Indoor residual spraying prophylactic	Quinine Coartem, ACT Artermether Artemisin Anumax ACT	40 55 55 50 80
2005-2006.	Prophylactic ITNs and Residual Spraying	Artermether Artemisin Anumax ACT Helfan, Paluther, Cotecxin	75 65 50 70 80

Source: Compiled by Author, 2007 based on data from Kericho district main hospital records, 1999-2006

The malaria control programmes in the district during 1999-2006 consisted mainly of prophylactic indoor residual spraying, health talks, and ITNs approaches and carried out mainly in more remote areas of Chilchila, Kipkelion, Belgut, Sigowet and Ainamoi divisions. The malaria control programmes benefited from GOK, Walter Reed (WR), WHO and other donors.

The specific examples of malaria control programmes, health education awareness/knowledge, training of health personnel, local initiatives and use of ITN in malaria control in the district presented as follows:

5.9 Health educational and awareness/knowledges in relation to malaria control and prevention in Kericho district.

An important component of malaria control prevention and management is provision of health education and general health information to the public regarding malaria control (WHO, 1986; MOH, 2001)

Health education related to control of malaria occurrence is a measure of effectiveness of the District Health System (DHS) in general. In this study the respondents were asked about health education provided by health providers and the number of times they were provided with such education yearly during the period 2002-2006, Appendix 10. Also sought from respondents was their knowledges of malaria; causes, symptoms, treatment and environmental sanitation. The responses to the above questions by respondents were classified as appropriate or inappropriate in accordance with the MOH guidelines which are distributed and can be obtained from all health facilities in the district. Table 5.9 shows the response of respondents (N=301) interviewed.

Table 5.9: Information on health education programmes and community awareness/knowledges of malaria in relation to malaria control and prevention in Kericho district, sample, (N=301)

Respondents knowledges about malaria	Correct responses overall	Information Sources			
		Radio	MOH	Newspapers	Others e.g. Meetings etc
Causes of malaria	200(66.5%)	220(73%)	149(49.5%)	80(27%)	36(12%)
Treatment of malaria	171(56.8%)	210(49.8%)	140(47.8%)	63(21%)	10(3%)
Prevention	160(53%)	190(63%)	131(44%)	50(17%)	12(4%)
Environmental sanitation	150(49.8%)	120(40%)	110(37%)	22(7%)	13(4.3%)
Use of local herbs to treat malaria	123(40%)	60(19%)	10(3%)	8(3%)	16(5%)
Symptoms	175(58%)	170(56%)	100(33%)	20(6.6%)	35(11.6%)

Source: Author, 2007 based on field studies in Kericho district in 2006.

From the results in Table 5.9 the overall number of health education provided by health providers is minimal at an average of one visit annually by health providers to communities in the district.

This suggests that the increasing trend in the upsurge in occurrences of unstable malaria is due to communities' little knowledge about unstable malaria. The 5 knowledge questions (Appendix 10) and presented in Table 5.9 shows that the overall awareness (knowledge) based on correct answers and explanations to symptoms was that 65% mentioned high fever, vomiting, general weakness, diarrhea; 95% mentioned mosquitoes as the cause of unstable malaria; 75% mentioned draining of stagnant water and clearing bushy vegetation around homestead; 58%, 70% and 50% mentioned Quinine, Chloroquine and Fansider respectively as methods of treating malaria but 30% could hardly specify correctly the correct dosage for each drug regiment. Out of n = 301 respondents asked the question of the source of information about malaria and treatment only, 35% mentioned the DHS, 60% mentioned local kiosks/shops, 45% mentioned mass media mostly radio channel. The above results suggests that generally provision of informations (knowledges) /education regarding malaria and its treatment in the district especially in remote rural areas of the district was lacking in Kericho district thus this suggests the reason for an upsurge in epidemic malaria cases due to development of anti-malaria drug resistance phenomenon by plasmodia.

5.10 On job–training of health personnel in Kericho district health facilities, 2000-2006.

The on-job training of health personnel in Kericho district health facilities was considered in this study as a component of resource management and an integral part of health systems so that improvement of competence and new skills are acquired, satisfaction among them is provided, acquinting them with new approaches and objectives of health is achieved and relating them with community set up. The relevant data on - job training of health staff was obtained and summarized in Table 5.10, from which it is clear that the main areas of on–job training of health personnel in Kericho district health facilities were: AIDs control (54%), Immunization (60%), Diarrhea (56%), Maternal child care

60%, Use of essential drugs 32%, tuberculosis and Leprosy 42.4%. Overall out of 250 health personnel in Kericho DHS less than 5% had attended on job training. Malaria control-on job training constituted only 31.2% of overall medical staff trained in 2000-2006 despite the fact that malaria is a leading health problem in the district which accounted for about 30.3 % of all hospitals malaria admissions.

Table 5.10: On-job training of health personnel in Kericho district health facilities, 2000-2006

Course Title of Staff	Number of MedicalAssistants Trained	Number of Rural Medical Assistants Trained.	Number of Maternal Child Health Assistants Trained	Total Number of Medical Staff Trained	Percentage Overall Medical Staff Trained
Malaria control	20	7	50	78	31.2
Aids control	60	25	50	135	54
Laboratory diagnosis. Use of diagnosis kits	-	-	-	-	-
Information systems	11	3	1	15	6.0
Use of essential drugs	50	10	20	80	32.0
Oral health	-	-	-	-	-
Immunization	100	35	15	150	60.0
Anaemia	-	-	-	-	
Diabetes	20	5	0	25	1.0
TB and Leprosy	60	36	10	106	42.4
Diarrhoea diseases	80	35	25	140	56.0
Vitamin A Deficiencies	40	10	10	60	24.0
Eye diseases	-	-	-	-	
Family planning	27	15	15	57	22.8
Maternal and child care.	100	35	15	150	60.0

Source: Compiled and computed by Author, 2007 based on data from Kericho district main hospital statistics, 2000-2006.

5.11 Local initiatives and technologies in malaria control and prevention in Kericho district.

In other countries of the world local plants and herbs have been used to efficiently control, prevent and treat malaria. For example the herb *Artemisia annua* or gingao in Chinese has been used to treat malaria in China for many years. This is because the herb contains artemisinin (ginghosu in Chinese), a drug which can effectively clear parasitaemia and malaria related manifestations (WHO, 1993; Rugemalila *et al*., 2000)

In Kericho district indigenous plants/herbs that are repellant to many insect species have been used by local Kipsigis communities to treat, repel or kill many varieties of insects but have not been documented or researched on. In this study an attempt was made to identify from the information supplied by the local community to questionnaires (Appendix 1) the local plants'/herbs' names in Kipsigis/Kalenjin language that have been used and continue to be used to repel or kill insects such as mosquitoes. Several of these herbs have been used to treat malaria fever. All respondents (N=301) in all divisions of the district were asked using a questionnaire (Appendix 1) to state the names of local herbs in Kipsigis language, dosage and method of preparation, specification of the patient's age in administering the dosage in treatment of malaria fever. Also asked was whether the herb named repel or kill other insects and the number and percentage of respondents (households) sampled in each division who supplied affirmative answers to plants/herbs names, knowledges of plant's/herb's use in relation to repulsion of mosquitoes and treatment of malaria is presented in Table 5.11 below

Table 5.11: The number and percentages of respondents' knowledges of the local herbs'/plants' names and use in relation to malaria treatment in divisions of Kericho district sample, N=301.

No.	Herb's/plant's name in Kipsigis	Botanical /Biological name	Division							
			Ainamoi N = 81	Belgut N = 70	Kipkelion N = 37	Londiani N = 35	Sigowet N = 36	Chilchila N = 21	Soin N = 16	Total N=301
1	Ngatumiat	*Cyathilaerinacea. SP*	60 (74.1)	63 (90.0)	31 (83.8)	29 (82.9)	33 (91.7)	16 (76.2)	10 (62.5)	242
2	Cheroriet	*Polyganum*	64 (79.0)	66 (94.3)	33 (89.2)	31 (88.6)	32 (88.9)	18 (85.7)	12 (75.0)	256
3	Leldet	*Acacia-Sieberiana*	61 (75.3)	67 (95.7)	34 (91.9)	32 (91.4)	28 (77.8)	15 (71.4)	9 (56.3)	246
4	Senetuet	*Senna Septemtrionalis*	77 (95.1)	64 (91.4)	30 (81.1)	31 (88.6)	32 (88.9)	16 (76.2)	11 (68.8)	311
5	Kelyot	*Acokanthera-schimperu*	60 (74.1)	62 (88.6)	29 (78.4)	23 (65.7)	27 (75.0)	12 (57.1)	7 (43.8)	220
6	Uswet*	*Nuclea divinorum*	53 (65.4)	51 (72.9)	17 (45.9)	18 (51.4)	23 (63.9)	14 (66.7)	8 (50.0)	184
7			45 (55.6)	60 (85.7)	28 (75.7)	15 (42.9)	22 (61.1)	9 (42.9)	7 (43.8)	186
8	Kipirosit*	*Chenopodium schraderianum*	39 (48.1)	42 (60.0)	28 (75.7)	16 (45.7)	16 (44.4)	9 (42.9)	6 (37.5)	156
9	Moriko*	*Tegetes minuta*	50 (61.7)	65 (92.9)	30 (81.1)	29 (82.9)	31 (86.1)	14 (66.7)	14 (87.5)	233

Source: Author, 2007 based on data from field studies in the district in 2006.

