EVALUATION OF MALARIA MORBIDITY TRENDS IN COMPLEX HUMANITARIAN EMERGENCY SETTINGS IN NORTH WESTERN TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT FOR THE REQUIREMENTS OF THE DEGREE OF MASTER OF ARTS IN MONITORING AND EVALUATION OF THE OPEN UNIVERSITY OF TANZANIA

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CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by the Open University of Tanzania a dissertation entitled; Evaluation of malaria morbidity trends in the complex humanitarian settings in north western Tanzania in partial fulfilment of the requirements for the degree of Master of Arts in Monitoring and Evaluation of the Open University of Tanzania.

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(Supervisor)

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Date

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DECLARATION

I, Siril Michael Kullaya, do hereby declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other Degree award.

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Signature

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Date

DEDICATION

This dissertation is dedicated to the Almight God, my dear wife Dr Apansia, my dear sons Nathaniel, Daniel and Jeriel, my highly esteemed teachers and my beloved parents.

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ABSTRACT

The excess mortalities and morbidities resulting from disease outbreaks which occur in complex humanitarian situations can be prevented through timely and effective preparedness and response planning. The aim of this study was to evaluate malaria morbidity trends in the complex humanitarian emergencies in North Western Tanzania in the past 8 years and the associated factors. The health facility records were reviewed to collect information on the number of confirmed malaria cases in the past 8 years from the refugee populations obtained from the health information system for the camp-based population. Total of 749 refugee camp residents were interviewed to collect information on malaria illness episodes and the associated factors. Malaria morbidity show both seasonal trends associated with temperature and rain variations and non-seasonal irregular fluctuations associated with epidemics, refugee population dynamics and global climatological events. Rainfall leads malaria morbidity by a time lag of 1 month whereas refugee population size leads malaria morbidity by a time lag of 3 months. Recurrent financial costs for managing uncomplicated malaria cases are on the increase despite efforts to subsidize the malaria treatment commodities. This increasing financial costs from the supply side is significantly associated with increasing malaria illness episodes (p-value <0.005). Wide range of factors appears to influence malaria morbidity in the complex humanitarian emergency settings in north western Tanzania. These range from climatological, household location and environmental factors, accessibility and use high impact interventions. Increasing financial costs for managing malaria cases calls for enhancing advocacy for funding and resource mobilization months prior to rainy seasons to mount effective malaria control response.

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LIST OF ABBREVIATIONS

ACF	Autocorrelation functions
ACTs	Artemisinin-based combination therapies
AIDS	Acquired Immuno Deficiency Syndrome
CDC	Centre for Disease Control
CHEs	Complex humanitarian emergency settings
CIs	Confidence intervals
DDT	Dichlorodiphenyltrichloroethane
DMO	District Medical Officer
DRC	Democratic Republic of the Congo
g/dl	Grams per deciliter
HIV	Human Immunodeficiency Virus
IASC	Inter Agency Standing Committee
IFRC	International Federation of Red Cross and Red Crescent
IMVC	Integrated Malaria Vector Control
IPT	Intermittent preventive treatment
IRS	Indoor residual spraying
ITNs	Insecticide-treated nets
LLIN	Long-lasting insecticidal nets
LSM	Larval Source Management
mRDT	Malaria rapid diagnostic tests
M&E	Monitoring and evaluation
MSF	Medecins San Frontiers (doctors without borders)
NIMR	National Institute for Medical Research

NMCP	National Malaria Control Programme
OR	Odds ratio
PACF	Partial autorrelation functions
RBM	Roll Back Malaria
RMO	Regional Medical Officer
SME	Surveillance Monitoring and Evaluation
THMIS	Tanzania Health and Malaria Indicator Survey
TVE	Total variance explained
UNHCR	United Nations High Commissioner for Refugees
UNISDR	United Nations International Strategy for Disaster Reduction
URT	United republic of Tanzania
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background to the Problem

The excess mortalities and morbidities resulting from disease outbreaks which occur in complex humanitarian situations can be prevented through timely and effective preparedness and response planning. Unfortunately, given the emergency nature of the events, enough knowledge of the particular disease of outbreak potential and the associated factors required for timely preparedness and response activities in complex humanitarian emergencies is often lacking. However, this knowledge can be generated through evaluation of disease trends from the past events from which lessons learned can be used to inform the preparedness and response planning for the present and future events.

Over decades, ethnic conflicts and political upheavals in Burundi, Rwanda and the Democratic Republic of Congo have led to states of complex humanitarian emergencies resulting into millions of citizens fleeing their countries and relocate as refugees in the neighboring countries (Lunn, 2006). Kigoma region, in North Western Tanzania has been receiving refugees from neighboring countries of Burundi and Democratic Republic of Congo (DRC) since 1970s mainly following the state of political unrest in the countries of origin leading to complex humanitarian emergencies.

The current crisis which started in April 2015, have caused significant number of refugees arriving in Tanzania from Burundi who were initially relocated to Nyarugusu camp. This camp, already hosting 65,000 refugees mainly from DRC since 1996, quickly became congested necessitating the opening of a new camps, namely Nduta in Kibondo district and Mtendeli in Kakonko district (UNHCR, 2017). The refugee influx has always being associated with changing trends and outbreak of communicable diseases such as cholera and malaria, which increase the risks for further mortalities as well as overuse of limited resources.

Over the past years, the top killers in most complex emergencies have been communicable diseases represented by malaria, diarrhoeal diseases and pneumonia and measles (Connoly et al 2004). In north western Tanzania, malaria has ranked higher than pneumonia and diarrhea as topmost cause of morbidity not only in complex emergency settings but also in the hosting communities. This has manifested as increased number of patients in the health facilities and in the communities, mainly involving children underfive years of age. In the year 2017, the increased malaria related morbidity was reported among the refugees residing in the camps in north western Tanzania (Inter agency, 2017).

Despite the nationwide control efforts over the years, malaria prevalence in Kigoma region has remained higher than the national average. This is shown in Figure 1 from the data extracted from the national malaria indicator surveys from 2008 to 2017. If the local factors associated with such disparities are not studied and addressed in time, Kigoma region will be in a danger of being left behind as Tanzania progresses to malaria pre elimination phase. Kigoma region ranked number one of the most malaria affected region in the country as of May 2018, with malaria prevalence of 24.4% (Ministry of Health, 2017).

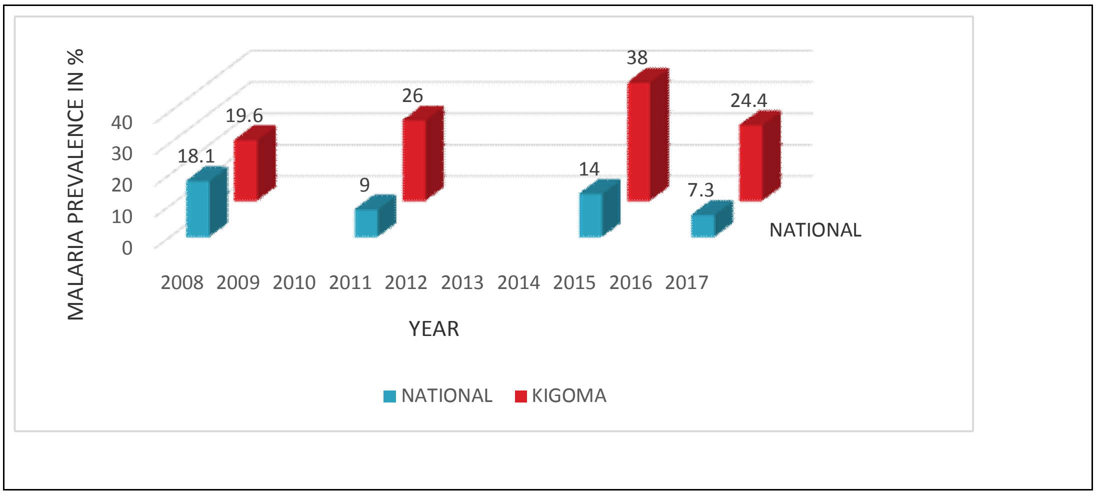

Figure 1.1: National and Regional Comparison of Malaria Prevalence from 2008 to 2017

Malaria trends follow local vectors capacity, socio economic situation and rainy seasons, the period during which most of the rural residents engage in agriculture. The costs and time consumed for health care seeking may enhance vicious cycle of disease and poverty in already impoverished populations (European Alliance against Malaria, 2007).

In the complex humanitarian emergency settings, factors responsible for malaria disease transmission interact in such a way as to result into high disease burden. These include increased population density in one area, poor housing conditions, fragile health infrastructures, population dynamics and host immunity, weakened nutrition for displaced populations, environmental deterioration and inadequate access to medicines (Meek et al, 2000). While movement of people in complex emergencies for instance from areas with low malaria transmission (low endemicity areas) to areas of high malaria transmission (hyperendemic areas), exposes the populations to higher malaria transmission than usual, overcrowded conditions and temporary shelters increase mosquito biting frequency. Combination of these factors may increase the risks for malaria outbreaks in the complex humanitarian emergencies. For instance, malaria outbreaks were reported in the refugee camp setting in north-west Tanzania in 1997 (URT, 2013).

Although excess morbidity and mortality can be avoided using the effective and available interventions, the situation can be overwhelming in case the interventions are not timely and tailored to local situations. Further research to tailor the interventions to local conditions have been suggested (Connoly et al 2004). There is, therefore, a need for enough knowledge of the associated factors to help predict the magnitude of the morbidity and to timely inform the preparedness and response activities. The knowledge will further input to the national and global strategy for malaria elimination strategies. The need for continued surveillance has been highlighted as one of the efforts to prevent re-establishment of malaria in areas where it has been eliminated and thus contributing to global malaria elimination goals (WHO, 2015).

1.2. Malaria Biology and Population at Risk

Malaria is a vector-borne infectious disease caused by protozoan parasites of the genus Plasmodium which are transmitted from man to man by blood sucking female Anopheles mosquitoes. Five species of the Plasmodium parasites namely *Plasmodium falciparum, P. vivax, P.ovale, P. malariae and P. knowlesi* infect humans. *Plasmodium falciparum* is the deadliest and found more commonly in sub Saharan Africa, the region which shoulders the heaviest of the malaria burden. The disease is endemic in 91 countries and territories where estimated 212 million new cases of the disease and 429 000 deaths were reported in 2015 (WHO, 2016).

In the complex humanitarian emergencies, children, pregnant women, and those with compromised immune systems such as HIV/AIDS and malnutrition are partcularly at the risk (Johns Hopkins and IFRC, 2008). Common vectors identified in recent survey in North western Tanzania refugee camps (MSF, unpublished) include *Anopheles gambie* (indoor biters), *A. arabiensis* (outdoor biters) and *A. funestus* (indoor biters). The knowledge of relevant behaviours of these vectors such as biting, and breeding patterns is important for planning malaria control interventions.

1.3. Statement of the Problem

About 30% of malaria deaths happen in countries affected by complex emergencies in Africa, where 90% of the annual deaths from malaria occurs. In north western Tanzania, malaria has ranked higher than pneumonia and watery/bloody diarrhea as topmost cause of morbidity, not only in complex emergency settings but also in the hosting communities. The highest morbidity and mortality often occur during the acute phase of the emergency. In the post emergency phase malaria morbidity which follows seasonal trends is often characterized by increased number of new cases of the disease reported in the health facilities.

Malaria morbidity control has far reaching consequences on economic improvement and poverty reduction in already impoverished populations. As increased number of cases occurs during the period in which most of the rural residents engage in agriculture, it enhances vicious cycle of disease and poverty among the refugees and the host communities.

Several factors including increased population density in one area, poor housing conditions, fragile health infrastructures, population dynamics and host immunity, weakened nutrition for displaced populations, environmental deterioration and inadequate access to medicines have been implicated to contribute the malaria burden in complex humanitarian emergencies. However, the relevance of these factors in the local north western Tanzania context remain to be investigated. Connoly et al have suggested research in identifying these local factors. Although excess morbidity and mortality can be avoided using the effective and available interventions, the situation can be overwhelming in case the interventions are not timely and tailored to local situations and other operational factors (Connoly, 2004).

Furthermore, given the acute nature of most of the emergencies, enough knowledge and complete information of prevalent diseases necessary to inform planning of the preparedness and reponse activities is lacking, prompting use of *ad hoc* interventions. There is a need for enough knowledge of the morbidity trends and the associated factors to help explain the disease occurrence and the magnitude of the morbidity problem. This will in turn help to timely inform the planning of preparedness and response activities. This in turn will guide informed decision on the selection and use of appropriate interventions rather than unjudicial/panic use of *ad hoc* control interventions during emergencies which may contribute to emergence of insecticide resistance in the vectors or drug resistance in the malaria pathogens. Spread of resistance in the wider population will likely cause re-emergence of the disease in areas where progress had been achieved, hampering the progress and achievement of global and national malaria elimination targets of 2030.

1.4 Research Objectives

1.4.1. Broad Objective

To evaluate malaria morbidity trends in the complex humanitarian emergencies in North Western Tanzania.

1.4.2. Specific Objectives

i. To assess the proportion of individuals diagnosed with malaria morbidity among population groups living in complex humanitarian settings in north western Tanzania in the past 8 years
ii. To determine the proportion of individuals with asymptomatic malaria among population groups living in complex humanitarian settings in north western Tanzania
iii. To explore the factors associated with malaria morbidity among population groups living in complex humanitarian settings in north western Tanzania
iv. To determine the minimum recurrent financial costs per annum required to manage uncomplicated malaria cases among population groups living in complex humanitarian settings in north western Tanzania

1.4.3. Research Questions

i. What is the malaria morbidity trend in the past 8 years in the complex humanitarian emergencies in North Western Tanzania?
ii. Are there asymptomatic reservoirs who could affect the malaria morbidity in the complex humanitarian situations?
iii. What are the factors which affect the malaria morbidity trends in the

complex humanitarian emergencies in NW Tanzania?

iv. What are minimum financial costs required in uncomplicated malaria case management in complex humanitarian emergencies in North Western Tanzania?

1.5. Justification of the Study

This study will generate required knowledge on malaria morbidity and associated factors among population groups living in refugee camps in North western Tanzania. This knowledge is indispensable in informing timely planning of preparedness and response activities as well as evidence on the need of engaging with other related sectors. The knowledge of financial costs for managing malaria cases will inform the health care planners working in the refugee operations about the minimum resources that must be there to mount effective responses especially during the rainy seasons in which there is likelihood of increased transmission.

Moreover, it will also underpin the need for advocacy for more funding and resource mobilization. Timely mobilization of financial resources and effective mounting of response activities will reduce an avoidable stock out of health commodities. Effective, timely and well-informed preparedness and response activities tailored to the local situations will help avoid *ad hoc* interventions in times of crisis thus reducing likelihood of excess disease morbidity and mortality in the complex humanitarian emergencies. Furthermore, timely and informed preparedness and response planning will reduce the likelihood of unjudicial use of *ad hoc* control interventions during emergencies which may contribute to emergence of insecticide resistance in the vectors or drug resistance in the malaria pathogens thus preventing re-emergence of the disease in areas where control progress have been made. This will eventually contribute to attainment national and global malaria goals of 2030.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter presents the theoretical and empirical overviews on which this study will be based. The burden of malaria and the control efforts in the world, Africa and Tanzania are reviewed from the historical perspectives. It also highlights the future strategies to eliminate the disease in the world. The factors associated with the malaria disease trends are thoroughly reviewed.

2.2. Definition of Concepts

Conceptual definitions provide the meaning of the key terms related to this study, which include malaria morbidity, trends and complex humanitarian emergencies.

2.2.1 Complex Humanitarian Emergencies

A humanitarian emergency is a calamitous situation (disaster) in which the functioning of a community or society is severely disrupted, causing human suffering and material loss that exceeds the affected populationðs ability to cope using its own resources (UNISDR, 2004) and so calls for immediate and appropriate responses and support to minimize its consequences. Humanitarian emergency is described as complex when it is associated with complex social, political and economic origins, breakdown of governmental authority and structures, and often human rights abuses and armed conflict (IASC, 1994). Complex emergencies can be though to evolve through phases from the alert (early warning) through acute and post-emergency to repatriation phase (John Hopkins and IFRC, 2008).

The acute emergency phase is the period where the crude (all-cause) mortality rate is above one death per 10,000 per day and it is characterised by events such as population displacement, change in authority, a breakdown in infrastructure such as health, impaired access to food, and higher mortality. Post-emergency phase is the period during which basic needs are met and mortality rates return to the level of the surrounding population (Meek et al, 2000).

2.2.2 Malaria Morbidity

Morbidity is a state of being unhealthy or diseased. Morbidity is described at population level as frequency of a disease occurrence in a specific area or population group at a given time period usually expressed in terms of prevalence and incidence rates. Disease prevalence is the proportion of people found to have a particular disease in a population at a particular point in time. Disease incidence rate is the proportion of new cases of a particular disease in a population observed over a given period of time.

Malaria morbidity can be described clinically using signs and symptoms such as presence of fever and other symptoms such as general body weakness, headache, vomiting, diarrhea and joint pains and be confirmed by demonstration of the presence of malaria parasites in the blood expressed quantitatively as number of malaria parasites on blood slide smear examined under microscope or qualitatively by rapid diagnostic tests (CDC, 2013, URT 2005). Uncomplicated malaria describes the clinical status of a patient diagnosed with malaria but without signs and symptoms of severe disease. These patients are treated as outpatients using oral antimalarials (URT, 2005). Complicated (severe) malaria is diagnosed by the presence of one or more of the following signs and symptoms (impaired consciousness/coma, severe anemia (hemoglobin<7g/dl), renal failure, acute respiratory distress syndrome, hypotension, disseminated intravascular coagulation, spontaneous bleeding, acidosis, hemoglobinuria, jaundice, repeated generalized convulsions, and/or parasitemia of > 5%. Patients with complicated malaria are managed as inpatients (CDC, 2013, URT, 2005).

