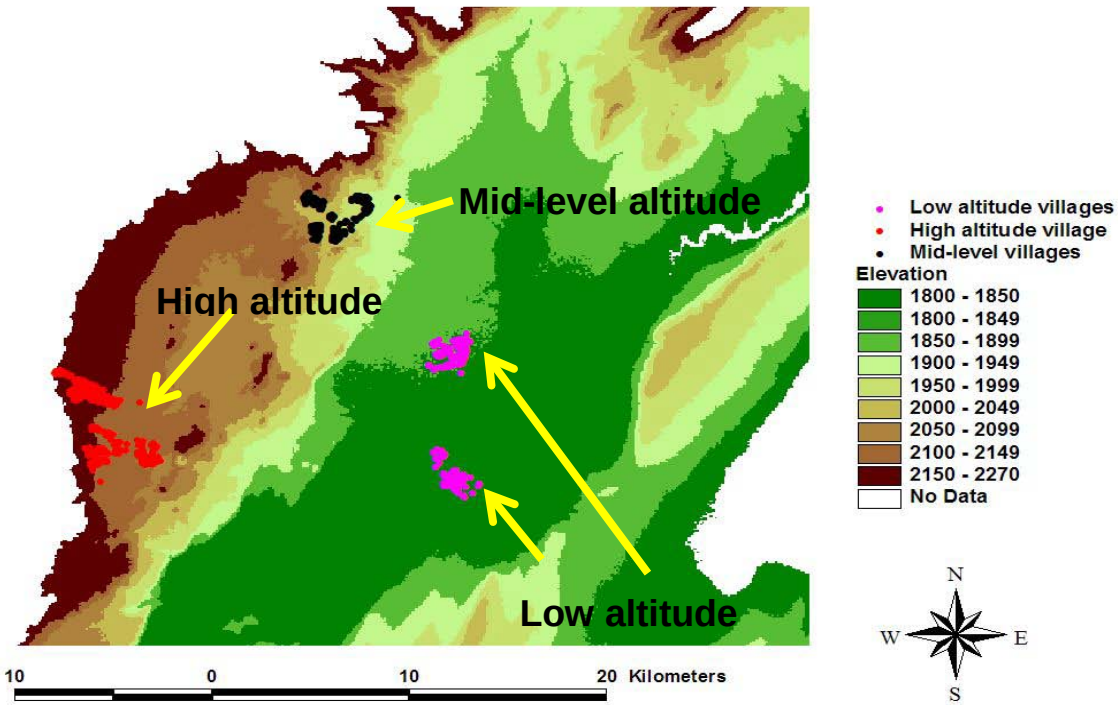
THE EPIDEMIOLOGY OF HIGHLAND MALARIA IN ETHIOPIA: A STUDY FROM BUTAJIRA AREA

ADUGNA WOYESSA GEMEDA



DISSERTATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D.) IN PUBLIC HEALTH ADDIS ABABA, ETHIOPIA

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THE EPIDEMIOLOGICAL ASPECTS OF HIGHLAND MALARIA IN ETHIOPIA: A STUDY FROM BUTAJIRA AREA

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Dedication

This work is dedicated to my wife, Chaltu and children, Robe and Abbo.

LIST OF ORIGINAL PAPERS

This thesis is based on the following papers which will be referred to in the text by their Roman numbers (I-IV).

I. Prevalence of malaria infection in Butajira area, south-central Ethiopia. Malar J. 2012, 11: 84.

II. Malaria risk factors in Butajira area, south-central Ethiopia: a multilevel analysis. Malar J. l2013,**12**:273.

III. Ownership and use of long-lasting insecticidal nets for malaria prevention in Butajira area, south-central Ethiopia: complex samples data analysis. BMC Public Health; 2014,14:99.

IV. Evaluation of CareStart™ malaria Pf/Pv combo test for *Plasmodium falciparum* and *Plasmodium vivax* malaria diagnosis in Butajira area, south-central Ethiopia. (Malar J. 2013; 12: 218).

ACRONYMS

AAU	Addis Ababa University
ACT	Artemesinin-based Combination Therapy
AIDS	Acquired Immuno-Deficiency Syndrome
BRHP	Butajira Rural Health Program
CDC	Communicable Disease Control
CI	Confidence Interval
CIH	Centre for International Health
DDT	Dichloro-diphenyl-trichloroethane
DSS	Demographic Surveillance Site
EDHS	Ethiopia Demographic and Health Survey
EHNRI	Ethiopian Health and Nutrition Research Institute
EMaPS	Ethiopian Malaria Prediction System
ENSO	El Nino-Southern Oscillation
GDP	Gross Domestic Product
GFTM	Global Fund to Fight AIDS, Tuberculosis and Malaria
GMAP	Global Malaria Action Plan
GPS	Global Positioning System
GTP	Growth and Transformation Plan
HEP	Health Extension Program
HEW	Health Extension Worker
HIV	Human Immuno-Deficiency Virus
HMIS	Health Management Information System

HSDP	Health Sector Development Program
ICC	Intra-Class Correlation
IRS	Indoor Residual Spraying
ITNs	Insecticide-Treated Nests
KMO	Kaiser-Meyer-Olkin
LLINs	Long-Lasting Insecticidal Nets
Masl	meters above sea level
MCP	Malaria Control Program
MDGs	Millennium Development Goals
MIM	Multilateral Initiatives on Malaria
MIS	Malaria Indicator Survey
MOFED	Ministry of Finance and Economic Development
MOH	Ministry of Health
MOI	Ministry of Information
MOR	Median Odds Ratio
NOCMOVBD	National Organization for the Control of Malaria and Other Vector-Borne Diseases
NPV	Negative Predictive Value
OR	Odds Ratio
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PCA	Principal Component Analysis
PCR	Polymerase Chain Reaction

PHCU	Primary Health Care Unit
PPS	Probability Proportional to Size Sampling
PPV	Positive Predictive Value
RBM	Roll Back Malaria
RDT	Rapid Diagnostic Test
SE	Standard Error
SNNP	South Nations Nationalities People
SP	Sulphadoxine-Pyrimethamine
SPH	School of Public Health
SPSS	Statistical Package for Social Science
SUFI	Scaling Up For Impact
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
USA	United States of America
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization

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SUMMARY

BACKGROUND

In Ethiopia, malaria is a major public health problem with seasonal and unstable distribution. Because of the country's diverse topography and climate, transmission of malaria varies with space and time; while the variability is more pronounced in highlands with low transmission. This calls for better understanding of malaria epidemiology to improve the control programmes in which measurement of magnitude is vital in malariology. However, there is paucity of information on magnitude of malaria, risk factors, effective use of vector control measures such as insecticide-treated nets in relationship with malaria infection and performance of multi-species detecting malaria rapid diagnostic tests (RDTs) where *Plasmodium falciparum* and *Plasmodium vivax* co-exist at highlands of low-endemicity.

OBJECTIVES

This thesis presents the findings of a research with the aim of assessing and understanding the epidemiology of highland malaria with specific aims of: (1) determining prevalence of malaria, (2) identifying malaria risk factors, (3) determining factors affecting household insecticide-treated nest (ITNs) ownership and utilization in relation to malaria infection, and (4) evaluating performance of malaria RDTs to detect *Plasmodium falciparum* and *Plasmodium vivax*.

METHODS

Community-based repeated cross-sectional studies were conducted in six rural *kebeles* of Meskan and Mareko Districts in Butajira area of Ethiopia between October 2008 and June 2010. The *kebeles* (Hobe, Bati Lejano, Dirama, Shershera Bido, Yeteker and Wurib) were selected in such a way that two were from one altitudinal stratum thus making a total of three strata: low (1,800-1,899 meters above sea level), mid-level (1,900-1,999 meters above sea level), and high (2,000-2,300 meters above sea level) altitudes. These *kebeles* are part of Demographic Surveillance System Site of the Butajira Rural Health Program (BRHP). A multi-stage sampling method was used to recruit study participants. The various stages were *kebeles* as first-stage, villages as second-stage, and households as third-stage units. A total of 3,393 individuals were recruited from randomly sampled 750 households in 16 villages. Probability proportion to size sampling method was applied to allocate the number of households to be sampled from each *kebele* and village. The study obtained data from

household interview, survey and recruiting all self-reported febrile cases. Household interview was undertaken by trained data collectors using pre-tested structured questionnaire. Household altitude reading and geo-reference was recorded from geographical positioning system location. Seasonal blood surveys were made on quarterly basis between October 2008 and June 2010. From the sampled households, all family members who consented to participate were requested for blood films. Besides, self-reported febrile cases were simultaneously checked for malaria infection using RDTs. Blood films were prepared and slides, processed, read, and cross checked using standard procedures. Parasite count was done but not used in the present studies. CareStart^{TM} Malaria *Plasmodium falciparum*/ *Plasmodium vivax* combo test result was compared with microscopy. Analytical tools including descriptive statistics, multilevel analysis, principal component analysis, and complex sample analysis were employed.

MAIN FINDINGS

The unadjusted prevalence of malaria was found to be 0.93 % [95% CI 0.79-1.07]; of 19, 207 people, 178 were positive; adjusted prevalence of malaria was estimated at 0.78 (95% CI: 0.48-1.29); of 19, 199 people, 178 were positive. *Plasmodium vivax* was dominant (86.5%, n=154) and the rest of the cases were due to *Plasmodium falciparum* (12.4%, n=22, seven with gametocyte) and mixed infections (1.1%, n=2).The prevalence varied among villages with the highest prevalence of 2.8% in Dadesso and Horosso villages (both <1,850 masl), and the lowest prevalence of 0.0% in Sunke Wenz and Akababi village (2,100-2,180 masl). Malaria prevalence decreased with altitude: 1.91% [95% CI (1.55-2.27)] in low, 1.37% [95% CI (0.87-1.87)] in mid-level and 0.36% [95% CI (0.25-0.47)] in high altitude zones; the highest prevalence was found at low altitude between October and November 2009. Moreover, malaria varied among age groups and the variation was different at different at altitudes. It reached its peak in children aged one to four years at mid-level and one to nine years at low altitudes. However, its prevalence at higher altitude was low and was similar across all age groups. *Plasmodium falciparum* malaria occurred rarely throughout the survey periods, with relatively more cases in October-November 2009 in the low altitude zone. *Plasmodium vivax* was found in all survey periods. However, its prevalence differed with respect to survey period and altitude. Variables like age (children aged below five and 5-9 years), altitude (low and mid-level altitude), and in houses with holes as individual-level factors; and village-level variables explained most of the variation (ICC= 94%) in individual

malaria infection. The estimates of village-level variances showed well marked differences in malaria infection.

Only 28.5% [95%CI 25.8-31.4] of the 739 households surveyed owned at least an ITN. Household ITN ownership was associated with household heads with no formal education, male-headed households, more beds in the house, absence of mosquito source reduction, and nonexistence of main water body. Male-headed households were also more associated with increased ITN ownership than female-headed ones. Households with ITN observed hanging, two and more number of ITN owned, not doing source reduction and less than a kilometer distance from main water body showed high association with use of ITN while the presence of more ITN observed hanging was a good predictor. Higher prevalence was found among people surveyed from ITN-owning than non-ITN-owning households (2.1% versus 0.5%). Malaria infection was more often observed in households owning at least an ITN than in their counterparts (unadjusted OR 4.1 [95% C.I. 2.2-7.6]).

Overall, 2,394 participants were enrolled in both survey settings. Overall, *Plasmodium* positivity was 10.9% (n=87) in household survey and 24.5% (n=392) from health centre visitors. Among 87 positives, 83.9% (n=73) were caused by *P. vivax*, 15.0% (n=13) were due to *P. falciparum*, and the rest 1.1% (n=1) were mixed infections of both species. Similarly, 78.6% (n=308) were *P. vivax*, 20.4% (n=80) were *P. falciparum*, and the rest 1.0% (n=4) were vivax and falciparum mixed infections. RDT missed 9.1% (n=8) in household and 4.3% (n=17) in health centre surveys among *Plasmodium* positive confirmed by microscopy. Similarly, 3.3% (n=24) in household and 17.2% (n=208) in health facility-based surveys were detected false positive. Microscopy and RDT showed agreement for 79 positives in household and 375 positives in health centre survey results. RDT performance varied in detecting *Plasmodium, P. falciparum* and *P. vivax* in both survey settings. Lowest PPV (64.3%) for *Plasmodium* and *P. falciparum* (77.2%) in health centres; and *Plasmodium* (76.7%) and *P. falciparum* (87.5%) in household surveys was determined. Lowest NPV was found in *P. vivax* in both health facility (77.2%) and household (87.5%) surveys. Precision of RDT showed seasonal variation that showed as low as 14.3% PPV (Dec. 2009), and 38.5% NPV (Nov. 2008) in health centre survey. Lowest PPV (40-63.6%) was observed in household surveys.

CONCLUSIONS AND RECOMMENDATIONS

The thesis demonstrated that highland fringe areas like Butajira are characterized by low prevalence of malaria dominated by *Plasmodium vivax*. Age, slight variation in altitude and

other household and village risk factors are associated with malaria incidence in the present study. Antimalarial interventions that take age, altitude and household risk factors into consideration are expected to have greater impact in reducing the incidence of malaria in such settings. Performance of malaria RDT detecting *P. falciparum* and *P. vivax* varied between health facility and household survey for both species. Age less than nine years, altitude and poor housing conditions were positively associated with higher prevalence of malaria. A further study on vivax epidemiology, ITN use and other vector control or malaria prevention options is recommended.

1. INTRODUCTION

1.1. Background of the study

Malaria is one of the major causes of illness and death worldwide. Of the seven billion total world population about 2.4 billion people (41% of the total population) are at risk of contracting the disease in 2007 (1). Globally, almost one billion people live under unstable or extremely low malaria risk situations. Although the disease is highly preventable and treatable, the recent World Health Organization (WHO) report showed that it caused approximately 655,000 deaths in 2010. Nine out of ten of those deaths were contributed from the African Region (2). Thus, malaria is globally considered as a priority diseases that caught attentions of various partners. Countries with high endemic malaria have targeted to reduce malaria morbidity and mortality by 75 percent by 2015 from the 2005 baseline level through application of an integrated package of preventive and treatment methods to achieve UN MDG (3). With the strong Roll Back Malaria Partnership, significant reduction of malaria burden was documented globally including in the African Region in the last decade (4), through large-scale application of key malaria preventive and treatment measures that used a new approach known as Scale-Up For Impact (SUFI) (5).

Malaria is endemic in 106 countries situated in the tropical and subtropical areas. The distribution of the disease varies with space and time. Generally, as the transmission season gets shorter, the risk of epidemics increases. In Africa, the areas with a short duration of malaria transmission tend to be located across the Sahelean belt, down through the Horn of Africa in the east Africa and throughout southern Africa. Thus, 26 African countries in this zone were at epidemic risk with varying proportion. Among the total 432.7 million people in 26 African countries, 124.7 million of the people were estimated to be at risk of climate dependent malaria epidemics (6).

Epidemic malaria comprises an equivalent of 12-25% of the annual worldwide malaria deaths. Eight of the 26 African countries including Ethiopia had 50% of their population at epidemic risk. Thus, 32.2 million people of the total 64.4 million people were at risk of epidemic in Ethiopia (6). The Ethiopian highlands situated between ≥1500 meters above sea level (masl) and 2500 masl are at high epidemic risk. They experienced repeated malaria epidemics in various

magnitudes including the recent one in 2003 (7-9). Since the population in these areas has a little or no protective immunity, previous epidemics caused higher cases of fatality. Abnormal weather conditions, population movement and resettlement and failure of antimalarial drugs were suggested as causes of the previous epidemics. Overall, there is scarce information on epidemiology of malaria in the highlands. A few previous epidemiological studies available were confined to endemic areas (<2000 masl) and in highland zones of intense transmission (10, 11). Thus, epidemiological assessment related to estimation of malaria prevalence, risk factors, effective use of preventive measures and quality of malaria rapid diagnostic tests are required at highlands with low endemicity and adjacent areas in Ethiopia.

1.2 Statement of the problem

Malaria is a major cause of illness and death that remains a major public health concern. Although a remarkable decline of the disease has been observed globally since the mid-2000s including in many African countries (4), there is a possibility of malaria resurgence unless the present interventions are sustained. Effective use of available interventions, uninterrupted supply of intervention commodities and strong surveillance system is imperative to sustain the current gains in reducing malaria burden. More research is needed to inform the decisions in this regard.

Most of the population of Ethiopian population inhabits the highland areas. Thus, half of the total population living between altitudes of 1,500 and 2,500 masl (masl) is at risk of malaria and the areas experience epidemics (9, 12). Several factors are responsible for malaria transmission in the highlands. Environmental factors such as temperature, rainfall and humidity are vital in maintaining local malaria transmission. Ecological changes are also important in creating favourable conditions in highland areas with cool temperature limiting transmission. In the East African highlands including Ethiopia, the environmental changes such as deforestation have been ascribed to increased trend of malaria transmission and several epidemics in late 1980s and early 2000s (13). Malaria transmission is remarkably influenced by environmental factors. Since the mid-2000s, malaria incidence declined (14-16). This was attributed to large-scale implementation of key malaria interventions since 2005 (17, 18).

The national malaria control program improved the interventions that included case management using artemisinin-combination therapies (ACT) (artemether-lumefantrine: AL) and, malaria rapid diagnostic tests (RDTs), indoor residual spraying (IRS), and long-lasting insecticidal nets (LLINs). In the following years, remarkable reduction of malaria burden was documented. In Ethiopia, a reduction of 73% in in-patient malaria cases and 62% deaths in children aged <5 years reduction were documented (16). In addition, a community-based deployment of AL demonstrated reduction of the risk of malaria-specific mortality by 37% in North Ethiopia (14). Despite the profound impact of interventions, malaria still remains the major cause of illness and death in the country. Under poor surveillance and lack of strong early warning system, there is a possibility of local malaria resurgence under abnormal weather conditions.

In addition, a recent national malaria guideline recommended that the presence of strong surveillance, monitoring and forecasting system to deploy vector control such as IRS above 2,000 masl (19). However, in health facilities with poor surveillance system and limited malaria early warning capacity and subsequent lack of preparedness plan the effect of epidemic might be severe. Repeated epidemics of different magnitude affected these areas. Previous epidemiological studies in the highlands of Ethiopia focused on areas with intense transmission (10, 11, 20).

More interestingly, *Plasmodium falciparum* and *Plasmodium vivax* co-exist with almost competing figures in Ethiopia. Thus, challenging the control efforts and might also be the future elimination prospects. However, information is patchy on magnitude of malaria and associated factors, and use of preventive measures in highland and highland-fringe. Thus, generating accurate information is necessary to strengthen malaria interventions already underway.

So far no study that collected longitudinal data on malaria with emphasis on altitudinal variation was conducted in Ethiopia. The present study acknowledged the seasonal malaria difference and designed to measure malaria in three different seasons of the year for two consecutive years. Malaria risk factors that could guide the targeted interventions were also assessed at different levels that could guide the targeted interventions. In addition, the effective utilization of all household members and related malaria infection was assessed. Finally, this study evaluated the

performance of malaria rapid diagnostic test that detects both falciparum and vivax malaria. Self-reported febrile cases at survey and health facility level were considered for this study.

1.3. Rationale and significance of the study

Malaria is one of the leading causes of illness and death globally. Most of the malaria burden is contributed by the sub-Saharan African countries. The relationship between global warming and malaria in the highlands has been an important concern in the areas. It was suggested that this expansion is more pronounced at the borders of malaria endemic areas and at higher altitudes within malarial areas (21). A study showed large potential increases of malaria transmission at highlands close to the climatic thresholds in Ethiopia (22). Malaria is a disease affected by a range of factors in addition to climate. However, climate provides the framework within which transmission is possible and other factors can affect malaria transmission only in spatio-temporal zones that are climatically suitable.

Understanding local malaria epidemiology at highlands under declining trends of malaria situation looks important. Therefore, population-based malaria prevalence estimate at varying altitude and season, identifying malaria risk factors at individual- and village-levels, and assessing the coverage and use of ITNs, and quality of the diagnostic tests can address the knowledge gap on malaria epidemiology in the highlands. This longitudinal data generated might be helpful in developing malaria prediction model in light of improving malaria early warning system in the country. This study also updates the importance of malaria infection in highland-fringe areas above 2000 masl and associated use of preventive tools.