The figures enclosed in brackets are the percentage numbers of respondents in the division who knew names of local herbs/plants for malaria treatment and repulsing away of mosquitoes.

The results in Table 5.11 indicate that majority of the communities in divisions of the district knew the local herbs/plants used to repulse mosquitoes and other insects as well as the local method of treatment/ prevention of malaria.

Majority of respondents in the range of 50-90% said they regularly used Ngatumiat (*Cyathilaerinacea. SP*), Cheroriet (*Polyganum*), Leldet (*Acacia-Sieberiana*), Senetuet (*Senna Septemtrionalis*) and other herbs to treat malaria fever as well as clear headaches in the patient.

Furthermore majority of the respondents (80%) said Kipirosit and Moriko (Mexican marigold) leaves are effective in driving away insects, however, the drugs contained in all the above plants/herbs are yet to be analysed and verified scientifically. The Kipsigis community have used the herbs since time 1850's and there is evidence to show that name "Kericho" in Kipsigis language means "medicine man/woman" and the district headquarter, Kericho used to be the main centre of treatment and control of different diseases including malaria or "Esset" in Kipsigis language.

The herbs listed 1-6, 8 and 9 are used to treat malaria fever. Their barks/roots are boiled in water for one hour and to a malaria patient when warm. The dosage is approximately 1 litre for an adult and 0.25-0.5 litres for a child of the dose. The dose helps the patient to have diarrhoea and clears malaria fever and parasatemia in the patient. Table 5.11.1 shows the herbs'/plants' names, method of preparation, dosage as well as the repulsion of the mosquitoes and other insects.

Table 5.11.1: Local herbs/plants in Kericho district used for treatment of malaria, killing and repelling away of mosquitoes

Herb's/plant's name in Kipsigis	Botanical /Biological name	Parts of herb/plant used	Preparation/dosage/ for malaria treatment	As repellant /methodsparts of herb/plant used	Insect type/ disease treated.
Ngatumiat	*Cyathilaerinacea*	Roots	Boild in water for ½ hr, 2-3cups for an adult		All insects e.g mosquitoes
Cheroriet	*Polygonum SP*	Leaves/ roots	Boiled in water for 1hr. 2-3 cups for an adult, 2 cups for children.		
Leldet	*Acacia-Sieberiana*	Roots	Boiled in water. 2-3 cups for an adult, 1-2 cups for a child.		
Senetuet	*Senna Septemtrionalis*	Leaves	Boiled in water for 1hr, 2-3 cups for an adult, 1 cup for a child.		
Kelyot	Acokanthera schimperi	Leaves/ roots	Boiled in fresh water 1 kg for 1 hour 2-3 cups for an adult, 1cup for a child		Clears malaria fever, clean intestines and bowel
Uswet*	*Euclea divinorum*	Roots/ leaves	1 kg Boiled in water for 1 hr, 2-3 cups for an adult, 1-2 cups for a child.		Clears headaches, clears malaria fever, cleans interstines and bowels
Kipirosit*	*Chenopodium schraderianum*	Leaves, Bark		Smear leaves/Bark on wall, floor etc	Repels away all insects such as mosquitoes etc
Moriko*	*Tegetes minuta*	Leaves Barks		Burned leaves/smoke	

Source: Author, 2007 based on data from field studies in Kericho district in 2006.

5.12 Use of impregnated treated bet nets (ITNs) in Kericho district

As outlined in section 2.10.2, methods used to avoid contact with vector mosquitoes include use of: insecticides, repellents and insecticide coils. The use of impregnated treated bed nets (ITNs) is receiving a wide popularity globally especially in malaria endemic tropical countries, because of its great success in reducing malaria mortality and morbidity in children and infants (Snow *et al.*, 2004) and is cost effective as compared to DDT (Some, 1999; Goodman *et al.*, 2000).

In this study information on the use of ITNs in the district was obtained from respondents (N=301) in all divisions of the district. The respondents in households were asked whether they used ITNs regularly (Appendix 1)daily and the responses were displayed in Table 5.12 below and appendix 13.

Table 5.12: Use of impregnated bed nets (ITNs) in Kericho district sample (N = 301) in 2006

Division	Ainamoi	Belgut	Kipkelion	Chilchila	Londiani	Soin	Sigowet
	n = 30(10%)	n = 18(5.9%)	n = 10(3.3%)	n = 9(3%)	n = 30(10%)	n = 20(6.6%)	n = 9(3%)

Source: Author, 2007 based on data shown in Appendix 13

The results in Table 5.12, Appendix 13 show that a small percentage of 29.2% of all households interviewed (N=301) used ITNs regularly in 2006. This is an indication that the district health system effectiveness in dissemination of information of malaria control targeting vector mosquito control is minimal. Most of respondents said the reason why they did not use ITNs was because they were expensive.

Furthermore, observation on the reason why ITNs were not widely used regularly by each household member was related to the structure of the houses; majority (90%) of households had two houses; one main house for sleeping without a fireplace and a separate one roomed kitchen with a fire place where school age going children and older family members usually slept. Most houses were grass thatched with either wooden or mud walls and (80%) of them did not have ceiling boards. The absence of fire place that could be used to smoke/ repel away mosquitoes and wooden/mud walls were conducive envronment for mosquitoes; the absence of ceiling boards in most houses limited use of ITNs. All these factors were main indicators of inability by households to control malaria transmission hence a possible contributing factor in the increase of malaria episodes in the district.

5.13 SWOT analysis: Management, control and prevention strategies of occurrence of malaria in Kericho district, 1999-2006

This section attempts to answer the question: How effective are control and prevention programmes and strategies regarding the occurrence of epidemic malaria in Kericho district?

In this study the results of SWOT analysis is summarized in Table 5.13 below where:

Strengths (S) are:

S_1: District malaria framework and health personell exist.

S_2: Basic legislation and malaria policy exist in Government health facilities

S_3: District malaria control and prevention programmes have been formulated through guidance of MOH e.g National malaria control strategy (NMCS, 2001-2010)

S_4: Outpatient and inpatient morbidity.

Data on malaria burdens are routinely collected by district health facilities and are available for use by health providers and research activities.

Weaknesses (W):

The weaknesses identified in the control and prevention of malaria are:

W_1: Limited malaria control funding.

W_2: Poor communication in remote areas of the district e.g. Kunyak in Chilchila division.

W_3: Lack of RDT kits in most of the health facilities in the district.

W_4: Limited health delivery mobile services in the district

W_5: Poor working conditions for health personnel

W_6: Limited number of health facilities in remote rural areas.

W_7: Ineffective implementation of malaria control and prevention guidelines

W_8: Limited malaria control education programmes in rural areas.

W_9: Lack of guidelines and policies regarding anti-malaria drug distribution control.

W_{10}: Limited awareness and use of ITNs in the district rural setting

W_{11}: Increasing poverty in the district

W_{12}: Poor leadership

W_{13}: Low standards of education

Opportunities (O) that exist in the district for malaria control and prevention are:

O_1: International malaria control initiatives and support e.g. WHO, RBM (1998); AMREF.

O_2: WHO, and Donor support and participation in malaria control projects in the district such as AMREF, Walter Reed Project, (2006), in the district.

O_3: Public awareness of impacts of occurrence of unstable/epidemic malaria and the need to control and prevent its occurrence.

O_4: Positive political will to control and manage occurrence of unstable/epidemic malaria in Kenya e.g free treatment of malaria announced by government in 2006.

O_5: Existence of malaria control and management unit in Kericho district.

O_6: Existence of the donor distribution of ITNs in the district.

Threats (T) that hinder control and prevention of malaria in the district include:

T_1: Poor state of road network in the district

T_2: Increasing poverty level in the district due to declining economic growth.

T_3: Declining confidence in Government by donor community regarding malaria control funding.

T_4: Corruption practices in the district

T_5: Lack of strong community involvement in anti-malaria decision making processes.