The definition of malaria morbidity by clinical signs poses significant problems because clinical signs of malaria can also be found in other febrile illnesses. Moreover, at population level, in areas with hypoendemic transmission, history of fever and positive blood slide may indicate malaria illness while in areas with hyperendemic transmission many people with positive blood slide may not have accompanying symptoms (Sylvie et al, 2017). In the past the use of clinical diagnosis has caused over diagnosis (Reyburn et al, 2007) and hence over prescription of antimalarial and erroneous interpretation and monitoring of malaria trends in the population.

Nowadays, with availability of reliable diagnostic tools and as Tanzania progresses towards sustained control and elimination of malaria, patients presenting with history of fever need to be thoroughly investigated. In Tanzania it is said in Swahili ñsi kila homa ni malariaò meaning not every fever is malaria (URT, 2013). The usefulness of this shift is that, health facility-based data on malaria morbidity can be used reliably to estimate malaria prevalence and incidence in the population. This study will use the malaria morbidity as recorded in the health facility records. We will explore malaria morbidity trends as change in pattern of malaria prevalence and incidence over the past 8 years among the refugee population in Kigoma region between 2010 and 2017.

2.2.3 Disease Trends

This refers to changes in a particular direction of a disease over time, place and persons affected. The study of disease trends is done through application of epidemiological principles. As defined below, several epidemiological terms are used to describe disease occurence in the population.

2.2.3.1 Disease Epidemic

This is defined as rapid increase in observed rates of a particular disease in a given population above the expected frequency. Global widespread of the epidemic is referred to as pandemic. Disease outbreak is used to describe either a disease epidemic and/or pandemic. Malaria epidemic is defined as situation in which the number of cases in a health facility or defined area for that period exceeds the expected by 50% (URT, 2011).

2.2.3.2 Endemic Disease

A disease is said to be endemic if its observed rate is consisitently associated with a particular population over time. Malaria hyperendemicity is a situation in which there is high malaria transmission through out the year in the population and it is associated high immunity in older age groups. Malaria hypondemicity is situation in which there low or seasonal malaria transmission in a particular population resulting into low immunity across the age groups. Malaria epidemics are prone to occur in hypoendemicity situation and often overwhelm the health care system

(WHO, 2015).

2.3 Theoretical Literature

2.3.1 Global Malaria Burden

Ninety-one countries in the world are affected with malaria where more than 3.2 million people, that is, nearly half of global population are at risk (WHO, 2016). Of these countries, only 15 of them accounted for 80% of global malaria burden in 2011 and with exception of India, they are in Africa, south of Sahara (WHO, 2017). According to the WHO world malaria report, in 2016 there were an estimated 216 million cases of malaria in the 91 countries, an increase of 5 million cases over 2015. Malaria deaths reached 445,000 in 2016, compared to 446,000 in 2015. Of the 445,000 malaria attributable deaths which occurred worldwide, 407,000 deaths (91%) were reported in Africa. There are regional, national and subnational disparities. In areas where malaria takes a huge toll on human health and well-being, the burden of malaria goes beyond the individual health consequences to affecting overall health system, socioeconomic development and population growth and structure (WHO, 2003).

2.3.2 Malaria Burden in Sub Saharan Africa

Sub Saharan Africa account for 80% of global malaria burden. The health consequences of malaria include anemia, low birthweight, epilepsy, and neurological problems. It not only compromises the health and development of millions of children throughout Africa but also cause significant adult mortality and morbidity (WHO, 2003). Notably, malaria burden goes beyond the health consequences. Malaria affected countries are among the poorest in the world, and typically have very low rates of economic growth and many have experienced declines in living standards in the last few decades (World Bank, 1998), malaria playing a significant role in the poor economic performance of these countries (Summers and Heston, 1994).

While short-term costs include indirect costs such as lost work time, transportation and economic losses and the direct costs of treatment and prevention; long term economic consequences of malaria impede flows of trade, foreign investment, and commerce and tourism (CDC, 2017). Repeated episodes of malaria expose the child to chronic malnutrition, susceptibility to other diseases, hindrance of a childós physical and cognitive development, attendance and performance at school. Increased child mortality prompts the family to have more children, thereby increasing the overall rate of population growth (CDC, 2017).

2.3.3 Malaria Burden in Tanzania

Tanzania has the third largest population at risk of stable (endemic) malaria in Africa after Nigeria and the Democratic Republic of Congo, the disease being the leading cause of outpatients, inpatients, and admissions of children less than five years of age at health facilities and important impediment to socioeconomic growth and welfare (IHI, 2014). Nearly 95% of the mainland Tanzania population is at risk, in which the climatic conditions favour transmission throughout almost the entire country. Prevalence of malaria in Tanzania show spatial and temporal variations in which zonal and regional disparities have been evident in the recent surveys. The surveys showed the prevalence to range from 0.4% in the elevated region of Arusha to 41.1% in the northwestern region of Kagera compared to similar survey of 2012 in which the prevalence range from 0.9% in the regions of Arusha, Kilimanjaro, Manyara and Singida to 33% in Geita region. Overall, malaria prevalence declined by 50% from 18.1% to 9.5% (URT, 2008, 2012).

In both surveys, malaria prevalence was significantly higher in the children living in household with low socioeconomic status and with mothers with low educational levels. The linkage between malaria and poverty can be corroborated with the situation in Kigoma region in northwestern Tanzania. According to United Nations Joint programme for Kigoma, it was noted from the recent national household survey that the region is the poorest in Tanzania with estimated poverty rate of 49%, and it is one of the two (together with Tanga), that has experienced increased poverty rates (UN, 2017 unpublished).

Moreover, the region faces unique challenge of being the largest receiver of asylum seekers/refugees coming to Tanzania from Burundi and DRC since 1970s. As of November 2017, it hosted more than 330,000 refugees from DRC and Burundi (UNHCR, 2017). The influx of refugees has always been accompanied with communicable disease outbreaks such as malaria and cholera affecting both the refugees and the host communities. The region experienced exceptionally high levels of malaria morbidity in 1997 and 2017 mostly affecting the refugee populations (URT, 2013, UNHCR, 2017).

2.4 Empirical Literature

2.4.1 Malaria Trends, Control Strategies, Achievements and Challenges

Malaria control initiatives in Tanzania have gone through different phases with successes and challenges over a period of more than 100 years (URT, 2013). These include larval mosquito control and parasite control using quinine during German colonial administration; mosquito control through IRS using DDT and the making of malaria a notifiable disease during British administration rule.

After independence Tanzania embarked on building her health system and throughout the 1970s and 1980s, the focus of malaria control was on presumptive treatment of fevers with chloroquine. Other important milestones include establishment of NIMR, launching of NMCP, changing of antimalarial policies and establishing malaria control strategy and national ITN policy. According to the national strategic plan for malaria, malaria epidemics were experienced in the Northwestern regions of Kagera and refugee populations in Kigoma in 1997 (URT, 2013).

A global initiative called Roll Back Malaria (RBM) Partnership was launched in 1998 with overall strategy of reducing malaria morbidity and mortality by reaching universal coverage of the interventions and strengthening health systems, by having actors in malaria control coordinate their activities and optimal use of resources at global, regional and country levels (RBM, 2018). Tanzania has developed national malaria strategic plans aimed at reducing malaria morbidity and mortality in Tanzania in line with the RBM goals. For instance, in 2002-2007 plan, four strategic approaches and three supportive strategies were adopted which included improved malaria case management through early diagnosis and prompt treatment, vector control through the universal use of insecticide-treated nets (ITNs), control of malaria in pregnancy, malaria epidemic prevention and control. The three supportive strategies included operational research, communication and monitoring and evaluation (URT, 2013).

In the 2008-2013 plan, the main areas of emphasis were malaria diagnosis and treatment; and integrated malaria vector control (IMVC) supported by improved M&E including operational research and epidemic early detection and response, community-based malaria control, behavioral change initiatives and retaining a focus on decentralized support through regional and district capacity building around malaria control (URT, 2014). The current plan 2013-2020 aims at reducing the average country malaria prevalence from 10% in 2012 to 5% in 2016 and further in 2020 to less than 1%.

The plan will be achieved by using the five core interventions namely; integrated malaria vector control (IMVC); malaria diagnosis, treatment, preventive therapies and vaccines; promotion of malaria prevention and curative services through information, education and communication; surveillance and monitoring and evaluation (SME) and programme management, partnership development and resource mobilization (URT, 2014). With RBM Partnership and the strategies, promising results were achieved in the period between 2000 and 2014.

Globally, there were reductions of cases from 237 million cases in 2010 to 210 million cases in 2014. However, there have been worrying upsurge of cases as from 2015 from 211 million to 216 million in 2016 (WHO 2016, 2017) and regional variations in reduction rates still exist. For instance, Kigoma region in Northwestern Tanzania had prevalence of 19.6% in 2008 and prevalence of 9% in 2012 while

Kagera had prevalence of 41.1% and prevalence of 9% in 2012. There has reported increase of malaria cases reported in the health facilities in Kigoma region involving both the refugees and host populations in 2016-2017 (URT, 2017 unpublished updates).

According to WHO, the progress in reducing cases and deaths due to malaria appear to have stalled in the recent years and the recent report shows that, this worrying trend is continuing (WHO, 2017), and it is attributed to limited funding, disruption of social and health systems in complex emergencies, unreliable diagnostic tests in some areas, antimalarial and insecticide resistances as well as weak malaria surveillance monitoring and evaluation systems (WHO 2016, 2017). On account of the noted regional variations in malaria prevalence and the recent upsurge of malaria cases in Northwestern Tanzania, additional factors need to be explored in the local context.

Studies and technical reports sucha as WHO reports, have pointed out factors which determine malaria morbidity trends in different population groups (Greenwood, 1989). To which extent they apply to Kigoma regional context and thus to inform the selection of local responses and resource mobilization remain to be investigated. Some of the factors highlighted in different studies include demographic factors, population groups and their movements (Hamzah et al 2018, Pim and Lisbeth, 2000), education and socio-economic status (Sheriff et al, 2014) and nutritional status (Hamid and Al 2016, Alice et al, 2004). Others include health system capacity for doing malaria surveillance, outbreak detection, preparedness and timely response (Richard et al, 2011), climate variability (Guofa et al 2004), environmental factors such as proximity to open water source, land use patterns and forest (Louise et al, 2009), human behavioral factors (Sarah et al, 2015, Denise et al, 2003), housing characteristics (Yazoume et al 2006) and accessibility and utilization of the interventions (Okech et al, 2008, Eline et al, 2003). According to Greenwood, the study of the spatiotemporal variations of malaria prevalence and the extent to which the identified local factors play in determining the low prevalence in one area and high prevalence in the next neighborhood in identifying and planning for appropriate interventions is needed (Greenwood 1989).

2.4.2 Association of Malaria Morbidity with Age and Population Groups

In Tanzania, malaria outbreaks have been reported in Kagera, Kigoma, Rukwa and Tanga regions (URT 2013, WHO 1998) over the past 30 years, and they have often been devastating in terms of morbidity and mortality, affecting nonimmune population groups mostly children and pregnant women. However, acquisition of immunity varies with age in different settings depending on transmission intensity (Doolan et al 2009, Carneiro et al 2010). As Northwestern region of Tanzania has been receiving refugees from 1970s from different malaria transmission intensities, knowledge of specific age and population groups affected will guide decision in the planning of interventions.

2.4.3 Association of Malaria Morbidity with Education and Socioeconomic Status

Studies have shown an intimate association of malaria with socio economic status. For instance, macro level estimates shown strong causal linkage between malaria morbidity and socioeconomic status in that countries with intensive malaria had lower income levels compared to countries without malaria, regardless of geographical location. (John and Jeffrey, 2001, WHO 2012). Micro level (individual and household) estimates have produced mixed results elsewhere (Worall et al 2005).

However, In Tanzania malaria has been shown to have causal linkage with poverty (Marcia and Monica 2012). Furthermore, the Tanzania national malaria surveys (URT, 2008, 2012) corroborate the findings as malaria prevalence in the country was found to be significantly higher in the children living in households with low socioeconomic status and with mothers with low educational levels. Poverty alleviation initiatives for Kigoma, poorest region in Tanzania can be informed by studying the regional trends of malaria. The informed control strategies could have synergistic impact on the ongoing poverty alleviation efforts.

2.4.4 Health System, Malaria Surveillance and Outbreak Detection

According to WHO, the capacity to detect, prepare and respond to malaria outbreak is suboptimal as many malaria affected countries have weak surveillance systems thus making it difficult for them to assess disease distribution and trends (WHO, 2017). This underscores the need for high quality and complete data on malaria incidence or prevalence. This will engender confidence around reported estimates, help bring to light the local populations at risk and generate vital information to guide selection and planning of strategies towards control and elimination.

2.4.5 Malaria Morbidity and Climate Variability

Climate attributes play important role in the transmission of malaria in the population. While high temperature and humidity enhance malaria parasite development within the mosquito (CDC, 2015), rains provide abundance of mosquito breeding and larva development sites and hence increase in mosquito populations (Chaves et al, 2012). Studies have shown association of malaria and warmer temperatures with peaks at 24-25·C (Alonso et al 2010, Gillioli and Mariani 2011, Mordekai et al, 2012) and that, short term variations in temperatures and rains are important initiators of malaria outbreak (Goufa et al, 2004). The extent of the effect of temperature and rainfall variations on malaria prevalence has not been documented in Tanzania. This is needed to inform local control strategies.

2.4.6 Accessibility and Utilization of Available Interventions

Malaria program interventions have been successful in reducing both mortality and morbidity over the last decade (WHO, 2014). These include access and use of the long-lasting insecticidal nets (LLINs), use of indoor residual insecticide spray (IRS), prompt diagnosis and management of malaria using efficacious anti- malarial drugs. Despite the availability of effective interventions stated above, still millions of at risk people, pregnant women and children with malaria had limited access and utilization in 2013 (WHO, 2014).

Some areas in Tanzania achieved promising results as was seen in Kagera while others experienced variable dynamics (URT, 2013). Interventions such as IRS has been used in 18 districts in Lake Victoria zone regions with promising results (URT 2008, 2012). IPTc was done in refugee camps in Uganda with commendable results as well (Mathew et al, 2017). No such interventions have been done in Kigoma region which currently hosts more than 330,000 refugees. Results of this study will shed some light on the need to adopt newer proven interventions as well as strengthening the existing/ongoing programme interventions.

2.4.7 Environmental and Household Characteristics

Malaria infections have been found to cluster in certain households (Melchior et al, 2017), signifying that household characteristics have influence on malaria transmission. In addition to living in a better constructed house which have been suggested to have protective against malaria (Katherine, 2015), the influence of other household attributes such as distance from swamp and forested areas and land use patterns (Tamara, 2008, Nayarani 2014) have also being suggested.

2.4.8 Human Knowledge, Social and Behavioral Factors

Human behavior attributes vary from beliefs, knowledge, attitude, treatment seeking and utilization of interventions. Although there has been advocacy for universal accessibility and coverage of key malaria interventions for the at risk population groups, the ownership and utilization rates have shown varying degrees (Zawadi et al, 2018). The practice by private and public health care providers and the use of community health workers have varying influences of care seeking behavior and utilization (Careen et al, 2012).

Other human factors such as human population movements across the borders as a result of refugee movements, social and commercial engagements have also been shown to have impact on malaria, disseminating the disease pathogens to other areas and replenish reservoir pools (Prothero, 1977, Martens and Hall, 2000). How malaria transmission and prevalence trends in Kigoma relate to cross border population movements between Tanzania, Burundi and DRC populations is not clearly known.

2.4.9 Role of Asymptomatic Reservoirs

In malaria endemic areas older groups are known to have acquired immunity to malaria and most often they have asymptomatic infections (Gupta et al, 1999, Bottius et al, 1996). These groups pose hidden threats to control and elimination of malaria by acting as parasite reservoirs. Newcomers such as non-immune migrants and children are thus exposed to increased risks of malaria. The role of the asymptomatic carriers in hyper endemic areas of northwestern Tanzania have not been studied. Knowledge of the role of these groups in malaria morbidity trends north western Tanzania will add new insight to program planning and identification of new interventions targeting these groups.

2.4.10. Malaria Morbidity and Nutritional Status

Adequate nutrition is known to positively influence both the acquired and natural immunity (Chandra, 1997). Inadequate nutrition has been shown to contribute to malaria associated morbidity indicating that malaria control programs interventions alone may not have the desired impact on childhood morbidity on a large scale without concomitant nutrition programs (Rhianna et al, 2016, Emmanuel et al, 2012). Kigoma is one of nine (9) regions in Tanzania found to have very high stunting rate, indicator of chronic malnutrition, of more than 40% in the last national nutrition survey of 2014 (URT, 2014). In the refugee populations in the same region, 2017 nutrition survey showed stunting rates ranging from 33% to 55% (UNHCR, 2017). Relative contribution of nutrition status in malaria in such situation may be needed to inform planning of comprehensive health and nutrition intervnetions in the complex humanitarian settings of north western Tanzania.

2.5 Research Gap

As pointed above in the theoretical and empirical literature as well as technical reports, there is clear demonstration of three important facts; first; the gains in the malaria control interventions in the past 10 years, second; the worrying upsurge of malaria cases in the past 2 years and third; the spatiotemporal variations in intervention responses at regional, national and subnational levels. The recent upsurge of malaria morbidity and the spatiotemporal variations malaria morbidity in different locations threatens the achievement malaria elimination goals and the sustainable development goals.