There are some important aspects of this study. The first is the methodological approach applied to detect the low prevalence of malaria in all seasons and inter-annual difference. So far, no such information has been communicated. Moreover, besides the information generated, both methodological approaches and analytical tools applied to measure malaria in low endemicity is believed to be helpful for improving malaria control efforts underway and future research endeavour. The second is that this study identified high variability of performance of malaria RDT at highlands. This is practically important as it calls for establishing quality control system and linking health posts with the nearest health center.

1.4. Conceptual framework for epidemiology of highland malaria

Unlike areas of intense transmission with persistently high prevalence of infection, areas of low to moderate transmission with the prevalence of infection vary widely and are even sensitive to even relatively small natural or man-made changes in the factors of transmission (23). In relation to the aim of the study the following conceptual framework illustrating the transmission of malaria in the highland areas is suggested (Figure 1). Six broad categories of factors affecting the distribution of human malaria infection in space and time and resulting in morbidity and mortality were identified (23). These factors include: (1) the natural environment and its impact on vector populations; (2) factors affecting transmission by the adult vector, including interaction between vector and parasites; (3) the parasite and some of its genetically controlled characteristics; (4) man the biological factors, including interaction between parasite and man; (5) man the behavioural, social and economic factors; and (6) specific malaria control measures. Thus, this study via its stipulated specific objectives made attempts to address the relationship of these factors in malaria infection. Overall, the present study determined prevalence of malaria (Paper-I), identified responsible factors for malaria (Paper-II), determined the effective use of preventive ITN in relation to malaria infection (Paper-III), and evaluated quality of diagnostic tool (Paper-IV). The figure below presents the relationship between factors affecting the malaria processes at the bottom and top of (or natural history of malaria). For instance, the vector control is likely to affect morbidity and mortality while its entomological impact is likely to be affected by the initial entomological situation, changes in the environment, the quality of operations and social and economic factors.

The suggested conceptual framework is a simplified one that lacks details of each component. For example, the study focusing on performance of malaria RDT in detecting *Plasmodium falciparum* and *Plasmodium vivax* compared to light microscopy is not clearly shown. In general, malaria RDTs are immunochromatographic methods designed to pick malaria parasite antigens in lysed blood to antibodies fixed to a strip of filter paper in a plastic cassette, card or dipstick format. Thus, the diagnostic results of RDTs are determined by parasitological status of an individual. An individual parasitological status is in turn depends on the entomological inoculation rate, acquired immune status of the population, genetic factors and drugs.

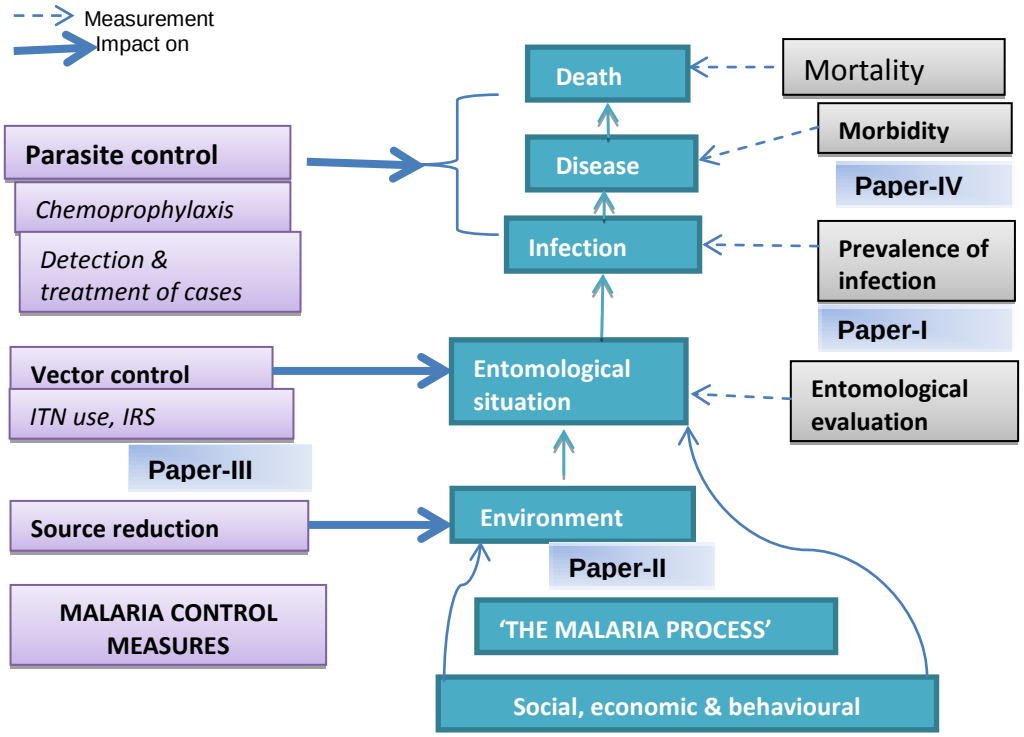

Figure 1: Conceptual framework for malaria epidemiology, Butajira area, Ethiopia, Oct.2008-Jun.2010.

The overall interaction of cellular immunity, circulating antibodies, and circulating immune complexes and circulating antigens influence the result of the immunodiagnostic test (23). This conceptual framework also guided us to the identification of appropriate methods based on the specific objectives. Thus, four studies included in this thesis (Annex-I) made attempts to address the knowledge-gap in understanding the epidemiology of malaria in the highlands.

1.5. Literature review

Based on the conceptual framework of the study this section presents the causative agents of malaria and vectors transmitting, malaria burden at different levels, factors limiting malaria epidemiology particularly at highland areas, and the control strategies underway in light of the research question.

1.5.1. Global burden of malaria

Malaria is widely distributed worldwide and endemic in 106 countries of the tropical and subtropical areas. *Plasmodium falciparum* and *Plasmodium vivax* are the major causes of the malaria episodes. The real malaria annual incidence and death figures are under estimated (24). In the past, annually an estimated 350-500 million clinical malaria episodes and >1 million deaths occur worldwide (25). However, a recent WHO report showed a declining trend of malaria burden. The real malaria annual incidence and death figures (24), and consequently a wide range of previous estimates (300-500 million clinical cases) have been used so far. According to the recent WHO report, in 2010, there were an estimated 216 million cases of malaria in 106 endemic countries and territories in the world. Of these, there were about 655, 000 estimated deaths (2). This is much lower than the estimated to 225 million episodes and 781,000 deaths (from 2009); and 240 million episodes and 850,000 deaths (from 2008) (26).

Most of malaria burden in the world occurs in the African Region. During 2010, 81% of the 216 million episodes of malaria (174 million cases) and 91% of deaths were contributed by this region. About 50% of the malaria deaths contributed by the sub-Saharan Africa come from Nigeria, Democratic Republic of Congo, Uganda and Ethiopia alone (26). On the other hand, children under 5 years of age contribute about 86% of the global malaria deaths (2). *Plasmodium falciparum* is the major cause of malaria burden in Africa. In the last decades, *Plasmodium falciparum* showed resistance to chloroquine and sulphadoxine-pyrimethamine (SP). The first line treatment for this species shifted to ACT and that is being developed (27).

In addition, malaria results in huge economic burden on the countries in malaria-endemic regions. Approximately, malaria costs African countries more than US$ 12 billion annually in direct losses (28), although the disease could be controlled for a fraction of that sum. Up to 40% of African health budgets are spent on malaria each year (5). Evidence has shown that countries with high proportions of falciparum had 1.3% lower economic growth rates than other countries (29). On the other hand, *Plasmodium vivax* is endemic in 95 countries in tropical, sub-tropical and temperate regions (30), and putting about 2.6 billion people at risk of infection. Ethiopia is among ten countries with the highest estimated population at risk of this species (30). *Plasmodium vivax* accounts for 70 to 390 million annual infections (31). Of these 10-20% occurs

in Africa, South of the Sahara. In eastern and southern Africa, 10% of malaria cases *a*re due to *Plasmodium vivax* (31).

1.5.2. Global malaria control program

Until1954, quinine and environmental measures were the only options for malaria control in some towns and areas in Europe (32). But those tools had a short-lived effect. Thus, the DDT (Dichloro-diphenyl-trichloroethane) discovery was a solution as a long-acting insecticide although long-lasting measures were still sought. Based on the successful elimination of malaria from Europe, the Americas and some parts of Asia and Oceania, WHO promoted the launching of global malaria eradication campaign in 1955. However, complete eradication failed in tropical countries due to climatic, social and economic conditions different from those prevailing in the temperate zone. For instance, after the initial reduction was obtained, malaria flare ups were observed in India by the 1970s (33).

The African Continent was not was not considered for the eradication program due to poor infrastructure for communication, low socio-economic condition and high endemicity of malaria (34). In spite of these gaps, Ethiopia, South Africa and Zimbabwe were the only countries that joined the eradication campaign (35). In the meantime, the WHO found that the time-bound global malaria eradication was unrealistic and stopped the program in 1969. Then, a long term global malaria control program (MCP) aimed at reducing malaria morbidity and mortality below the public health importance was adopted (33). However, the periods between 1970s and 1980s were identified as the time when malaria control deteriorated and resurgent malaria was recorded (36). This mostly affected mostly people in Latin America, Asia and Africa. Then, in 1992 WHO convened a global Ministerial Conference on Malaria in Amsterdam to draw up a global strategy for renewed attack on malaria. This conference has brought governments, health agencies, and donor organizations together to coordinate their initiatives and resources in the control of malaria as reflected in the World Declaration on the Struggle against Malaria (37). In addition, malaria endemic countries endorsed global malaria control strategy that comprised four basic technical elements such as to provide early diagnosis and prompt treatment; to plan and implement selective and sustainable preventive measures, including vector control; to detect early epidemics, contain or prevent them; and to strengthen local capabilities in basic and applied

research to permit and promote the regular assessment of a country's malaria situation, in particular the ecological, social and economic determinants of the disease (37). This renewed focus on malaria control has prioritized the African Region through the accelerated implementation of malaria control project held between 1997 and 1998 (38). Next, in 1998 the WHO, WB, UNICEF and UNDP founded the Roll Back Malaria (RBM) partnership which was aimed to halve the suffering caused by malaria by 2010 (39).

The RBM focused on malaria in the highly endemic areas of Africa. Forty four of the fifty malaria-affected countries in Africa were convened to the African Summit on RBM in Abuja, Nigeria in April 2000. Subsequently, targets were set and it was agreed to meet again in 2010. These targets focused on early diagnosis and prompt treatment and increased coverage of preventive measures in children under five years and pregnant women (28). In order to sustain the malaria control efforts, a funding mechanism called the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) was established in 2002. Its purpose was to help financing the global battle against HIV/AIDS, tuberculosis, and malaria (40). In addition, the Millennium Development Goals (MDGs)[1] set in 2000 recognize that malaria must be controlled if Africa is to escape from the cycle of extreme poverty and disease. The MDG6, which is focusing on malaria is to have it halted by 2015 and begin to reverse the incidence of the disease. This has been made more specific by the UN Millennium Project's working group on malaria as "Reduce malaria morbidity and mortality by 75 percent by 2015 from the 2005 baseline level." Thus, the working group on malaria recommended that countries where malaria is rife should use an integrated package of preventive and treatment methods to achieve this goal (3). Thus, the member organizations of the RBM Partnership launched the Global Malaria Action Plan. The Plan is a comprehensive document for global malaria control and elimination (5). The presence of adequate resources and effective intervention tools as well as successful reduction of malaria in the last decades helped to move towards this ambitious plan. Decline of malaria in nine African countries, and more than 25 outside Africa was reported in the last decade (41). Thus,

[1]The UN MDGs by 2015 are: 1. Eradicate extreme poverty and hunger, 2. Achieve universal primary education, 3. Promote gender equality and empower women, 4. Reduce child mortality, 5. Improve maternal health, 6. Combat HIV/AIDS, malaria and other diseases, 7. Ensure environmental sustainability, and 8. Develop a global partnership for development.

the beginning of the 21st century is remarkable mainly due to gains obtained in reducing malaria cases and deaths using currently available control tools for the disease. Consequently, in 2011 there were estimates that, if control efforts were sustained, malaria could be eliminated from one-third of all affected countries within a decade.

1.5.3. Malaria transmission

Malaria is a disease caused by protozoa of the genus *Plasmodium*, family Plasmodiidae, suborder Haemosporidiidae, and order Coccidia. Four *Plasmodium* species including *Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae,* and *Plasmodium ovale* were known to cause human malaria parasites (42). Additionally, the fifth malaria parasite of monkeys of Southeast Asia, *Plasmodium knowlesi*, was found that frequently infected humans (43).

Plasmodium typically undergoes two types of asexual division: schizogony in the vertebrate; and sporogony in the mosquito vector. Within the vertebrate host, schizogony is found both within erythrocytes (erythrocytic schizogony) and in the liver tissues (exo-erythrocytic schizogony). The sporogonic cycle, which is very important stage of the parasite's cycle in terms of determining the probability of transmission, is affected by environmental factors. The duration of the sporogony is very sensitive to temperature. On the other hand, the minimum ambient temperature below which the parasite does not develop in the vector is important. For example, this threshold is 15^{o}C for *Plasmodium vivax* and 19^{o}C for *Plasmodium falciparum* (44).

Moreover, the duration for completion of mosquito's aquatic stages (egg, larva, and pupa) to develop to adult depends on temperature and nutritional factors in their environment. The time required for development is shorter at higher temperatures. Blood meals are generally taken every 2-3 days, followed by the laying of the next batch of eggs. The feeding frequency also depends on the ambient temperature. The survival or longevity of the adult female depends on the humidity and temperature. In Africa, five very efficient vector species (*Anopheles gambiae*, *Anopheles arabiensis*, *Anopheles funestus*, *Anopheles nili* and *Anopheles moucheti*) transmit malaria (45). In African highlands, *Anopheles gambiae* s. s., *Anopheles arabiensis* and *Anopheles funestus* are the most important vector species. *Anopheles gambiae* s. s. and *Anopheles arabiensis* species mainly breed in open, sun-lit, small and temporary rain pools and

sometimes pools formed in streams and rivers resulting from draught conditions. *Anopheles funestus* breeds in permanent water bodies such as swamps, ponds and edges of lakes.

1.5.4. Malaria endemicity and transmission intensity

Malaria is described as endemic when there is a measurable incidence both of cases and of natural transmission over a succession of years (46). Various terms have been used to designate degrees of endemicity. Four classes of endemicity of malaria based on the parasite rate in children aged 2-9 years have been widely applied (46, 47). These classes include parasite rate in children of 2-9 years as a rule in Hypoendemic: <10%; Mesoendemic: 11-50% (may be higher during part of a year); Hyper-endemic: >50% (may be higher during part of a year); and parasite rate in infants; and Holoendemic: constantly over 75%. A spleen rate was also proposed but it was found that it cannot be taken as a reliable index for the amount of malaria.

The intensity of malaria transmission is extremely diverse mainly with respect to resistance to change. Thus, a more general classification of malaria is whether malaria transmission is stable or unstable. In the stable malaria, the prevalence of infection is persistently high and only little affected even by relatively large natural or man-made changes in the factors for transmission. In contrast, in unstable malaria, the prevalence of infection varies widely and is very sensitive to even relatively small natural or man-made changes in the factors of transmission (44, 47). Consequently, collective immunity is low in populations of unstable areas and can be affected by severe epidemics pertinent to slight changes in equilibrium of transmission components mainly in the environment (42).

1.5.5. Ethiopia: background review

1.5.5.1. Geography and climate

Ethiopia is a land-locked country in the tropical climate zone of the Greater Horn of Africa. The country experiences great geographical diversity, its topographic features range from the highest peak at Ras Dashen, 4,550 meters above sea level (masl), down to the Affar Depression, 110 meters below sea level (48). The climate varies with topography, from as high as 47 degrees Celsius (^{o}C) in the Affar Depression to as low as 10^{o}C in the highlands. Ethiopia's total surface area is about 1.1 million square kilometers. Of that area, only a small proportion (0.7%) is

covered by water body (49). Djibouti, Eritrea, the Republic of the Sudan, the Republic of the Southern Sudan, Kenya, and Somalia border the country.

The central topographic feature of the country is constituted of a high plateau and a chain of mountains; with elevations varying between 1,500 and 3,000 masl, and some peaks over 3,500 masl. The East African Rift Valley runs from northeast to southwest through the country creating a discontinuity of the central plateau. In Ethiopia, highland areas (≥1,500 masl) were considered as disease free and inhabited by 82% of the nation's population (50). The highland areas are surrounded by the lowlands (<1500 masl), where the remaining 18% of the total population (most pastoralists) lives. Rainfall, temperature and relative humidity are strongly correlated with altitude (51). Such altitude-dependent climate zones have long been recognized in Ethiopia and include the *Kolla* (hot lowlands ≤1,500 masl; mean annual temperature of 23-33^{o}C; annual rainfall of 100-900 mm), *Weyna Dega* (1,500-2,500 masl; mean annual temperature 16-29^{o}C; annual rainfall of 400-2,400 mm); and *Dega* (cool humid highlands ≥2,500 masl; mean annual temperature of 10-16^{o}C; and annual rainfall of 1,000-1,600 mm) (52, 53).

The country has three seasons including *Kiremt* (the main rainy season from June to September), *Bega* (the dry season from October to December/January), and *Belg* (the small rainy season from February/March to May). The mechanisms of rainfall formation for each season vary as briefly described (54). In general, the mean maximum temperature is highest from March to May and the mean minimum temperature is lowest from November to December. The general distribution of annual rainfall is seasonal and also varies in amount, area, and time as it moves from the southwest to northeast (55).

1.5.5.2. Population

About 92 million people lived in Ethiopia as of July 2012 (49) and with annual growth rate of 2.9%. Ethiopia's population is young 45% below the age of 15 years (49). Over the last two decades, the population has increased from 53.5 million in 1994 to 73.8 million in 2007 (56). There was a slight decline in the population growth rates from 2.9% in 1994 to 2.6% in 2007. Ethiopia is one of the least urbanized countries in the world; only 16% of the population lives in urban areas (56). The majority of the population lives in the highland areas. Thus, 45% of the people live in *Weyna Dega*, 37% in *Dega* and the rest in *Kolla* (18%) climatic zones (53). There

are 76 different ethnic groups with 286 different languages. Christianity and Islam are the main religions; about half of the populations are Orthodox Christians, one-third are Muslims, about one in every five (18%) are Protestants, and 3% are followers of traditional religion (56). The literacy rate for women is 29 percent and 59 percent for men (57). The gross enrolment ratio in primary schools at national level is 94% (58).

1.5.5.3. Political system and administrative units

At present, a federal system of government exists. The government is made up of two tiers of parliament, the House of People's Representatives and the House of the Federation. Since the mid-1970s, major changes in the administrative boundaries have been made three times. Currently, Ethiopia is administratively structured into nine regional states (Tigray, Affar, Amhara, Oromiya, Somali, Benshangul-Gumuz, Southern Nations, Nationalities and Peoples: SNNP, Gambela, and Harari), and two city administrations (Addis Ababa, and Dire Dawa). Again the regional states and city administrations are further divided into *Woredas* (districts), which is the basic unit of planning and political administration at the lower level. The *Woredas* are further sub-divided into the lowest administrative units called *kebele*s.

1.5.5.4. Economy

Ethiopia's economy is based on agriculture, which accounts for 43% of the gross domestic product (GDP) (48), and 85% of total employment. Coffee has long been one of the main export items of the country; however, other agricultural products are currently being introduced on the international market. Between 1974 and 1991, the country operated in a central command economy but has since moved toward a market-oriented economy.

To help attain the Millennium Development Goals (MDGs) by 2015, Ethiopia adopted the Plan for Accelerated and Sustained Development to End Poverty (PASDEP), the second poverty reduction strategy, covering the period 2005/06 to 2009/10 (59). In keeping within place, the economy has grown in real GDP at a rate of 11% *per* annum in the past five years. With an average population growth rate of 2.6%, the GDP growth rate translates to an 8.4%% growth in average annual *per* capita income (56). The Growth and Transformation Plan (GTP) has been developed for the next five years, designed to maintain rapid and broad-based economic growth and eventually to end poverty (60). In 2013, the country is also engaged in plans to continue the

construction of its Grand Renaissance Dam on the Blue Nile, which is planned to develop electricity for domestic consumption and export (49).