T_6: Lack of strong and serious political will and commitment by the Government in malaria control issues.

T_7: Poor environmental sanitation, health and conservation enforcement in the district.

Despite the existing threats and weaknesses in malaria control programmes there are several existing opportunities as summarized in Table 5.13.

Table 5.13: SWOT analysis, management, control and prevention strategies of occurrence of malaria in Kericho district, 1999-2006

Internal Forces / External Forces	STRENGTHS (S) S_1 S_2 S_3 S_4	WEAKNESSES (W) W_1 W_2 W_3 W_4 W_5 W_6 W_7 W_8 W_9 W_{10}
OPPORTUNITIES (O) O_1 O_2 O_3 O_4 O_5	These are expected to lay effective approaches to manage and control malaria particularly to strengthen S_3 and S_4	Expected strategies and effective management approaches to maximize on O_1, O_2, O_3, O_5, and O_6
THREATS (T) T_1 T_2 T_3 T_4 T_5 T_6 T_7	Expected to strategise and offer effectiveness in management approaches to maximise on strengths S_1, S_2, S_3 and S_4 and to minimise threats T_1, T_2, T_3, T_4, T_6 and T_7.	Expected strategic and effective management approach to minimise threats and weaknesses e.g. to deal with Threats and weaknesses.

Source: Author, 2007 based on literature review and field studies in Kericho district in 2006.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents summary, findings of research, conclusions and policy recommendations and avenues for further research on epidemic malaria. The following issues have been investigated:

i. The patterns and trends of occurrence of unstable malaria burdens in Kericho district of Kenya.
ii. The underlying physical and socio-economic determinants of occurance of unstable malaria.
iii. The relationship between malaria morbidity and a household characteristic.
iv. Methods of control and preventation of occurance of malaria burdens in the district.

The above issues were investigated by answering the following research questions:

i. What are the emerging patterns and trends in occurrences of unstable malaria burdens?
ii. What are the patterns and trends of climatic elements?
iii. What is the relationship between malaria burdens and climatic elements?
iv. What is the relationship between a household's characteristics and occurrence of malaria morbidity in a household?
v. What are the strategies and programmes instituted by health providers in control and prevention of malaria burdens in the district?

vi. What are the local initiatives and technologies for control and prevention of occurrence of malaria in the district?

The following hypotheses were tested:

- There are no significant temporal trends discernible in occurances of malaria morbidity in Kericho district
- There is no significant relationship between variation in occurences of malaria burdens and change in time in Kericho district.
- There is no significant relationship between temporal variation in occurance of malaria burdens and variation in climatic change.
- There is no significant relationship between temporal variation in occurance of malaria and socio-economic factors

The conceptual framework in this study was to explain and account for the occurrence of unstable malaria burdens and to accomplish the main objectives of this study the following data were collected:

i) Secondary data: the malaria burdens data and climatic data were obtained from Kericho health facility and Kericho meteorological station respectively for the period 1988-2005.

ii) Primary data: the household's characteristics were obtained from randomly sampled (N=194) households using questionnaires while information on key issues on malaria burdens and challenges of malaria management and control were obtained from key medical staff in Kericho district main hospital.

The statistical techniques used to organize, process, analyze and present data were tables, means, ranges, percentages and regression analysis. GIS was used to create malaria zonations and SWOT analysis were used to map malaria morbidity and to analyse effectiveness of malaria control programmes in the district respectively.

6.1 Patterns, trends and distribution of malaria burdens

Outpatient malaria cases grew from 19643 cases in 1989 to 124408 or a growth of 106.7% per annum (1989-1994) and a growth rate of 101.9% per annum between 1995-2002. Malaria hospital admissions grew from 2425 cases to 3670 cases in 1988-1994 or a growth rate of 10.27% per annum and a growth rate of 42.8% per annum between 1995-2002. Death grew from 23 in 1988 to 31 in 1994, a growth rate of 6.9% per annum and in 1995-2002 number of malaria death changed from 84 cases to 160 cases or an annual increase of 18.1% during 1988-2002. A total of 70611 malaria hospital admissions were recorded in health facilities in the district and resulting in 1476 deaths due the disease or 21 malaria deaths in every 1000 hospital admissions during 1988-2002. Malaria hospital admissions were seasonal in pattern of occurrence and were mostly in months of June-July of each year. Overall malaria cases followed seasonal patterns of temperature and rainfall e.g. between April-July malaria hospital admissions increased and decreased in September – October and case of fatality rates (1988-2002) ranged between 0.02% to 4.2%; it changed from 9.5 cases 23.6 cases per 1000 in 1988-1999 and 2.2 to 20.7 of cases per 1000 malaria admission. Malaria hospital admissions was on upward trend in 1988-2002 with a growth rate of 111.13% per annum while malaria death rate grew by 10.486% per annum during the same period.

6.2 Patterns and trends of climatic elements

The annual mean temperature, rainfall and relative humidity in Kericho district in 1988-2005 were 17.6°C, 153mm and 64.6% respectively while their monthly mean values were 17.7°C, 162.3mm and 65% respectively during the same period. There was a positive annual mean trend in temperature with a annual growth of 0.0443% or 0.8°C during the synoptic period 1988-2002 but there was no noticeable trend in monthly mean temperature during the same period; hottest and coolest months were February and March with means of 18.6°C and 16.8°C respectively.

Negative trend in mean annual rainfall was recorded during the synoptic period 1988-2005, with a change of 20mm and a negative growth 0.78%. The mean annual rainfall was 162.7mm and two rainy seasons were observed namely; first rainy season was April-May when a mean of 241mm was recorded and second rainy season lasting between end of September and end of November when a mean of 162mm was recorded. February was the driest month with a mean rainfall of 93mm.

The mean annual relative humidity was 65%. Mean relative humidity during April-May was 72% and 54.6% during dry season January-March. Overall high malaria cases followed seasonal patterns occurring after high rainfall followed by high temperature, 241mm and 18.6°C mostly between end of May and July each year during 1988-2002.

6.3 Results of t-test

6.3.1 Trend in malaria hospital admissions, 2 sample periods, 1988-1995 and 1995-2002

The t-test (Table 4.2.3.2) revealed that the trend in observed number of malaria hospital admissions was significant (t-computed value of 2.7523 > t-critical value of 2.4) at 0.05 level of significance hence the null hypothesis which stated that there was no significant temporal trends discermible in occurrences of malaria morbidity in Kericho district was rejected at 0.05 level.

6.3.2 Trend in deaths due to malaria, 2 sample periods, 1988-1995 and 1995-2002.

The result of t-test (Table 4.2.2.4) has revealed that the computed t-value of 2.68 critical value of 2.365 at 0.05 level of significance hence there was a significance difference in mean malaria deaths for the two sample periods.

6.3.3 Trend in annual mean temperature, rainfall and relative humidity

The results of t-test (Table 4.2.2.5) has revealed that the computed t-value of 2.4065 < t-critical value of 3.2447 at 0.05 level which implies that at 0.05 there was no significant difference in the annual mean temperature for two sample periods, 1988-1995 and 1995-2002. The results of t-test (Table 4.2.2.6 and 4.2.2.7,) have shown that t computed values of 0.13, 0.78 are less than corresponding t-critical values of 2.4 and 2.4 respectively at 0.05 levels implying that there was no significant change in annual mean value of rainfall and relative humidity in the two sample periods considered above.

6.4 Correlation analysis

Results (Table 4.3.3) have revealed that malaria cases (morbidity) in a household was strongly correlated (0.943) with frequency of visits to the nearest health facility and this value was significant at 0.05 level in a two tailed test. However malaria morbidity lowly (0.134) correlated with family size. Malaria morbidity in a household correlated positively (0.321) with distance to the health facility and this value being significant at 0.01 level in a 2-tailed test, positive sign implies that distance from a household influenced malaria morbidity, i.e. longer distances from a household led to delay in prompt treatment of malaria and could have caused increase malaria transmission in a household. Family income correlated negatively (-0.114) with family size, a correct sign implied that low family income was associated with large family size. Maternal age correlated negatively (-0.309) with family size and significant at 0.01 level. The sign implied that mothers who spent longer time in schooling had smaller family sizes. Family income correlated positively with each of the variables, maternal age and maternal education with values of 0.205 and 0.238 respectively and both values being significant at 0.01 level in a 2-tailed test. However income did not have effect on malaria occurrences in a household or effect on the number of visits to a health facility by a household member.