Many factors have been shown to influence malaria morbidity trends elsewhere, but no such studies have been conducted in Kigoma region in Northwestern Tanzania which is currently the poorest region in the country and hosts more than 330,000 refugees from DRC and Burundi, countries known to have different malaria transmission patterns. The reasons for the upsurge and the variations of malaria prevalence are therefore worthy finding at sub national level. This study therefore aims to evaluate malaria morbidity trends in the complex humanitarian settings in Kigoma region Northwestern Tanzania to fill the research gap and inform timely planning malaria interventions in such situations.

2.5 Conceptual Framework

2.5.1 Malaria Morbidity as Dependent Study Variable

As shown in the table below, malaria morbidity is conceptualized as an outcome resulting from interactions involving the humans (host), malaria parasite and the Anopheles mosquito (vector) in the internal and external environments. The control interventions seek to counteract such interactions, the success of which depends on the optimal accessibility and utilization of the interventions.

2.5.2. Independent Variables

Internal environment factors include the parasite and acquired host immunity which are thought to be determined by age and country of origin. External environment factors include mosquito populations which vary with external temperature and rainfall patterns, land use, housing characteristics and availability of mosquito breeding sites.

Table 2.1: Study Variables

Dependent variables	Malaria morbidity (1). Confirmed number of cases with parasitemia (2). Reported malaria illness episodes		
Independent variables	Internal environment	External environment	
	Internal biological factors	Social Factors	Physical and biological factors
	Parasite and host immunity	Human health behavior, access to interventions and utilization	Climate, mosquito and humans
	Age Sex Asymptomatic reservoirs	Literacy Knowledge LLINs ACT	Climate Open water sources Housing

Source: Researcher, 2018

External social factors include population movements, knowledge, beliefs and practices and literacy. Control interventions such as long-lasting insecticide treated nets, indoor residual spraying, mosquito larva source management (LSM), reliable diagnosis and effective treatment and effective surveillance, monitoring and evaluation influence malaria morbidity depending on the accessibility and utilization by the target populations.

CHAPTER THREE

METHODOLOGY

3.1. The Study Setting

Tanzania is a country located in East Africa (composed of Tanzania Mainland and Islands of Zanzibar and Pemba) with an area of 945,000 km^2 and population of 49,928,923 people according to 2012 population census (URT 2012). The country experiences an annual increase of 2.7% of the population and has household size approximated at 5.1 members. In addition, the country hosts more than 300,000 refugees from DRC and Burundi, located in 3 camps in Kigoma region in the northwestern part of the country.

Administratively, Tanzania Mainland is divided into 26 regions and 163 administrative districts which are further subdivided in descending order into divisions, wards, streets (in urban areas), and villages and hamlets (in rural areas). The climate of the country varies with geographical zones and topography (URT 2013) as follows; alone the coast, it is tropical type characterized by hot, humid conditions and rainy season between March and May; the northern and southern highlands experience semi-temperate type with the short rains (*vuli*) between November and December and the long rains (*masika*) between February and May.

The lake basins of Victoria, Tanganyika and Nyasa experience relatively heavier rains and are usually warm and humid; the central plateau is relatively dry (*kiangazi*) with considerable seasonal variations in temperature. Total rainfall varies spatiotemporally, increasing towards the north around Lake Victoria and reaching the peak during the period of March and May. The average duration of the dry season is 5 to 6 months.

3.2. Study Area

The study took place in 3 administrative districts of Kigoma region in north western Tanzania namely Kasulu, Kibondo and Kakonko. The region lies between latitudes 3.6 and 6.5 south of Equator and longitudes 29.5 and 31.5 east of Greenwich. It shares borders with four regions and two countries: the northern border is shared with Kagera region and Republic of Burundi; with Katavi region on the southern side; Tabora and Geita regions on the eastern side and Democratic Republic of Congo on the western side. The region has a total area of 45,087 square kilometres, 17,295 square kilometres of which are covered with swamps, permanent rivers and lake water. The climate of Kigoma region consists of tropical type characterized by long wet rainy season beginning from October to May (URT, 1998).

The host population of the three selected districts, (excluding the refugee population) is estimated at 167,555 for Kakonko, 261,331 for Kibondo and 425,794 for Kasulu (URT, 2012). There are 3 refugee camps in the regions namely: Nyarugusu camp in Kasulu district with refugee population of 149,894, Nduta camp in Kibondo district with refugee population of 119,089 and Mtendeli camp in Kakonko district with refugee population of 46,161. Human settlements in both host and refugee populations are organized in a hierarchical order from the household level. In the refugee communities it starts from households to villages through clusters and zones to the camp level while in the host communities it starts from household to hamlets through villages, wards and divisions to the district level. The 3 camps have a total of 45 zones, 641 villages and 57,284 households.

3.3 Study Population

The study population consisted of persons aged zero years (born in the year of study) and above living in the selected households from the 3 refugee camps.

3.4. Study Design

The study design was both cross sectional study design involving one-time collection of quantitative data from a random sample of study population and laboratory confirmed malaria data from the health facilities and local pharmaceutical companies, office of the regional medical officer and regional meteorogical agency.

3.5 Sample Size

Since the last malaria survey was done in 2012 and so current prevalence is not known, the sample size was calculated from arbitrary prevalence of 50% using the following formula for the cross-sectional study design involving proportions and design effect (DE) for cluster sampling designs.

N= (DE) Z^2 (1-p) p/ Ů^2

Where:

N = Minimum sample size for cross sectional study

Z= Standard normal deviation corresponding to 95 % confidence level = 1.96.

p= Proportion under consideration (arbitrary malaria prevalence)

Ů= Marginal error, which is 5% and DE of 2.5

Sample size will be = $(1.96^2)\ (0.5^2)/0.05^2$

= (384)(2.5)

= 960

On account of practical constraints stated below under section 3.10.1, a total of **749** study participants were recruited.

3.6. Sampling Procedure

Stage wise cluster random sampling technique was used in which 17 out of 45 zones were randomly selected in the 3 camps from which a random sample of 73 villages were selected using a lottery process. Then a total of 749 persons were studied from households systematically selected from the 73 villages. Any person aged zero years and above living in the selected household with relevant clinical note or health facility identification number, willing to participate in the study after informed consent was recruited into the study.

3.7. Inclusion Criteria

Any person aged zero years and above living in the selected household with relevant clinical note or health facility identification number, willing to participate in the study after informed consent. In the collection of historical data, only laboratory confirmed malaria cases were counted.

3.8. Data Collection

3.8.1. Pre-Testing of Research Tools

Pre-testing of research tools was done in the few selected participants in the study area after ethical clearance, with consequent appropriate changes in the questionnaire before being used in the target population. This ensured that the questions are clearly worded, specific and appropriate for the population and follow in a logical order.

3.8.2 Tools and Personnel

Research assistants were duly trained community health workers, acceptable and trusted in their communities and able to communicate in respective local refugee language. Prior to data collection they were retrained on the administration of the questionnaire, malaria testing procedures and interpretation of the results. Pretested structured questionnaires were used to collect the information from the adult participants and from the care givers of the recruited children. Blood specimens for examination of malaria parasites was collected from all the participants using sterile prickers, absorbent cotton wool, methylated spirit, a clean glass and malaria rapid diagnostic cassette which consist of a highly sensitive and specific malaria Pf Ag rapid diagnostic test able to detect P falciparum specific histidine rich protein-2 (Pf HRP-2) in human whole blood specimen.

3.8.3 Procedure in the Field

Following informed consent, all the participants were interviewed to collect information on their socio-demographic characteristics including age, sex, education/literacy, knowledge of malaria symptoms, presence of malaria symptoms, and number of malaria episodes suffered in the past 12 months, response to malaria symptoms, adherence to treatment and the availability and use of malaria mosquito nets. Household risk factors such as presence of possible mosquito breering sites were also assessed.

The data were collected by the principal investigator assisted by research assistants who were duly trained on how to administer the interview, filling in of the forms and collection of the blood specimens. The health facility records were reviewed to collect information on the number of confirmed malaria cases in the past 5 and 8 years from the host and refugee populations respectively obtained from the regional health management information (HMIS) for host population and from health information system (HIS) for the camp based population. The calculation of incidence was based on population estimates from the recent national census for the host population while for the refugee population it was based on the 60 monthly population updates obtained from the health information system (HIS) records.

The information on the market price of rapid malaria diagnostic tests, ALu, paracetamol, drug dispensing bags and gloves were obtained from the local Tanzanian pharmacies. Information on approximate time spent on uncomplicated malaria cases by clinicians, laboratory technicians and drug dispensing staff were obtained from the respective health personnel together with their salary scale and daily working hours. From these, the minimum recurrent financial costs of managing uncomplicated malaria cases were estimated. Information on climatic variables (temperature, rainfall and humidity) were obtained from the regional meteorological agency.

3.8.4 Procedure for Quality Control

For quality control puposes, blood slide for malaria parasites were done from randomly selected from known mRDTs at the regional laboratory at Maweni Referral Hospital using Giemsa staining techniques under a regular method as elaborated in WHO Bench Aids for Malaria Diagnosis 2000 (WHO, 2000). The microscopist was blinded, that is, he was not be aware of the mRDTs results results prior to examination.

3.9 Data Management and Statistical Analysis

3.9.1 Data Preparation, Cleaning and Validation

The incoming questionnaire data were revisited for completeness, clarity and availability of all the relevant information prior to entering data into the capturing template. Ambigous and irrelevant responses were not entered into the data capturing template. The template was prepared in the Microsoft Excel 2013. The data were then be spot checked on random basis for accuracy. The entered data were summarized to check that all the data are within acceptable limits and boundaries. The resulting data set were entered into IBM SSPS statistics 22 and EPI INFO 3.5.4.for further analysis. IBM SSPS statistics 22 was particularly used for time series analysis.

3.9.2 Descriptive Statistics

Descriptive analysis was done at the level of individual participants and the health facility. Univariate analysis was used to determine frequencies and the proportions which were presented with their corresponding 95% confidence intervals (CIs). For comparison purposes the incidence of malaria was expressed by number of cases per 100,000 populations. Numerical data were presented with their mean values and standard deviations. The time series analysis was done to determine monthly changes in malaria incidence over the past 8 years from 2010 to 2017.

3.9.3 Inferential Statistics

The relationship between categorical variables and the determinant factors were examined using analytical cross-tabulations in which odds ratio (OR) and 95% confidence interval were estimated for 2x2 cross-tabulations. For 2xk cross-tabulations, Pearsonôs chi squared statistic (G^2) and *P*-values will be estimated for each factor.

Principal component and factorial analysis were done to determine the financial costs per annum required to to manage uncomplicated malaria cases. Trend analysis and Chi squared statistic for trend were used to determine changes of malaria incidence over time. The influence of meteorological factors and population dynamics was assessed. Application of multiple logistic and linear regressions for factors with significance level <0.05 was done to test the association of malaria morbidity with the identified factors.

3.10 Potential Study Limitations and Sources of Errors

3.10.1 Practical Problems

i. Missing and incomplete information from the HMIS and HIS data bases.
ii. Inappropriate responses from some of the participants
iii. Financial, security and logistics contraints made it difficult to study Tanzanian participants living in hard to reach sparsely located villages.

3.10.2 Sources of Errors

a) Sampling error

Due to practical problems stated above, the intended sample of 960 participants could not be reached

b) Hawthorne effect is a form of confounding which occurs when research study participants know that they are being studied and alter their performance because of the attention they receive from the experimenters. They may admit having slept under mosquito net to impress the interviewers or hide the net in anticipation of sensitizing the need for further donations from donor agencies.

3.11 Ethical Issues

Ethical clearance was obtained from the Open University of Tanzania Research Ethical Committee. Permission to conduct research in the camps was obtained from relevant authorities including Department of Refugee Services of the Tanzania Ministry of Home Affairs and from Kigoma Regional Administrative Secretary. Each study participant was informed on aims and procedures of the study. Consent was obtained from each caregiver of the selected child. The blood samples were strictly used for the specified study purposes only and in no circumstances were they used for any other purpose or shipped out of the study area. The study particiapnts found to have malaria with or without symptoms were referred to the nearby health facility for further assessment and management.

CHAPTER FOUR

RESULTS

4.1 Registration and Enrolment

Routine administrative data: The 8 years period total number of monthly malaria cases (96 months) and the corresponding population updates for the refugee populations from January 2010 to December 2017 was obtained from Nyarugusu refugee camp HIS. The data for October 2010 and December 2013 were missing. However, the approximate data for December 2013 was deduced using the available 2013 annual summary report, thus reducing the data set to 84 months.

The available data for malaria cases from the host populations in Kasulu, Kibondo and Kakonko districts and the meteorological data (temperature, rainfall) were from 2013 to December 2017. These were obtained from regional HMIS and the regional meteorological center respectively. Only January 2013 was missing for Kibondo whereas January to July 2013 malaria data were missing for both Kasulu and Kibondo. Moreover, the number of cases reported from these districts kept on increasing progressively with time. This may signify improvement in facility utilization, surveillance and reporting.

Sample survey data: Seven hundred and forty-nine (749) participants aged from zero years and above living in the selected households in the three refugee camps in Kigoma region, with or without symptoms of malaria were enrolled in this study. These consisted of 300 (40.1%) participants from Nyarugusu camp, 299 (39.9%) participants from Nduta and 150 (20.0%) participants from Mtendeli camp. Participation rate was 99.9% (749/750) as one interview in Nduta camp was not completed. Five (5) health care providers were also interviewed to provide information on their average time spent in managing one case of uncomplicated malaria, daily working hours and salary scale. The price for various malaria management drugs and other related commodities were quoted from 2 and 3 wholesale pharmacies in Kigoma and Dar es Salaam respectively.

4.2 Basic Descriptions

4.2.1 Basic Statistics from the Routine Administrative Data

Malaria morbidity trend: The total number of malaria cases reported among the refugee population in Nyarugusu from 2010 to 2017 was 753,568 (monthly average unadjusted 7,932, adjusted 8,923) with an average of 94,196 cases per year.

Table 4.1: Number of Confirmed Malaria Cases Reported In Host Population Districts and in Nyarugusu Refugee Camp from 2010 to 2017

Year	Location	Total	Monthly average		Monthly incidence
			Malaria cases	Population	
2010-17	Nyarugusu	753,568 (94,196 per year)	7,932	90,023	8,923.2
2014-17	Kasulu	371,486	7,739		1,683.9
2013-17	Kibondo	459,711	7,792		2,981.5
2014-17	Kakonko	214,118	4,556		2,537.1
2010	Nyarugusu	63,477	5,771	60,150	9,678.1
2011	Nyarugusu	49,345	4, 112	62,396	6,608.5
2012	Nyarugusu	73,515	6,126	65,181	9,463.5
2013	Nyarugusu	59,464	5,406	68,181	7,947.1
	Kasulu				
	Kibondo	35,267	3,206		1,226.8
	Kakonko				
2014	Nyarugusu	65,469	5,456	63,919	8,528.0
	Kasulu	37,569	3,130		8,823.3
	Kibondo	84,136	7,011		2,682.9
	Kakonko	37,569	3,131		1,868.5
2015	Nyarugusu	152,718	12,726	117,567	12,347.9
	Kasulu	64,003	5,334		1,252.6
	Kibondo	117,474	8,430		3,746.0
	Kakonko	35,269	3,206		1,913.6
2016	Nyarugusu	117,748	9,812	136,727	7,103.3
	Kasulu	62,305	5,192		1,219.4
	Kibondo	101,158	8,430		3,225.7
	Kakonko	55,912	4,659		2,780.8
2017	Nyarugusu	166,389	13,865	141,755	9,776.7
	Kasulu	207,609	17,300		4063.2
	Kibondo	121,676	10,139		3,880.0
	Kakonko	85,368	7,114		4,245.4

Source: Field data, 2018

Table 4.1 shows estimated malaria illness episodes were 1.05 per person per year (94,196/90,023). The cases reported from the host population districts of Kasulu, Kibondo and Kakonko were 371,486 (monthly average unadjusted 7,739, adjusted 1,684), 459,711(monthly average unadjusted 7,792, adjusted 2,982) and 214,118 (monthly average unadjusted 4,556, adjusted 2,537) respectively.

The absolute number of malaria cases shows an obvious general increasing trend while the adjusted monthly number of cases per 100,000 population shows only a slightly increasing trend (Figure 4.1) Trend of malaria morbidity in Nyarugusu refugee camp as expressed in number of cases (a) and the incidence (b). There is seasonal trend with double peaks/spikes between December/January and May/June and low transmission from July to October. The peaking starts again from November usually in response to bimodal rainfall patterns.

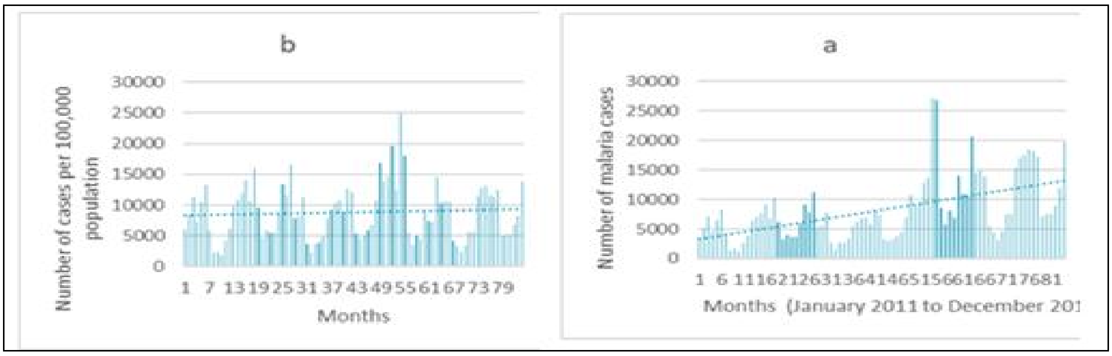

Figure 4.1: Trend of Malaria Morbidity in Nyarugusu Refugee Camp
Source: Field data, 2018

As shown in Figure 4.2, this seasonal pattern is not obvious in the host population data from 2013 to 2016. The pattern however becomes evident in 2017 as number of cases reported increases.