1.5.5.5. Healthcare delivery system

The Ethiopian Health Policy endorsed in 1993 is committed to fulfill the needs of the majority of the rural population targeting on the development of effective promote preventive and curative services of health care. This policy also emphasizes on the decentralization and democratization of the health services, ensuring access of health care to all the population, promoting and enhancing national self-reliance in health development by mobilizing and efficiently utilizing internal and external resources including community participation (61). Thus, in order to put this policy into action the government has designed a 20-year Health Sector Development Programme (HSDP) since 1997/1998, following a set of rolling five-year plans. HSDP not only serves as a comprehensive national plan but also as a guiding framework for further regional and district detailed planning and implementation activities. The recent HSDP IV extending from 2010/11 to 2014/15 is targeted to improve the provision of quality health services and the development of a community health insurance strategy for the country. It also prioritizes maternal and new born care, and child health. In addition, HSDP IV aimed to overcome the spread of major communicable diseases such as HIV/AIDS, TB and malaria (60).

A three-tier health system including a Primary Health Care Unit (PHCU), a district hospital, a zonal hospital and a specialized hospital was established to address the prevailing health problems of Ethiopia. A PHCU is the lowest level, which is envisaged to promote, preventive and basic curative health services. A PHCU is consists of a health center and five satellite health posts (61). Since 2004, MOH initiated a Health Extension Program (HEP) to ensure universal access to primary health care and equity of essential health care to citizens. The basic concept of HEP is to empower the community to produce and maintain their own health through transfer of the right knowledge and skills. Malaria prevention and control, particularly treatment of cases, is one of the components of health extension packages implemented by health posts (62).

1.5.5.6. Health indicators

In Ethiopia, one of the priorities of the HSDP IV was improving child health, with a goal to reduce the under-five mortality rate to 68 per 1,000 live births and the infant mortality rate to 31

per 1,000 live births by 2015 (63). During the five-year period of the 2011 survey, infant mortality rate was 59 per 1,000 live births, and child mortality was 31 per 1,000 children surviving to age one year. The under-five mortality rate was 88 *per* 1,000 live births. Infant mortality has declined by 42% over the 15-year period preceding the survey from 101 deaths per 1,000 live births to 59 deaths per 1,000 live births (56).

Furthermore, under-five mortality has declined by 47% over the same period from 166 deaths per 1,000 live births to 88 deaths per 1,000 live births. Under-five mortality decreased from 166 deaths *per* 1,000 live births in the 2000 survey to 88 in 2011, while infant mortality decreased from 97 deaths per 1,000 live births in the 2000 survey to 59 in the 2011 survey. On the other hand, the overall children vaccination coverage remained the lowest. During 2011 survey, only 24% of children aged 12-23 months were fully vaccinated. While this represents a 19% increase from the level reported in the 2005 EDHS, the percentage of children who are fully vaccinated remains far below the goal of 66% coverage set in the HSDP IV (63).

A maternal mortality ratio (MMR) was 676 deaths *per* 100,000 live births during the seven-year period preceding the 2011 survey (56). The estimated MMR is almost the same in the 2011 EDHS (676) as it was in 2005 EDHS (673). The HSDP IV target is to reduce anaemia prevalence nationally to 12%. Overall, 17% of women aged 15-49 and 44% of children aged 6-59 months are anaemic. In comparison with the data from the 2005 EDHS, the prevalence of any anaemia has declined. The total population life expectancy at birth was estimated at 56.56 years in 2012. The country's health expenditure was 3.6% of GDP in 2009, which is the lowst in the world (49). Water and vector-borne communicable diseases are the main causes of health problem in the country. Emerging non-communicable diseases also contribute significantly to both morbidity and mortality (64).

1.5.6. Malaria in Ethiopia

1.5.6.1. Malaria epidemiology

Malaria has been endemic in Ethiopia for many years. The concentration of the Ethiopian population in the highlands is said to be due to widespread occurrence of malaria in the lowlands (53). European travelers also documented the dominance of malaria in the lowlands mainly adjacent to the river basins (65). About three-fourths of the landmass of Ethiopia below 2,000

masl has been considered as either malarious or potentially malarious (66). However, recent studies found the occurrence of endemic malaria beyond 2,000 masl (12, 67).

In Ethiopia, characteristically malaria is seasonal and unstable, except in western lowland areas with perennial transmission. The presence and magnitude of the disease is determined by altitude and climatic factors (7, 68). Thus, malaria occurs immediately after the light rainy season of March and April and long rains of June through September. Owing to the seasonal nature of malaria transmission that exists for short duration followed by long period absence of the disease, generally the population fails to acquire immunity against the disease. Thus, recurrent epidemics of different magnitude and frequency attacked the people (7, 38).

Of the four human malaria parasites reported from Ethiopia, *Plasmodium falciparum* (60%) and *Plasmodium vivax* (40%) are epidemiologically the most important species in Ethiopia (68). *Plasmodium malariae* (<1) is found sporadically in some areas. *Plasmodium ovale* was found in a few patients who live or lived in western lowlands of the country, and this part of the country was suggested as lying in the *Plasmodium ovale* belt of Africa (69). However, no recent information is available showing the presence of *Plasmodium ovale* in the country is available. The malaria parasite distribution varies with altitudinal location and season. A changing pattern of species distribution was found with intensive agricultural activities and settlement projects. The dominance of *Plasmodium falciparum* and *Plasmodium vivax* in Gambella, south western Ethiopia was observed (70), unlike the earlier findings that documented varying proportion of the entire four parasite species (71).

The anopheline fauna of Ethiopia is highly diversified; a total 42 *Anopheles* species have been recorded (53). Studies in the past confirmed that the principal malaria vector in Ethiopia is *An. arabiensis* (10). This species has been reported as the vector for most of the epidemics recorded in the country. *Anopheles arabiensis* breeds in small, temporary, sunlit water collections created during the rains. Such breeding places are abundant in many places, just following main rainy season. The other species are *Anopheles funestus* and *Anopheles pharoensis*, considered the most important secondary vector of malaria next to *An. arabiensis* (53). Both species prefer large, permanent, and shaded water bodies with emergent vegetation, irrigation canals and lakeshores.

Anopheles nili was identified as vector of local importance in malaria transmission in Gambella, Ethiopia (72).

1.5.6.2. Highland malaria in Ethiopia

Highland malaria has been the major public health concern in Ethiopia. Highland malaria is also known as epidemic malaria. In the past malaria stratification that was based on duration of malaria transmission such as only near water, <3 months, 3-6 months, and > 6 months (53). However, the recent stratification used rainfall and temperature information that identified four major eco-epidemiological malaria strata (73). These are: malaria-free highlands, where no local malaria transmission exists (above 2,500 masl), epidemic-affected highland-fringe, areas (between 1,500 and 2,500 masl), and seasonal transmission areas (lowlands below 1,500 masl), and malaria stable areas (limited to the western lowlands and river basins). Of these, two strata including highlands affected by occasional epidemics (between 2,000 and 2, 500 masl), and highland-fringe with low transmission (between 1,750 and 2,000 masl) are considered as high epidemic risk. The highland malaria is an epidemic or unstable malaria that is occurring above 1,500 masl in Ethiopia (7).

Epidemic malaria in highland areas represents a significant public health problem. In these areas there is low risk of infection in highland areas impairing acquisition of functional immunity. Subsequently, it results in severe epidemics of high case fatality affecting both adults and children (74). The highland areas of Ethiopia, mainly along the Rift Valley and in western, central and eastern areas are especially prone to periodic epidemics (7). So far, the epidemics have occasionally been reported at higher altitudes reaching 2,400 masl during the 1958 epidemic (8) and 2,500 masl during the 2003 (8). Both the 1958 and 2003 epidemics were associated with abnormal increase in the minimum temperature in the Ethiopian highlands. The malaria cases and deaths caused by previous epidemics are summarized and presented below (Table 1). Since most of the epidemics remain undocumented and not available for analysis this list might not fully describe the full picture of malaria epidemics in highlands of Ethiopia. Malaria in the highland areas occur in localized sites with optimal condition for mosquito breeding. The highland areas that experience epidemics were always located in a valley with a basin-like depression in a plateau, places where water collects and malaria mosquitoes breed

(75). In addition to altitude and climate, the role of other factors such as ecological and climate changes associated with highland malaria are briefly presented as follows.

Some interacting environmental factors such as altitude, temperature, rainfall, ecological and climate changes are known to be influencing malaria transmission at highlands. In Ethiopia, altitude is one of the oldest defenses against malaria. Hills and mountains, have therefore, been recognized as natural shelters against the heat and diseases of the lowlands for at least several centuries in Ethiopia (53, 75).

Table 1: Summary of cases and deaths caused by malaria epidemics occurred between 1958 and 2003 in Ethiopia.

Years	Cases	Deaths	Areas affected
1958	3 million	150,000	Northern & central highlands
1965 & 1973	500,000	120,000	Northern & eastern highlands
1985-7	200,000	40,000	Western
1991	2 million	No report	Wollo, Tigray, Shoa and Gondar
1991-2	700,000	759	Highland-fringe Rift Valley, South, & North western
2003	6.1 million	45-114	Amhara, Oromia, SNNP** and Tigray Regions

*Sources [Abeku, 2003, Fontaine, 1961, Negash, 2005, Mengesha, 1998]; **SNNP=South Nations Nationalities and Peoples.

Altitude-limiting levels for transmission have been described as approximately 2,000 masl in many African countries including Ethiopia and 1700-1800 masl in Democratic Republic of Congo and Zimbabwe (42). The effects of low temperatures are likely to be restricted to discrete highland areas in Ethiopia and all the East African highlands (76).

Altitude and temperature are strongly correlated and for every 100-meters increase in altitude, temperature decreases by 0.5^{o}C (42). So, high altitudes were related to low temperatures. Ambient temperature is critically important both for the development and survival of the mosquito vector and parasite (75), and subsequently influences malaria transmission at

highlands. Thus, the duration of sporogony increases hyperbolically with decreasing environmental temperatures to a point at which parasite development ceases altogether. Optimum conditions for sporogony are between 25^{o}C and 30^{o}C and it ceases below 16^{o}C. However, the critical temperature for sporogony varies by parasite species; it is 19^{o}C for *Plasmodium falciparum* and 15^{o}C for *Plasmodium vivax* (47).

In practical terms, transmission is commonly assumed to be limited to months in which the average temperature is above the threshold (47). Above 35^{o}C, sporogony slows down considerably and it is also delayed by fluctuation of low temperatures. Moreover, high temperatures are associated with more rapid development of vectors and also with increased frequency of feeding by female anophelines. In contrast, extreme high temperatures result in the development of smaller and less fecund adult mosquitoes, and thermal death of mosquitoes occurs at 40-42^{o}C (42). On the other hand, the association of malaria transmission and rainfall including in epidemic situations has been well documented in Ethiopia (7, 9, 68, 77). *Anopheles gambiae* often breeds in temporary, turbid water bodies such as hoof prints or rain puddles, whereas *Anopheles funestus* prefers permanent water bodies. Both temporary and permanent water bodies depend on adequate rainfall. Ecological changes are known for creating suitable factors for mosquito breeding and suitable microclimate. For instance, small-scale environmental changes such as irrigation and deforestation are observed to have influenced malaria epidemiology. Data from Tigray, North Ethiopia suggest that parasite rates in the vicinity of dams are higher than those in outlying areas (78). A recent review has also shown an overlap in the rise of malaria incidence and prevailing environmental changes in the last three decades in the East African Highlands including Ethiopia (13). More specific evidence from the highlands of southwest Uganda showed that establishment of malaria attributed to changes in microclimatic factors due to land use changes (79). The areas between 1,500 and 2,400 masl were under extensive farming activity. This was followed by increased mean indoor resting densities of *An. gambiae* s. l. and malaria cases. This has been cited as typical example of how malaria is established in the highlands due to extensive agricultural activities. A study has demonstrated that the mean indoor temperatures of houses located in the deforested area was 1.2^{o}C higher than in houses located in the forested area during the dry season and 0.7^{o}C higher during the rainy

season. Overall, deforestation enhances mosquito reproductive fitness, increasing mosquito population growth potential in the western Kenya highlands (80).

Furthermore, in the highlands, malaria transmission is sensitive to temperature. In other words, even with relatively small changes in the climate of highland areas could lead to significant increases in the local altitudinal limits of malaria transmission. This creates a large proportion of non-immune community that could be at high risk of infection. In the last century, a temperature rise of 0.75^{o}C was estimated and an increase of 0.18^{o}C *per* decade was presumed in the last 25 years (81). This warming of the globe has been associated with resurgence of malaria in the highland areas in Ethiopia particularly and the African Region generally during the1990s (36, 77, 82-85). In Ethiopia, there was a rise of minimum temperature by 0.4^{o}C in the last decades (86), and a rise of all the temperature variables by 0.2^{o}C per decade was observed in similar settings of the Kenyan highlands during the last three decades (87).

1.5.6.3. History of malaria control efforts in Ethiopia

Malaria control efforts in Ethiopia have been underway for more than half a century. They started in the mid-1950s and underwent series of organizational changes as described below. Established malaria control efforts in Ethiopia started in the 1950s as pilot control projects. The control pilots also served for testing the efficacy of DDT in different eco-epidemiological settings of the country and as a training ground for the subsequent Malaria Eradication Service in 1959 (35). Those projects were in Kobo-Chercher (1955), Upper Awash Valley (1956), and Dembia Plain (1957) (69).

Malaria eradication service was established in 1959. In 1964 a comprehensive assessment was made and a plan for eradication for the period 1966-1980 was worked out. That plan called for the division of the country into four areas (A, B, C and D), with the execution of preparatory, attack, consolidation and maintenance phases proceeding by stages in each area (88). In area A (North Ethiopia), in March 1966 residual spraying was undertaken as part of eradication campaign. Following three rounds of spraying, a study in 1967 found out only a slight decline in *Plasmodium falciparum* in northern and north-eastern parts of the country (88). Both the technical and financial supports from WHO/USAID and UNICEF as well as the gains of

countries in malaria elimination influenced Ethiopia to join the eradication campaign (35). However, following the recommendation of the 22nd World Health Assembly Resolution of 1969, the status of malaria programme of Ethiopia was reviewed by a team from the WHO in May 1970, June 1972 and April 1977. Minor gains were obtained in limited areas of malaria eradication operational areas. The reduction in malaria prevalence was achieved in some areas at the beginning of the campaign and opened development opportunities in the fertile lowlands of the country (69).

The MCP replaced malaria eradication services in 1971. That program was organized as vertical structure and functioning throughout the country with 17 zonal and 72 sector offices and above 100 laboratories (69). Then, physical integration of MCP with the basic health services took place in 1977. This has adversely affected the morale of experienced MCP professionals that resulting in decline in the quality of malaria control activities (89), and resurgence of malaria followed.

The Ministry of Health revised the integration of MCP and broadened the program to accommodate other major vector-borne diseases including, Schistosomiasis and Onchocerciassis (89). Accordingly, under the auspices of the Ministry of Health, semiautonomous National Organization for the Control of Malaria and Other Vector-Borne Diseases (NOCMVD) was reorganized in 1986. However, in the case of other vector-borne diseases, effort in the control was limited to preliminary research findings related to their epidemiology with no national implementation program. The NOCMVD applied selective vector control supported by environmental control through regular community participation during the mid-1980s (69). Again, during the mid-1980s malaria control effort was challenged by many outbreaks throughout the country. This was the time when huge population movement took place due to the resettlement in Gambella and Metekel in 1984-5. In addition, 16 major agro-industrial development schemes with a population of a quarter of a million were underway during the same period (53). Thus, unprecedented high incidence of malaria was documented during the mid-and late1980s (90).

After the establishment of regional health bureaus control of malaria has been decentralized and integrated with the general health services since July 1993 (91). Then regional and zonal malaria control program offices were established. The goal of MCP was to reduce mortality and morbidity due to malaria to an extent that it will no longer be a major public health problem (92). In order to meet this goal a five-year strategic plan with four main strategies was designed on the basis of the global malaria control strategy (37). These strategies were to provide early diagnosis and prompt treatment, plan and implement selective and sustainable vector control measures, detect early, prevent or contain epidemics, and strengthen local capacity in basic and applied research (92).

The Ethiopian National MCP focused on strengthening malaria control efforts. In order to fill the gaps in the workforce, training of health personnel was conducted in 1996. Thus, to solve this acute problem, MOH trained 42 vector biology technicians for one year. Again, in collaboration with the Netherlands Government and the WHO, it trained 27 high-level health professionals in a standard three-month course of the WHO in 1996 (91). The latter training has been underway until recently. In the last 15 years period, the National MCP of Ethiopia gained momentum in the fight against malaria. It has designed series of five-strategic plans on the basis of the global malaria control strategy and applied RBM goals and targets.

1.5.6.4. Current malaria control strategies

In Ethiopia, early diagnosis and prompt treatment; selective vector control; and epidemic prevention and control have been the main components of the national malaria control program since 2000 (91). Providing prompt and effective treatment is expected to prevent most cases of uncomplicated malaria from progressing to severe and fatal illness. To avoid this progression, treatment must begin as soon as possible, generally within 24 hours after symptom onset. Effective malaria treatment requires improved diagnosis of malaria (i.e. laboratory-based microscopy or use of multi-species RDTs); well-trained health workers in health sectors; and constant availability of highly efficacious medicines as close to the patient as possible to ensure prompt access. The WHO recommends universal parasitological diagnosis of malaria to ensure targeted use of antimalarial drugs for those individuals who actually have malaria (18).

The selective vector control strategy comprises indoor residual spraying (IRS) and long-lasting insecticidal nets (LLIN). The primary effects of IRS towards curtailing malaria transmission are through reducing the life span of vector mosquitoes so that they can no longer transmit malaria parasites from one person to another; and reducing the density of vector mosquitoes. In areas of unstable malaria transmission, IRS will prevent seasonal increases in transmission, will prevent and control epidemics, and can eliminate local transmission of malaria. The average IRS coverage was approximately 20% until 2007 (15), and has increased to about 50% at present (93). IRS is an important preventive measure. Appropriate targeting and timing is essential in order to have a significant effect on prevention of epidemics and reduce the incidence of transmission. IRS should be applied prior to the transmission season or the anticipated epidemic. As LLIN ownership and use in the country reaches universal coverage and is sustained over time, the epidemic threat is expected to be diminishing.

Areas below 2,000 masl are prone to seasonal epidemics, while those above 2000 masl are occasionally affected due to change in annual weather conditions compounded largely by deficient rainfall and high temperatures. LLINs are an effective tool to significantly reduce morbidity and mortality due to malaria. They have three main effects, knocking-down (incapacitating or killing), repelling, and acting as physical barrier (94). As indicated in the HSDP IV and the national malaria strategic plan 2011-2015, LLINs should be provided to households in malaria endemic areas (<2000 masl). Additionally, some *kebele*s above this altitude may be targeted for LLIN distribution as well, if there is documented evidence of repeated malaria outbreaks (19).

The aim of LLIN distribution is to cover all sleeping spaces in households in malaria-endemic areas so that universal coverage can be ensured. The number of LLIN provided to each household will be equal to the number of sleeping spaces, thus, on average targeted for universal coverage of LLIN with one LLIN *per* sleeping space. More than 30,000 HEWs have been posted to each newly constructed health post in 15, 000 *kebele*s in 2009. The main strategies for the HEP to increase use of LLINs were approaches like use of social behaviour change, and communication and implementation of community-based social communication activities (19).

2. AIM OF THE THESIS

2.1. Overall aim

The overall aim of this thesis was to describe the epidemiology of highland malaria with emphasis to the magnitude and associated factors as well as interventions in various altitudes in Butajira area, south-central Ethiopia.