6.5 Regression analysis

Simple regression models have revealed upward trend in malaria hospital admission, morbidity, death and temperature (Figure 4.2.1.1 c-e and 4.2.2.b grew at rates of 111.13%, 109.52%, 10.486% and 0.0443% per annum respectively during the period 1988-2002 whereas downward trends in annual rainfall and relative humidity grew negatively at 0.7329% and 0.005% respectively. The number regression regarding malaria hospital admissions, malaria morbidity and malaria deaths produced coefficients of determinations of 0.3052, 0.8539 and 0.3479 implying that time (1988-2002) accounted for 30.52%, 85.39% and 34.79% of the variation in these burdens respectively during the period 1988-2002. Further regression analysis results (Tables 4.3.4 and 4.3.5) show that the significant variables to be retained in multiple regression model linking malaria morbidity and household's explanatory variables were maternal age and distance to the health facility and the coefficient of determination R^2 =0.118 i.e the model predicted only 11.8% of malaria cases in a household. The F-calculated value of 6.18 was larger than F-critical values 2.30 and 3.22 at 0.05 and 0.01 levels of significance respectively hence there was a significance difference in the relationship between temporal variation in occurances of malaria cases in a household and socio-economic factors. Thus the null hypothesis stated that there was no significant relationship between temporal variation in occurance of malaria cases (morbidity) and socio-economic factors was rejected.

6.6 Cullen malaria epidemic detection technique

The Cullen (1984) malaria epidemic detection technique identified malaria epidemic years as 3 and twelve months as epidemic during the surveillance period 1988-2002. The epidemic years were 1990, 1998, and 2002 when exceptionally high malaria hospital admissions were recorded in Kericho district main hospital. Paedriatic malaria hospital admissions data in the health facilities followed asymmetric distribution with coefficient of skewness values of 0.3138 and 0.2776 for untransformed and transformed malaria admissions data respectively during surveillance period 1988-2002.

6.7 SWOT Analysis

SWOT analysis results has revealed future strategies for effective malaria control programmes in Kericho district. Overall, strategies, opportunities and strengths in malaria control should be stepped up in the district to meet long term control strategies and to be in line with NMCS, 2001-2010. There is a need to develop district based malaria control programme data base and a strong political wiil by the government to provide funds and health services for malaria control programmes in the district. The strong will by the government to provide funds towards malaria control programmes would also attract further funding from Non-governmental agencies towards the same e.g. W.H.O e.t.c.

6.8 Geographic information system (GIS)

GIS created 5 malaria zones based on annual incidences of malaria morbidity; highest malaria zone had 10835 – 15029 cases covered lower highland AEZ in Kipkelion and Ainamoi divisions; high malaria zone had 7917-10834 cases covered upper highlands and upper midland AEZs in Kipkelion Chilchila and Soin divisions, medium malaria zone had 6239-7916 cases and covered midland AEZ in Belgut, Sigowet and parts of Ainamoi division, low malaria zone had 5367-6238 cases covered upper highland AEZ in Chilchila and Londiani divisions and least malaria zone has less than 5366 cases and covered higher parts of upper highland AEZ in Londiani and Chilchila divisions.

6.9 Reporting rate by health institutions.

Reporting rate changed from 27.2% to 67.1% in 1999-2003 against the number of 85 health facilities in the district in 2003. The mean number of reporting health institutions was 60% and the mean reporting rate was 44.9% implying that 55% of all health institutions were not reporting to Health Information System (HIS).

6.10 Control of occurrence of malaria murdens

Results showed effectiveness of anti-malaria drugs, Coartem, Arthemisinin, Helfan Paluther and Cotecxin ranged between 60% and 80% in 2006. Only 29.2% of households sampled (N=301) used ITNs regularly and more, 60% of respondents interviewed bought anti-malaria drugs from local kiosks/shops without the prescription from qualified health personnel. Majorly of respondents interviewed said that indoor residual spraying of houses was very effective in controlling mosquitoes and 70% of respondents use local herbs/plants namely, *Polyganum, Acacia-sieberiana, Cyathilaennacea SP and Septenitrionalis* to treat and control malaria in households.

6.11 Policy implication of research findings

On the basis of the findings of this study, the following policy recommendations are made:

i. During secondary data collection in the district hospital, a number of missing or deficient health records were noted or some health institutions in the district were no reporting to health information system (HIS). Deficiency of data included missing files/records or gaps in health records in Kericho district main hospital which is supposed to be supplied with all the health statistics from other health centers in the district. This was particularly so regarding health data/records before the 1999. Thus it is recommended that an effort be made to enhance data collection, storage and retrieval using latest technology and health data from health facilities should be communicated on time from health centers to HIS or Kericho district main hospital. In addition each health facility should develop its database on health data and other documents related to health delivery aspects and networking with other institutions e.g. district information and documentation centre should be enhanced.

ii. The government through MOH should be the sole agent in sourcing, distribution and regulation of anti-malaria, drugs. This is to ensure availability of quality drugs and their appropriate use.

iii. This study has identified environmental sanitation e.g. uncollected disposal of used plastic materials to have reinforced transmission of malaria in the district hence the government and other health providers should step up environmental sanitation to include possible ban use of some plastic materials or introduction of non-plastic (organic) to replace or limit the use of plastic material..

iv. The government should step up efforts to reduce malaria burdens by providing more malaria education to public, improvement of accessibility to health facilities, free malaria treatment, the priority to include infants, children and expectant mothers.

v. This study has found out that there exist Kenya, NMCS, 2001-2010 policy guidelines and institutional framework and interventions to control malaria. However, integration of health education e.g. in primary schools programmes should be included so that children begin to know malaria and methods of its control as they grow.

vi. The government and other health providers should step up campaigns on the regular use of ITNs in all households.

vii. Indoors residual spraying of houses should be stepped up in the district and that this exercise should be undertaken at least once yearly e.g. in May.

6.12 Academic and practical contribution of the study

This study has made the following academic and practical contribution.

i. A link between occurrence of unstable malaria and both socio-economic and climatic factors and time.

ii. A conceptual, methodological and practical aspects of occurrence of malaria burdens and their control. Using discussions, observations and interviews very useful informations on the local methods for malaria treatment and control were obtained.

6.13 Suggetions for further research

The following are areas deemed as requiring further research:

i. Local methods and initiatives for malaria treatment and repulsing away of mosquitoes and particularly their toxologic pharmacologic and pharmakinetic properties of indigenous herbs and plants.

ii. Mapping and analysis of changes in environmental factors using GIS models for land in relation to malaria burdens and their control.

iii. Impacts of deforestation on re emergence of malaria epidemics in the highlands of Kenya.

iv. Impact of malaria burdens on socio-economic environments.

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APPENDICES

Appendix 1: Questionnaires: Socio-economic and physical environmental determinants of occurrence of malaria

Introduction

My name is Warkach Kipkorir Tonui from Kenyatta university. I am undertaking a research in malaria. My research permit is:
No. MOEST 13/001/36C.526/2 issued by the Ministry of Education. To accomplish this research I require household data and health data from Kericho district main hospital and other health facilities in the district.

Malaria causes a lot of suffering and poverty to very many people in Kenya and can kill victims especially infants, children and expectant mothers if not correctly diagnosed and promptly treated by a trained health personnel. I am requesting you to supply me/my research assistant with the information required. The informations you give shall be treated confidentially. This exercise is purely for academic purposes and it is hoped the results will have policy implications regarding control of malaria at household level and the whole district generally. I thank you very much for your co-operation in this exercise.

Date of Interview: 27th August 2006
Name of Interviewer: W.K. Tonui

A. Social environmental factor

Kindly complete Table 1 as accurately as you can (household head)

Table 1:

1 Household No.	2 Division	3 Zone	4 Zone Sub-location	5 Village	6 Age	7 Marital Status	8 Family Size	9 Sex	10 Education Statistics
		1. UH 2. LH 3. UM 4. LM							1. Std. 4 2. Std. 5-8 3. Secondary 4. Post-Secondary 5. Others (Specify)

B. Economic factor

11. Number of huts/houses meant for sleeping including stores and number of persons per room ________________________, interviewer estimates mean distances (m) apart ___________

12. House type (interviewer see)
    (a) Grass thatched roof, mud walls/2 bedrooms/wooden windows with/without ceiling board and/separate grass thatched roofed with mud walls kitchen [ ].
    (b) Iron sheet roofed/mud walls/2 bedrooms, wooden windows with/without ceiling board separate grass thatched kitchen with 1 window [ ].
    Others (specify)

    (c) Other (specify)____
13. Do you own a Radio/TV set? (a) Yes [ ], (b) No [ ], None [ ].
    (d) Others (Specify) ________________________________
14. If Yes in 13 above, state whether you listen/watch, news/adverts and state times you do this ________________________________
15. Domestic Animals
    (a) Goats/sheep [ ]
    (b) Goats/Cattle/Sheep [ ]
    (c) Others (Specify) _________________________________
16. State the number of domestic animals in15 above.______________
17. State your farm size (a) < 3 acres (b) 3-10 acres
    (c) > 10 acres (d) Others ____________________
18. Crops grown
    (a) Tea/Maize/Beans [ ]
    (b) Tea/Maize [ ]
    (c) Maize/Tea/Sugarcane [ ]

(d) Others (Specify) ______________________________

19. Occupation over the last 5 years.
    (a) Peasant/subsistence crop activation
    (b) Small tea scale/Dairy farmer
    (c) Small scale tea/sugarcane/dairy farmer
    (d) Others (specify) ______________________________

20. Specify your monthly income (approximate) in Kenya Shillings.
    (a) 1,500-2,500
    (b) 2,501-3,000
    (c) 3,001-4,500
    (d) >4,500
    (e) Others (specify)

C. Physical environmental factor of household.

21. Topography of household: Drainage of surrounding homestead (Interviewer see)
    (a) Well drained [ ]
    (b) Several pools of stagnant water [ ]
    (c) Others (Specify)
    In 21 above, state whether you usually drain away stagnant water.