Figure 4.2: Comparison of trends of malaria morbidity in the host population districts and in Nyarugusu refugee camp

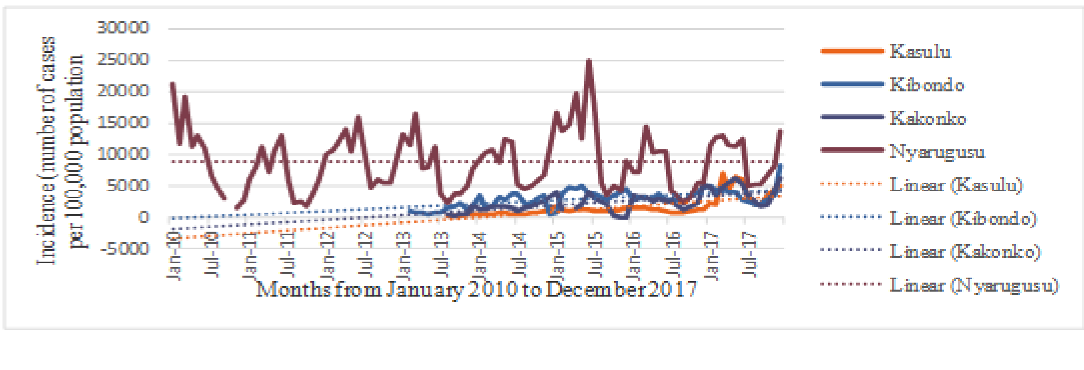

Figure 4.2: Comparison of Trends of Malaria Morbidity in the Host Population Districts and In Nyarugusu Refugee Camp

Meteorological Trends: The mean monthly temperature of 29.1^{0}C (minimum 1.6^{0}C, maximum 32.0^{0}C) and mean monthly total rainfall of 77.6mm (minimum 0.0, maximum 249.9mm) were recorded in Kigoma region between January 2013 and December 2017 (Table 4.2).

Table 4.2: Trend of Temperature and Rainfall recorded in Kigoma Region between 2013 and 2017

Period	Parameter	Total	Monthly average	Range (min-max)
2013- 2017	Temperature (^{0}C)		29.1	1.6-32.0
	Rainfall (mm)	4,656	77.6	0.0-249.9
2013	Temperature(^{0}C)		29.3	276-30.8
	Rainfall (mm)	1078.5	75.3	0-249.9
2014	Temperature(^{0}C)		29.3	28.1-31.1
	Rainfall (mm)	866.2	72.1	0-167
2015	Temperature(^{0}C)		27.3	1.6-32.0
	Rainfall (mm)	964.9	80.4	0-181.6
2016	Temperature(^{0}C)		29.9	28.1-31.5
	Rainfall (mm)	923.1	76.9	0-201.9
2017	Temperature(^{0}C)		29.7	27.9-31.4
	Rainfall (mm)	823.3	68.6	0-197.8

Source: Field data, 2018

The rainfall pattern shows a fluctuating and general decreasing trend. Seasonal bimodal peaks are observed in January-March and October-December which appear to precede malaria transmission. June to September are relatively dry months. The temperature pattern shows general seasonal pattern in which May-October appear to be relatively hotter than the rest of the other months. Except for random variations, there appear to be constant high mean monthly temperatures between the years 2013 and 2017 with slight general linear trend. However, the year 2015 appears exceptional in which the temperatures were relatively high throughout the year with remarkable low values recorded in July. Temperature variations (for instance below mean 29.1^{0}C) appear to coincide with malaria transmission peaks. This is particularly evident from plots of temperature variations with the number of malaria cases (Figure 4.4(b).

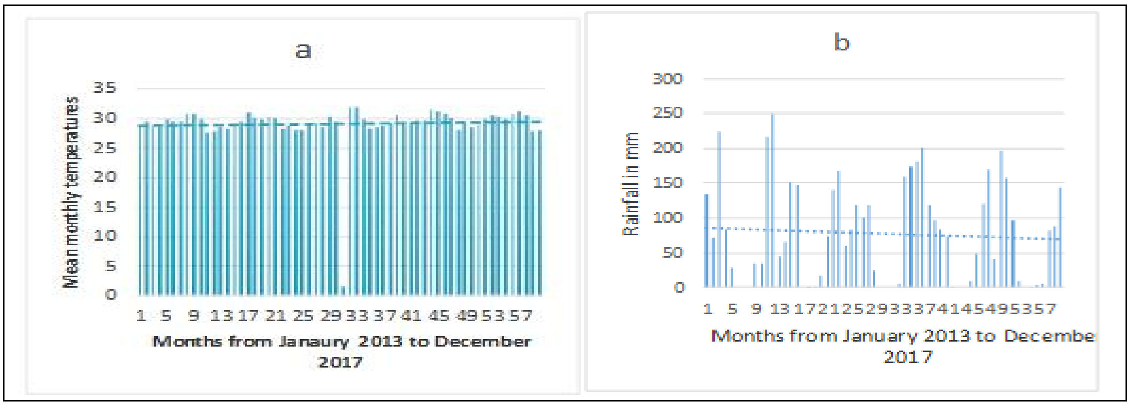

Figure 4.3: Trend in Temperature (a) and Rainfall (b) in Kigoma Region
Source: Field data, 2018

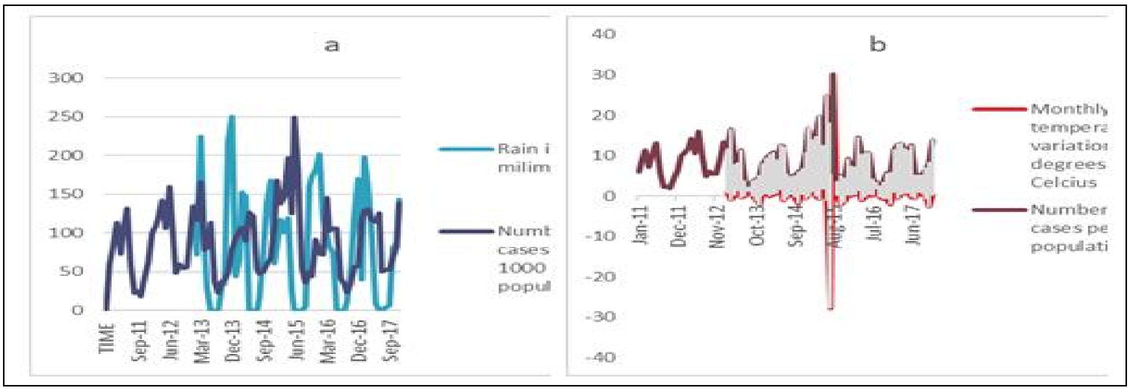

Figure 4.4: Trend of Malaria Incidence with Rainfall (a) And Monthly Temperature Variations (b)
Source: Field data, 2018

There was malaria epidemic in July 2015 when there were record low temperatures. The years 2015 and 2017 had two of the highest recorded malaria morbidity (152, 718 cases in 2015 and 166,389 cases in 2017) accompanied with an outbreak in which the July 2015 malaria incidence exceeded the incidence of the month (previous 12 months apart) by 70.4% (Figure 4.6).

Population dynamics: Population size in Nyarugusu refugee camp has been relatively stable since its inception in 1996. However, following the influx of refugees from neighboring country in 2015, there has been a general increasing trend with significant spikes in 2015 and 2017. It is worthy noting that there has remarkable increase in malaria morbidity in the camp in these periods as shown in Figure 4.5.

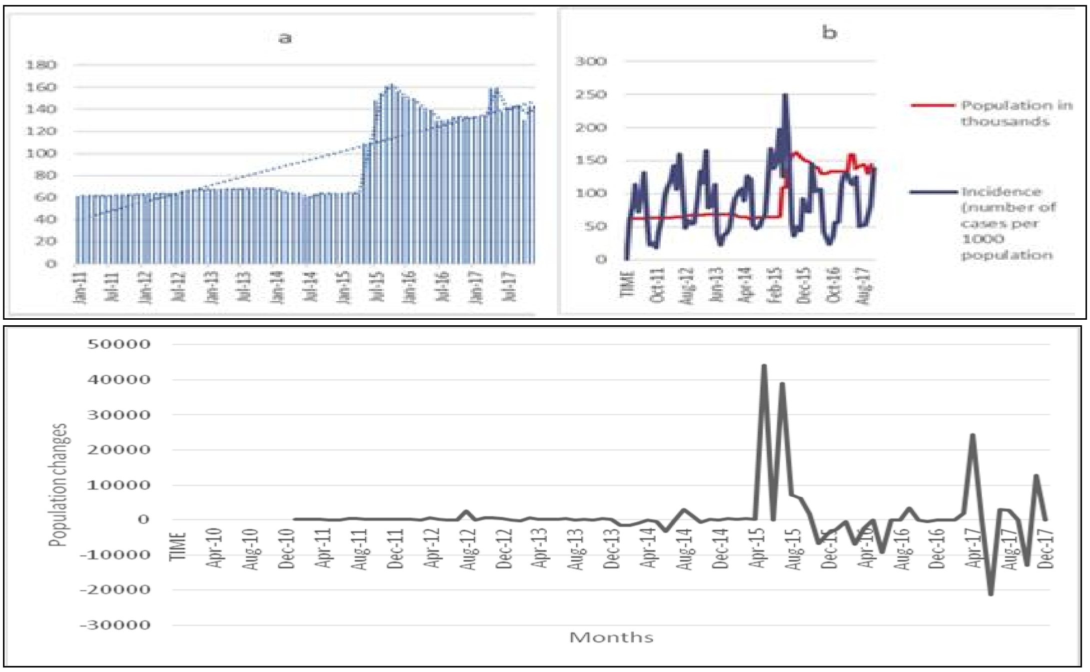

Figure 4.5: Trend of Population size (a) and malaria morbidity (b) in Nyarugusu refugee camp
Source: Field Data, 2018

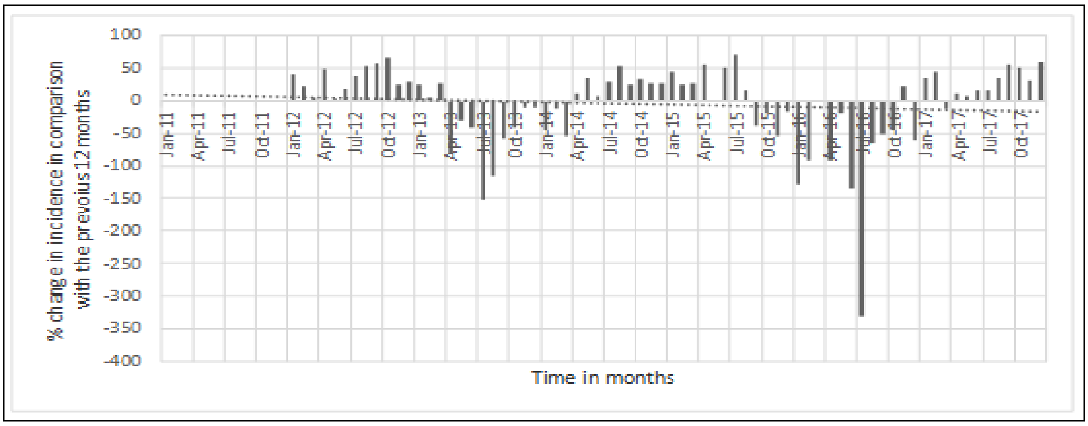

Figure 4.6: Percentage Change in Monthly Malaria Incidence from the Previous Season
Source: Field data, 2018

4.2.2 Basic Characteristics from the Sample Survey Data

Socio-demographic characteristics: The baseline characteristics of the study participants and households are shown in Table 4.3. Of the 749 participants, 199 (26.8%) were children aged between 0-5 years and 543 (73.2%) were aged above 5 years. Male to female ratio was 42.6% to 57.4%. Of the interviewed participants, 318 (43.2%) had informal education, 310 (42.1%) had primary education, 101 (13.7%) had secondary education and 7 (1.0%) had some form of post-secondary education, (Table 4.3). There were 377 (50.4%) who did not know how to read and write.

Malaria illness episodes in the past 12 months: Of the interviewed particiapants, 558 (75.8%) have had experienced at least one episode of malaria illness which required antimalarial treatment in the past 12 months, among whom, 238 (32.3%) have had one illness episode and 320 (43.5%) have had 2 or more malaria ilness episodes. One hundred and seventy-eight (178 (24.2%) have had not any malaria illness episode in the past 12 months. Most of the malaria illness episodes were reported in April, May, June and July among those who were interviewed.

Table 4.3: Baseline Characteristics of the Study Participants and Households

A. Study population characteristics	Number (%)	95% CI
Participantôs age (years)		
0 ï 5	199 (26.8)	23.7 to 30.2
6- above	237 (73.2)	69.8 to 76.3
Participantôs sex		
Male	318 (42.6)	39.1 to 46.1
Female	428 (57.4)	53.9 to 60.9
Education level of the participant		
Informal	318 (43.2)	39.6 to 46.9
Primary	310 (42.1)	38.5 to 45.8
Secondary	101 (13.7)	11.4 to 16.5
Post-secondary	7 (1.0)	0.4 to 2.0
Participantôs literacy (read and write)		
Yes	343 (45.9)	42.2 to 49.5
No	377 (50.4)	46.8 to 54.0
Not sure	28 (3.7)	2.5 to 5.4
Participantôs malaria symptoms on study day		
Symptomatic	192 (25.9)	22.8 to 29.2
Asymptomatic	538 (72.5)	69.1 to 75.7
Undetermined	12 (1.6)	0.9 to 2.9
Participantôs malaria RDT results		
Positive	72 (10.0)	8.0 to 12.5
Negative	642 (89.4)	86.9 to 91.5
Undetermined	4 (0.6)	0.2 to 1.5
Malaria RDT positivity rate		
Among symptomatic participants (n=176)	42 (23.9%)	17.8 to 30.9
Among asymptomatic participants (n=524)	28 (5.3%)	3.6 to 7.7
Participantôs knowledge of malaria symptoms		
At least 2 malaria symptoms known	266 (93.7)	90.2 to 96.2
One malaria symptom known	16 (4.9)	2.7 to 8.1
No known malaria symptom	4 (1.4)	0.4 to 3.6
Response to malaria symptoms (within 24 hours)		
Self-medication	14 (1.9)	0.9 to 3.0
Seek formal health care	721 (97.8)	96.7 to 98.8
Seek traditional healer	2 (0.3)	0.0 to 0.3
Participants completion AL dose		
Completed dose	526 (74.9)	71.5 to 78.1
Did not complete dose	113 (16.1)	13.5 to 19.1
Not sure	63 (9.0)	7.0 to 11.4
Malaria illness episodes (in past 12 months)		
No known episodes	178 (24.2)	21.2 to 27.5
At least one episode	558 (75.8)	72.5 to 78.8
Mosquito net ownership (in past 12 months)		
Yes	550 (74.0)	70.7 to 77.1
No	191 (25.7)	22.6 to 29.0
Do not remember	2 (0.3)	0.0 to 1.1
Mosquito net used last night		

A. Study population characteristics	Number (%)	95% CI
Yes	420 (56.4)	52.7 to 60.0
No	322 (43.2)	39.6 to 46.9
Not sure	3 (0.4)	0.1 to 1.3
B. Household characteristics		
House roofing material		
Iron sheets	290 (39.1)	35.6 to 42.4
Plastic sheeting	172 (23.2)	20.4 to 26.2
Grass	279 (37.7)	34.4 to 41.3
House wall material		
Iron sheets	11 (1.5)	0.7 to 2.4
Plastic/cotton sheeting	51 (6.9)	5.1 to 8.8
Soil/mud bricks	672 (90.7)	88.4 to 92.7
Grass	3 (0.4)	0.0 to 0.9
House neighborhood to forested area		
Yes	191 (33.1)	29.3 to 37.1
No	386 (66.9)	62.9 to 70.7
Water pools near house in rain season		
Yes	365 (57.3)	53.3 to 61.2
No	272 (42.7)	38.8 to 46.7

Source: Field data, 2018

Presence of malaria symptoms and knowledge of malaria symptoms among the study participants. Of the study participants, 192 (25.9%) had at least one malaria symptom on the day of interview whereas 538 (72.5%) were asymptomatic. There were 284 participants who were interviewed regarding their knowledge of malaria symptoms, of whom 266 (93.7%) had a knowledge of at least two malaria symptoms. Four (1.4%) had no knowledge of any single malaria symptom.

RDT tests and adherence to prescribed antimalarial drug: Malaria rapid diagnostic test (RDT) was positive in 72 (10.0%) of the study participants. The test was positive in 42 (23.9%) among the interviewed participants who were symptomatic whereas among the asymptomatic participants the test was positive in 21 (5.3%) of them. When asked about their response to malaria symptoms within 24 hours of recognition, 721 (97.8%) admitted to seeking care from formal health care facilities, 14 (1.9%) did self-medication and 2 (0.3%) from traditional healers. On

AL treatment adherence, 526 (74.9%) completed the prescribed dose, 113 (16.1%) did not complete the dose and 63 (9.0%) were not sure whether or not they managed to complete the prescribed dose.