2.2. Specific aims

The specific aims were to:

I. Determine prevalence of malaria;

II. Identify malaria risk factors;

III. Determine factors affecting household ITNs ownership and utilization in relation to malaria infection; and

IV. Evaluate the precision of multi-species identifying malaria RDTs compared to Giemsa-stained light microscopy.

3. SUBJECT S AND METHODS

3.1. The study area and population

This dissertation is based on studies conducted in Meskan and Mareko districts, located about 130 km south of Addis Ababa (Figure 2). These districts are found in Guraghe Zone, Southern Nations Nationalities and Peoples (SNNP) Regional State of Ethiopia. The study considered six rural *kebele*s (the smallest administrative units) out of the total ten in the Demographic Surveillance Site (DSS) of the Butajira Rural Health Program (BRHP) (95).

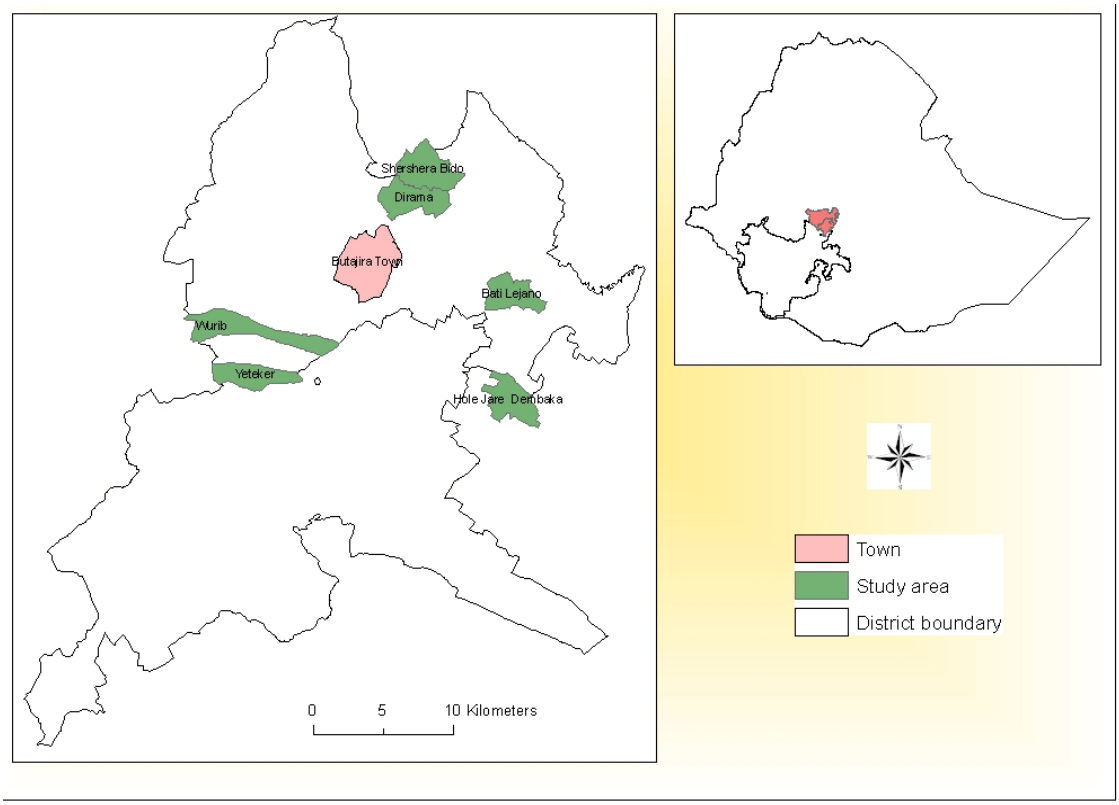

Figure 2: Location of the study sites, Butajira area, South-central Ethiopia.

The meteorological data for the last nine years showed that the mean annual rainfall of the study area was 945 mm (yearly range 510 mm to 1,329 mm), below the average annual rainfall records in 2009 and 2010. The main rainy season is usually from June to September. The mean

temperature was 18.2 degrees, with average annual minimum and maximum temperature of 10.0 and 26.3 degrees Celsius (^{o}C), respectively. The study was conducted in the temperate zone of highland area with an altitudinal transect between 1,800 masl and 2,300 masl stratified into three climatic zones.

In 2008, there were 58,335 people living in the BRHP DSS. Half (50.1%, n=29,243) of the population were females. Of the total population, 26,834 of the people lived in our study areas. Most people in the area practice subsistence farming. Pepper at low altitude and *khat* (*Catha edulis*) at high altitude areas are the main cash crops. The main staple food in the highlands is Enset (*Ensete ventricosum*), and in the lowlands maize, wheat, barley and *Teff* (*Eragrostis tef*) are the main crops. Animal husbandry is carried out with the farming.

Odamo, Kelakel, and Asass rivers flow through the area. The population usually obtains health services at health posts found in each *kebele*, three health centers (two at low and one at high altitude) and two hospitals in the area. During this study, two private clinics and two drug vendors were also found to be operating in the study area. Malaria is one of the important causes of sicknesses in Butajira area. Between 2004 September and 2010 August, 32.3% (19,923 of 61,654) were microscopically confirmed malaria cases from Butajira and Enseno Health Centers, and Butajira Hospital. On average, more than 10 thousand malaria suspected cases visited these public health facilities between 2002 and 2010. IRS operation was performed mainly for epidemic control in the low altitude areas of the present study area. During 2009/2010, a spraying of houses were done to control malaria outbreak in Hobe and Bati Lejano *kebele*s. The selection of the study area was due to its location in DSS and its connection with Addis Ababa University as part of the BRH P. Different localities with varying altitude were found to be suitable for the present study of malaria epidemiology.

3.2. Study design

This thesis used data obtained through community-based repeat cross-sectional study design. Each study considered in this thesis employed quantitative research methods. Table 2 below briefly presents the study designs, study populations and data collection periods of each paper included in this thesis.

3.3. Sample size calculation

The sample size required for this thesis was estimated as follows. Estimation of the sample size for Paper-I (malaria prevalence) was based on 4.1% prevalence from three Ethiopian regions (96). Using assumptions of expected prevalence of 4%, margin of error =1%, α=5% (95% confidence level), design effect =2 and 15% non-response rate, a sample size of 3,393 people was calculated. Thus, with the assumption of 4.5, average family size of 3,393 people were recruited from 750 households. Paper II and III used the sample size estimated (n=3,393) to measure malaria prevalence in this study area (97), considered this sample size to be adequate to assess risk factors of malaria infection and household ITN possession and usage (n=750) in Butajira area.

Table 2: Summary of the study design, population and survey period, Butajira area, Ethiopia, Oct. 2008-Jun. 2010.

Paper	Topic	Study design	Study population	Study period
I	Prevalence of malaria infection in Butajira area, south-central Ethiopia	- Community-based repeated cross-sectional blood survey in six *kebele*s - Interview on malaria risk	19,207 people screened for malaria infection in six surveys	Oct. 2008-Jun. 2010
II	Malaria risk factors in Butajira area, south-central Ethiopia: A multilevel analysis	- Community-based repeat cross-sectional blood survey in six *kebele*s	19,199 people screened for malaria in six surveys	Oct. 2008-Jun. 2010
III	Use of insecticide-treated mosquito nets and malaria infection in a malaria highland-fringe area of south-central Ethiopia	- Household survey in six kebeles - Community-based repeat cross-sectional blood survey in six *kebele*s	739 households 19,207 people screened for malaria infection in six surveys	Oct.-N0v. 2008 Oct. 2008-Jun. 2010
IV	Performance of CareStart™ Malaria Pf/Pv combo test for diagnosis of *Plasmodium falciparum* and *Plasmodium vivax* malaria in Butajira area, south-central Ethiopia	- Community-based repeat cross-sectional blood survey in six kebeles - Screening of febrile malaria suspected cases	2,394 febrile cases (public health facilities= 1,598, & Surveys= 796)	Oct. 2008-Dec. 2009 (Health facilities) Oct. 2008-Jun. 2010 (surveys)

3.4. Survey instrument and sampling

This thesis is based on studies that employed a community-based prospective design based on repeated cross-sectional surveys. A multistage sampling method was used to recruit study participants. Thus, the different stages were *kebele*s as the first-stage unit, villages as the second-stage, and households as the third-stage (98). Six rural *kebele*s (Hobe, Bati Lejano, Dirama, Shershera Bido, Yeteker and Wurib) (Table 3), two from each of the three different altitudinal strata, were selected. The strata were: low altitude (1,800-1,899 masl), mid-level altitude (1,900-1,999 masl) and high altitude (2,000-2,300 masl) areas. The target of our survey were 4,816 households residing in those six *kebele*s. Sixteen villages (or clusters of households) with 750 households were randomly selected from the six *kebele*s for the surveys using probability proportion to size (PPS) sampling method. Since we expected lower malaria prevalence in the highlands, proportionally selected more households from the highlands (Table 3).

3.5. Data collection

This thesis used data obtained from household interview, seasonal blood survey and self-reporting febrile cases. The content of all data collection tools is presented (appendices). The details of these data collection methods are sequentially presented in the following sections.

3.5.1. Household interview

Data collection was done using pre-tested structured questionnaire and format prepared for this purpose. Pre-testing of the data collection tool was performed in an adjacent *kebele*. All data collectors were fluent in the locally spoken languages.

Table 3: Proportion of study and sample households, Butajira area, Ethiopia, Oct. 2008-Jun. 2010.

Strata/*Kebele*s	Villages		Households	*Kebele*s	
	Total, n	Sampled, n	Target, n (%)	Study, n (%)	Sampled, n (%)
Low altitude					
Hobe	8	4	845 (17.8)	439 (18.8)	95 (12.7)
Bati Lejano	8	4	879 (18.6)	448 (19.1)	105 (14.0)
Mid-level altitude					
Drama	3	1	523 (11.0)	271 (11.6)	130 (17.3)
Shershera Bido	4	2	436 (9.2)	341 (14.6)	120 (16.0)
High altitude					
Yeteker	8	4	963 (20.3)	488 (20.8)	140 (18.7)
Wurib	3	1	1,090 (23.0)	354 (15.1)	160 (21.3)
6 *Kebele*s	**34**	**16**	**4,816 (100)**	**2,341 (100)**	**750 (100)**

Data collection through house-to-house was done by DSS enumerators or supervisors of each study *kebele*s (Figure 3). All family members who consented to participate in the study were included. The principal investigator and a supervisor from Butajira DSS did the daily field supervision and cross-checking of filled-in questionnaires. The altitude readings of the sample households were recorded using hand-held Global Positioning System (GPS) (Garmin eTrex ®). The principal investigator and two data collectors (postgraduate students from Addis Ababa University) conducted the GPS recording.

Figure 3: Designing of the study, training and household data collection, Butajira area, Ethiopia, Aug. 2008- Jun. 2010.

Socio-demographic characteristics, household assets, ITN use and various malaria risk factors were obtained using interview. However, ITN ownership and its condition were checked through observation. In this thesis ITN is defined as a factory-treated net that does not require any further treatment. Use of ITN is reportedly at least a family member slept under ITN prior night to the survey. Household assets were used to compute household wealth status. Household wealth status is a measure based on an index that divides the household population into quintiles reflecting household ownership of assets.

3.5.2. Seasonal blood survey

Seasonal blood surveys were performed for all family members of sampled households. Six cross-sectional surveys were done on the same households for two consecutive years. Thus, surveys were done in October-November 2008 (a month after the main rainy season), in January-February 2009 (dry season), in June-July 2009 (main rainy season), in October-November 2009,

in January-February 2010, and in June 2010. To ensure maximum response rate of participants, households with absentees were revisited once more. Thin and thick blood smears were prepared from all family members who consented for the study. Blood specimen processing, examination, and reporting of results were done using standard guidelines (99). Accordingly, the smears were air dried, put in slide boxes, and examined by a trained and experienced malaria microscopist at the field laboratory in Butajira (Figure 4).

Figure 4: Blood film collection and processing at field (a) and malaria diagnosis (b) at Butajira field laboratory, Butajira area, Ethiopia, from Oct. 2008 to Jun. 2010.

Thin films were fixed with methanol, and both thin and thick films were stained with 3% Giemsa stain for 30 minutes. Microscopic examination was done using 1000x magnification. During microscopic examination, a slide was regarded as negative after examining 100 fields without finding any parasites (99). Malaria is defined as detection of either *Plasmodium falciparum*, *Plasmodium vivax*, or mixed infection of both species upon microscopic examination.

3.5.3. Evaluation of CareStart™ Malaria RDT

During 2008/2009 there was a demand to introduce multi-species detecting RDT in the malaria control program of Ethiopia. Thus, various academic and research institutions were requested for

field evaluation of CareStart™ Malaria *Plasmodium falciparum*/ *Plasmodium vivax* Combo test (designated as RDT afterwards). In this study, self-reported febrile cases were recruited at public health facilities and house-to-house surveys to evaluate the performance of the RDT. Febrile cases were requested for blood specimen for preparing thin and thick films and simultaneously checked for malaria parasites using RDT (Figure 4). RDT results were declared within 20 minutes, while thin and thick films were kept for later examination using microscopy. Specimen collection and reporting result for malaria RDT were performed using procedures recommended by the company.

3.6. Data management and quality control

Data entry and cleaning was done using Epi Info version 6 (Centers for Disease Control and Prevention (CDC), Atlanta, Georgia (USA). The data were carefully cross-checked against the hard copy in the case of filled-in questionnaires. A training manual was prepared for data collectors and training was effected. The questionnaire was translated from English to the local language (Amharic) and back to English to check for consistency.

To quality assure the microscopic examinations, all positive and 10% of the negative slides were re-examined by a second microscopist. In the six surveys, seven of 2,094 slides (0.3%) showed discordant results. The agreement between the first two readers was excellent (kappa = 0.88). A third reader, blinded to previous results, re-examined those seven slides (six vivax malaria and one negative).

3.7.1. Prevalence of malaria infection (Paper I)

Data was analyzed using SPSS Statistics version 18.0 (*SPSS*, Inc., 2009, Chicago). Paper I used only descriptive statistics to present malaria prevalence. Prevalence was calculated by dividing the number of people who had Plasmodia species infection by the total number of people examined from the study population. Chi-squared test and 95% confidence intervals were used to compare differences between proportions. Households with missing values were not considered for analysis.

3.7. Statistical analysis

This study employed various statistical tools as summarized in the table below (Table 4).

Table 4: Different statistical tools applied to different studies, Butajira area, Ethiopia, Oct. 2008-Jun. 2010.

Paper	Data type	Statistics	Software	Effect size
I	Longitudinal	Descriptive statistics	SPSS 18.0	95% CI, *p*-value
II	Longitudinal	Multilevel Model (MLM), Mixed-effects Logistic Regression Analysis	STATA 11.0	95% CI, *p*-value, MOR, IOR-80
III	Longitudinal, & Cross-sectional	Principal Component Analysis (PCA); Complex Samples Analysis	SPSS 20.0, IBM® SPSS® Statistics	Odds Ratio, 95% CI, *p*-value
IV	Longitudinal	Descriptive statistics, Sensitivity, Specificity, PPV, NPV, *Kappa statistic*	SPSS 20.0, IBM® SPSS® Statistics	95% CI

OR=Odds Ratio, MOR=median odds ratio, IOR-80=interval odds ratio at 80%, CI=confidence interval.

3.7.2. Malaria risk factors (Paper-II)

The mixed-effects logistic regression in the STATA 11.0 software (StataCorp, College Station, Texas, USA) was used by employing multilevel analysis. Because of the binary nature of the dependent variable and to consider the hierarchical data structure (Table 5) with possible correlation between the repeat observations in individuals, a multilevel logistic regression model was fitted as recommended (100). This model computes the regression using a two-stage system of equations, which involves the lowest level and higher level equations.

In this case, individual as the lowest-level that explains the individual variation within each village; and village-level that explains variation among villages were entertained (Table 5). Previous malaria epidemiological studies have also applied multilevel analysis to identify malaria risk factors (11, 101).

Table 5: Two-level structure; individuals are clustered within villages, Oct. 2008 to Jun. 2010, Butajira area, Ethiopia.

# . **Higher Level** (Village) [n=16]	**Lowest Level** (Individuals) [N=19,199]
Dadesso	470
Horosso	1,381
Semeno	423
Wulbareg	668
Fasilo and Shibale	928
Gobrano	357
Goyiban	1,090
Yimero	230
Shershera	1,606
Bido	1,387
Kelakel	3,037
Wedo Zuriya	3,771
Agarega and Zenbaba Kolo	778
Kinbot and Jetena	1,150
Sunke and Wenz Akababi	1,032
Zenaba Kolo and Shifo	891

Villages are clusters of households in each study *kebele*.

The multilevel modeling is a stepwise process and the following three steps were performed. The first step, examined the empty model, i.e. without adjusting for predictors. The second step included individual-level predictors with village-level, and the final model was fitted using village-level and individual-level predictors identified significant in the second step to obtain the full model.

A total of 16 villages were selected from low, mid-level, and high altitudes. As shown in figure 5 below, the **pink**-coloured areas are those located in low altitude, the **dark**-coloured ones are from mid-level altitude, and the **red**-coloured ones are from high altitudes.

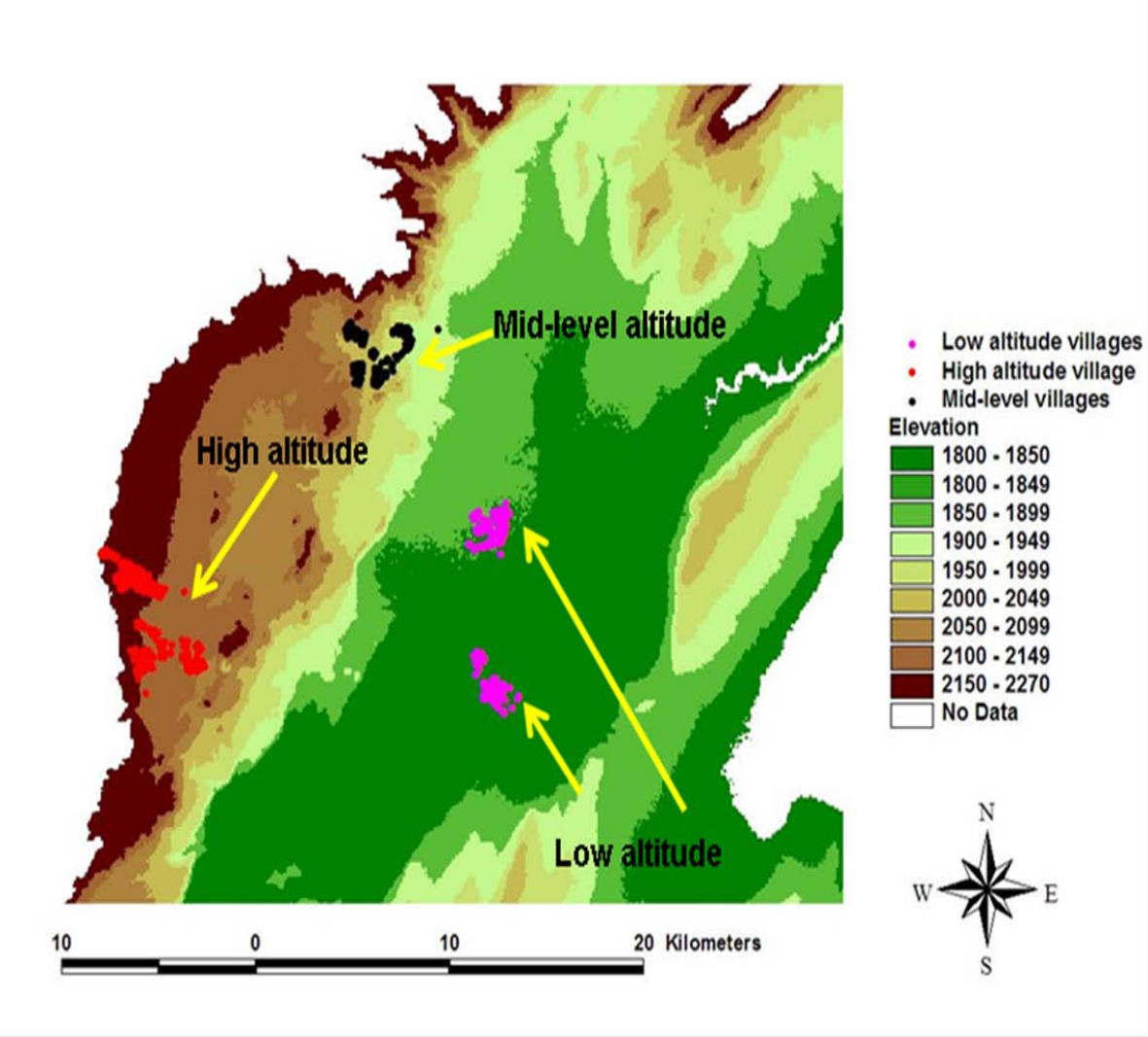

Figure 5: Showing villages at low, mid-level, and high altitudes, Butajira area, Ethiopia, Oct. 2008-Jun. 2010.