22 Vegetation, uncollected/used plastic and polythene papers around homestead.
    (a) Tall uncut grass [ ]
    (b) Tea bush and short cut grass [ ]
    (c) Short cut grass and some bushy vegetation [ ]
    (d) Others (Specify) ______________________________

23. State and name approximate distance (Km) from house to the nearest low cost hospital/clinic where you usually seek medical treatment;
    Name ______________________ Distance ________________ Km.

24. Why do you prefer the hospital/clinic named in 23 above?
    ____

D. Perceptions/beliefs/knowledges regarding unstable malaria occurrence.

25. Have you heard of unstable malaria or epidemic malaria?
    (a) Yes [ ] (b) No [ ]

26. Do you know what malaria is?
    (a) Yes [ ] (b) No [ ]

27 If your answer in 26 above is yes, what causes malaria?
    a) Drinking dirty water [ ]
    b) Eating certain green vegetables [ ]
    c) Bite of an infected Mosquito (Mbu) usually at night [ ]
    d) Others (Specify) ______________________________

28. Do you know that malaria can kill? a) Yes [ ] b) No [ ]
c) Others ____

29. Symptoms of malaria are:
a) Fever, paining joints, Nausea, sweating and vomiting [ ]
b) Cough and diarrhoea [ ]
c) Pains in joints, cough and diarrhoea [ ]
d) Others (specify) ____

30. Do you know that unstable malaria (epidemic) can kill if not promptly treated by a qualified doctor?
a) No [ ] b) Yes [ ]
c) Others (Specify)____________

31 Do you know also that unstable malaria can cause mental illness, abortion, or stillbirth?
a) No [ ] b) Yes [ ]
c) Others (Specify)____________

32. Which environmental factors help spread unstable malaria in your household?
(a) Stagnant water, bushy vegetations, crowded dwellings Surrounding homestead [ ]
(b) Not taking anti-malaria drugs weekly [ ]
(c) Others (Specify) ____

33. When did you contract malaria last? Day [ ] Month [ ] Year [ ]

34. State the number of malaria cases in your household in the last 2-4 weeks before this intervention in 2006.
a) 1 b) 2 c) 3 d) 4
e) Others (Specify) ________

35. Do you know what an impregnated mosquito bed net (ITN) is?
a) No [ ] b) Yes [ ] c) others (specify) ________

36. State when unstable (highland) malaria usually occurs
a) Wet season
b) Dry season
c) End of wet season
d) Others (Specify)___________

37. State the name of the hospital or clinic you usually attend for medical care
________________.

:. Malaria control: local Initiatives of malaria control and treatment

38. Kindly fill the following Table 4 regarding local malaria control initiatives.

Table 3: Local methods of malaria control

Herbs Name in Kipsigis	Dosage & method of administering the herbs	Specification of patients age for the dosage	Where obtainable	Preparation and Storage

39. Regarding 38 above state other local methods for repulsing away mosquitoes____________________________

40. What first thing do you do when you or any member of your family is suspected to have contracted malaria?

a) Consult a village Medicine Man/Woman/witchcraft [ ]
b) Buy anti-malaria drugs from the nearest Kiosk/shop and use them as directed by the owner of the Kiosk/shop [ ]
c) Consult a nurse/doctor in the nearest clinic/hospital [ ]
d) Take herbs
e) Others (Specify)________________

41. Which anti malaria drugs do you usually take to treat severe (unstable) malaria?

a) Malariaquin [ ] b) Chloroquin [ ] c) Quinine [ ]
d) Fansidar [ ]
e) Amodiaquine [ ] f) Panadol [ ] g) Aspirin [ ]
h) Others (Specify)__________________________

42. For the last five years, state whether the anti malaria drugs you have stated in 42 above has always been effective in treating malaria or not.

a) Effective [ ] (b) Has become less effective [ ]
c) Others (Specify)__________________________

43. How many times has Government Health Officer(s) visited this village to advice on malaria problem during the last three rainy seasons.

a) 1-2 [ ] b) 3-4 [ ] c) 5 [ ] d) Never [ ] e) Others (Specify)

44. Where do you usually buy your anti-malaria drugs?

a) Kiosk near my house [ ] b) Shop near my house [ ]
c) Buy from street vendor in the market [ ]

d) Clinic/Hospital/Chemist/Pharmacist [ ]
e) Others (Specify)
State whether the kiosk/shop owner advises you on the dosage required

45. Do your entire family usually use mosquito impregnated bed nets (ITNs) during the nights?
a) No [ ] b) Yes [ ] c) Others (Specify)
If no, state why

46. Do you drain stagnant water around your homestead during rainy season?
a) No [ ] b) [ ] c) Others (Specify)

Appendix 2: Kericho district main hospital malaria cases: 1988-2002.

YEAR	MONTH		INPATIENT CASES				LABORATORY	
			<5 year old		>5 year old		EXAM	POS+ cases
			ADM	DEATH	ADM	DEATH		
1988	January	475	82	0	115	0	482	46
	February	398	63	0	112	0	413	40
	March	562	75	0	152	0	564	57
	April	575	80	0	123	0	548	55
	May	566	65	1	160	0	565	113
	June	712	120	0	134	0	681	136
	July	1113	116	3	130	3	913	274
	August	916	97	5	161	2	807	202
	September	530	72	1	117	0	507	51
	October	499	60	1	100	2	360	36
	November	502	48	0	191	2	340	33
	December	455	48	1	104	2	334	32
1989	January	425	77	1	98	4	345	52
	February	490	81	1	105	2	480	72
	March	564	101	1	141	0	441	44
	April	708	74	0	199	3	624	93
	May	938	114	1	192	1	864	130
	June	1226	124	2	204	4	940	188
	July	1319	146	0	200	0	1137	227
	August	1127	96	0	186	0	958	192
	September	861	70	0	125	0	712	100
	October	663	71	0	112	1	581	87
	November	627	62	1	103	2	416	45
	December	480	52	0	86	4	278	30
1990	January	920	90	1	133	1	591	47
	February	1510	148	2	260	0	1012	152
	March	2404	215	2	385	2	1562	234
	April	1800	162	3	290	5	1172	176
	May	3172	226	5	317	26	1811	254
	June	2459	207	14	391	22	2073	456
	July	1105	171	13	299	5	963	212
	August	1767	214	4	334	5	1608	321
	September	1528	166	3	334	7	1111	108
	October	1647	142	1	321	4	1127	115
	November	1616	98	0	272	0	1016	99
	December	2861	109	0	323	0	2149	429