Household characteristics: Household characteristics were assessed in terms of house roofing and wall material, neighborhood to open water pools during rain season and neighbor hood to long grassed or bushy areas. Of the interviewed participants, 290 (39.1%) resided in iron sheet roofed houses, 172 (23.2%) in plastic/cotton sheeting roofed houses and 279 (37.7%) resided in grass thatched houses. Most of the respondents (672 (90.7%) resided in mud brick walled houses, whereas a few of them resided in the other house types such 11 (1.5%) in the iron sheet walled houses, 51 (6.9%) in plastic/cotton sheeting walled houses/tents and 3 (0.4%) in grass walled houses. Moreover, 365 (57.3%) of the respondents admitted to reside near open water pools during rain seasons whereas 191 (33.1%) reside near grassed/bushy areas.

Mosquito net ownership and use: Mosquito net ownership and use was assessed by asking if the respondent got a net in the past 12 months in the mass didtribution campaign and whether he/she slept under the net last night prior to the interview. Of the interviewed participants, 550 (74.0%) admitted to have got the mosquito nets in the past 12 months, 191 (25.7%) did not get the nets while 2 (0.3%) did not remember to have got the nets. However, 420 (56.4%) slept under mosquito net a night prior to the interview, 322 (43.2%) di not sleep under any mosquito net and on stratifying mosquito use with ownership in the past 12 months, 155 (28.2%) did not sleep under any mosquito net in the night prior to the interview.

Close to two thirds of under-fives (60.3%) slept under mosquito nets a night prior to the interview compared to participants aged more than 5 years (54.9%). The top three reasons provided for not sleeping under the mosquito net were lack of ownership (140 (43.8%), worn out nets (115 (35.9%) and lost nets 34 (10.6%). Others included insufficient numbers of mosquito nets in relation to the household size, nets were exchanged for cash, stolen, inhibitory warm weather, dirty nets and habitual dislike to sleep under mosquito net.

Minimum direct financial costs for managing uncomplicated malaria illness episodes: A total of 1153 (mean 1.566) malaria illness episodes in the previous 12 months were reported by the study participants. Using cost of illness approach from the supply side, recurrent financial costs (medical related) pertaining to drugs, diagnostic tests, related consumables and the estimated health care workers remunerations were explored, and the summary results are as shown in the Table 4.4. The average direct financial cost required to manage one uncomplicated malaria illness episode is shown to be 8217.1 Tanzanian shillings (equivalent to 3.65 US dollars).

Table 4.4: Estimated Minimum Direct Financial Costs for Managing Uncomplicated Malaria Cases

1. Malaria illness episodes	Mean	95% CI	Total
	1.6	1.4-1.7	1153
2. Recurrent financial costs	Per episode		
a. AL	3682.7	3404.70-3955.40	2,710,500
b. Paracetamol	476.4	436.90-514.80	350,662.5
c. Gloves	282.0	264.40-301.60	207,540
d. Malaria RDT	1253.3	1175.00-1340.60	922,400
e. Dispensing envelope	75.2	70.50-80.40	55,344
f. Clinician	1407.8	1317.40-1503.50	1,036,150
g. Laboratory technician	406.3	381.50-435.00	299,000
h. Dispensing officer	633.4	593.80-677.50	466,158
Total cost	8217.1	7644.70-8774.90	6,047,755

Source: researcher, 2018

4.3 Inferential Statistics

4.3.1 Multiple Logistic Regression Analysis

Factors associated with Malaria Morbidity from the Sample Survey: To explore the factors associated with malaria morbidity in the study population, several factors were evaluated. These included age, sex, education level, literacy, residence, knowledge of malaria symptoms, adherence to malaria treatment regimen, presence of and response to malaria symptoms, mosquito net ownership, neighborhood to seasonal water pools and to grassy/forest areas and house structure. Malaria illness episodes experienced in the previous 12 months appear to vary across the three the camps. In Nyarugusu camp in which refugees from Burundi and DRC reside, 234 (79.4%) participants reported to have experienced at least one malaria illness episode in the previous 12 months.

In Nduta and Mtendeli camps both which host refugees from Burundi, 207 (70.4%) and 117 (79. 6%) respectively, reported to have had experienced at least one malaria illness episode in the previous 12 months. This variation is nor a mere random variation (p-value 0.02). Mosquito net ownership was found to be associated with malaria morbidity in that 395 (72.7%) of participants who got mosquito nets in the previous 12 months experienced malaria illness episodes compared to 157 (84.0%) of participants who did not get mosquito nets during the same period. The difference between the two groups was not a mere random variation (p-value 0.002).

There was statistically significant association between net ownership and use (OR 16: 95%CI: 10.2-23.5) as 392 (71.7%) of participants who slept under a mosquito net a night prior to the interview got the net in the previous 12 months while 165

(86.4%) participants who did not sleep under a mosquito net and did not got the net in the previous 12 months. Participantøs neighborhood to open water pools during rain seasons was found to be associated with malaria morbidity. Of the interviewed participants who experienced at least one malaria illness episode in the previous 12 months, 81.1% resided in areas prone to seasonal water pools compared to 74.1% who did not reside in or close to such areas. The difference between the two groups was not a mere random variation (p-value 0.036, OR 1.5; 95%CI: 1.03-2.19). The participantøs neighborhood to grassy/forest areas were associated with malaria morbidity although the difference between the groups was not statistically significant (p- value 0.056, OR 1.54; 95%CI: (0.97-2.50).

Malaria morbidity appears to vary across the age groups, with reduced risk as age increases (OR 0.87; 95%CI: 0.63-1.28). For instance, of the participants who experienced at least one malaria illness episodes in the previous 12 months, 141 (73.8%) were aged 0-5 years compared to 411 (76.4% aged above 5 years. As with other factors (Table 4.5), the differences between the age group categories evaluated were not statistically significant. To control for the effect of any possible confounders, multiple logistic regression analysis was applied to the factors with significant association with malaria morbidity in the study population. The results (Table 4.6) show that participantøs house neighborhood to open water pools (adjusted OR 1.55; 95% CI: 1.06-2.27) and participantøs mosquito net ownership (adjusted OR 1.81; 95%CI: 1.14-2.86) were strongly associated with at least one malaria illness episode, indicating that the differences observed in the groups are not mere random variations (p-values 0.02 and 0.01) respectively.

Table 4.5: Factors associated with malaria morbidity

Factor evaluated	Category	Number (%) who experienced at least one episode in the previous 12 months	G^2	P value	OR(95%CI)
Participant's location (camp)	Nyarugusu Nduta Mtendeli	234 (79.4) 207 (70.4) 117 (79.6)	7.81	0.02	
Mosquito net ownership	Yes No	395 (72.7) 157 (84.0)	9.49	0.002 (0.0036)*	0.51 (0.33-0.79)
Neighborhood to open water pools in rain season	Yes No	291 (81.1) 200 (74.1)	4.39	0. 036	1.5 (1.03-2.19)
Neighborhood to grassy areas	Yes No	155 (82.9) 558 (75.8)	3.64	0.056	1.54 (0.97-2.50)
Other factors e.g house roofing			09	0.38	0.87 (0.63 - 1.28)
House wall			3.26	0.35	
Age	0-5 years > 5 years	73.8 76.4	0.51	0.48	
Education level			0.50	0.92 (0.97)*	
Literacy			4.02	0.12	
24 hours response			4.02	0.23	
Sex			0.89	0.34	1.23 (0.72-2.06)
Adherence to treatment	Yes No	425 (81.3) 88 (77.9)	0.68	0.41	
Symptoms			2.95	0.2 (0.18)	
Knowledge			2.22	0.33 (0.30)	
RDT results			0.27	0.87 (0.67)	

Source: Field data, 2018

Table 4.6: Factors Associated with Malaria Morbidity (Multiple logistic regression)

Factor	Adjusted OR	Coefficient	95%CI	p-value
Participant's location (camp	0.85	-0.16	0.66 to 1.08	0.19
Mosquito net ownership	0.65	0.44	0.44 to 0.95	0.02
Neighborhood to open water pools in rain season	1.81	0.59	1.44 to 2.85	0.01

Source: Field data, 2018

4.3.2 Factorial and Linear Regression Analyses

Predicting Changes in Minimum Financial Cost for Managing One Uncomplicated Malaria Case from Changes in Malaria Episodes: Scatter plots were used for each of the factors used in the computation of minimum financial cost required for managing one uncomplicated malaria illness episode, to ascertain the linear relationship followed with univariate linear regression. Each of the factors was linearly correlated with the total financial cost as shown in the Table 4.7.

Table 4.7: Component Loadings and the Factors Which Determinine Uncomplicated Malaria Treatment Costs

Original factors	Coefficients (with p-value <0.005)		Component loadings		
	Regression (B)	Correlation (r^2)	1	2	3
Malaria episodes	5227.3	0.97	0.881	0.473	
AL	5.1	0.98	0.604	0.786	0.133
Paracetamol	14.8	0.89	0.401	0.915	
Gloves	20.0	0.97	0.881	0.473	
Malaria RDT	6.5	0.97	0.881	0.473	
Dispensing envelope	108.9	0.97	0.881	0.473	
Clinician	5.8	0.97	0.881	0.473	
Laboratory technician	20.1	0.97	0.881	0.467	
Dispensing officer	12.9	0.97	0.881	0.473	

Source: Field data, 2018

Table 4.8: Extracted Factors Which Determine Changes in Uncomplicated Malaria Treatment Costs

Extracted factors	%TVE	Regression (B)	95% CI	p-value
A. Malaria episodes	99.6	2423.10	2405.50-2440.70	<0.005
Medication-AL		1.20	1.19-1.21	<0.005
B. Malaria episodes	99.6	3644.20	3509.70-3737.40	<0.005
Medication- PCM		5.30	5.10-5.5.0	<0.005
C. Malaria episodes	99.9	2591.684	2581.20-2607.90	<0.005
Medications (AL)		1.000	0.99-1.01	<0.005
(PCM)		0.997	0.94-1.03	<0.005
Constant		0.141		0.9

Source: Field data, 2018

To counter the problem of multicollinearity a factorial analysis by principal component method was performed for the linearly correlated factors used to compute the financial costs. As shown in the rotated component matrix in Table 4.7, three (3) factors (with Eigen values greater than 1) were extracted, which were related to malaria episodes and medications and could account for most (total variance explained (TVE): 99.9%) of the total variability.

Application of multiple linear regression analysis of total financial costs and the selected factors shows that financial costs for managing uncomplicated malaria episode is strongly associated with malaria morbidity (malaria illness episodes) and the related medications. This association is statistically significant (p- value <0.005). As shown in Table 4.8, the change in financial costs per unit change in malaria episode can be roughly estimated using the equation: Cost change= 2591. 684(illness episode) +1.0(AL cost) +0.997 (paratacemol cost) +0.141.

4.3.3 Time Series Analysis

Trends of malaria morbidity, meteorological variables and population size

malaria morbidity: The plots of sequence, autocorrelation and partial autocorrelation functions of malaria incidence indicate non stationarity signifying the presence of a general linear trend. The stationarity was achieved by both first order nonseasonal differencing and first order seasonal differencing. There were significant negative spikes at lag 1 and 12 with gradually declining PACF, indicating seasonal and non seasonal moving average process in the time series malaria data. There are also significant spikes at lag 2, 3, 4, 5, 7, 8, 10 and 11.

Based on value of stationary R^2, presence of significant coefficients, Bayesian information criteria (BIC) and non-significant Box-Ljung statistic, ARIMA model (0, 1, 5) (0, 1, 1) was selected (Table 9). This shows that malaria morbidity as observed from January 2011 to December 2017, dispalys (1) a general linear trend, appearing to increase over time (non seasonal trends term d=1 in the model), (2) seasonal variation with peaks from January to June and from November to December.

The period from July to October is one of low malaria transmission; (3) the data observed at one particular time are correlated with random seasonal variations from the previous season (seasonal trends term D=1 in the model); (4) irregular, unpredictable non seasonal fluctuations. The observations seen at one particular time are correlated with random irregular variations from the previous one to five months (moving average terms q=5 in the model) and (5) do not appear to depend on successive observations from month to month (autoregressive terms p=0 in the model). This model can explain 64.4% of changes in malaria morbidity in Nyarugusu.

Table 4.9: Statistics for the Tested ARIMA Models

Model	R^2	BIC	Box-Ljung statistic	Coefficient (p-value)
MA 1	0.624	7.0	32.7 (0.008)	0.516 (<0.001)
MA 2	0.624	7.0	32.7 (0.005)	0.511 (<0.001)
MA 3	0.627	7.1	29.6 (0.009)	0.455 (<0.001)
MA 4	0.637	7.2	23.5 (0.036)	0.464 (<0.001)
MA 5	0.644	7.2	18.1 (0.114)	0.459 (0.001)
MA 7	0.602	7.5	25.4 (0.005)	0.547 (0.999)
MA 8	0.656	7.4	9.0 (0.034)	0. 558 (0.968)
MA 10	0.676	7.7	15.0 (0.036)	0.666 (0.999)
MA 11	0.670	7.6	15.9 (0.014)	0.345 (0.998)
MA 12	0.704	7.6	9.8 (0.08)	0.391 (0.999)

Source: Field data 2018

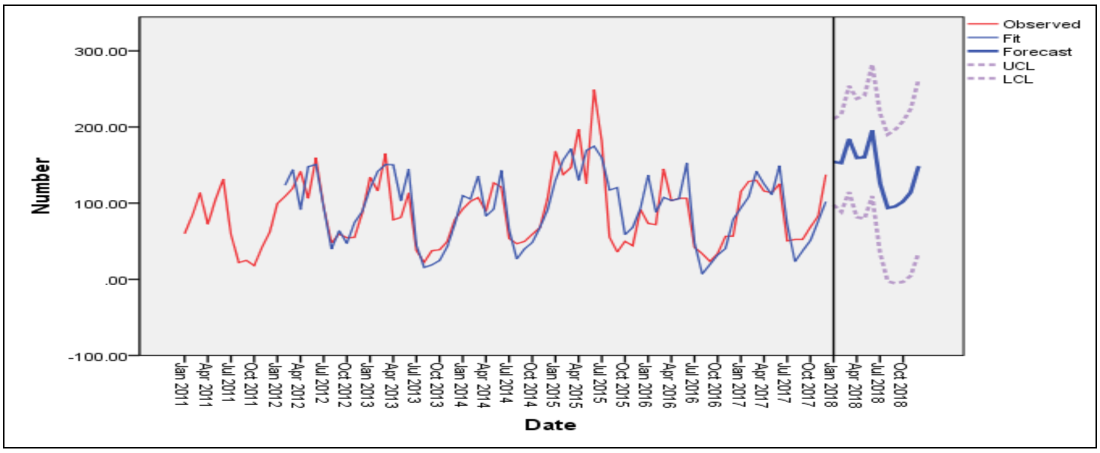

Figure 4.7: Predicted Malaria Incidence Using The Selected ARIMA Model
Source: Field data 2018

Table 4.10: Predicted Malaria Incidence Using The Selected ARIMA Model

Time of the year	Number of cases per 100, 000 population	95% Confidence Interval	
		Upper confidence limit	Lower confidence limit
Jan-18	15, 420	21, 072	9, 768
Feb-18	15, 266	21, 684	8, 849
Mar-18	18, 419	25, 384	11, 454
Apr-18	15, 951	23, 725	8, 178
May-18	16, 030	24, 120	7, 939
Jun-18	19, 568	28, 206	10, 930
Jul-18	12, 688	21, 840	3, 535
Aug-18	9, 377	19, 017	0
Sep-18	9, 576	19, 676	0
Oct-18	10, 221	20, 767	0
Nov-18	11, 445	22, 415	475
Dec-18	14, 863	26, 243	3, 482

Source: Field data, 2018

Temperature: The sequence, autocorrelation and partial autocorrelation function plots of temperature show stationarity meaning that no presence of linear trend over the period under review. However, there was a seasonal pattern as evidenced by the presence of negative significant spike at lag 12 indicating seasonal moving average process in the time series. This was accounted by using the ARIMA (0, 0, 0) (0, 1, 1). Applying this model, the resultant residual ACF and PACF plots and the forecasts are shown in Figure 4.8.

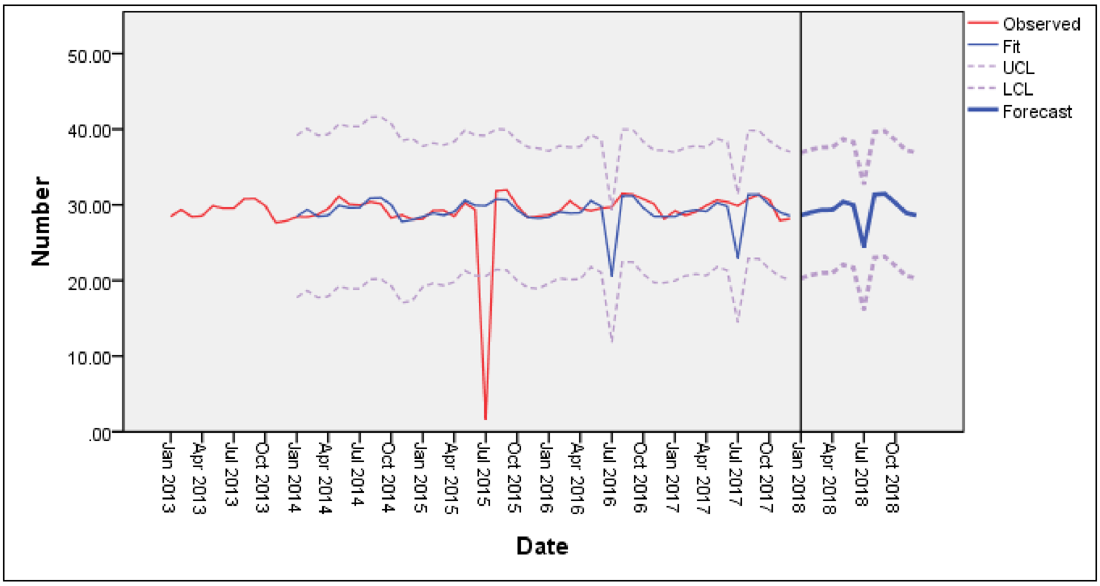

Figure 4.8: Predicted Temperatures Using the Selected ARIMA Model
Source: Field data, 2018

Rainfall: The plots of sequence, autocorrelation and partial autocorrelation functions show non stationarity indicating the presence of general decreasing linear trend as well as a seasonal pattern as indicated by negative significant spike at lag 12. This seasonal moving average process in the time series was accounted for by application of ARIMA (0, 1, 0) (0, 1, 1).