Descriptive statistics was performed to examine the characteristics of predictor variables. Multicollinearity was checked using linear regression as recommended (102), but no such evidence was found. A cross-level interaction between age groups and altitudinal strata were checked. Adjusted odds ratios with 95% confidence intervals and standard errors obtained from regression coefficients were used to assess the associations of the predictors and outcome variable.

Statistical significance was considered at $p<0.05$. Intra-class correlation coefficients (ICC), median odds ratios (MOR) and 80% interval OR (IOR-80) were computed to estimate village-level variance in *Plasmodium* infection. MOR and IOR-80 are recommended for estimating variability of binary outcomes to overcome contextual and interpretational problems with intra class correlation coefficient (ICC) in a binary outcome (100). The household wealth status was calculated using measureable assets. The details for computing household wealth status was described in our previous work (97).

3.7.3. Ownership and use of ITNs in relation to malaria infection [Paper-III]

In this study descriptive statistics, Principal Component Analysis, PCA, (SPSS 18.0), and Complex Samples Analysis (IBM® SPSS® Statistics, IBM Corp.) were used. SPSS software was used to do PCA to construct the relative household wealth index, as previously recommended (12, 103, 104). The ownership of household assets, type of usual water sources, type of product, and house construction material were used to build the wealth index as input to PCA. Household asset included land, cow, truck, mill, sewing machine, fridge, television, electricity line, telephone line, and kerosene. Types of products were wheat and barley, *Teff* (*Eragrostis tef*), pepper, Enset (*Ensete ventricosum*), and *Khat* (*Catha edulis*). House construction materials were types of roofing and presence of window.

Before performing PCA, suitability of the data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of 0.3 and above. The Kaiser-Meyer-Oklin (KMO) value was 0.88, greater than the recommended value of 0.6 and Bartlett's Test of Sphericity reached statistical significance (Chi-square =4479.4, *P*-value <0.0001). Thus, both test results were supporting the factorability of the correlation matrix. The PCA result was repeated with alterations until the resulting model was suitable for the survey data. Finally, we selected 11 indicators to run the final PCA. PCA revealed the presence of two components with eigenvalues above 1, explaining 36.0% and 9.8% variance in the dataset, respectively. The first principal component (with eigenvalues of 5.04) represented 36.0% of the variance in the sample and was used to generate the wealth index of the study households. The typical orthogonal rotation method known as varimax was used to minimize complexity of factors (simplify columns of loading matrix) by maximizing variance of loadings on each factor.

Eleven variables with greatest weights were loaded on the first principal component: possession of motorcycle (0.937), sewing machine (0.869), truck (0.869), television (0.809), grain-mill (0.646), lantern-kerosene (0.610), phone (0.575), electricity line (0.568), bicycle (0.423), types of sleeping places (0.356) and cart (0.355). The wealth index varied from -.256 to 13.27. Then, we ordered all households into three wealth groups: the "lowest" ranked group (30.9%, n=228), followed by the "middle" ranked group (35.7%, n=264), and finally the top third in the "higher" ranked group (33.4%, n=247). Paper III used data obtained through complex sample and hence Complex Samples Data Analysis was applied. This sampling method utilized cluster sampling of *kebele*s, villages and households. Thus, households within clusters were more similar than households randomly sampled from the population as a whole. This sampling design effectively reduces the information contained in each degree of freedom, which is called design effects (105). Complex sample violates the assumptions of independence of observations compelling to correct for design effects during data analysis. Evidence showed that data analysis that does not consider correcting for design effects leads to underestimation of standard errors and results in significance tests that are inappropriately sensitive (106).

A common practice to consider for appropriate modeling of the complex sample is computing weights for each individual in the data set as recommended (107). Briefly, weighting is used to correct disproportional sample sizes and adjust the collected data to represent the population from which the sample was drawn. The weight a case has is usually a function of the likelihood of inclusion in the sample. To adjust such distortion within a sample, every case will be assigned a weighting factor, by which the corresponding data is multiplied. This factor is determined by the proportion of the respective group or stratum in the population divided by the proportion of that group or stratum in the sample (the inverse of the sample fraction in each group). The weighting factor for each sample household was obtained by applying the syntax available in SPSS commands and procedures. The weighting factor equals % in population divided by % in sample. Household is the weighting factor in this study. The calculated values were assigned to each sample and saved as a new variable using SPSS syntax. The other important step in accounting for design effects is adjusting or normalizing weights. Weights were adjusted by dividing the weight by the mean of weights. Similarly, the adjusted weighting were saved to the

dataset for each case and accounted for all statistical operations. P-values <0.05 were considered statistically significant.

3.7.4. Evaluation of CareStart™ Malaria RDT [Paper-IV]

The WHO recommended cut-off for sensitivity (95%) and specificity (90%) was applied to categorize malaria RDTs with low precision (108). Paper IV applied descriptive and *Kappa* statistics for data analysis. Sensitivity, specificity, positive and negative predictive values were computed from cross tabulation of performance of RDT against microscopy as used by another study(109). Descriptive statistics was obtained as SPSS outputs. *Kappa* statistics was computed using recommended procedures (110).

3.8. Ethical consideration

The studies obtained ethical approval from Institutional Review Board of the College of Health Sciences of the Addis Ababa University, and from the Ministry of Science and Technology of Ethiopia. The local and regional health authorities were informed. Individual informed consent was obtained from adults, and from parents or guardians of children aged less than 18 years. Both electronic and hard copy of the information collected from each participant was kept confidential. In addition, data analysis was performed on coded individual data. Blood film collection procedure, which is routinely used in health facilities, was applied. Fingers were cleaned with alcohol swab and gently pricked with sterile blood single-use lancets to obtain 4-6µl of blood to prepare thin and thick films. For febrile cases, blood films were collected and applied on grooves of malaria RDTs using a capillary prepared for this purpose. Blood film collection was performed by trained and experienced health professionals. Obviously, a transient pain can be experienced after pricking. Participants were advised to hold their pricked finger with alcohol swab to stop more bleeding. Malaria RDT result was declared after 20 minutes and all patients with malaria during the survey were directly treated according to the national guideline (111). Moreover, artemether-lumefantrine and chloroquine stocks were kept at health posts for treatment of cases occurring between our repeated surveys. Participants were informed that they can drop out from the study at any time. This was equally explained during interview and house-to-house survey.

4. MAIN FINDINGS

The main findings of this thesis are based on four studies as stipulated in the specific aims. Those studies consisted of estimating malaria prevalence, identifying risk factors, using ITNs and malaria infection, and evaluating performance of CareStart^{TM} Malaria rapid diagnostic tests detecting *Plasmodium falciparum* and *Plasmodium vivax*. The summary of main findings in each paper is presented in Table 6 below and details described in the following section.

Table 6: Summary of the main findings of each study, Butajira area, Ethiopia.

Topic	Main findings
Malaria prevalence	Low malaria prevalence at highland-fringe area (0.93%, 178 of 19,207); Malaria prevalence increased from high to low altitudes: Low (1.91%), Mid-level (1.37%) and high (0.36%); Prevalence varied among villages (0%-2.8%), higher at low altitude; Malaria varied among different age groups, and varying in different ways at different altitude; Malaria present throughout the year, but predominant following main rainy season; *Plasmodium vivax* was found in all survey periods, but varied with respect to survey period.
Malaria risk factors	Malaria is age and altitude dependent; Malaria is more prevalent in children aged <5 and 5-9 years; low altitude, mid-level altitude, and houses with holes; Multilevel analysis identified individual-level (age) and village-level risk factors (altitude).
Use of ITNs and malaria infection	Very low ITN coverage (28.5%) with higher deficit between the targets of the NMCP; Household ITN ownership associated with no education, absence of main water body, not practicing source reduction, presence of two or more beds, and male-headed household; Use of ITN associated with number of ITN hanging, owned, not practicing source reduction and located within a kilometer distance; More malaria infection observed in individuals from ITN-owning households (2.1%) compared to their counterparts (0.5%)
Performance of malaria RDT	Varying sensitivity for different settings: (1) at field: 90.8% for *Plasmodium,* and (2) health facility: 95.7% for *Plasmodium*; Lower PPV (76.7%) for *Plasmodium falciparum*, and lower NPV (77.2%) for *Plasmodium vivax*.

4.1. Prevalence of malaria infection [Paper I]

The unadjusted prevalence of malaria was 0.93 % [95% CI 0.79-1.07]. However, the prevalence varied among the villages with the highest prevalence of 2.8% in Dadesso and Horosso villages (both below 1,850 masl), and the lowest prevalence (0.0%) at Sunke Wenz and Akababi village (2,100-2,180 masl). Malaria also varied with altitude with prevalence of 1.91% [95% CI (1.55-2.27)] in low, 1.37% [95% CI (0.87-1.87)] in mid-level and 0.36% [95% CI (0.25-0.47)] in high altitude zones. The highest prevalence was found at low altitude between October and November 2009 (Table 7).

Table 7: Prevalence of malaria in different altitudes in six survey periods, Butajira area, Ethiopia, 2008-2010.

Seasons	Low		Mid-level		High		Total, n (%)
	Pos. /Exam., n	Prev., %	Pos. /Exam., n	Prev., %	Pos. /Exam., n	Prev., %	
Oct.-Nov.'08	16/1003	1.59	2/353	0.57	2/2060	0.97	20 (11.36)
Jan.-Feb.'09	6/928	0.65	2/348	0.57	3/1929	0.15	11 (6.25)
Jun.-Jul.'09	16/951	1.68	8/339	2.36	3/1937	0.15	27 (15.34)
Oct.-Nov.'09	43/924	4.76	8/345	2.32	20/1941	1.03	71 (40.34)
Jan.-Feb.'10	21/920	2.28	6/317	1.89	7/1890	0.37	34 (19.32)
Jun. '10	4/822	0.49	2/338	0.59	7/1862	0.37	13 (7.39)
Total	106/5548	1.91	28/2040	1.37	42/11619	0.36	176 (100)*

Pos. =positive, Exam. =Total examined, Prev. = Prevalence;
*Two were mixed infections of falciparum and vivax malaria.

Malaria varied among age groups, and in a different way at varying altitudes. At mid-level altitudes, malaria infection reached its peak in children aged one to four years and at low altitudes in children aged one to nine years. However, its prevalence at higher altitude was low and was similar across all age groups (Figure 6).

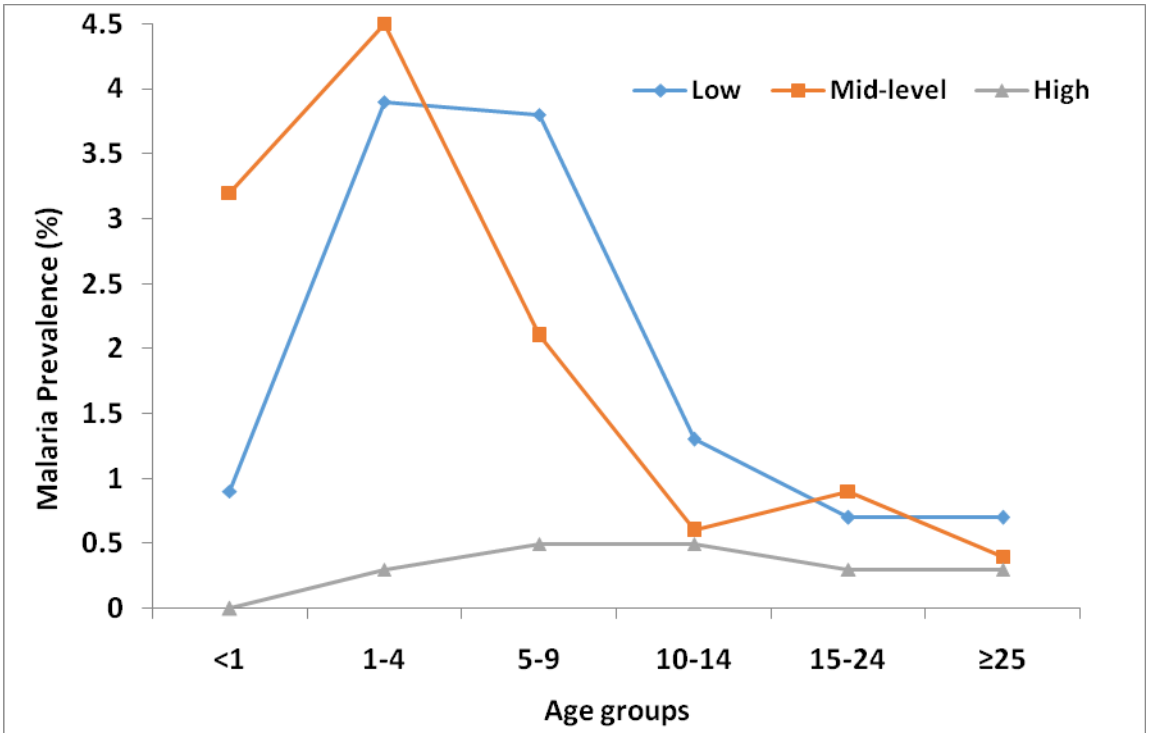

Figure 6: Age-specific prevalence of all forms of malaria infection by altitudinal strata, Butajira area, Ethiopia, 2008-2010.

Table 8: shows that *Plasmodium falciparum* malaria occurred rarely throughout the survey periods, with relatively more cases during the survey from October-November 2009 in the low altitude zone.

Table 8: Prevalence of Plasmodium falciparum (n=22) in Butajira area, Ethiopia, 2008-2010.

Altitude Zone	Low		Middle		High	
Season	Pos. /Exam., n	Prev., %	Pos. /Exam., n	Prev., %	Pos. /Exam., n	Prev., %
Oct-Nov.'08	0/1003	0	2/353	0.57	0/2060	0
Jan.-Feb.'09	0/928	0	0/348	0	0/1929	0
Jun.-Jul.'09	6/951	0.63	0/339	0	0/1937	0
Oct.-Nov.'09	11/924	1.19	0/345	0	3/1941	0.15
Jan-Feb.'10	0/920	0	0/317	0	0/1890	0
Jun. '10	0/822	0	0/338	0	0/1862	0
Total	17/5548	0.31	2 /2040	0.10	3/11619	0.03

Pos. = Positive, Exam. = Total examined, Prev. = Prevalence.

Plasmodium vivax was found in all survey periods; however, the prevalence of *Plasmodium vivax* differed with respect to survey period and altitude (Table 9).

Table 9: Prevalence of Plasmodium vivax (n=154) in Butajira area, Ethiopia, 2008- 2010.

Altitude Zone	Low		Middle		High	
Seasons	Pos. / Exam., n	Prev., %	Pos. / Exam., n	Prev., %	Pos. / Exam., n	Prev., %
Oct.-Nov.'08	16/1003	1.59	0/353	0	2/2060	0.97
Jan.-Feb.'09	6/928	0.65	2/348	0.57	3/1929	0.15
Jun.-Jul.'09	10/951	1.05	8/339	2.36	3/1937	0.15
Oct.-Nov.'09	32/924	3.46	8/345	2.32	17/1941	0.87
Jan.-Feb.'10	21/920	2.28	6/317	1.89	7/1890	0.37
Jun. '10	4/822	0.49	2/338	0.59	7/1862	0.37
Total	89/5548	1.60	26/2040	1.27	39 /11619	0.34

Pos. = Positive, Exam. = Total examined, Prev. = Prevalence.

4.2. Malaria risk factors [Paper-II]

A total of 19,199 individuals with complete data were used for this study. Most of the participants were 15 years of age and above with a mean (±SD) age of 20.4 (±17.1) years. About 51% of the participants were females. Malaria prevalence was estimated as 0.78 (95% CI: 0.48-1.29) in adjusting for residence of village and 0.93 (95% CI: 0.81-1.08) in unadjusted estimation. In our similar work, we found most of the infections were due to *Plasmodium vivax* (86.5%, n=154) and the rest due to *Plasmodium falciparum* (12.4%, n=22) and mixed infections (1.1%, n=2). Multilevel multivariate logistic regression analysis found persistent association of age, altitudinal strata and house status with higher risk of malaria infection (Table 10). Children aged below five years (adjusted OR= 3.62; 95% CI: 2.42-5.40) and those aged 5-9 (adj. OR= 3.46; 95% CI: 2.34-5.12) were affected most. The low altitude (adj. OR= 5.15; 95% CI: 2.57-10.32; IOR-80: 3.45-7.69), mid-level altitude (adj. OR= 3.32; 95% CI: 1.62-6.81; IOR-80: 2.22-4.95) and houses with holes in walls (adj. OR= 1.58; 95% CI: 1.11-2.25; IOR-80: 1.06-2.36) were also associated with increased malaria infection.

Table 10: Predictors of malaria risk obtained from multilevel logistic regression analysis, Butajira area, Ethiopia, Oct. 2008 to Jun. 2010.

Factors	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Fixed effects		
Individual-level factors		
Age groups		
<5	3.66 (2.45-5.46)**	3.62 (2.42-5.40)**
5-9	3.47 (2.35-5.14)**	3.46 (2.34-5.12)**
10-14	1.52 (0.90-2.59)	1.50 (0.88-2.55)
Gender: Male	1.33 (0.99-1.80)	1.25 (0.93-1.69)
Village-level factors		
Altitudinal Strata		
Low	4.97 (3.07-8.03)**	5.15 (2.57-10.32)**
IOR-80%		(3.39-7.84)
Mid-level	3.06 (1.47-6.37)*	3.32 (1.62-6.81)*
IOR-80%		(2.18-5.05)
Wealth group		
Lowest	1.62 (0.81-3.23)	0.75 (0.37-1.55)
Middle	1.15 (0.68-1.96)	0.97 (0.57-1.65)
House status		
Dilapidated	0.98 (0.59-1.62)	0.94 (0.56-1.57)
Walls with holes	1.57 (1.11-2.23)*	1.58 (1.11-2.25)*
IOR-80%		(1.04-2.41)

*p<0.05, **p<0.001, IOR-80=interval odds ratio-80.

Table 11 presents the individual- and village-level variance using coefficients and 95% confidence interval. The estimates of village-level variances showed well explained differences in malaria infection. The village-level intercept variance for the individual-level predictor (0.77 [95% CI: 0.31-1.95]; SE=0.21) and final model (0.053, [95% CI: 0.004-0.680]; SE=0.15) were lower than that of empty model (0.84, [95% CI: 0.34-2.09]; SE=0.21). The ICC value for the final model was 94.0%.

Table 11: Results showing coefficients of multilevel models predicting the probability of Plasmodium infection, Butajira area, Ethiopia, Oct. 2008 to Jun. 2010.

Parameters	Empty model Coefficients [95% CI] (SE)	Individual-level predictor model Coefficients [95% CI] (SE)	Final model Coefficients [95% CI] (SE)
Fixed effects			
Village intercept	0.78 [0.48-1.29] (0.25)	0.36 [0.48-1.29] (0.29)	0.16 [0.09-0.27] (0.27)
Age group			
<5		1.28 [0.88-1.68] (0.20)**	1.28 [0.88-1.69] (0.20)**
5-9		1.23 [0. 84-1.63] (0.20)**	1.24 [0.85-1.63] (0.20)**
10-14		0.41 [-0.12-0.94] (0.27)	0.40 [-0.12-0.93] (0.27)
Gender: Male		0.22 [-0.08-0.52] (0.15)	0.22 [-0.08-0.52] (0.15)
Strata			
Low			1.64 [0.94-2.33] (0.35)**
Middle			1.20 [0.48-1.92] (0.37)*
Wealth status			
Lowest			-0.28 [-0.08-0.52] (0.37)
Middle			-0.03 [-0.56-0.50] (0.27)
House status			
Dilapidated			-0.01 [-0.56-0.50] (0.26)
With holes			0.46 [0.10-0.81] (0.18)*
Random effects			
Village intercept variance	0.84 [0.34-2.09] (0.21)	0. 77 [0.31-1.95] (0.21)	0.053 [0.004-0.680] (0.15)
ICC (%)	20.3	19.0	1.1
MOR	2.39 (0.21)	2.30 (0.21)	1.24 (0.15)
PCV (%)	-	8.3	94.0

*$p<0.05$; SE=standard error of variance, ICC = intra-class correlation coefficient, MOR=median odds ratio, PCV= proportional change variance.