1991	January	2415	221	0	449	0	2119	318
	February	2116	190	0	300	3	1336	120
	March	1812	116	0	227	2	1068	128
	April	1612	98	0	142	0	1207	181
	May	1224	104	2	200	2	1038	158
	June	1591	124	0	225	0	1304	235
	July	1613	124	0	304	0	1396	279
	August	1517	111	0	190	0	1211	182
	September	1618	116	0	229	0	1315	171
	October	1723	140	0	350	0	1179	130
	November	1786	152	0	322	1	1546	156
	December	1037	90	0	116	0	621	62
1992	January	690	82	0	120	0	616	55
	February	628	84	0	118	1	453	47
	March	825	100	0	159	0	754	128
	April	715	75	0	160	0	664	106
	May	1644	150	0	303	0	1439	245
	June	1215	117	0	211	1	1057	233
	July	1850	163	1	370	2	1643	394
	August	926	89	1	156	3	615	68
	September	933	89	5	142	1	604	60
	October	802	70	1	145	3	536	48
	November	716	65	0	131	2	482	29
	December	677	65	0	126	0	462	48
1993	January	625	56	2	91	2	522	61
	February	702	66	0	114	1	601	96
	March	743	66	2	125	3	637	76
	April	765	81	4	137	1	677	91
	May	693	80	2	140	1	636	65
	June	1021	115	4	175	4	903	153
	July	1158	115	5	272	4	1082	281
	August	748	61	1	157	2	517	75
	September	880	63	0	200	2	615	66
	October	488	45	0	192	1	432	47
	November	720	58	2	110	2	600	62
	December	821	50	2	109	0	487	34
1994	January	629	71	0	122	0	570	59
	February	591	68	0	83	1	377	40
	March	587	97	2	106	1	438	57
	April	1456	140	4	121	2	843	131
	May	2087	184	3	189	2	1625	325
	June	1341	221	2	264	1	1200	258
	July	3303	249	5	315	3	1885	452
	August	1630	225	3	287	1	1403	248
	September	1650	153	0	120	1	1363	184
	October	726	78	1	144	0	512	26
	November	1116	61	0	111	0	841	93
	December	1285	67	0	86	0	924	117
1995	January	1068	54	5	81	5	776	93
	February	1239	71	2	100	3	914	103
	March	1114	105	1	133	6	684	94
	April	1281	78	2	117	2	707	99
	May	613	106	4	130	4	481	48
	June	643	121	8	136	6	643	67
	July	703	125	3	156	2	703	163
	August	510	85	4	119	3	510	74
	September	440	74	1	102	3	440	35
	October	593	103	3	134	2	474	49

	November	460	79	2	105	4	368	34
	December	368	66	3	81	5	294	28
1996	January	1327	77	1	210	6	1083	119
	February	946	72	5	199	2	839	88
	March	769	64	2	126	7	651	78
	April	951	121	1	196	2	888	123
	May	1177	136	3	207	7	949	153
	June	1052	111	5	152	6	894	104
	July	1509	122	6	215	4	1242	217
	August	1343	84	3	197	3	1087	112
	September	967	80	2	159	2	626	63
	October	944	74	1	135	4	587	61
	November	781	66	7	110	4	488	52
	December	647	66	6	114	2	439	47
1997	January	1301	236	10	420	16	1437	187
	February	1435	119	7	393	13	1373	152
	March	1345	354	12	445	20	1606	225
	April	1189	219	5	225	10	1157	173
	May	1500	244	7	256	12	1400	246
	June	1612	190	9	298	14	1455	218
	July	3001	258	20	395	34	2450	662
	August	2981	242	14	346	21	2377	303
	September	1916	200	7	323	11	1289	135
	October	1091	245	9	297	7	978	88
	November	2663	249	11	352	5	2199	219
	December	1870	222	6	314	10	1658	187
1998	January	1950	245	3	310	7	1335	142
	February	3974	350	2	379	5	2319	278
	March	2587	376	3	456	3	1867	189
	April	6318	432	5	527	9	3486	628
	May	5493	415	6	494	16	4205	715
	June	5000	398	10	448	30	3846	769
	July	4155	411	13	500	27	3401	544
	August	1753	212	11	289	20	1553	127
	September	3071	252	7	316	7	1796	211
	October	4057	399	3	460	8	2482	472
	November	2314	125	5	201	6	1252	175
	December	4126	279	3	314	6	2243	347
1999	January	634	79	2	297	4	629	37
	February	524	92	4	365	6	667	69
	March	450	73	3	290	3	543	56
	April	3147	91	4	384	6	2363	310
	May	690	300	6	554	7	1268	137
	June	1460	379	7	604	10	1859	211
	July	733	231	9	425	13	1096	153
	August	588	142	2	253	2	748	77
	September	341	100	2	299	2	535	59
	October	547	158	1	342	3	729	87
	November	610	139	2	318	5	697	73
	December	250	140	2	289	3	529	66
2000	January	328	19	4	200	9	350	49
	February	582	180	5	267	6	796	116
	March	577	130	1	141	8	607	71
	April	396	124	6	278	12	640	64
	May	445	118	5	362	10	747	82
	June	447	130	4	342	8	740	99
	July	429	74	5	385	8	716	71
	August	383	78	2	350	4	581	59
	September	333	82	3	311	3	526	54

	October	347	170	2	311	3	620	74
	November	313	104	3	299	4	528	60
	December	275	92	2	277	2	479	42
2001,	January	372	174	7	316	6	639	65
	February	433	194	3	303	4	670	67
	March	776	264	2	388	11	962	77
	April	595	185	3	324	3	747	82
	May	547	141	4	279	10	748	75
	June	409	206	5	234	9	685	48
	July	553	177	4	278	10	787	71
	August	410	128	2	291	9	583	55
	September	362	179	2	323	5	597	62
	October	337	164	4	308	3	607	73
	November	329	87	2	256	10	475	48
	December	240	108	4	341	3	545	54
2002	January	333	209	10	349	10	691	30
	February	352	124	3	207	6	472	47
	March	253	135	6	317	10	553	66
	April	321	148	7	254	12	530	85
	May	655	201	7	393	6	1259	127
	June	2155	597	17	632	22	2522	296
	July	3630	878	16	861	34	3917	630
	August	1739	299	9	430	16	1772	172
	September	629	218	4	321	12	791	82
	October	523	123	6	303	9	635	64
	November	277	95	2	279	13	485	24
	December	382	160	3	272	10	585	59

Source. Kericho district main hospital statistics, 1988-2002

Appendix 3: Patterns and trends of malaria morbidity: Kericho district, 1998 - 2005

Months/Year	1998	1999	2000	2001	2002	2003	2004	2005
January	1951	4005	2765	4834	4262	9833	6593	9544
February	3974	2766	3338	4801	4507	10818	6688	9226
March	2587	3683	4112	7547	3202	11339	8205	7514
April	6318	3147	4168	3387	3932	7030	7701	6318
May	5493	5537	7283	3337	5425	6696	10248	10078
June	5000	6489	6290	5188	18080	14888	16656	9028
July	4155	8591	3354	5643	23616	18712	15158	12184
August	1753	4738	4296	5124	11923	8285	8355	11357
September	3071	2236	3916	4527	4996	5706	7491	10807
October	4057	2766	3461	4451	4321	6716	7150	8212
November	2314	2663	2899	3990	2704	4237	6215	5837
December	4126	1870	2874	3046	3617	5196	5344	4203

Source: Kericho district main hospital-statistics, 1998-2006.

Appendix 4: Patterns and trends of malaria outpatient morbidity: Kericho district, 1999-2005

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999	4005	2766	3683	3147	5537	6489	8591	4738	2236	2763	2663	1870
2000	2765	3338	4112	4168	7283	6290	3354	4296	3916	3461	2399	2874
2001	4834	4801	7547	2775	3337	4464	4634	3579	4254	4451	3486	3046
2002	4262	4507	3202	3932	5425	15817	23615	11454	4996	4321	2104	3617
2003	9833	12406	11369	7030	6696	14888	18862	8285	5706	6716	4237	5106
2004	6593	6688	8205	7701	10248	16656	15158	8355	7143	7150	6215	5344
2005	6756	9226	9340	6318	10078	9028	12184	1380	10758	8212	5837	4203

Source: Kericho district main hospital- statistics, 1999- upto September 2006.

Appendix 5: Trends of malaria outpatient, total admissions and deaths: Kericho district, 1988-2002.

Year	Outpatient (OP) Cases	Total hospital Admissions due to malaria	Deaths
1988		2873	23
1989	19643	2833	28
1990	10014	6607	137
1991	11240	4637	10
1992	92232	3290	21
1993	40792	2678	43
1994	124408	3672	31
1995	114408	2611	84
1996	60158	3193	91
1997	53775	6839	289
1998	44808	8582	215
1999	49667	6237	109
2000	48491	4797	110
2001	55875	5178	125
2002	87853	7693	260

Source: Kericho district main hospital-statistics 1988-2006.

Appendix 6: Trends of climatic elements in Kericho district, 1988-2005.

Year	Mean Annual Temperature (ºC)	Mean Annual Rainfall (mm)	Mean Annual Relative Humidity (%)
1988	17.4	192.4	67.1
1989	17.1	171.8	55.7
1990	17.3	155.3	65.1
1991	17.3	167.9	66.8
1992	17.7	166.5	67.4
1993	17.5	142.2	62.7
1994	17.5	167.1	64.8
1995	17.7	144.4	65.0
1996	17.3	171.6	67.4
1997	17.9	149.8	62.1
1998	18.0	182.0	65.5
1999	17.5	155.0	63.9
2000	17.8	150.0	63.9
2001	17.6	173.9	67.2
2002	17.8	174.1	64.8
2003	18.0	162.0	62.9
2004	17.9	150.0	65.1
2005	18.2	151.8	61.6

Source: Kericho meteorological station stations statistics, 1988-2005

Appendix 7: Patterns of mean monthly temperature, rainfall and relative humidity in Kericho district, 1988-2005.