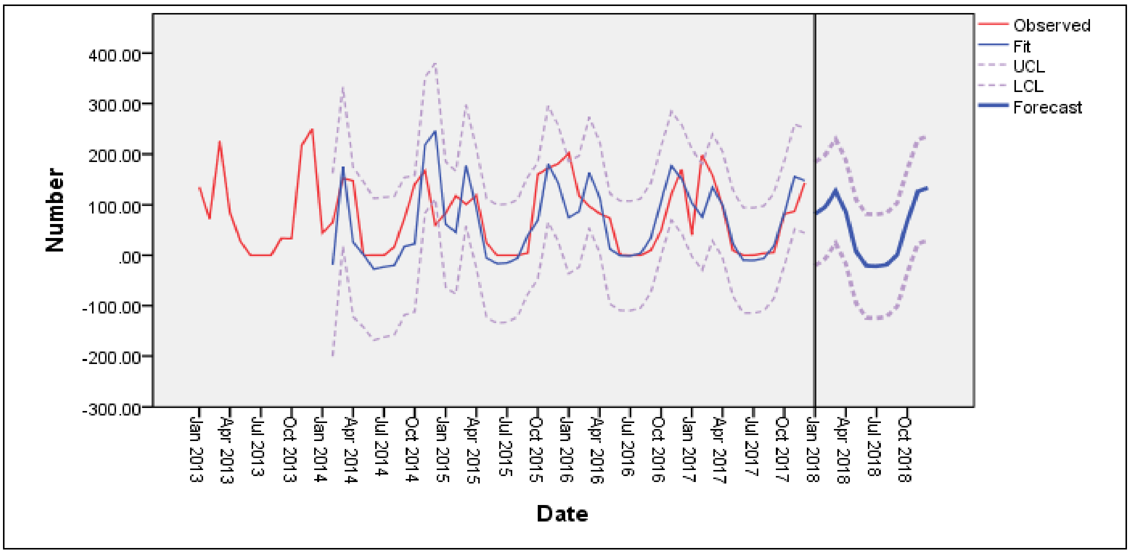

Figure 4.9: Predicted Rainfall Trend Using the Selected ARIMA Model
Source: Field data 2018

Table 4.11: Predicted Meteorological Parameters Using the Selected ARIMA Model

Time	Predicted climate parameters		Upper confidence limit	Lower confidence limit
Jan-18	Temperature (^{0}C)	28.6	36.9	20.3
	Rainfall (mm)	81.9	184.6	0
Feb-18	Temperature (^{0}C)	29	37.3	20.7
	Rainfall (mm)	96.0	198.7	0
Mar-18	Temperature (^{0}C)	29.3	37.6	21
	Rainfall (mm)	127.1	229.9	24.4
Apr-18	Temperature (^{0}C)	29.3	37.7	21
	Rainfall (mm)	85.9	188.5	0
May-18	Temperature (^{0}C)	30.4	38.7	22.1
	Rainfall (mm)	7.0	109.7	0
Jun-18	Temperature (^{0}C)	30	38.3	21.7
	Rainfall (mm)	0	81.7	0
Jul-18	Temperature (^{0}C)	24.4	32.7	16.1
	Rainfall (mm)	0	80.8	0
Aug-18	Temperature (^{0}C)	31.4	39.7	23.2
	Rainfall (mm)	0	83.9	0
Sep-18	Temperature (^{0}C)	31.5	39.8	23.2
	Rainfall (mm)	1.0	103.8	0
Oct-18	Temperature (^{0}C)	30.3	38.6	22
	Rainfall (mm)	67.5	170.0	0
Nov-18	Temperature (^{0}C)	29	37.3	20.6
	Rainfall (mm)	125.9	228.7	23.2
Dec-18	Temperature (^{0}C)	28.6	36.9	20.3
	Rainfall (mm)	132.9	235.6	30.1

Source: Field data, 2018

Population dynamics: The plots of the sequence, ACF and PACF of the population data show non stationarity signifying increasing general trends and marked variabilities in 2015 and 2017 after first order differencing (Figure 4.11). The ACF and PACF of the differenced series look similar with positive significant spikes at lag 2 indicating the presence both autoregressive and moving average processes in the data. The selected model was ARIMA (2, 1, 2) (0, 0, 0).

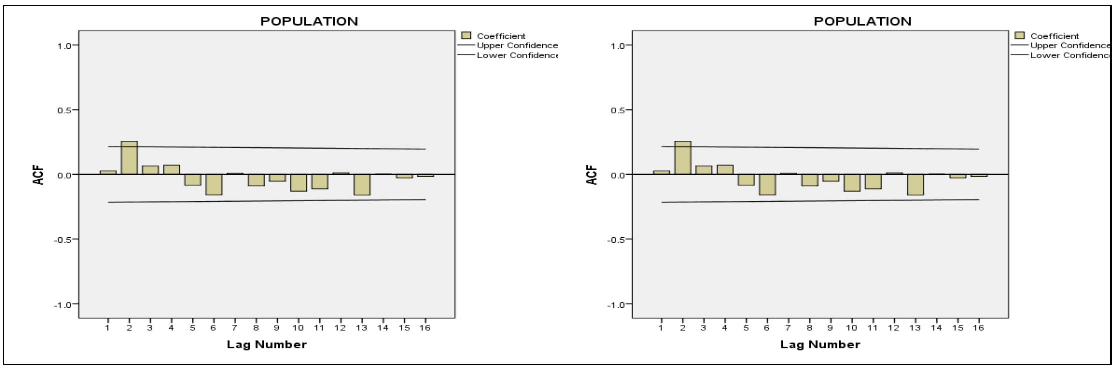

Figure 4.10: ACF and PACF Plots of Population Size
Source: Field data; 2018

Relationship of malaria morbidity with meteorological and population factors

cross correlation of malaria morbidity and climatic parameters: This was done to find out how temperature and rainfall variations explain the variation in the malaria morbidity data by considering the negative lags on the cross-correlation functions. The plot of CCF (Figure 11) of malaria incidence with rain and rain variations shows that rainfall leads malaria transmission by a lag of one month. The changes in rainfall below average in one particular month are strongly correlated with above average malaria transmission in the following month.

The plot of CCF of malaria morbidity with temperature and temperature variations show that temperature parameters in a given month coincide with malaria morbidity of that particular month. The changes in temperature below average in a given month is strongly correlated with increased malaria transmission above average in that particular month. The plot of CCF of malaria morbidity with population size shows that malaria morbidity is strongly correlated with population size/dynamics in the CHEs, the later leading the former by a lag 3 months (Figure 12).

Cross Correlation of Malaria Morbidity and Climatic Parameters: This was done to find out how meteorological and population factors explain the variation in the malaria morbidity data by considering the negative lags on the cross-correlation functions. The plots of CCF of malaria incidence with rain and rain variations shows that rainfall leads malaria transmission by one month. The changes in rainfall below average in one particular month are strongly correlated with above average malaria transmission in the following month.

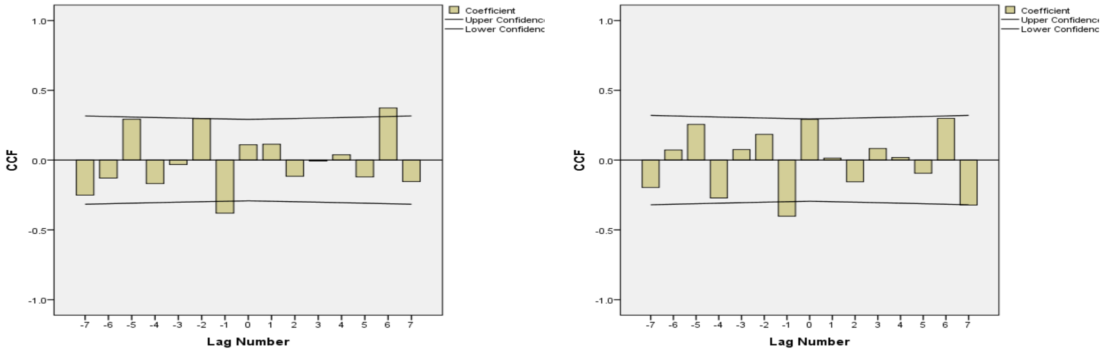

Figure 4.11: CCF Plots of Variation of Malaria Incidence with Rainfall and Rainfall Variation
Source: Field Data; 2018

The plots of CCF of malaria morbidity with temperature and temperature variations show that temperature parameters in a given coincide with malaria morbidity that particular month. The changes in temperature below average in a given month is strongly correlated with increased malaria transmission above average in that particular month. As shown in the Figure 4.12, the CCF of malaria morbidity with population shows that malaria morbidity is strongly correlated with population size/dynamics in the CHEs, the later leading the former by a lag 3 months. It is worth to note that, the years 2015 and 2017 marked with notable population variabilibities (Figure (b) below) are the years in which there was record high malaria transmission.

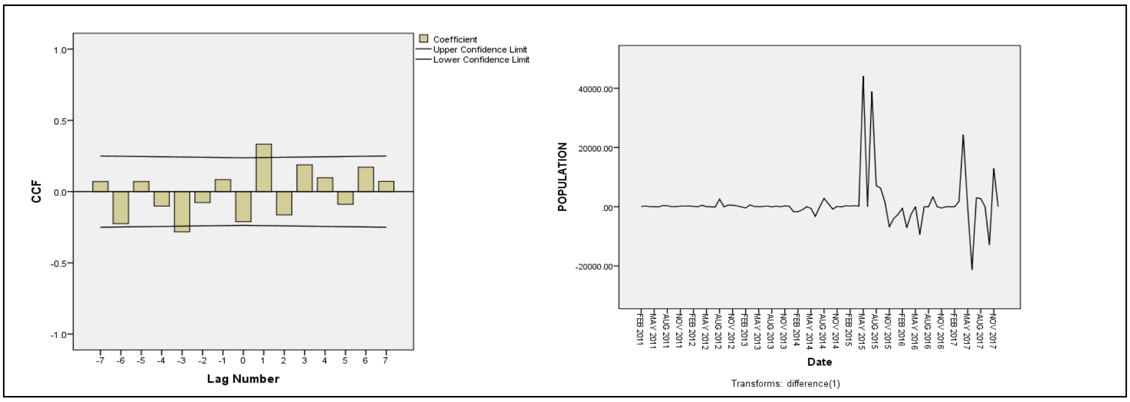

Figure 4.12: CCF Plots of Variation of Malaria Morbidity with Population Size
Source: Field data 2018

CHAPTER FIVE

DISCUSSIONS

The goal of studying disease trends in the complex humanitarian emergencies from the past events is to generate lessons learned which can be used to inform the preparedness and response planning for the present and future events. This helps to reduce excess mortalities and morbidities from disease outbreaks which results from lack of enough knowledge of the diseases, their patterns and associated factors. Monitoring and evaluation of disease trends including malaria morbidity is one of the tools to achieving this goal.

One of the major observations in the findings of this study is that, overall pattern of absolute number of malaria cases and the incidence is that of increasing trend with seasonal (predictable) and non-seasonal (unpredictable) fluctuations. While Tanzania has experienced malaria reduction from prevalence of 18.1% in 2008 to 7.3% in 2017, Kigoma region has experienced the increased malaria morbidity from prevalence of 19.6% in 2008 to 24.4% in 2017 (URT, 2017), with malaria epidemic outbreak having occurred in the refugee population in the region in July 2015. Incompleteness of health information from the host population might have left such epidemics go unnoticed, posing a significant challenge to planning of epidemic preparedness and response and achievement of malaria elimination targets of 2030.

However, with the improvement of HMIS in the host population in the recent years, the changes in patterns can be identified on timely basis going forward. High proportion of asymptomatic participants (72.5%) and the low RDT positivity rate among both the symptomatic (23.9%) and asymptomatic (5.3%) participants is consistent with low transmission period of the year which spans between July and November.

There are also commendable observations which indicate good performance of malaria control programme in the refugee settings. These include the use of health information teams (designated community health workers) in health education and promotion activities and collection of health information. For instance, 93.7% of the participants had knowledge of at least 2 malaria symptoms, 97.8% sought formal health care within 24 hours of onset of malaria symptoms and 74.9% adhered with malaria treatment as prescribed by the health professionals.

There is still a lot to be done to improve early detection and planning of preparedness and response activities in the complex humanitarian emergency settings in Kigoma and to make sure that the region is not left behind in the achievement of malaria elimination targets. This is supported by the observed increasing malaria morbidity trends with 75.8% of the participants having reported to experience at least one malaria episode in the previous 12 months, unpredictability nature of the epidemics and population dynamics and a discrepancy between mosquito net ownership (74.0%) and use (56.4%) which are comparable with the findings of the 2017 malaria indicator survey.

The Hawthorne effect and recall bias may be argued to have influenced the response by the interviewees regarding mosquito net ownership and use and malaria illness episodes experienced in the past 12 months. The fact that retrospective data for malaria episodes in the past 8 years (1.04 episodes per person per year) and the episodes elucidated from the interview (1.6 episodes per person per year in the previous 12 months in 2017), are comparatively closer, shows that the Hawthorn effect cannot be the only explanations for the findings of high morbidity, mosquito net ownership and use observed, but rather the findings are close to the true picture. This is in agreement with studies done in similar settings (Connolly, *et al.* 2004) and the morbidity reports from north western Tanzania in 2017 (Interagency, 2017).

5.1 Factors Associated With Malaria Morbdity

5.1.1 From the Interview

Location: Our study showed that among the refugee population the probability of having one or more malaria episode in the past 12 months statistically significantly differ across the three camps (p-value 0.02). This corroborate other studies (Caudart et al, 2006) which have suggested spatial heterogeneity as one of the factors accounting for malaria morbidity variability in the same population. This could indicate spatial differences in the distribution of malaria vectors and neighborhood to mosquito breeding sites, village/locality area, population size, environmental differences and/or differences interventions use and coverage. Some of these factors have been pointed in other studies (Bousema et al, 2010), Kreuls et al, 2008).

Mosquito net ownership and use: Our study shows that mosquito net ownership is strongly associated malaria morbidity by reducing probability of having one or more malaria illness episodes in the past 12 months by a resident in the study area (unadjusted OR 0.51 (0.33-0.79, p-value 0.002; adjusted OR 0.65, p-value 0.02). As it could be expected, the mosquito net use a night prior to the interview could not be associated with malaria morbidity suffered in the past 12 months.

However, in the light of low mosquito net utilization rate (56.4%), issues related to low utilization of mosquito nets warrant further exploration and incorporation into prgram planning so that the target population could benefit from the protective effect of the mosquito nets. For instance our study elucidated some of the reasons for not using the mosquito nets and found that lack of ownership (43.8%) and worn out nets (35.9%) accounted for most of the reasons provided. Others included insufficient numbers of mosquito nets in relation to the household size, nets were exchanged for cash, stolen or lost nets, inhibitory warm weather, dirty nets and habitual dislike to sleep under mosquito net. In our case resource mobilization to increase frequency distribution of the nets coupled with advocacy, behavioral change and communication strategies could improve the net utilization dynamics in complex humanitarian emergencies.

Housing and environmental characteristics: In our study we found that 90.7% of the houses have walls made of mud bricks and they are roofed with iron sheets (39.1%), grass (37.7%) and plastic sheetings (23.2%). While housing structural characteristics namely roofing and wall material as well as neighborhood to forests/grassy areas (OR 1.54 (0.97-2.50, p-value 0.056) did not show statistically significant association with malaria morbidity, the surrounding environmental characterictics namely presence seasonal water pools near the houses show strong association with malaria morbidity (unadjusted OR 1.5 (1.03-2.19, p-value 0.036; adjusted OR 1.81, p-value 0.01). This is corroborated with a study in northern Tanzania which showed strong association of local malaria transmission with rainy season and proximity to water (Oesterholt et al, 2006). This underlines the importance of shelter planning and environmental management especially during the high malaria transmission season.

5.1.2 Sociodemographic Characteristics

Age, education, literacy and gender: Our study did not show statistically significant association of sociodemgraphic factors such as age, education, literacy and gender with one or more episodes of malaria in the past 12 months in the study population. In other works and studies such association has been suggested.

5.1.3 Knowledge of Malaria Symptoms and Early Care Seeking in Reponse to the Symptoms

Knowledge of malaria symptoms have been associated with early care seeking (Kullaya et al, 2010, unpublished) which in turn contributes to reducing the burden of the disease (O'Meara, 2008). Our study has shown that 93.7% of the study participants had a knowledge of at least 2 malaria symptoms and that 97.8% sought formal health early, within 24 hours of recognizing the symptoms. However, no statistically significant association of knowledge of symptoms and malaria morbidity was found. The fact that, these interventions have worked elsewhere but not in complex humanitarian emergencies context in North western Tanzania, there could be a need for further explorative studies to find out which other interventions can be incorporated into the control programs to support the ongoing interventions.