Moreover, the MOR values for the empty (2.39±0.21), individual-level predictors (2.30±0.2) and final (1.20±0.16) models were large indicating the between-village difference in the risk of malaria infection. MOR equal to 1.20 shows that difference between-village increased by 1.20 times the individual OR of getting a malaria infection when randomly picking out two persons in different villages.

4.3. Ownership and use of ITNs in relation to malaria infection [Paper-III]

Of the total 739 household heads interviewed more than half (55%) were females. The age of participants varied from 18 to 99 years and with mean age of 39.2 years. Of the 739 households surveyed, 28.5% [95%CI 25.8-31.4] owned at least an ITN, with a mean of 1.54 [95% CI 1.45-1.63] ITNs *per* household. Households possessing ≥2 ITNs were less than half (47.4% [95% CI 40.0-55.0) and all of them were from low altitude. Household ITN ownership was higher in low altitude (n=155, 62.1% [95% CI 56.2-67.6]; $F_{(1, 285)}$ =16.3, P<0.001) than in high altitude (n= 16, 3.5% 95% CI [2.1-5.7%]; $F_{(1, 452)}$ =377.1, P<0.001). Among ITN-owning households (n=171), 85% [95% CI 79.0-89.5] had at least a family member who slept under a net (n=142) the night *prior* to the survey. However, we observed ITN hung in less than half (43.6% [95% CI 36.3-51.2%]) of the households owning at least an ITN (data not shown).

Household heads with no formal education had above 35-fold higher ITN ownership compared to those with formal education. Household characteristics such as absence of main water body (above 6-fold), not doing mosquito source reduction (more than 3-fold) and presence of two or more beds in the household were significantly associated with increased household ITN possession than their counterparts. Male-headed households were also significantly associated with increased ITN ownership than female-headed households (Table 12).

Table 12: Predictors of household ITN ownership (N= 739) obtained from Complex Samples Logistic Regression Model, Butajira area, Ethiopia, Oct.-Nov. 2008.

Household characteristics	Unadjusted		Adjusted	
	OR	95% CI of OR	OR	95% CI of OR
Household head Education				
Not educated	**31.3**	**9.4-104.4**	**35.1**	**10.6-116.2**
Educated	1		1	
Wealth status				
Low	1.5	1.0-2.2	1.3	0.7-2.4
Middle	**0.5**	**0.3-0.9**	0.8	0.4-1.5
High	1			
Female-headed				
No	1.3	0.9-2.0	**1.7**	**1.05-2.89**
Yes	1		1	
Number of beds				
1	1			
≥2	**2.1**	**1.4-3.1**	**2.7**	**1.6-4.6**
Mosquito source reduction				
No	**4.7**	**3.1-7.0**	**3.4**	**2.1-5.5**
Yes	**1**		**1**	
Main water body				
None	**6.5**	**3.9-10.8**	**6.4**	**3.5-11.8**
<1 km	1.9	1.2-2.9	1.1	0.6-1.9
≥1km	1			

HH head's educational status, wealth status, gender, number of beds, mosquito source reduction and distance from main water body were included in the final model and controlled for these variables.

Households with ITN observed hanging, two and more number of ITN owned, not doing source reduction and farming occupation showed statistically significant association with the likelihood

to use ITN. Of those, the presence of more ITN hanging in a household is a good predictor of ITN use (Table 13).

Table 13: Predictors of household ITN use (N=171) obtained from Complex Samples Logistic Regression Model, Butajira area, Ethiopia, Oct.-Nov. 2008.

Household factors	Unadjusted		Adjusted	
	OR	95% CI of OR	OR	95% CI of OR
No. of ITNs hanging				
0	1			
1-2	**12.1**	**3.5-42.4**	**21.0**	**5.2-85.1**
No. of ITNs owned				
1	**1**			
2-4	**4.3**	**1.5-12.1**	**4.8**	**1.3-17.5**
Mosquito source reduction				
No	**2.8**	**1.2-6.9**	**4.2**	**1.3-13.6**
Yes	1		1	
Wealth status				
Low	**3.3**	**1.1-9.9**	**3.55**	**1.04-12.14**
Middle	0.7	0.3-1.9	0.51	0.15-1.69
High	1		1	
Main water body				
None	1.3	0.5-3.3	1.7	0.6-5.4
<1 km	2.1	0.7-5.8	**3.9**	**1.2-12.1**
≥1 km	1		1	

HHs with hanging nets, number of ITN owned, mosquito source reduction, wealth status and distances from main water body were entered into the final model and controlled for these variables.

About two-thirds (63.6%) of the participants were from low wealth index category; while less than 10% each were from households with middle and high wealth index categories in ITN-owning households. Higher prevalence was found in people surveyed from ITN-owning than non-ITN-owning households, 2.1% versus 0.5%, (Table 14). Malaria infection was more often observed in households owning at least an ITN than in their counterparts (unadjusted OR 4.1 [95% C.I. 2.2-7.6]; $F_{(1, 22)} = 25.2$, $P<0.001$) (data not shown).

Table 14: Household ITN ownership status in relation to malaria infection in Butajira area, Ethiopia, Oct. 2008-Jun. 2010.

Variables	Total slides screened	**Prevalence (P) of malaria infection**			
		Total	ITN-owning	None ITN-owning	
		P (95% CI), n	P (95% CI), n	P (95% CI),	n
Overall	**19199**	**1.0 (0.8-1.2), 178**	**2.1 (1.6-2.8), 94**	**0.5 (0.4-0.7),**	84
Age					
<5	3042	1.8 (1.0-3.3), 54	3.4 (2.2-5.4), 29	1.0 (0.4-2.5),	25
5-9	3513	1.8 (0.9-3.7), 59	4.5 (2.4-8.1), 38	0.7 (0.4-1.2),	21
10-14	2702	0.8 (0.4-1.5), 20	1.5 (0.9-2.6), 9	0.5 (0.2-0.9),	11
15-99	9942	0.5 (0.4-0.6), 45	0.8 (0.5-1.5), 18	0.3 (0.2-0.5),	27
Sex					
Male	9347	1.2 (0.7-2.0), 99	2.6 (1.5-4.4), 56	0.6 (0.4-0.8),	43
Female	9852	0.8 (0.5-1.3), 79	1.7 (1.3-2.2), 38	0.5 (0.3-1.0),	41
Altitudinal strata					
Low	5547	1.9 (1.5-2.4), 107	2.3 (1.7-2.9), 91	1.0 (0.6-1.7),	16
Mid-level	2034	1.4 (0.9-2.3), 29	1.1 (0.4-2.7), 1	1.4 (0.8-2.4),	28
High	11618	0.3 (0.2-0.5), 42	0.4 (0.1-1.6), 2	0.3 (0.2-0.5),	40
Survey seasons					
Oct.-Nov. 2008	3419	0.7 (0.3-1.8), 20	1.8 (0.6-5.2), 14	0.2 (0.1-0.8),	6
Jan.-Feb. 2009	3205	0.4 (0.2-0.6), 11	0.6 (0.3 1.1), 4	0.3 (0.1-0.7),	7
Jun.-Jul. 2009	3229	0.9 (0.4-1.7), 27	1.9 (0.9-3.7), 14	0.5 (0.2-1.0),	13
Oct.-Nov.2009	3213	2.4 (1.5-4.0), 72	5.3 (3.2-8.5), 38	1.3 (0.9-1.8),	34
Jan.-Feb. 2010	3120	1.1 (0.6- 2.3), 35	2.6 (1.4-4.8), 21	0.5 (0.2-1.2),	14
Jun. 2010	3013	0.4 (0.2-0.9), 13	0.4 (0.1-1.5), 3	0.4 (0.2-1.0),	10
Wealth index					
Low	6379	1.8 (1.2-2.5), 111	2.1 (1.3-3.3), 79	1.2 (0.8-1.8),	32
Middle	6419	0.7 (0.4-1.2), 40	3.6 (1.8-7.1), 12	0.4 (0.3-0.7),	28
Higher	6401	0.3 (0.2-0.8), 27	0.6 (0.2-2.2), 3	0.3 (0.1-0.8),	24

4.4. CareStart™ Malaria RDT Precision [Paper-IV]

This study used complete data from 2,394 self-reportedly febrile cases. Febrile cases visiting OPD were prospectively recruited at two health centres (66.8%, n=1,598) and household surveys (33.2%, n=796). More participants were recruited from Enseno Health Centre (73.7%, 1,178 of 1,598) and the rest from Butajira Health Centre (26.3%, 420 of 1,598). Mean (±SD) age was 13.9±13 and median 10 years (one month to 70 years) health centre surveys; and 19.7±18.2 (one month to 99 years) with median 13 years in household surveys. A total of 31 infants (six from household and 25 from health centre surveys) suspected for malaria were screened.

The microscopic results showed that 10.9% (n=87) of people examined were *Plasmodium* positive in the household surveys. Of those, 83.9% (n=73) were caused by *P. vivax*, 15.0% (n=13) were due to *P. falciparum*, and the rest 1.1% (n=1) were mixed infections due to both vivax and falciparum malaria. Similarly, 24.5% (n=392) of people were malaria infected among febrile cases visited health centres. Among them, 78.6% (n=308) were *P. vivax*, 20.4% (n=80) were *P. falciparum*, and the rest 1.0% (n=4) were mixed infections due to both vivax and falciparum malaria. Eight of 25 (32%) children below six months were diagnosed as *P. vivax* infected.

Plasmodium infection varied among different age groups, and males were more infected than females in both survey settings. Higher proportion of the malaria infection occurred during peak malaria transmission in both survey settings. About 67% of the total positives cases were screened during October-November 2009 and about 20% during October-November 2008 in household surveys. Moreover, above half of the positives during October 2009 and one-fifths during August and November 2009 each, in the health facility-based surveys (Table 15).

Table 15: Characteristics of study participants in household and health facility-based surveys, Butajira area, Ethiopia, 2008-2010.

Factors	Household survey (N=796), n%	Microscopy positive (n=87), n(%)	Health centres (N=1,598), n (%)	Microscopy positive (n=392), n(%)
Age groups				
<5	178 (22.4)	27 (31.0)	495 (31.0)	117 (29.8)
5-9	150 (18.8)	28 (32.2)	293 (18.0)	84 (21.4)
10-14	86 (10.8)	10 (11.5)	179 (11.2)	56 (14.3)
≥15	382 (48.0)	22 (25.3)	63 (39.5)	135 (34.4)
Gender				
Male	382 (48.0)	48 (55.2)	754 (47.2)	203 (51.8)
Female	414 (52.0)	39 (44.8)	844 (52.8)	189 (48.2)
Seasons				
Oct.-Nov.2008	603 (75.7)	17 (19.5)		
Oct. 2008			63 (3.9)	9 (2.3)
Nov.2008			18 (1.1)	12 (3.1)
Jan.-Feb.2009	46 (5.8)	2 (2.3)		
Jun.-Jul. 2009	46 (5.8)	9 (10.3)		
Aug. 2009			156 (9.8)	76 (19.4)
Sept. 2009			28 (1.8)	13 (3.3)
Oct.-Nov.2009	100 (12.6)	58 (66.7)		
Oct.2009			721 (45.1)	201 (51.3)
Nov.2009			521 (32.6)	78 (19.9)
Dec.2009			91 (5.7)	3 (0.8)
Jan.-Feb.2010	0			
Jun.2010	1 (0.1)	1 (1.0)		

Table 16 presents the sensitivity, specificity, positive and negative predictive values of CareStart^{TM} RDT compared to microscopy in both surveys. CareStart^{TM} RDT showed low sensitivity in overall *Plasmodium* (90.8%) and *P. falciparum* (87.5%) in household survey; and in *P. vivax* (92.8%) in health facility surveys.

Table 166: Performance of CareStart^{TM} Malaria *Plasmodium falciparum*/*Plasmodium vivax* Combo test in febrile cases, Butajira area, Ethiopia, Oct.2008-Jun. 2010.

Setting/indicators	Sensitivity	Specificity	PPV	NPV	*Kappa*
Health Centres					
All *Plasmodium*	95.7 (93.2-97.3)	82.7 (80.5-84.8)	64.3 (60.3-68.1)	98.3 (97.3-99.0)	0.69
*P. falciparum**	95.9 (88.7-98.6)	92.8 (89.3-95.2)	77.2 (67.6-84.5)	98.9 (96.8-99.6)	0.81
*P. vivax**	92.8 (89.3-95.2)	95.9 (88.7-98.6)	98.9 (96.8-99.6)	77.2 (67.6-84.5)	0.81
Household surveys					
All *Plasmodium*	90.8 (82.9-95.3)	96.6 (95.0-97.7)	76.7 (67.7-83.8)	98.8 (97.7-99.4)	0.81
*P. falciparum**	87.5 (52.9-97.8)	98.5 (91.9-99.7)	87.5 (52.9-97.8)	98.5 (91.9-99.7)	0.86
*P. vivax**	98.5 (91.9-99.7)	87.5 (52.9-97.8)	98.5 (91.9-99.7)	87.5 (52.9-97.8)	0.86

*Mixed infections excluded, PPV= Positive predictive value, NPV= Negative predictive value.

Similarly, low specificity observed in overall *Plasmodium* (82.7%), and *P. falciparum* (92.8%) in health facility surveys, and in *P. vivax* (87.5%) in household surveys. Moreover, lowest PPV was determined in overall *Plasmodium* (64.3%) and *P. falciparum* (77.2%) in health facility; and

overall *Plasmodium* (76.7%) and *P. falciparum* (87.5%) in household surveys. Negative predictive value of the test was good in both overall *Plasmodium* and *P. falciparum*. However, lowest NPV was found in *P. vivax* in both health facility (77.2%) and household (87.5%) surveys. The test and microscopy showed almost perfect agreement for household and health centres surveys (Table 16).

Figure 7 presents varying RDT performance among different seasons in household surveys. Sensitivity varied between 82.3% and 100%, and specificity between 78.4% and 98.6%. Low sensitivity (82.3) was observed during October-November 2008 and low specificity (78.4%) during June-July 2009. The lowest PPV of 63.6% (October-November 2008), 40.0% (January-February 2009), and 50.0% (June-July 2009) was obtained; and it appears corresponding with malaria infection of 19.5%, 2.3% and 10.3%, respectively. Over all RDT precision was found to be better during October-November 2009 (Figure 7).

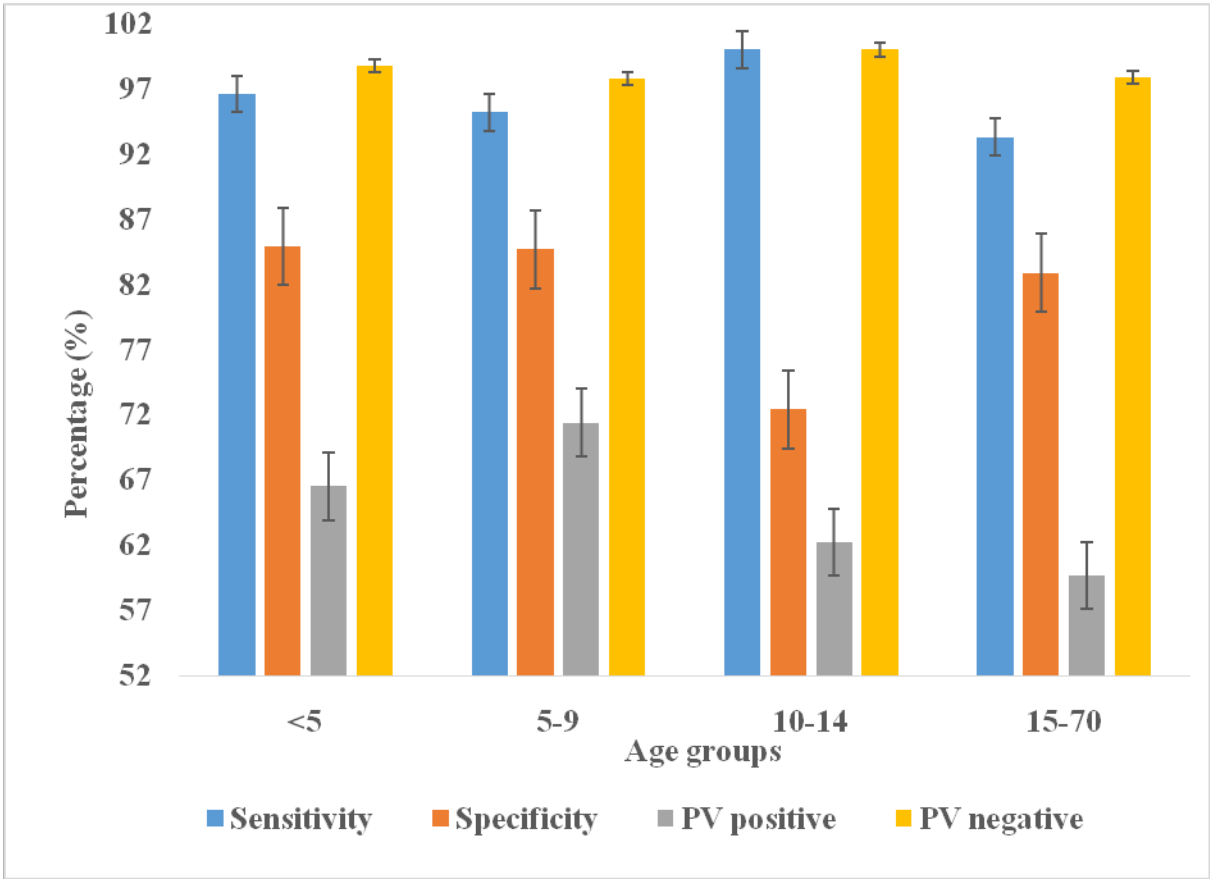

Figure 7: CareStart™ Malaria RDT performance in different seasons for household surveys, Butajira area, Ethiopia, Oct.2008-Nov. 2009.

The highest proportion of positives (40.3%, 71 of 176) were found during October-November 2009 compared to the rest of the seasons (6.2-19.3%) (97). In health facility surveys, the sensitivity was between 93.6% and 100%. Good sensitivity of from 98.7% to 100% was observed, except the relatively low sensitivity during October 2009 (94.5%) and November 2009 (93.6%). Specificity (73.6-96.3%) while substantial differences in PPV and NPV. Low PPV of 60.9-92.3% in all seasons, and the least (14.3%) in December 2009 was observed. Highest NPV (97.3-100%) was obtained, except the lowest (38.5%) was found in November 2008, which overlapped with a few malaria suspected cases (n=18) were screened (Figure 8).