Month	Temperature (ºC)	Rainfall (mm)	Relative Humidity (%)
January	17.95	117.7	57.6
February	18.60	93.2	51.5
March	18.60	179.0	58.6
April	17.95	232.5	69.8
May	17.45	249.9	73.3
June	17.15	157.7	71.2
July	16.80	157.3	70.1
August	17.10	182.3	68.9
September	17.40	148.9	68.2
October	17.40	184.3	67.0
November	17.35	153.2	66.0
December	17.75	95.8	57.9

Source: Kericho meteorological station statistics, 1988-2005

Appendix 8: Distribution of health personnel in Kericho district government health facilities, 2000-2005.

Year	2000			2001			2002		
Health Division	Doctors	Clinical Officers	Nurses	Doctors	Clinical Officers	Nurses	Doctors	Clinical Officers	Nurses
Ainamoi	14	25	120	14	1	120	14	30	120
Belgut	0	2	5	0	2	5	0	1	5
Kipkelion	0	0	5	0	0	5	0	1	5
Sigowet	0	1	6	0	0	6	0	1	6
Soin	0	0	4	0	0	4	0	1	4
Chilcila	0	1	4	0	1	4	0	1	4
Londiani	1	2	20	1	5	20	1	5	20

Year	2003			2004			2005		
Health Division	Doctors	Clinical Officers	Nurses	Doctors	Clinical Officers	Nurses	Doctors	Clinical Officers	Nurses
Ainamoi		30	120	14	30	120	14	30	120
Belgut		2	5	0	2	5	0	2	5
Kipkelion		1	5	2	2	5	0	0	5
Sigowet		1	6	0	1	6	0	1	6
Soin		0	4	0	0	4	0	0	4
Chilcila		1	4	0	1	4	0	1	4
Londiani		6	20	1	7	20	1	7	20

Source: Kericho district main hospital statistics 2000-2005.

Appendix 9: Health centres and availability of clinical microscope and rapid diagnostic tests kits (RDTS) in Kericho district health facilities 2000-2006.

Year	2000		2001		2002		2003	
Health Division	MC	RDTS	MC	RDTS	MC	RDTS	MC	RDTS
Kericho district main hospital	3	1	3	1	3	1	3	1
Londiani	1	1	1	1	1	0	1	1
Sigowet	1	1	1	0	1	0	1	1
Sosiot	1	1	1	0	1	0	1	1
Kipkelion	1	1	1	0	1	0	1	1
Kipsitet	1	1	1	0	1	0	1	1
Fort Ternan	1	1	1	0	1	0	1	1

Year	2004		2005		2006		TOTAL
Health Division	MC	RDTS	MC	RDTS	MC	RDTS	
Kericho main district main hospital	3	1	3	1	3	1	12
Londiani	1	1	1	1	1	1	6
Sigowet	1	1	1	1	1	1	6
Sosiot	1	1	1	1	1	1	6
Kipkelion	1	1	1	1	1	1	6
Kipsitet	1	1	1	1	1	1	6
Fort Ternan	1	1	1	1	1	1	6

Source: Kericho district main hospital statistics, 1999-2006

Appendix 10: Information on health education and community awareness/ knowledges in relation to malaria control and prevention in Kericho district sample,(N=301) In 2006

No.	Respondents knowledges about malaria	Information Sources				
		Correct overall response	Radio	MOH(GoK)	Newspapers	Others e.g meetings, (Barazas) etc
1	Causes of malaria	200	220	149	80	36
2	Treatment of malaria	171	210	140	63	10
3	Prevention of malaria	160	190	131	50	12
4	Environmental sanitation e.g. collection of waste plastics	150	120	110	32	13
5	Use of local herbs to treat malaria	123	60	10	8	16
6	Symptoms of malaria fever.	175	170	100	20	35

Source:.Author, 2006, based on field studies in Kericho district in 2006.

Appendix 11: Distribution of episodes of occurrence of unstable malaria morbidity by divisions of Kericho district, 1999-2006.

Division	1999	2000	2001	2002	2003	2004	2005	2006
Ainamoi	6930	9632	10114	19486	28978	25205	4856	105201
Belgut	4990	5688	4128	8393	13705	63901	2720	103525
Kipkelion	5622	9032	8044	18742	17840	14682	1874	75836
Chilchila	6199	6598	4840	8431	9110	6825	1608	37468
Londian	3381	3332	2804	6621	8329	10111	2485	37063
Soin	5436	8023	6413	9625	10860	13152	1874	55411
Sigowet	7702	9091	7048	13821	16669	1516	3505	69352

Source: Compiled by Author 2006, based on Data from Kericho district main hospital statistics, 1999-2006.

Appendix 12: Respondents seeking medical professional advice in divisions of Kericho district, sample (N = 301) in 2006

Response	Sigowet	Belgut	Soin	Ainamoi	Chilchila	Kipkelion	Londiani
Proportion seeking professional advice	n = 36	n = 70	n = 16	n = 86	n = 21	n = 37	n = 35
General medical advice	13	33	8	10	9	11	21
Advice on the use of appropriate drug and source	10	31	4	13	8	10	9
Use of anti-malaria drug from local kiosks and shops	14	32	5	30	9	12	20

Appendix 13: Use of impregnated treated bed nets in division of Kericho district, sample (N=301)in 2006

Division	Ainamoi	Belgut	Kipkelion	Chilchila	Londiani	Soin	Sigowet
	n = 30	n = 18	n = 10	n = 9	n = 30	n = 20	n = 9

Source: Author, 2006 based on field studies in Kericho district in 2006

Appendix 14: Some selected household characteristics, Kericho district sample (N=194) In 2006

Household no.	Malaria cases	Family Size	Family Income (Kshs.)	Maternal Age	Maternal Education	Distance to the nearest health facility (Km)	Number of visits to the health facility (KM)
1	2	6	3001-4500	52	Secondary	5	2
2	3	7	>4500	54	Std. 5-8	4	3
3	1	6	>4500	53	Std. 5-8	1	1
4	3	5	1500-2500	46	Std. 5-8	4	3
5	2	7	>4500	51	Std. 5-8	6	3
6	1	5	3001-4500	49	Secondary	5	0
7	0	5	>4500	49	Post- secondary	0	0
8	2	4	>4500	47	Post-secondary	0	2
9	2	5	2501-3000	47	Secondary	7	2
10	2	7	>4500	53	Std. 5-8	7	2
11	3	5	3001-4500	47	Secondary	6	3
12	2	6	>4500	49	Secondary	5	2
13	2	6	>4500	51	Std. 5-8	9	2
14	2	9	>4500	53	Std. 4	8	2
15	1	6	>4500	63	Std. 5-8	1	1
16	1	8	>4500	56	Post-secondary	3	1
17	1	4	3001-4500	53	Secondary	1	1
18	1	6	2501-3000	43	Std. 5-8	1	1
19	1	8	>4500	53	Std. 5-8	1	1
20	1	6	>4500	50	Std. 4	2	1
21	1	4	3001-4500	36	Secondary	2	1
22	1	6	>4500	54	Post-secondary	1	1