5.1.4 Adherence to Treatment

Malaria program interventions including effective case management using AL have been successful in reducing malaria mortality and morbidity in the past decade

(WHO, 2014). This has also demonstrated as the impact of AL dose completion on malaria morbidity (Barnes et al, 2005). Our study has shown that AL dose completion rate was high (74.9%). However there no statistically significant evidence to explain the difference between those who did complete the dose and those who did not complete the dose as to the acquistion of one or more malaria illness episides in an individual. This implies that although improvements have been made in malaria case management using 6 dose AL, such interventions alone may not have not been able to address the high burden of malaria morbidity in complex humanitarian emergency settings.

5.1.4.1 Asymptomatic Carriers

This survey was in a period of the year in which malaria transmission is low and it was household based. It involved participants of whom 10% habour malaria parasites in their bodies, who were not actively seeking care (5.3% had no symptoms while the 23.9% had symptoms). This pool constitute a potential reservoir which can contribute to malaria spikes in rainy seasons. Statistical significance may not have been seen, but it has been demonstrated in other studies **(**Khatib, Skarbinski, Njau *et al*, 2012), Moonen, Cohen, Snow *et al*, 2010), that asymptomatic reservoirs and non severe symptomatic individuals with low care utilization rate are silent threats. The studies have suggested programs such as active case finding and home-based initiatives to target such groups.

5.1.4.2 Financial Costs For Managing Uncomplicated Malaria

Tanzania has been the beneficiary of AMFm initiative managed by Global Fund aimed at expanding access to affordable and effective antimalarial drugs (ACTs) by driving down the price of the most effective malaria medicines (McNeil, 2009). In this context, our study, to determine the recurrent financial costs required to manage one case of uncomplicated malaria was based on subsidized AL prices. The direct recurrent financial costs were found to be Tsh 8,217 (3.65 US dollars).

This finding is in agreement with findings elsewhere in Africa (Onujekwe et al, 2013), Alemayehu et al, 2017). For instance in Nigeria, the other beneficiary of AMFm initiative, the recurrent, direct financial costs for managing a case of uncomplicated malaria presenting at the OPD was 3.05 US dollars. Although our approach did not include non medical costs like transport and other indirect costs, the costs for managing malaria cases in the health facility are nonetheless high, given the high transmission particularly in the rain season and increased number of malaria episodes. For the example we found that, a unit increase in the malaria episodes would cause the tota costs of treatment to increase by Tsh 2591.684 (1.15 US dollars) on average even if the medical related costs remain constant. This underscores the need for continued resource mobilization in addition to advocacy for antimalarial subsidies in the comlex humanitarian emergency settings.

5.1.5 From the Secondary Data Analysis

5.1.5.1 Surveillance, epidemic preparedness and reponse

The fourth of the five core components of the national malaria strategic plan 2014-2020 is SME, which is essential for timely malaria epidemic preparedness and effective response (URT, 2017). The SME underscores the necessity for improved quality, completeness, and timeliness of malaria information within the routine health information system and that health system should develop capacity to be able to detect malaria epidemics within one week and respond to the outbreak within two weeks from the time of onset. In our findings the completeness of the malaria data from the host population districts were not optimal, often accompanied with under reporting and with inconsistent patterns particularly before 2013 but has shown improvement in the more recent years.

This may indicate the gains from transformation and inclusion SME as core intervention in the malaria strategic plan and the establishment of a common electronic platform, through the District Health Information System (DHIS) in the recent years (URT, 2017, WHO, 2018). The presence of effective SME with quality, complete and timely information makes it possible for timely detection, preparedness and response to any possible epidemics and avoids erroneous attribution of increasing trends to improvement of detection of cases and reporting.

Rainfall variations: Our findings demonstrate the well known association of malaria transmission with rainfall in that, malaria transmission follows seasonal rainfall. The CCF of malaria morbidity with rainfall shows that rainfall leads malaria morbidity by one month, the result which is biologically plausible as it was also demonstrated in another study (Teklehaimanot et al, 2004). Rainwater provides breeding sites for aquatic development stages of the malaria mosquitoes. When rains vary from maximum, the stagnant pools of water are created which favour development of juvenile stages of the mosquitoes (van der Hoek et al, 1998, Sheeetal et al, 2013). This is consistent with our findings which shows that rainfall variation below the monthly average is correlated with the increase in malaria morbidity.

Temperature variations: Interation between malaria morbidity and temperature is complex as the temperature affect the mosquito development and behavoir as well as the malaria parasite development within the mosquito until it becomes transmissible, the period known as extrinsic incubation period (Lyimo et al, 1992). Not only that also interation differs in different geographical areas characterized by such factors as altitude and whether rural or urban setting (Teklehaimanot et al, 2004). Our results show mean monthly temperatures have not changed in the past 8 years.

However, there have been short term temperature flactuations which appear to coincide with malaria transmisssion peaks. In the year 2015 in July, there was a record low temperatures which were accompanied with malaria outbreak in the refugee camps. It has demonstrated that significant change in climate variability has coincided with increased magnitude in one area and shown lagged correlation in other areas (Guofa et al, 2004). Mordekai et al has pointed out that optimal malaria transmission occurs at temperatures 25 and decreases at temperatures above 28. Shapiro et al has demonstrated that proportion of mosquitoes becoming infectious decreases at temperatures above 27. If we assume other factors to remain constant, temperature variation below mean 29.1 could be accompanied with malaria transmission peaks as it has been demonstrated in our findings. Precise association of temperature variation in our study is limited with unavailability of daily temperature data.

Random and irregular events: The pattern of population size in Nyarugusu camp shows a general increasing linear trend with marked rapid increase observed in April 2015 and January 2017 as a result of conflicts in the neighboring countries. It is interesting to note that, the years 2015 and 2017 had two of the highest recorded malaria morbidity (152, 718 cases in 2015 and 166,389 cases in 2017) accompanied with an outbreak, the July 2015 malaria incidence exceeding the previous 12 months incidence by 70.4%. With CCF showing strong association of malaria morbidity with population size in the CHE settings and the later leading the former by 3 months, population dynamics in the CHEs should be explored further as potential factor to put into consideration when planning for malaria control programs in such settings.

The association is quite complex (Martens and Hall, 2000) and we do not know whether the association is direct or indirect through phenomena such as biological factors, climate, food, overwhelmed health system and economic security. Some studies (Marshall et al, 2009, Solomon et al, 2011) have shown assciation of armed conflicts which result into change in population dyanmics with climatic variations. Others have shown direct association of malaria morbidity with population movements in CHEs (Martens and Hall, 2000, Olivia et al, 2012). Malaria outbreak were reported and documented among the refugee populations in North western Tanzania following the refugee influx from neighboring country in 1997-1998 (Crowe, 1997, URT, 2013). Coincidentally, the years 1997/98 and 2015/16 were reported to have experienced strongest (https://ggweather.com/ enso/oni.htm) global climatic events known as ENSO which have also been associated disease epidemics such as malaria (Grove and Adamson, 2018).

Whatever the case it might be, understanding the influence of and predicting the population dynamics as well as global and local climatic events in the CHEs may be important in planning malaria control programs in such settings (Martens and Hall, 2000). Cross border coordination have been suggested to help control diseases like malaria in two regions or countries with different transmission characteristics but connected with population movements (Olivia et al, 2012). Such coordination can include disease surveillance and communication coordination mechanisms.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the main findings from this study, putting down conclusions from the findings and formulating recommendations for actions, policy review and where necessary suggest for further studies.

Main findings

6.1 Malaria Morbidity

Malaria morbidity in Kigoma region in general and in CHEs in particular in North western Tanzania is on increasing trends despite nationwide strides in recent years towards malaria elimination. The total number of malaria cases reported among the refugee population in Nyarugusu from 2010 to 2017 was 753, with an average of 94,196 cases per year. The average number of malaria illness per person per year is 1.05 and 1.6 from the routine administrative data and sample survey findings respectively.

In the host population districts, the cases reported from Kasulu, Kibondo and Kakonko were 371,486, 459,711 and 214,118 respectively. Malaria is also on increasing trend as the number of cases reported from these districts kept on increasing progressively with time in the recent years probably with improvement in facility utilization, surveillance and reporting. However, the incompleteness of malaria data particularly before 2013 obscures the true picture. There is a seasonal trend with double peaks/spikes between December/January and May/June and low transmission from July to October. The season trends follow the rainfall pattern.

Temperature variations appear to coincide with high malaria transmission. There is non-seasonal irregular fluctuations in malaria morbidity which appear to follow local population size variability in the CHEs and to some extent the global climatological events

6.2 Recurrent Financial For Managing Uncomplicated Malaria Cases

The average direct financial cost required to manage one uncomplicated malaria illness episode is estimated to be 8217.1 Tanzanian shillings (equivalent to 3.65 US dollars). Recurrent financial costs for managing uncomplicated malaria cases are on the increase despite efforts to subsidize the associated malaria treatment commodities. The increasing malaria morbidity is significantly associated with increasing financial costs (p-value <0.005).

6.3 Meteorological Variables

The rainfall pattern shows a fluctuating and general decreasing trend. Seasonal bimodal peaks are observed in January-March and October-December which appear to precede malaria transmission. From time series analysis, rainfall appear to lead the malaria transmission by one month. June to September are relatively dry months. The temperature has remain relatively constant over the period under review, except for short term random variations, there appear to be constant high mean monthly temperatures (29.1^0C) between the years 2013 and 2017. The temperature pattern shows general seasonal pattern in which May-October appear to be relatively hotter than the rest of the other months. The short-term variations appear to coincide the malaria transmission.

6.4 Population Size

Population size in Nyarugusu refugee camp has been relatively stable in the years prior to 2015 influx. However, following the influx of refugees from neighboring country in 2015, there have been general increasing trends with significant spikes in 2015 and 2017 accompanied with epidemics. Population changes have been shown to lead to malaria morbidity spikes. The time series analysis shows a time lag of 3 months.

6.5 Location, Household and Environmental Factors

More than half (57.3%) of the respondents admitted to reside near open water pools during rain seasons. The house/shelterôs neighborhood to open water pools during rain seasons was found to be associated with malaria morbidity. The malaria illness episode in the previous 12 months was experienced by 81.1% who resided in areas prone to seasonal water pools compared to 74.1% who did not reside in or close to such areas. The difference between the two groups was not a mere random variation (unadjusted OR 1.5; 95%CI: 1.03-2.19, p-value 0.036, and adjusted OR 1.55; 95% CI: 1.06-2.27, p-value 0.02). Malaria illness episodes experienced in the previous 12 months appear to vary significantly (p-value 0.02) across the three the camps of Nyarugusu camp (79.4%), Nduta (70.4%) and Mtendeli (79. 6%).

6.6 Program Interventions

We found 93.7% had knowledge of at least two malaria symptoms, 97.8% admitted to seeking care from formal health care facilities in response to malaria symptoms within 24 hours of recognition and 74.9% completed the prescribed AL dose. However the finding of 10% and 5.3% malaria positivity rate among the symptomatic and asymptomatic participants respectively in a household survey (active case finding) in a low transmission season points to a huge work still need to be done.

We found that 74.0% of the respondents got the mosquito nets in the past 12 months and 56.4% slept under mosquito net a night prior to the interview. Close to two thirds of under-fives (60.3%) slept under mosquito nets a night prior to the interview compared to 55% recorded in the 2017 National Malaria Indicator Survey (TMIS 2017). Eighty four percent (84.0%) of participants who did not get mosquito nets during the same period experienced malaria illness episodes compared to 72.7% of the participants who got the mosquito nets (p-value 0.002).

6.7 Conclusions

Malaria morbidity in Kigoma region in general and in CHEs in particular is on increasing trends despite nationwide strides in recent years towards malaria elimination. The populations at risk and those living in CHEs may be in danger of being left behind in malaria elimination efforts. In the host population districts, the number of cases reported kept on increasing progressively with time in the recent years probably with improvement in facility utilization, surveillance and reporting. However, the incompleteness of malaria data particularly before 2013 obscures the true picture based on routine administrative data.

Malaria morbidity show both seasonal trend associated with temperature and rain variations and non-seasonal irregular fluctuations associated with epidemics, local population dynamics and global climatological events. Malaria illness episodes are strongly associated with environmental factors such as household location and neighborhood to areas prone to seasonal water pools.

Recurrent financial costs for managing uncomplicated malaria cases are on the increase despite efforts to subsidize the associated malaria treatment commodities. This increasing financial costs from the supply side is significantly associated with increasing malaria illness episodes. The rainfall pattern shows a fluctuating and general decreasing trend. The observed seasonal trend appear to precede malaria transmission and morbidity by a time lag of one month.

The temperature has remain relatively constant over the period under review, except for short term random variations, which appear to coincide with malaria morbidity The population size in Nyarugusu camp has shown a general increasing trend in the recent years with significant spikes in 2015 and 2017 accompanied with epidemics. Population changes have been shown to lead to malaria morbidity spikes by a time lag of 3 months High rates of knowledge of malaria symptoms, health care seeking, antimalarial treatment adherence and accessibility to malaria mosquito nets do not match with utilization. Malaria parasites were detected in 10% of symptomatic and 5.3% in this household survey in which the respondents were sought for actively.

6.8 Recommendations

From the findings, discussions and the conclusions of this study, we draw recommendations for improving planning and implementation of malaria control interventions in the CHEs and ultimately reducing malaria morbidity in the target populations and contribute to malaria elimination efforts. Our recommendations are grouped into 3 categories namely operational, programming and policy recommendations.

Operational;

1. The government through the RHMT and CHMTs, local and international organizations should enhance efforts to continue and sustain malaria disease surveillance, monitoring and evaluation to improve malaria data completeness and timeliness. This will provide reliable evidence for timely planning, preparedness and response to malaria outbreaks in the CHEs.
2. There should be enhanced community mobilization and sensitization through health education and promotion aimed at behavioral change so as to bridge the gap beween knowledge and accessibility to the interventions and their utilization by the intended populations.

Programming;

3. The government through the NMCP, local and international organizations should explore and discuss ways to initiate, prioritize and optimize high impact interventions. These include increasing access to, and ownership of LLINs, IRS implementation, pre season mass prophylaxis and larval source management to at risk populations in CHEs in Kigoma region.

Policy;

4. As factors associated with malaria morbidity trends are multifaceted, the government, local and international organizations should engage with other sectors such meteorological agencies, environment, water and sanitation,

protection and shelter and use the information generated by these sectors in planning for malaria control interventions in the CHEs

5. With ever increasing financial costs for managing increasing malaria cases and illness episodes, there should be concerted efforts by partners to advocate for more funding and timely resource mobilization especially months prior to high malaria transmission seasons. The populations at risk in the CHEs should get access to subsidized antimalarial prices especially during high transmission seasons.

REFERENCES

Alemayehu, H., Bernt, L., Wakgari, D, Taye, G., Eskindir, L., Bjarne, R. (2017). Economic burden of malaria and predictors of cost variability to rural households in south-central Ethiopia. *PLoS ONE*, 12(10), e0185315.

Alonso, D., Bouma, M. J., Pascual, M (2010). Epidemic malaria and warmer temperatures in recent decades in an east African highland. *Proc Biol Sci.*, 278(1712), 1661ï 1669.

Barnes, K. I., Durrheim, D. N., Little, F., Jackson, A., Mehta, U., Allen, E., Dlamini, S. S., Tsoka, J., Bredenkamp, B., Mthembu, D. J., White, N. J., Sharp, B. L. (2005). Effect of artemether-lumefantrine policy and improved vector control on malaria burden in KwaZulu-Natal, *South Africa. PLoS medicine*, 2(11), e330.

Benno Kreuels, Robin Kobbe, Samuel Adjei, Christina Kreuzberg, Claudia von Reden, Kathrin Bäter, Stefan Klug, Wibke Busch, Ohene Adjei, Jürgen May (2008). Spatial Variation of Malaria Incidence in Young Children from a Geographically Homogeneous Area with High Endemicity, The Journal of Infectious Diseases, 197(1), 85ï 93.

Bousema, T., Drakeley, C,, Gesase, S., Hashim, R., Mosha, F., Otieno, S., Carneiro, I. & Gosling, R. (2010). Identification of Hot Spots of Malaria Transmission for Targeted Malaria Control, *The Journal of Infectious Diseases,* 11, 1764ï 1774.

Caldas, M, Castro, D. & Fishe, M. G. (2012). Is malaria illness among young children a cause or a consequence of low socioeconomic status? Evidence from the United Republic of Tanzania; *Malaria Journal*, 23, 56-68.

Carneiro, I., Roca-Feltrer, A., Griffin, J. T., Smith, L., Tanner, M., Armstrong, J., Greenwood, B., Schellenberg, D. (2010). Age-patterns of malaria vary with severity, transmission intensity and seasonality in sub-Saharan Africa: a systematic review and pooled analysis. PLoS One.

CDC, (2013). Treatment of Malaria, Guidelines for Treatment of Malaria in the United States, USA.

Chaves, L. F., Satake, A., Hashizume, M., Minakawa, N. (2012). Indian Ocean Dipole and rainfall drive a Moran effect in East Africa malaria transmission. *J Infect Dis.,* 205(12), 1885-91.

Connolly, M. A., Gayer, M., Michael, J., Salama, P., Spiegel, P. & Heymann, D. L. (2004). Communicable diseases in complex emergencies: impact and challenges, *Lancet,* 364, 1974ï 8.

Doolan, D. L, Dobano, C, Baird, J. K. (2009). Acquired immunity to malaria., *Clin Microbiol Rev.* 22(1), 13-36.

European Alliance against Malaria, (2007). Malaria and poverty, working for Malaria ï free world.

Gallup, J. L, Sachs, J. D. (2001). The Economic Burden of Malaria. *American Journal* of *Tropical Medicine* and *Hygiene,* 64(2), 85-96.

Gaudart, J., Poudiougou, B., Dicko, A., Ranque, S., Toure, O., Sagara, I., Diallo, M., Diawara, S., Ouattara, A., Diakite, M. & Doumbo, O. K. (2006). Space-time clustering of childhood malaria at the household level: a dynamic cohort in a Mali village. LSHTM Research Online.