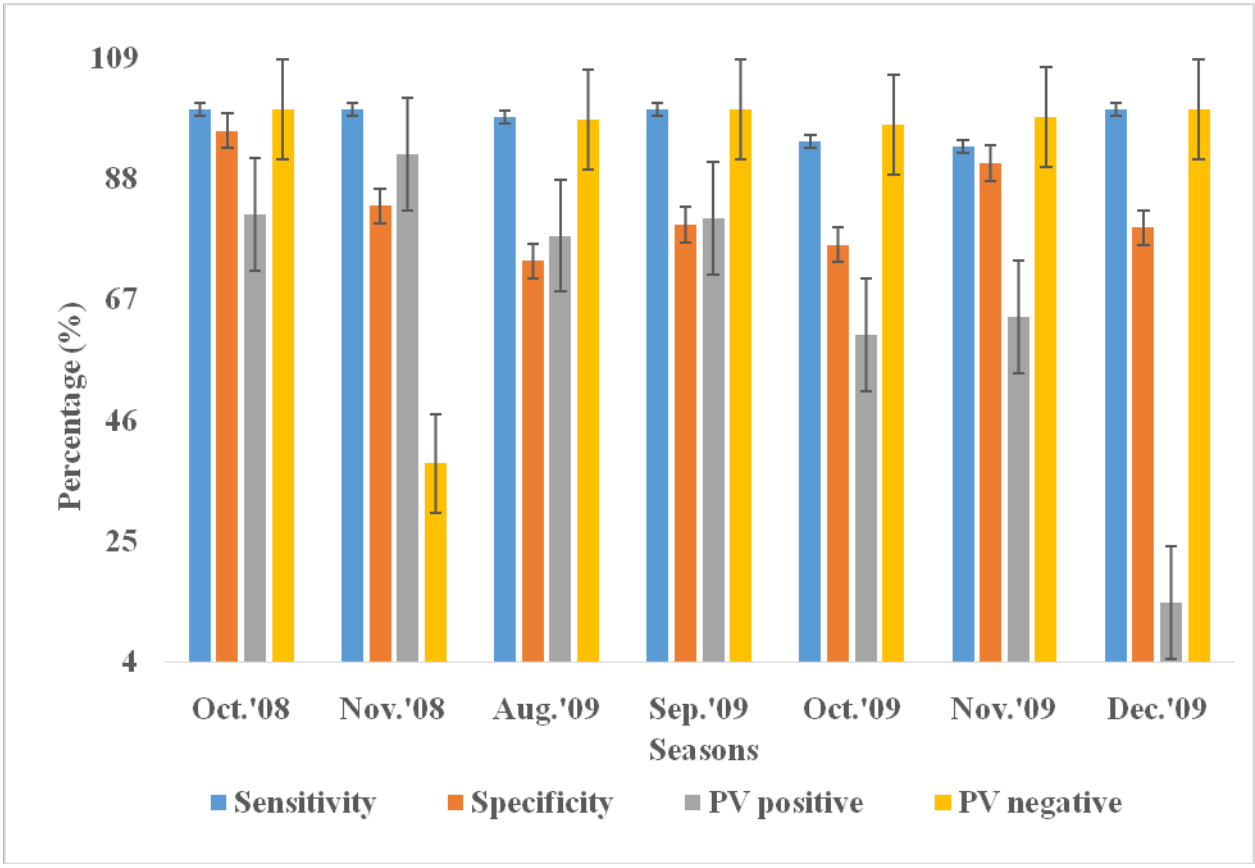

Figure 8: CareStart™ Malaria RDT precision in various seasons for health facility surveys, Butajira area, Ethiopia, Oct.2008-Dec. 2009.

Low sensitivity was seen in <5 aged (84.6%) and 5-9 aged (89.5%) children compared to older children, 10-14 years (100%) and ≥15 years (95.4%). However, good specificity with almost similar precision (94.7-97.5%) was revealed in different age categories; and low PPV (67.7-89.3%), and highest NPV (97.3-100%) was determined (Figure 9).

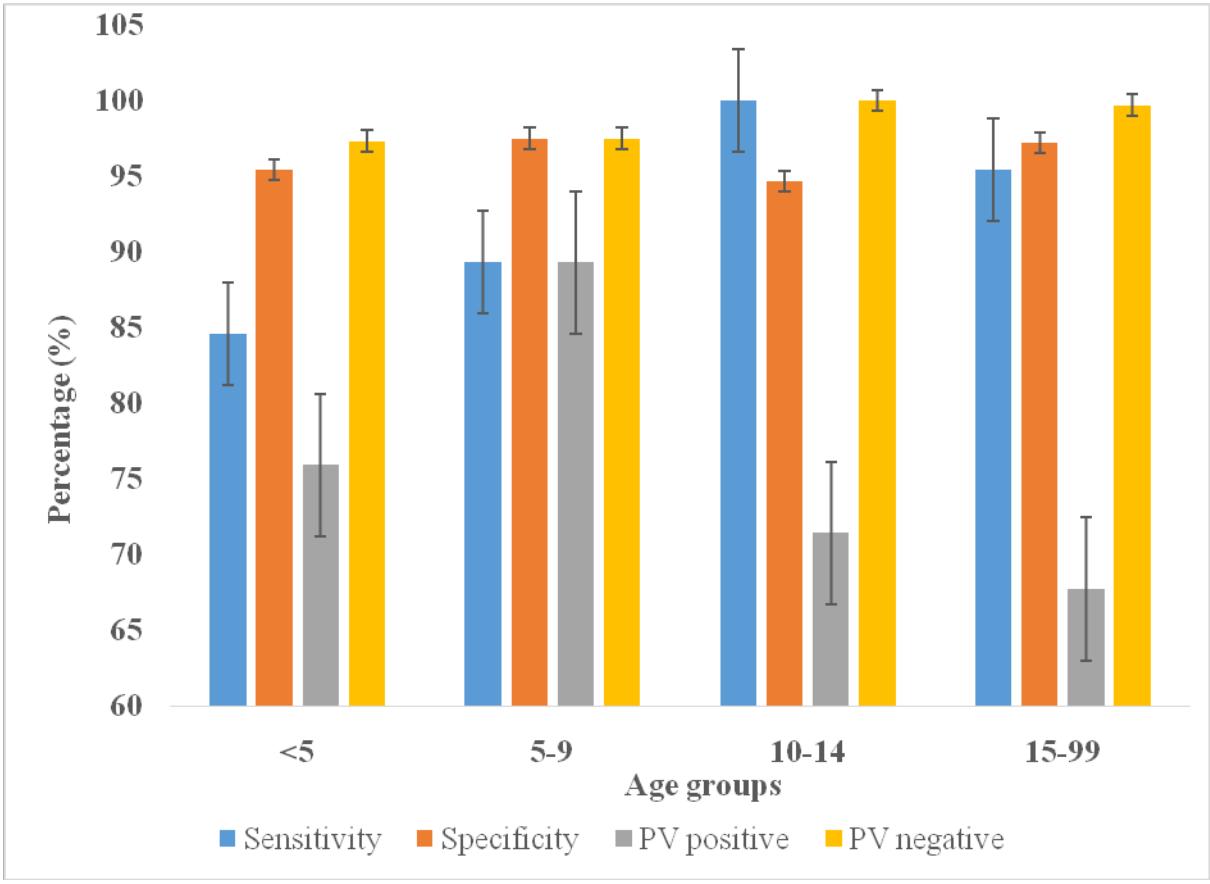

Figure 9: CareStart™ Malaria RDT precision for different age categories in household surveys, Butajira area, Ethiopia, Oct.2008-Nov. 2010.

In health facility-based surveys, RDT demonstrated persistently good sensitivity (95.2-100%) in children aged between <5 and 10-14 years, except 93.3% in ≥15 years. Low specificity (72.4%-84.9%) and PPV (59.7-71.4) was observed in all age groups, extremely low PPV in <5 and ≥15 years. (Figure 10). NPV was the highest throughout the survey in both survey settings.

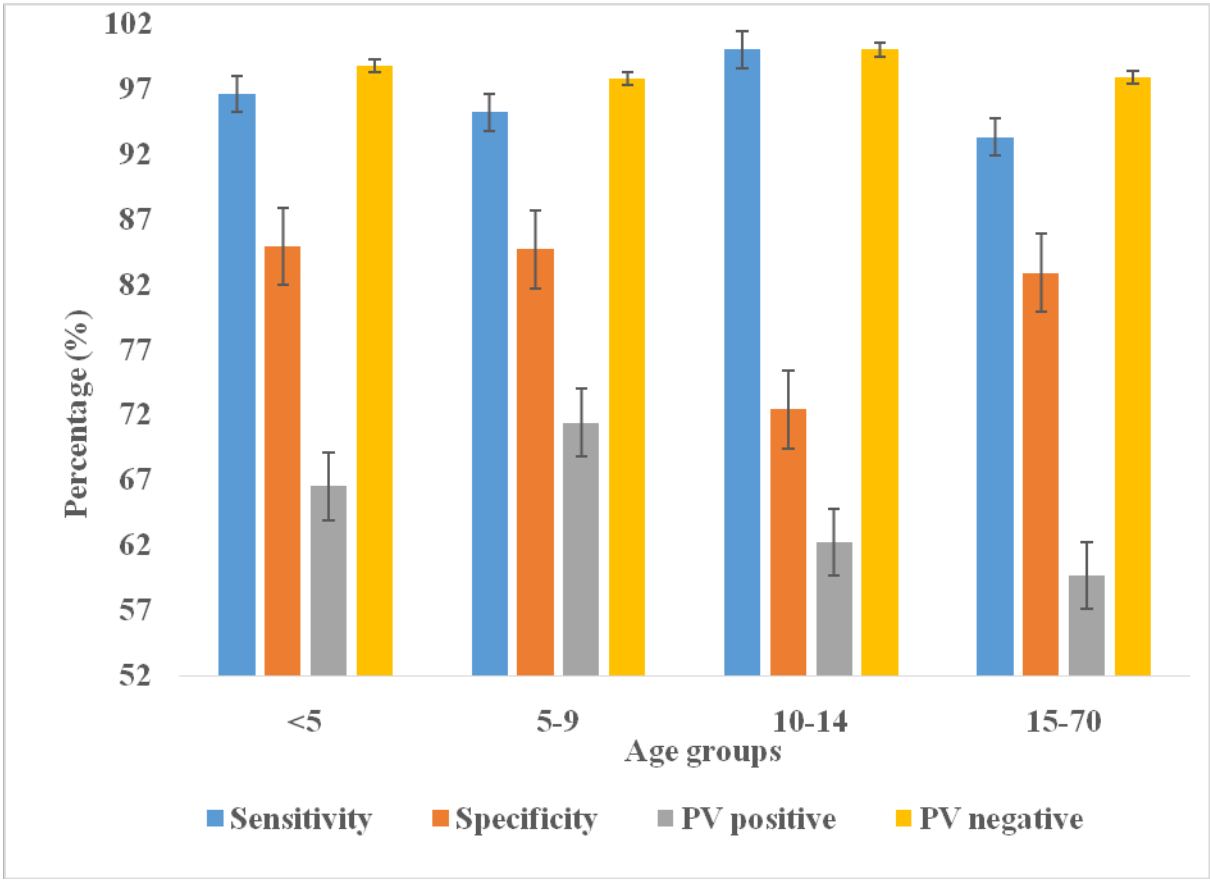

Figure 10: CareStart™ Malaria RDT precision for different age categories in health facility surveys, Butajira area, Ethiopia, Oct.2008-Dec. 2009.

CareStart™ RDT missed a few *P. vivax* (4.5%, n=10) and *P. falciparum* (5.9% n=5) with asexual parasite count of ≥ 500 p/µl of the microscopy confirmed at health facilities. Moreover, the RDT failed to detect 10.3% (n=7) of vivax malaria, five of those with ≥ 500 p/µl and the rest two with <200 p/µl in household survey. However, a single (1 of 13) falciparum case was missed by RDT in household surveys (Table 17).

Table 17: Comparison of asexual parasite count per micro-litre (p/µl) and RDT result in health centres and household surveys, Butajira area, Ethiopia, 2008-2010.

Setting/*Plasmodium*	*Plasmodium vivax* (n=220)		*Plasmodium falciparum* (n=85)*	
Health centres visit	RDT negative, n	RDT positive, n	RDT negative, n	RDT positive, n
60-199	0	0	0	1
200-499	0	5	0	5
500-4,999	3	107	2	19
5,000-90,000	7	98	3	55
Total, n (%)	10 (4.5)	210 (95.5)	5 (5.9)	80 (94.1)
Setting/*Plasmodium*	*Plasmodium vivax* (n=68)		*Plasmodium falciparum* (n=13)	
Household surveys	RDT negative, n	RDT positive, n	RDT negative, n	RDT positive, n
40-199	2	3	1	0
200-499	0	4	0	0
500-4,999	4	36	0	6
5,000-90,000	1	18	0	6
Total, n (%)	7 (10.3)	61 (89.7)	1 (7.7)	12 (92.3)

5. DISCUSSION

5.1. Methodological considerations

This part presents consideration of whether the associations or differences observed are real, which applies to all research. Internal validity is associated with valid inference in a population studied. This can be affected by sample, selection bias, information bias and statistical confounding (112).

5.1.1. Study design and sample size

This study uses different designs, and each design has its own strengths and limitations. The nature of the disease under investigation, the type of exposure, and the available resources limits the choice of an epidemiological study design (113). This study used descriptive study design, including cross-sectional surveys. A cross-sectional survey collects data at one point in time. This permits the prevalence of a disease of interest to be assessed. The advantage of cross-sectional survey is it permits a large number of variables to be examined. One problem is that cross-sectional studies often have difficulty determining the time order of events (114). However, this study design has no dimension of time, so it cannot support conclusions on the risk of disease or on the inference on causality (115).

To overcome this limitation (Paper-III), anyone family member who used ITN *prior* to the night of the survey was interviewed. A cross-sectional survey is also known for its low response rate. However, this study had found a high response rate. In general, descriptive study design is concerned with describing the general characteristics of the distribution of a disease, particularly in relation to person, place, and time. Thus, descriptive data provide valuable information to improve resource allocation and plan for effective prevention or education programs. In addition, descriptive studies have often provided the first important clues about possible determinants of a disease (113).

All study designs involve some implicit (descriptive) or explicit (analytic) type of comparison of exposure and disease status. In this study observational analytic investigation was employed. The investigator simply observes the natural course of events. A prospective cohort study, one of the basic groups of observational study was used. In a cohort study, subjects are classified on the basis of the presence or absence of exposure to a particular factor and then followed for a specified period of time to determine the development of disease in each exposure group. In prospective cohort studies, the investigator looks forward from an exposure to an outcome (113). It is often possible to investigate a particular hypothesis using cohort study design. The investigator can often use more recent records or even assess the exposure directly or through questioning the participants themselves, and information on potential confounders can also be obtained from study subjects. If the sample size is large and follow-up is complete, data from prospective cohort studies can be regarded as particularly reliable and informative.

The present study used adequate sample size and almost complete follow up of 94.4% both for paper-I and paper-II, and 98.5% for paper-III. Thus, the present study can be considered as informative in estimating the prevalence of malaria (Paper-I), and identifying malaria risk factors (Paper-III). The choice of a study design best suited for investigation of an issue at a given time is influenced by particular features of the exposure and disease, logistic considerations of time and resources, as well as results from previous studies and gaps in knowledge that remain to be filled (113). For most epidemiologic hypotheses, it is necessary and desirable to employ both descriptive and analytic design strategies.

5.1.2. Internal validity

This refers to the validity of the questionnaire itself; that is, its ability to measure what it is designed to measure (116). In other words, it is important to find out whether and to what extent alternative explanations such as chance, bias, or confounding variables accounted for the observed association (113). As with any epidemiologic investigation, an evaluation of the validity of a cohort study requires consideration of the roles of chance, bias, and confounding variables as an alternative explanation for the study findings.

5.1.2..1. Chance

Chance refers to the likelihood that sampling variability (random error) accounted for the observed association. The role of chance is assessed by performing test of statistical significance or by estimating the confidence interval of the effect (114). We addressed the role of chance by performing appropriate statistical tests and estimating the confidence intervals and *P* value. In epidemiological research, *P* value of less than or equal to 0.05 shows, by convention, that the association is statistically significant (113, 114). One problem inherent in the interpretation of the P value results from the fact that it is a composite measure that reflects both the magnitude of the difference between the groups and the sample size. Consequently, even a small difference may be statistically significant, or deemed unlikely to be due to chance; if the sample size is sufficiently large and, conversely, a larger effect may not achieve statistical significance if the sample size is insufficient (113). Thus, the confidence interval can provide all the information of the *P* value in terms of deciding whether an association is statistically significant at a specified level. In addition, the effect of sample size can also be ascertained from the width of the confidence interval itself. The narrower the confidence interval, the less is the variability in present in the estimate of the effect, reflecting a larger sample size. On the other hand, the wider the confidence interval, the greater is the variability in the estimate of the effect, reflecting a smaller sample size (113).

5.1.2..2. Selection bias

In general, the potential for selection bias is less of a concern in cohort studies. In prospective cohort studies, since exposure is assessed prior to the occurrence of a disease, it is unlikely that the outcome could influence the classification of exposure. If knowledge of the disease affects the selection or classification of exposed and non-exposed individuals to be included in the study, selection bias may result. The prior local knowledge of health professionals was used to recruit six *kebele*s, two from each three altitudinal strata. The geographical accessibility of the potential study *kebele*s during all seasons of the year including the rainy season was assessed during the designing stage. In the BRHP DSS *kebele*s were classified as low, mid-level, and high altitudes (95), and we applied similar classification. This information was supported by malaria

data from health posts, and qualitative altitudinal classification proposed by a senior malaria parasitologist and experts from Meskan District Health Office.

Over all, topographic features and ecological setting of the study area was assessed by EMaPS collaborators during January 2008. This procedure might imply prior knowledge about malaria. However, a multi-stage sampling (*kebele*, village and households) method was applied there was no chance to select households directly based on their malaria risk. Moreover, no altitude measurement was used to classify into different altitudinal strata during designing and sampling stage. Generally, malaria is more prevalent at low altitude and government ITN distribution was targeted to these areas. According to MOH strategic plan, ITN distribution is focused to cover households in endemic areas (<2000 masl). Only 10% of the slides with negative results and all positive slides were sent to second-reader in all studies. Thus, sampling bias in selecting for rechecking is potentially unavoidable. In the evaluation of performance of malaria RDT compared to light microscopy (Paper-IV), mixed infections were removed from analysis. This might have overestimated the agreement between readers.

5.1.2.3. Information bias (misclassification)

Information or observation bias is a systematic error that results when information is differentially obtained from different study groups. Interviewer bias, recall bias and differential misclassification in ascertainment of exposure or disease, are the common forms of information bias. Interviewer bias was of concern in the interview of households during the baseline survey to determine household's effective ITN use (Paper-III) studies that employed interview questionnaires. The study on ITN use (Paper-III) was based on single cross-sectional study, while studies on estimating prevalence (Paper-I) and identifying malaria risk factors (Paper-II) used repeated cross-sectional survey.

In Paper-II, the prospective design of this study has allowed recording of potential risk factors for all family members before the outcome was known, and the outcomes were measured not based on interviews. To minimize measurement errors questionnaires were pretested. Besides, interviewers received proper training and they were blinded about the expected outcome measures to avoid measurement bias. Moreover, self-reported febrile cases from sampled

households and health centers were recruited for the evaluation of quality of diagnostic test (Paper-IV). Those cases reported to health centers look more specific to malaria cases otherwise. There is also a possibility of measuring fever and using clinical algorithms before sending to laboratory for parasitological confirmation. In addition, measured malaria incidence during October 2009 was higher than the rest of the season, implying higher malaria positivity.

5.1.2.4. Confounding

Confounding refers to factors that obscure the relationship between the presumed cause and presumed effect (116). Confounding can lead to either the observation of apparent differences between study groups when they do not exist or conversely, the observation of no differences when they do exist (113). In our study, estimate of the outcome and responsible factors varies with age at different altitude (Paper-I & Paper-II). Thus, such baseline differences need to be accounted for in the design or analysis of epidemiological studies. A study on household ITN use (Paper-III) applied to balance ITN distribution channel was different between malaria endemic and higher altitude areas; and more malaria infection at low altitude. In Paper-III, complex samples analysis was employed to consider altitudinal variation ITN abundance. The papers in this thesis have attempted to control for confounding in the design (Paper-I) and analysis (Papers-II&III) using multilevel multivariate and complex samples analyses.

5.1.3. External validity

External validity or generalizability refers to the wisdom of projecting the questionnaire results obtained from a study to other populations, to other settings, or to other time periods (116). In other words, validity applies to conclusions; a large gap between conclusions drawn and data acquired may indicate poor validity. This study was conducted in a rural setting in south-central Ethiopia, which is characteristic of rural Ethiopia. However, local variation in malaria prevalence (Papers-I and II), household ITN use (III) and performance of malaria RDT (Paper-IV) within the country at highlands limits the generalizability of this study. Paper-IV addressed performance of malaria RDT compared to light microscopy at highlands with low transmission.