23	1	6	>4500	50	Post-secondary	1	1
24	1	8	1500-2500	46	Std. 5-8	2	1
25	1	3	>4500	29	Secondary	3	1
26	1	6	>4500	52	Std. 4	1	1
27	1	3	1500-2500	32	Std. 5-8	1	1
28	2	7	>4500	51	Std. 5-8	7	2
29	2	6	3001-4500	40	Secondary	7	2
30	2	7	2501-3000	48	Std. 5-8	6	2
31	2	3	3001-4500	39	Post-secondary	6	2
32	2	4	3001-4500	43	Secondary	3	2
33	2	4	3001-4500	40	Secondary	3	2
34	2	7	3001-4500	53	Std. 5-8	6	2
35	1	4	>4500	40	Secondary	1	1
36	2	4	3001-4500	34	Post-secondary	3	2
37	2	10	3001-4500	60	Std. 5-8	9	1
38	2	4	3001-4500	39	Secondary	5	2
39	3	10	>4500	60	Std. 5-8	5	3
40	3	4	3001-4500	41	Post-secondary	4	3
41	3	5	2501-3000	47	Secondary	4	3
42	3	7	>4500	51	Post-secondary	4	3
43	2	5	3001-4500	46	Std. 5-8	5	2
44	2	5	>4500	40	Secondary	6	2
45	2	5	3001-4500	46	Post-secondary	6	2
46	2	5	3001-4500	49	Secondary	5	2
47	2	6	3001-4500	53	Std. 5-8	5	2
48	3	4	2501-3000	38	Secondary	3	3
49	2	5	>4500	40	Post-secondary	6	2
50	2	6	3001-4500	43	Post-secondary	6	2
51	3	7	>4500	50	Std. 5-8	4	2
52	1	6	>4500	45	Std. 5-8	6	1
53	1	6	>4500	49	Post-secondary	2	1
54	1	6	>4500	49	Post-secondary	2	1
55	1	3	>4500	36	Std. 5-8	2	1
56	1	4	3001-4500	41	Std. 5-8	4	1
57	1	6	3001-4500	68	No Education	4	1
58	1	3	>4500	39	Std. 5-8	5	1
59	1	5	3001-4500	49	Std. 5-8	4	1
60	1	6	3001-4500	50	Std. 4	3	1
61	1	5	>4500	47	Std. 5-8	3	1
62	1	7	>4500	61	No Education	2	1
63	1	5	>4500	49	Std. 5-8	3	1
64	1	6	3001-4500	63	No Education	1	1
65	1	8	>4500	57	Std. 4	3	1
66	1	6	>4500	46	Std. 5-8	3	1
67	1	8	>4500	65	No Education	2	1
68	1	6	>4500	45	Std. 5-8	5	1
69	1	3	>4500	39	Secondary	5	1
70	1	4	>4500	45	Secondary	1	1
71	1	3	>4500	38	Secondary	2	1
72	1	4	3001-4500	40	Secondary	3	1
73	1	4	>4500	41	Secondary	3	1
74	1	6	>4500	60	Std. 5-8	3	1
75	1	3	2501-3000	30	Std. 5-8	2	1
76	1	3	>4500	36	Post-secondary	3	1
77	1	6	>4500	51	Std. 5-8	3	1
78	1	2	3001-4500	34	Secondary	1	1
79	1	3	>4500	30	Post-secondary	3	1
80	1	3	>4500	39	Post-secondary	1	1
81	1	4	>4500	42	Post-secondary	3	1

82	1	6	>4500	51	Std. 5-8	5	1
83	1	3	>4500	32	Post-secondary	1	1
84	1	6	>4500	50	Secondary	6	1
85	1	4	>4500	40	Secondary	3	1
86	1	3	>4500	36	Secondary	4	1
87	1	4	>4500	43	Post-secondary	1	1
88	1	6	>4500	50	Std. 5-8	3	1
89	1	3	3001-4500	38	Secondary	4	1
90	1	5	>4500	44	Secondary	4	1
91	1	4	>4500	43	Post-secondary	5	1
92	1	4	>4500	40	Secondary	4	1
93	1	6	3001-4500	51	Std. 4	2	1
94	1	3	>4500	39	Post-secondary	4	1
95	1	4	>4500	40	Post-secondary	1	1
96	1	5	3001-4500	48	Secondary	5	1
97	1	4	>4500	40	Secondary	6	1
98	1	6	>4500	45	Secondary	5	1
99	1	6	>4500	50	Std. 5-8	5	1
100	1	4	>4500	39	Post-secondary	4	1
101	1	6	>4500	60	Std. 5-8	2	1
102	1	4	>4500	40	Post-secondary	1	1
103	1	6	>4500	43	Std. 5-8	3	1
104	1	5	>4500	40	Secondary	1	1
105	1	4	>4500	42	Post-secondary	1	1
106	1	6	>4500	60	Std. 5-8	2	1
107	1	3	3001-4500	40	Post-secondary	2	1
108	1	5	3001-4500	50	Std. 4	6	1
109	1	3	>4500	34	Post-secondary	1	1
110	1	5	3001-4500	55	Secondary	4	1
111	1	3	>4500	35	Post-secondary	3	1
112	1	5	3001-4500	52	Std. 5-8	3	1
113	1	3	>4500	39	Secondary	2	1
114	1	5	>4500	42	Secondary	1	1
115	1	4	>4500	40	Post-secondary	3	1
116	2	5	1500-2500	45	Std. 4	10	2
117	1	4	1500-2500	40	Secondary	5	1
118	1	3	2501-3000	40	Std. 5-8	3	1
119	1	5	2501-3000	60	Secondary	2	1
120	1	4	2501-3000	55	Std. 5-8	2	1
121	1	7	2501-3000	55	Std. 5-8	10	1
122	1	5	3001-4500	50	Secondary	1	1
123	1	4	1500-2500	35	Post-secondary	2	1
124	1	3	3001-4500	32	Secondary	1	1
125	1	6	>4500	69	Std. 4	3	1
126	1	6	2501-3000	48	Post-secondary	1	1
127	1	4	>4500	40	Std. 5-8	1	1
128	1	4	2501-3000	40	Post-secondary	4	1
129	1	3	>4500	30	Post-secondary	2	1
130	1	5	>4500	40	Post-secondary	1	1
131	1	3	>4500	39	Secondary	1	1
132	1	3	1500-2500	41	Std. 5-8	2	1
133	1	6	1500-2500	50	Std. 4	1	1
134	1	6	1500-2500	45	Std. 5-8	1	1
135	1	4	1500-2500	35	Std. 4	10	1
136	1	5	2501-3000	40	Std. 5-8	1	1
137	1	3	1500-2500	29	Std. 4	1	1
138	2	5	3001-4500	43	Secondary	4	2
139	2	7	3001-4500	49	Std. 5-8	6	2
140	3	5	3001-4500	37	Secondary	6	2

141	1	7	2501-3000	67	Std. 4	7	1
142	1	5	2501-3000	67	Std. 5-8	4	1
143	1	5	3001-4500	46	Std. 5-8	3	1
144	1	8	2501-3000	59	Std. 5-8	9	1
145	1	5	1500-2500	38	Std. 4	3	1
146	1	7	2501-3000	32	Secondary	6	1
147	1	8	>4500	50	Secondary	4	1
148	1	8	3001-4500	48	Std. 5-8	5	1
149	1	7	3001-4500	49	Std. 5-8	3	1
150	1	4	3001-4500	43	Secondary	1	1
151	2	4	2501-3000	40	Secondary	3	3
152	1	4	2501-3000	43	Secondary	1	1
153	1	7	1500-2500	52	No Education	3	1
154	1	4	3001-4500	33	Post-secondary	1	1
155	1	5	>4500	43	Post-secondary	3	1
156	1	4	>4500	20	Std. 5-8	3	1
157	1	9	1500-2500	45	Secondary	3	1
158	1	3	>4500	36	Post-secondary	1	1
159	2	5	2501-3000	40	Secondary	3	2
160	2	6	3001-4500	50	Secondary	6	2
161	1	11	1500-2500	36	Secondary	2	1
162	1	5	1500-2500	43	Secondary	3	1
163	2	6	2501-3000	45	Std. 5-8	3	2
164	2	5	2501-3000	45	Std. 5-8	4	2
165	1	9	1500-2500	32	Std. 4	2	1
166	2	4	2501-3000	34	Std. 5-8	5	2
167	2	6	3001-4500	47	Secondary	3	2
168	2	9	>4500	64	Std. 5-8	4	2
169	2	8	3001-4500	53	Std. 4	3	2
170	1	3	1500-2500	36	Secondary	1	1
171	1	4	>4500	40	Secondary	9	1
172	1	5	2501-3000	40	Std. 5-8	2	1
173	0	5	2501-3000	29	Std. 5-8	5	0
174	1	4	>4500	28	Post-secondary	12	1
175	1	7	1500-2500	26	Std. 5-8	5	1
176	0	6	>4500	40	Secondary	6	0
177	0	5	>4500	55	Secondary	1	0
178	1	12	1500-2500	54	Post-secondary	2	1
179	0	10	1500-2500	28	Std. 5-8	5	0
180	1	6	1500-2500	45	Std. 5-8	1	1
181	1	7	3001-4500	40	Std. 5-8	5	1
182	2	11	>4500	50	Post-secondary	6	2
183	1	9	1500-2500	42	Std. 5-8	2	1
184	1	4	1500-2500	24	Std. 5-8	1	1
185	0	6	1500-2500	30	Post-secondary	5	0
186	0	2	>4500	29	Secondary	1	0
187	1	7	1500-2500	31	Post-secondary	2	0
188	0	5	1500-2500	30	Post-secondary	5	0
189	1	6	1500-2500	42	No Education	3	1
190	1	10	>4500	36	Post-secondary	2	0
191	1	11	>4500	59	Std. 5-8	9	0
192	2	6	>4500	48	Secondary	5	2
193	1	4	>4500	37	Post-secondary	1	1
194	2	5	>4500	42	Secondary	4	2

Source: Author, 2006 based on field studies in Kericho district in 2006