Gillioli, G. & Mariani, L. (2010). Sensitivity of Anopheles gambiae population dynamics to meteo-hydrological variability: a mechanistic approach. *Malar*

J*ournal*, 1(9), 328.

Greenwood, B. M. (1989). The microepidemiology of malaria and its importance to malaria control. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 83, 25ï 29.

Grove, R. & Adamson, G. (2018). *El Niño Events and the History of Epidemic Disease Incidence.* In: El Niño in World History. *Palgrave Studies in World Environmental History.* London: Palgrave Macmillan.

Hailay D Teklehaimanot, Marc Lipsitch, Awash Teklehaimanot and Joel Schwartz (2004). Weather-based prediction of Plasmodium falciparum malaria in epidemic-prone regions of Ethiopia. Patterns of lagged weather effects reflect biological mechanisms. *Malaria Journal,* 20043, 41.

Hamid Yimam Hassen, J H Al (2016). The association between chronic undernutrition and malaria among Ethiopian children aged 6 - 59 months: A facility-based case-control study. *South African journal of child health,* 10(1), 63.

Hasyim, H., Nursafingi, A., Haque, U., Montag, D., Groneberg, D. A., Dhimal, M., Kuch, U. & Müller, R. (2018). Spatial modelling of malaria cases associated with environmental factors in South Sumatra, Indonesia; *Malaria Journal,* 17, 87.

Hopkins, J. & IFRC (2008). Public Health guide for emergencies, 3rd Ed., WHO.

IASC, (1994). IASC Consolidated Appeal Process Guidelines, The Inter-Agency Standing Committee (IASC).

IHI, (2014). Malaria status in Tanzania Mainland: An Overview . Retrieved on 20th March, 2019 from; www.ihi.eprints.org.

Inter-agency, (2017). Operational updates on the Burundi refugees situation, ReliefWeb.

Kelly-HopeEmail, L. A., Hemingway, J. & McKenzie, F. E. (2009). Environmental factors associated with the malaria vectors Anopheles gambiae and Anopheles funestus in Kenya. *Malaria Journal,* 8, 26.

Korenromp, E. L., Miller, J., Cibulskis, R. E., Kabir Cham, Alnwick, D. & Dye, C. (2003). Monitoring mosquito net coverage for malaria control in Africa: possession vs. use by children under 5 years; *Tropical Medicine and International Health,* 8(8), 693ï 703.

Kullaya, S. M. (2010). Childhood malaria case management practices using artemether-lumefantrine in settings without microscopy in Kibaha and Kisarawe districts. *Tanzania Journal of Health Research*, 12(4),

Lindblade, K. A., Steinhardt, l., Samuels, A., Kachur, S. P. & Slutsker, L. (2013). The silent threat: asymptomatic parasitemia and malaria transmission, *Expert Review of Anti-infective Therapy,* 11(6), 623-639.

Lunn, J. (2006). The African Great Lakes Region: An End to Conflict? House of Commons.

Lyimo, E. O., Takken, W. J. & Koella, C. (1992). Effect of rearing temperature and larval density on larval survival, age at pupation and adult size of Anopheles gambiae. *Entomol. exp. appl.,* 63, 265-271.

Marshall B. Burke, Edward Miguel, Shanker Satyanath, John A. Dykema, David B. Lobell (2009). Warming increases the risk of civil war in Africa. *Proceedings of the National Academy of Sciences,* 106(49), 20670-20674.

Martens, P., & Hall, L. (2000). Malaria on the Move: Human Population Movement and Malaria Transmission. *Emerging Infectious Diseases,* 6(2), 103-109.

Matthew, E., Coldiron, E., Lasry, M., Bouhenia, D., Das, P., Okui, D., Mwanga, J., Langendorf, S., Elder, G. Salumu, L. & Grais, R. F. (2017). Intermittent preventive treatment for malaria among children in a refugee camp in Northern Uganda: lessons learned; *Malaria Journal*, 16(1), 218.

McNeil, D. G. (2009). *Plan Tries to Lower Malaria Drug Cost*. New York: McNeill.

Meek, S., Rowland, M. & Connolly, M. (2000). Outline Strategy for Malaria Control in Complex Emergencies: Roll Back Malaria Complex Emergencies Network, WHO.

MJAM Oesterholt, JT Bousema, OK Mwerinde, C Harris1, P Lushino, a Masokoto, H Mwerinde, FW Mosha and CJ Drakeley (2006). Spatial and temporal variation in malaria transmission in a low endemicity area in northern Tanzania.

Mordecai, E. A, Paaijmans, K. P., Johnson, L. R, Balzer, C., Ben-Horin, T., de Moor, E,, McNally, A., Pawar, S, Ryan, S. J., Smith, T. C., Lafferty, K. D. (2012). Optimal temperature for malaria transmission is dramatically lower than previously predicted. *Ecol Lett*, 16(1), 22-30.

Mustafa, H. S., Malik, E. M., Tuok, H. T., Mohamed, A. A., Julla, A. I. & Bassili, A. (2009). Malaria preventive measures, health care seeking behaviour and malaria burden in different epidemiological settings in Sudan, *Tropical Medicine and International Health,* 14((12), 1488ï 1 495.

Mwandagalirwa, M. K., Levitz, L., Kyaw, L., Thwai, J., & Carrel, M. (2017). Individual and household characteristics of persons with Plasmodium falciparum malaria in sites with varying endemicities in Kinshasa Province, Democratic Republic of the Congo; Malaria Journal, 16(1), 456.

Mwangwa, K., Bigira, F., Kapisi, V., Clark, J., Osterbauer, T., Greenhouse, B., Sturrock, B., Gosling, H., Liu, R. & Grant, J. D. (2015). Poor housing construction associated with increased malaria incidence in a cohort of young Ugandan children. *The American journal of tropical medicine and hygiene,* 92(6), 1-10.

NeillEmail, O., Charlotte, G., Dierickx, S., Mwesigwa, J., Okebe, J. & Peeters, K. (2015). Foul wind, spirits and witchcraft: illness conceptions and health-seeking behaviour for malaria in the Gambia; *Malaria Journal*, 1, 14, 167.

Njama, D., Dorsey, G., Guwatudde, D., Kigonya, K., Greenhouse, B., Musisi, M., & Kamya, M. R. (2003). Urban malaria: primary caregiversô knowledge, attitudes, practices and predictors of malaria incidence in a cohort of Ugandan children. *European Journal of Tropical Medicine and Internationl Health,* 8(8), 685-692.

Nyakeriga, A. M., Troye-Blomberg, M., Chemtai, A. K., Marsh, M. & Williams, T. N. (2004). Malaria and nutritional status in children living on the coast of Kenya, *The American Journal of Clinical Nutrition,* 80(6), 604ï 1610.

Okech, B., M., Kamau, A., Muiruri, S., Mutiso, N., Nyambura, J., Mwatele, C., Amano, T., Mwandawiro, C. S. (2008). Use of integrated malaria management reduces malaria in Kenya; PLoS One.

O'Meara, W. P., Noor, A., Gatakaa, H., Tsofa, B., McKenzie, F. E., & Marsh, K. (2008). The impact of primary health care on malaria morbidity--defining access by disease burden. *Tropical medicine & international health: TM & IH, 14*(1), 29-35.

Onwujekwe, O., Chima, R., Okonkwo, P. (2000). Economic burden of malaria illness on households versus that of all other illness episodes: A study in five malaria holo-endemic Nigerian communities; 54; December 2000

Prothero, R. M. (1977). Disease and mobility: a neglected factor in epidemiology. *Int J Epidemiol.* 6(3), 259-67.

Reyburn, H., Mbakilwa, H., Mwangi, R., Mwerinde, O., Olomi, R., Drakeley, C., & Whitty, C. J. (2007). Rapid diagnostic tests compared with malaria microscopy for guiding outpatient treatment of febrile illness in Tanzania: randomised trial. *BMJ (Clinical research ed.),* 334(7590), 403.

Richard, E., Cibulskis, 1., Maru, A., Ryan, W., Mac, O. & Dye, C. (2009). Worldwide Incidence of Malaria in 2009: Estimates, Time Trends, and a Critique of Methods; PLoS Med. 2011.

Shapiro, L. L M., Whitehead, S. A., Thomas, M. B. (2017). Quantifying the effects of temperature on mosquito and parasite traits that determine the transmission potential of human malaria. *PLoS Biol.* 2017; 15(10):e2003489.

Sheetal, P., Silal, K. I., Barnes, G., Kok, A., Mabuza, F. (2013). Exploring the Seasonality of Reported Treated Malaria Cases in Mpumalanga, South Africa. PLOS.

Sheriff, T., Sonko, M. J., James. J., & Lamin, B. S., Jarju, U., Musu, K. & Alieu, S. (2014). Does socio-economic status explain the differentials in malaria parasite prevalence? Evidence from The Gambia; *Malaria Journal,* 13: 449

Solomon, M., Hsiang, K. C. & Mark, A. C. (2011). Civil conflicts are associated with the global climate; *Nature*, 476, 438-441

Sylvie, M., Foumane, V., Besnard, P., Fortes, F. & Carnevale, P. (2017). Malaria overdiagnosis and subsequent overconsumption of antimalarial drugs in Angola: Consequences and effects on human health; *Acta Tropica,* 1, 58-63

Tamara, C., Bryan, G., Denise, N., Maiteki-Sebuguzi, C., Edmund, S. S., Seto, M., Kamya, Rosenthal, P., Grant, D. (2008). Factors Determining the Heterogeneity of Malaria Incidence in Children in Kampala, Uganda; *The Journal of Infectious Diseases,* intervation stage review.

UNHCR, (2017). Inter-agency operational update on the Burundi refugee situation, November 2017.

UNHCR, (2017). Tanzania refugee situation statistical report, November 2017.

UNIDSR, (2004). Living with a risk. A global review of disaster reduction initiatives.

UNM (2017). United Nations Joint programme for Kigoma, 2017-2021. Tanzania.

URT, (2005). National Guidelines for Diagnosis and Treatment of Malaria.

URT, (2008). Tanzania HIV and malaria Indicator Survey.

URT, (2011). The National Integrated Disease Surveillance and Response (IDSR) Guidelines 2nd edition.

URT, (2012). Tanzania HIV and malaria Indicator Survey.

URT, (2013), National Malaria Strategic Plan 2014ï 2020.

URT, (2014). National Malaria Strategic Plan 2013-2020.

URT, (2017). Health Data Collaborative (THDC) Launch Meeting: Update of M&E Strengthening Initiatives (M&E SI) A Tanzanian Platform for Health Information and Accountability, Dar es Salaam, Tanzania.

URT, (2017). Kigoma Regional Health Management Information System Updates Unpublished. Kigoma, Tanzania.

van der Hoek, W. & Konradsen, F. & Perera, D. & Amerasinghe, H. & Amerasinghe, F. (1998). Correlation between rainfall and malaria in the dry zone of Sri Lanka. *Annals of tropical medicine and parasitology.* 91, 945-9.

Watsierah, C. Onyango, R., Ombaka, J., Abongôo, B. & Ouma, C. (2012). Provider knowledge of treatment policy and dosing regimen with artemether-lumefantrine and quinine in malaria-endemic areas of western Kenya; *Malaria Journal*, 11(1), 436.

WHO, (1998), WHO Malaria in the United Republic of Tanzania.

WHO, (2003). Africa malaria report.

WHO, (2012). World Malaria Report 2012. Geneva: World Health Organization

WHO, (2014). World malaria report 2014.

WHO, (2015). Global Technical Strategy for Malaria 2016ï 2030.

WHO, (2015). *Guidelines for treatment of malaria*, third edition, WHO.

WHO, (2016). Malaria fact sheet.

WHO, (2017). Malaria fact sheet 2017.

WHO, (2017). World malaria report 2017.

WHO, (2018). Malaria surveillance, monitoring and evaluation: a reference manual.

Worrall, E., Basu, S., Hanson, K. (2005). Is malaria a disease of poverty? A review of the literature. Trop Med Int Health. 2005.

Yazoumé. Y., Moshe. H., Valérie, L, Simboro, S., Issouf Traoré and Rainer Sauerborn (2006). Housing conditions and Plasmodium falciparum infection: protective effect of iron-sheet roofed houses, *Malar J.* 2006; 5: 8.

Zawadi, M., Hans, O., Moore, S., Bradley, J. Jason, M., & Lorenz, L. (2014). Mosquito net coverage in years between mass distributions: a case study of

Tanzania; *Malaria Journal*, 2018

Zhou, G., Minakawa, N., Githeko, K. A. & Yan, G. (2004). Association between climate variability and malaria epidemics in the East African highlands. *Proceedings of the National Academy of Sciences*, 101(8) 2375-2380.

APPENDICES

3.14. English version of the questionnaire

Topic: Evaluation of malaria morbidity trends in the complex humanitarian emergencies settings in northwestern Tanzania

Identification

District………………………………………

Setting (camp/host residence)……………….

Geographical positioning……………………..

Interviewee's number…………………………….

Interviewer's number……………………………

Date of interview…………………………….

Starting time ………………………………..

Finishing time…………………………………

3.15. English version of the questionnaire

The questionnaire for evaluation of malaria morbidity trends in the complex humanitarian emergency settings in north western Tanzania.

Interviwer's number | | | Interviwee's number: | | |

District………………………………………………

Name of the camp…………………………………...

Date of interview………………………………………

Interview start time: ………………………………...

Interview end time:……………………………….

A. Introduction :

My name is .... According to the 2018 Ministry of Health report, Kigoma region ranks number in malaria transmission and morbidity in Tanzania Mainland. The objectives of this interview is get information on the situation in your area and identify factors responsible for the high malaria transmission. The evidence will help us design and plan appropriate interventions to control malaria in this area. The responses to this interview will be strictly kept confidential as you have seen that no name of any person or institution written in this paper. Thank you for your time and cooperation.

A. Demographic and health information of the participant

1. Year of birthé é é é é é é é

1. ☐

2. Sex of the participant

2.☐

a. Male

b. Female

3. Education level

3. ☐

a. Informal

b. Primary

c. Secondary/vocational training

d. Post-secondary

4. Ability to write and read

   4. ☐

   a. Yes
   b. No
   c. Not sure

5. What are the symptoms of the malaria disease on the study participant? (check list) 5. ☐

   a. Symptomatic
   b. Asymptomatic
   c. Undetermined

6. RDT done and the result

   6. ☐

   a. Reactive
   b. Non-reactive
   c. Normal

7. Knowledge of malaria symptoms in the study participant (check list attached)

   7. ☐.

   a. More than 2
   b. 1 to 2 symptoms
   c. None

8. What do they do in the first 24 hours of symptoms recognition

   8. ☐

a. Buy pain/fever relieving from a shop
b. Seek care in the modern health facility
c. Consult traditional healer
d. Any other (specify)

9. How many doses of AL do they consume after being prescribed by the clinician

9. ☐

a. 6 doses
b. Less than 6 doses
c. I am not sure

10. Episodes of malaria illness in the past 12 months which necessitated administration of antimalarial drugs (observe for any evidence e.g. clinic card)

10. ☐

a. Zero
b. One
c. Two
d. Three
e. Any other

11. If you experienced one or more episodes, mention the months they happened to you. é

Participant's household characteristics

12. House roofing material

12. ☐

a. Iron sheeting

b. Plastic sheeting

c. Grass

d. Any other (specify)

13. Type of wall material for the house

13. ☐

a. Iron sheeting

b. Plastic sheeting

c. Mud

d. Grass

e. Any other (specify)

14. Household is located near to areas prone to open water pools during rainy season. 14. ☐

a. Yes

b. No

15. Household is located near to the nearby forested/grassy area

15. ☐

a. Yes

b. No

16. Mosquito nets received in the past one year

16. ☐

a. Yes

b. No

c. Not sure

17. Mosquito nets used last night (observe where possible)

17. ☐

a. Yes

b. No

c. Not sure

18. If the above answer is No, what are the reasons for not using the mosquito nets

é é

é é

c. **Health facility information**

19. What is the level of the facility?

19. ☐

a. Hospital

b. Health centre

c. Dispensary

d. Any other (specify)

20. Review of confirmed malaria cases from 2010 to 2017é é é é é é é é é é ..

21. Review of population size updates from 2010 to 2017é é é é é é é é é é é

22. What is the average number of malaria consultations you normally make per day?

é é

23. Amount of time in minutes per person with suspected malaria spent by health care provider.

a. Clinical consultationé é é .

b. Laboratoryé é é é é é é

c. Pharmacyé é é é é é é .

24. Review of salary scale

a. Clinician

b. Laboratory

c. Dispensing officer

25. Market price in average of patient-health care worker contact é é é é é 25. ☐

26. What is the market price of RDT test?

é é é é é é é é é é é é é é é é é é ... 26. ☐

27. Market price of AL

tableté 27. ☐

28. Market price for supportive medications

é é é é é é é é é é é é é é é é é .. 28. ☐

d. **<u>Meteorological information</u>**

29. Monthly temperature records for the years between 2010 and

2017é é é .é é é é .. 29. ☐

30. Monthly rainfall for the years between 2010 and

2017é é ..é é é é é é é é é é .. 30. ☐

Check list: Knowledge of the symptoms of uncomplicated malaria in children

Participants were asked how they recognize uncomplicated malaria in a person having malaria illness episode. They were allowed to give spontaneous responses which were recorded. The symptoms numbered 1-5 are commonest in under-fives and the symptoms numbered are more common in persons aged more than 5 years (URT 2005).

1. Fever
2. Body weakness
3. Vomiting and diarrhea
4. Poor appetite
5. Pallor
6. Headache
7. Joint pains
8. Body ache
9. Cough