Since a cross-sectional study collects all data at one point in time, this permits the estimation of prevalence of a condition or variable of interest to be assessed. The advantage of a cross-

sectional study is that it allows a large number of variables to be examined. In addition, it allows that methods can be standardized by the researcher, and clear-cut definitions may be applied to the exposure and endpoints. Some of the disadvantages of cross-sectional study are that it has no dimension of time, so it cannot support conclusions on the risk of disease (115). In this regard, to minimize the effect of this limitation of shorter duration the studies in this thesis used repeat cross-sectional studies. We measured the variables on quarterly basis for two years. Cross-sectional studies may also exhibit recall bias and low response rate. However, the response rate was higher for all studies. The response rate was 94.4% (19,207 of 20,339) for the prevalence study, 94.4% (19,199 of 20,339) for the risk factor assessment, and 98.5% (739 of 750) for the household ITN use and ownership. Nevertheless, the household response on the use of ITNs the night prior to the survey might be affected by the social-desirability bias. The ownership was determined by observation. This thesis is based on studies with careful design. Random sampling was applied to ensure all villages and households had equal chance of being selected. All family members of the selected households were requested for blood specimen. *Kebele*s were also identified based on already set criteria. Measurement of parasitological data and information were obtained using interview and standard protocols and procedures. The present studies were conducted in two of the seven strata identified by MOH and WHO-Ethiopia (73). The studies were limited to six rural *kebele*s at altitudinal transect (1,800-2,300 masl) located within a radius of 20 km around Butajira Town. Thus, findings obtained from this localized area could be applied cautiously to similar geographical areas of the country. However, differences in malaria control measures and cultural contexts as well as socio-economic situations still maintain variability. The estimate of malaria prevalence obtained in six surveys is a typical methodological design that can be applied by future research. The findings could also be helpful in planning malaria control.

5.2. Discussion of main findings

5.2.1. Prevalence of malaria infection [Paper-I]

This study showed that malaria occurs sporadically at high altitude, and the prevalence of malaria increases towards the lowlands. Malaria prevails throughout the year, but predominantly occurs after the main rainy season. However, the prevalence varied greatly among villages at all altitudes. Higher prevalence of malaria was observed in the low altitudes than in the highland altitudes, which suggest that the high altitude population has lower immunity to malaria, as a result of limited prior exposure to the disease.

Our finding of malaria cases at high altitudes as high as 2,200masl is in line with a study conducted in adjacent localities (117). Another study reported malaria cases at altitudes as high as 2,500 masl and above even extending beyond 3,000 masl (12). But the geographic origin of the malaria cases was not well documented. The low estimate for malaria prevalence is consistent with a study in Ethiopia (118), and a previous estimate elsewhere (119). Areas of such low endemicity may be recognized as hypo-endemic (47), and they are considered to be vulnerable to epidemics. The variability in the prevalence of malaria among villages is in agreement with previous studies in highland areas of Ethiopia (120), and studies conducted in other regions with similar unstable malaria transmission (121, 122). The present results showed the seasonality of malaria, and this is in accordance with other studies (117, 120).

The finding of increased proportion of vivax malaria is consistent with a study at high altitude in the Butajira area (117), and a study in Akaki Town and the environs (67). Recent studies also show a shift from falciparum malaria to vivax malaria (120, 123). However, other studies report the consistent dominance of *Plasmodium falciparum* (20, 124). The findings of malaria cases as high as 2,200 masl during such a non-epidemic year can be explained by the occurrence of endemic malaria in the highlands beyond its previous cut-off transmission band. An increase in the daily minimum temperature of 0.4^{o}C per decade has been recorded in the highlands of Ethiopia (86). Probably, this temperature rise has favoured the occurrence of malaria by keeping minimum temperatures in the highlands above the cut-off for sporogony, or development of the malaria parasite in mosquitoes (47).

The village-level variability can be explained by the clustering of mosquitoes in villages nearer to mosquito breeding sites, as documented in a previous study (125). Although this study lacks mosquito sampling data, the influence of clustering of mosquitoes in space on similar malaria case distributions is well documented in a highland area adjacent to Lake Ziway (10) and in Arba Minch (126), lowland area of Ethiopia. The occurrence of malaria depends on adequate rainfall and temperature. In areas with a temperate climate, transmission is commonly limited to months in which the average temperature is above the minimum required for sporogony (47). This illustrates the inverse relationship of decreasing malaria prevalence with increasing altitude. Temperature is a limiting factor for sporogony of malaria parasite. A previous study conducted at highlands also showed malaria prevalence decreases as altitude rises (127, 128). The increase in vivax malaria in the highland-fringe areas could be explained by the high transmissibility of *Plasmodium vivax*, which is related to its typical biological features, including the immediate appearance of gametocytes, the presence of hypnozoites, and shorter sporogony (47, 129). There is also a suggestion that the intensive malaria control efforts using artemether-lumefantrine targeted to *Plasmodium falciparum* since 2005 (111) could explain the dominance of *Plasmodium vivax* (123), which might get competitive advantage. In support of this suggestion, a study in Thailand where both *Plasmodium falciparum* and *Plasmodium vivax* co-existed showed that an intensive malaria control that used primaquine against *Plasmodium vivax* resulted in successful reduction of both species simultaneously (130). This study indicated that *Plasmodium vivax* was more transmissible than *Plasmodium falciparum*.

5.2.2. Malaria risk factors [Paper-II]

The study on malaria risk demonstrates that age of children and altitude are significantly associated with the risk of malaria infection at hypo-endemic highland rural setting of south-central Ethiopia. Multilevel modeling found differences in children aged below five, 5-9 years, low altitude, mid-level altitude and houses with holes in walls showing increased malaria risk in Butajira area, Ethiopia. Using village-based categorization showed strong variation in malaria prevalence. Like other studies, this study has also limitations. Because of the cross-sectional nature of the survey, a causal relationship cannot be established. Some of the strengths of this

study were using multilevel modeling and repeated cross-sectional surveys to avoid related biases.

The finding of more malaria infection in children 5-9 years is consistent with a study conducted in highlands of Ethiopia (11), highland areas of Kenya (121), and Tanzania (127). However, this result is in contrast with a study performed in low transmission setting in Ethiopia (118), and Eritrea (119). The finding of increased malaria infection in low and mid-level altitudes, adjacent to malaria transmission cut-off area, is in harmony with studies from highlands (127, 131). More malaria infection in houses with holes is consistent with results of another study (132). The information illustrating larger MOR in all the three models reflects that village-level grouping is important to understand variations of the risk of getting malaria infection, which is in line with a study conducted elsewhere in Ethiopia (125), and Madagascar (101). It is not clear why age-dependent malaria risk is found in such low-endemic highlands such as Butajira area, where malaria risk is expected to be uniform across all age groups. The possible explanations could be the overlapping of different activities of children and *Anopheles* biting behaviour (11). The finding of high malaria risk in low altitude can be explained by the presence of suitable high ambient temperature (133), and topography that favours mosquito abundance (134). The increased risk of malaria in houses with holes can be interpreted as increased access of mosquitoes to bite humans. Housing conditions allowing mosquito entrance were indicated as malaria risk factors (20, 135). Another study found association of more malaria infection with poor quality of housing (136). In conclusion, our finding demonstrates that altitude and age are associated with higher malaria risk at the upper limit of highlands of mainly low-endemicity. This result suggests the importance of ecological variables like villages to consider focused interventions that addresses children below 10 years of age. Future studies should consider designing more frequent observation and sorting out the proportion of relapse cases from new infections.

5.2.3. Ownership and use of ITNs in relation to malaria infection [Paper-III]

The ITN use was highest for households owning more ITN in the lowland malarious areas where the government distributed bed nets to all households. ITN ownership was low in the highlands, and most of the highland users bought the bed nets themselves. Interestingly, the poor, families

with low education status living in the lowlands and adjacent to potential mosquito breeding sites used bed nets more than others, probably reflecting that perceived risk of malaria is more important than wealth and educational status. This study tried to explicitly examine the use of ITNs by all household members, which makes it different from previous studies that focused only on the vulnerable groups.

ITN ownership and use, and malaria prevalence in a highland-fringe area were also investigated. Such populations are at increased risk of epidemics without suitable interventions. Household ITN use was obtained by self-report and that may be subject to social-desirability bias. This might be resulting in an overestimation of ITN use as a previous study reported (137). Secondly, this study was a cross-sectional survey done during a peak malaria transmission season, and we might thus have overestimated the real situation of ITN use. A previous study has shown seasonal differences in ITN use in highland areas (134). The data analysis took complex samples into account and avoided reporting biased information. The low ITN ownership observed is similar to a previous study (96) and also comparable to another study (138).

The ITN use in this study was the highest compared with the Ethiopian 2007 Malaria Indicator Survey (MIS) (15) but similar to one conducted in a highland area of Kenya (139). The absence of ITN distribution among over a quarter of the households located at elevations from 1,900 to 1,999 masl and higher might have accounted for the low ITN ownership status in our study. We found that ITN use was associated with malaria exposure, and low ITN use in highland areas with low malaria transmission might not be surprising though the bed net distribution mechanisms differed.

The current finding of increased ITN ownership in household heads with no formal education differed from earlier studies in Ethiopia (140). The finding related to educational status and ITN ownership can be explained more by a recent study that demonstrated knowledge in malaria prevention and control might not result from formal education only, but also other sources such as non-formal and informal education (141).

Our study showed that households with additional beds had increased ITN possession. Obviously, more beds are expected in households with large family and additional nets were allocated during the distribution as per the national ITN distribution strategy (17). A positive association of household family size and ITN ownership was documented (139). The negative association between household mosquito source reduction and ITN ownership found in the present study is in accordance with a previous study (140). Moreover, an increased ITN ownership in male-headed households was in agreement with a study in Nigeria (142).

The finding that households with at least an ITN seen hanging were more likely to use their ITN is in harmony with other studies (143, 144). A few of the households surveyed had hanging ITNs during the survey. A study from Zambia also demonstrated that the strongest factor affecting ITN use was the presence of an ITN hanging (144). They reported of those ITNs hanging, only 10% were not used the previous night. The present finding of about five-fold highly likely to use ITN in households owning two or more ITNs was in harmony with other studies in Ethiopia (138, 145), and also in many African countries (139, 146). ITN use increases with more number of ITNs available in ITN-owning households. The present result showing increased ITN use among households not using mosquito source reduction is in line with another study (147). This suggests that other malaria prevention activities/products appeared to substitute for nets rather than combined effects. The finding of higher ITN use in households living adjacent to permanent water bodies than their counterparts is in agreement with another study (148). Thus, households with increased risk of getting malaria are more aware of the increased risk and more inclined to use protective measures. We observed that households in the low wealth category had higher ITN use as documented elsewhere (147, 149).

Since 2007, the Ethiopian malaria control strategy is targeted to achieve 100% ITN coverage of all households at risk of malaria, <2000 masl. We observed that over a quarter of the households geographically located between 1,900 masl and 1,999 masl elevations were not covered by the government-sponsored ITN distribution. Parasitological surveys also demonstrated the presence of malaria infection throughout those areas (97). Households located at high altitude, presumably at low malaria risk, got their ITNs from different sources unlike those living at low altitude that

secured theirs through government channels. Our finding of more malaria infection in ITN-owning households is in agreement with other studies (12, 150). Presumably, ITNs with holes owned by poor families failed to protect man-vector contact and malaria infection. A study found individuals from the poorest households were more likely to sleep under nets with holes compared to the least poor (151). In this study household ITN use was not assessed over time. A survey done 10 months later also showed high malaria prevalence in households with ITNs. Thus, in order to obtain full protection from malaria infection using ITN requires possessing an intact net and persistently sleeping under net every night. Our analysis only considered clusters at household level and did not consider individual level to compare ITN-users and non-users in relation to status of malaria infection. In conclusion, this study shows that there is a deficit between the nationally targeted household ITN ownership and use in the highland-fringe area of south-central Ethiopia. Therefore, malaria intervention activities should focus on improving the availability and teaching effective use of ITN in populations at risk of highland-fringe malaria.

5.2.4. CareStart™ Malaria RDT Precision [Paper-IV]

This study found varying precision of CareStart™ RDT to detect *P. falciparum* and *P. vivax* in "active" and clinical settings of highland-fringe areas of south-central Ethiopia. A greater proportion of RDTs than slides gave positive result for *Plasmodium*. In the survey, the test showed low sensitivity and high specificity for *P. falciparum*, but vice versa for *P. vivax*. The test revealed lower PPV for *P. falciparum* and lower NPV for *P. vivax*. Overall, season substantially influences RDT precision with good sensitivity at health facilities compared to household survey. However, specificity was found to be low in both settings with comparable results. Interestingly, better NPV obtained unlike lowest PPV in both survey settings. RDT showed low sensitivity in children aged below 10 years. No strong evidence for contribution of low parasite density for missed *Plasmodium* detection by the test product.

This study has got some limitations. Despite the existence of various technical limitations related to preparation of specimen and reading as well as competency of microscopists, light microscopy was used comparison of RDT performance (152). Thus, PCR could be the ideal gold standard in RDT evaluation (152), as applied in recent studies (153, 154). The use of PCR appears plausible in hypoendemic areas like the present study area (155). There might be a possibility of multiple

enrollments of participants between the two survey settings. Some of the strengths of this study include generating large sample data in different seasons at highlands of low malaria endemicity other studies recent studies. RDT evaluation was performed using well trained and competent health personnel at different settings. It is believed that the strengths of this study outweigh the limitations. Thus, conclusions drawn and recommendations suggested considerably valuable both in improving malaria control efforts and future research endeavor.

The present finding of low sensitivity for *P. falciparum* (87.5%) and *P. vivax* (92.8%) using CareStart^{TM} RDT is comparable with a study conducted in south-west (85.6% for *P. falciparum,* and 85.0% for *P. vivax*) and North-West (92.9% for *P. falciparum*, 90.9% for *P. vivax*) Ethiopian highland areas (156, 157). But the present finding reported lower sensitivity compared to other studies in South (99.4% for *P. falciparum* and *P. vivax*); North-East (98.5% *P. falciparum* and 98.0% for *P. vivax*); and South-West (96.4% for *P. falciparum*, and 95.3% for *P. vivax*) Ethiopia (109, 158, 159). The low PPV value obtained in this study is in line with a study in South-West Ethiopia (156), and in low endemicity areas elsewhere (160). The varying RDT performance in different seasons in the present household survey is generally consistent with another study in hypoendemic highland zones in Kenya and Uganda (161). Moreover, the finding of low PPV and temporally varying correspondingly with prevalence using household survey is in agreement with other studies (155, 161). However, the results with good sensitivity and specificity from health facility were consistent with other studies done at health facilities (109, 158, 159). The present finding of the lowest PPV and NPV during two months, November and December 2009, end of malaria transmission season normally in most parts of Ethiopia. The present result is in line with a recent study (155). The finding of less variability in RDT performance in different age categories is consistent with an evidence that showed age has no effect on malaria RDT performance (162). Various factors such as clinical and epidemiologic characteristics of the study populations, reference standards and products of different lots influence the results of RDT-based diagnosis (152, 163, 164). Thus, comparison of RDT results difficult. Similarly, the present study used data generated from large population and varying transmission seasons. However, field evaluation of CareStart^{TM} RDT precision used a short duration of peak malaria transmission.

The present finding of low sensitivity of *P. vivax* (health facilities) and *P. falciparum* (survey) disagrees with other studies that consistently found multi-species RDTs to better detect *P. falciparum* infection than non-falciparum infection, most probably *P. vivax* (165, 166). The low sensitivity in health centres for *P. vivax* may be interpreted as due to low performance of multi-species RDTs for this species. The low sensitivity obtained in this study may be explained by several factors pertinent to the manufacturing process and environmental conditions (152, 164, 167). The present study was performed in highland area with no extreme weather condition.

In addition, low-prevalence, or hypoendemic, malaria poses particular diagnostic challenges since low population prevalence reduces the PPV of tests (155). Moreover, test sensitivity suffers when parasite densities within individual infections are low (168). The hypoendemicity diminishes test sensitivity, as well as the PPV (168). Very low overall prevalence of malaria was found in the present study area (97), which is known to influence RDT performance as reported (155). The varying performance of sensitivity for *P. falciparum* and *P. vivax* for survey and health facility might be interpreted as the difference in clinical condition of patients. Study participants visiting health facilities might be clinically more specific than otherwise. Review evidences showed that higher RDT sensitivity in studies involving patients seeking relief from moderate to severe disease in clinical settings while low RDT sensitivity in studies that enrolled patients by means of “active” case finding (152, 162).

The RDT had low NPV for *P. vivax* at both survey and health centres. A past study showed that less sensitive for non-*P. falciparum* than for *P. falciparum* (169). There is rich evidence that extremely low sensitivity for both HRP-2 and p-LDH tests and batch specific problems were suspected (164). This implies that RDT missed some malaria cases or false negatives were higher. Review evidence cited a study that occasional false negative results may be caused by: (i) deletion or mutation of the HRP-2 gene; (ii) anti-HRP-2 antibodies in humans may explain why some tests were negative despite significant parasitemia; and (iii) presence of an inhibitor in the patient’s blood preventing development of the control line (163). The present finding of low PPV in *P. falciparum* is likely due to sequestration (170). False positive RDT results occur in a few percent of tests, which can be due to cross-reactivity with rheumatoid factor in blood (164, 167). Cross-reactivity with heterophile antibodies may also occur (163).

6. STRENGTHS AND LIMITATIONS

6.1. Strengths

In order to obtain unbiased estimate of malaria prevalence in highland area of low-endemicity, community-based repeated cross-sectional surveys were employed. In highlands of Ethiopia, malaria varies mainly in place and time (7). Thus, the present study used a study design that considered these variations. We measured prevalence of malaria in each three seasons described earlier (section 2.2) and this was also repeated for another year. In addition, the study areas were stratified into three altitudinal zones: low, mid-level, and high altitudes. More participants were sampled from high altitudes, presumably with low prevalence. Overall, unbiased estimate of malaria prevalence was obtained using longitudinal data generated in areas including high altitude, previously considered as malaria-free. Moreover, the study included in this thesis applied advanced statistical analysis such as multilevel analysis (Paper-II), and Complex Samples Data Analysis (Paper-III).

6.2. Limitations

Practically, employing repeated cross-sectional survey appears expensive and impossible to apply in national malaria control programmes. Thus, at low levels of malaria, measuring prevalence is relatively ineffective and uneconomic and case-detection becomes the most effective and more economical method for epidemiological evaluation (23). Both fever and ITN use data were found from reported information. Thus, taking body temperature reading and spot check and confirmation of the ITN used the previous night would have been applied to obtain unbiased information.

7. C ONCLUSIONS

Understanding the epidemiology of malaria is the basis for designing effective and appropriate interventions for the national malaria control. Thus, community-based surveys are considered as more reliable in measuring magnitude of malaria and associated factors in low endemic highland setting with high epidemic potential. The findings of this study are believed to be helpful in planning and assessment of program successful. This thesis made emphasis on some critically important areas in malaria epidemiology and preventive measures as well as performance of malaria RDTs at highland and highland-fringe areas. It examined the prevalence of malaria infection, risk factors, use of ITNs and malaria infection using repeated cross-sectional survey, and made an evaluation of performance of *Plasmodium falciparum* and *Plasmodium vivax* malaria rapid diagnostic tests compared to light microscopy at survey and health facilities.

- Low prevalence of malaria (0.93%) predominantly due to *Plasmodium vivax* (86.5% and *Plasmodium falciparum* (12.4%) and mixed infections (1.1%) were noted, with the adjusted prevalence being 0.78%. Of those *Plasmodium falciparum* infections, above a third had gametocyte (32%, 7 of 22), which were obtained following abnormal rainfall distribution extended to dry season in 2009. All gametocytes were in children aged below 14 years.
- Malaria occurs sporadically at high altitudes, and its prevalence increases towards the lowland. It predominantly appears after the rainy season. Malaria prevalence varied greatly among villages at all altitudes. More children had malaria in the lowlands than in the highland population, which suggests that the highland population has lower immunity to malaria as a result of limited prior exposure to the disease.
- Increased malaria infection was associated with age and altitude while housing condition was only marginally related to increased malaria risk. Higher risk of malaria was observed in children aged below nine years in areas below 2,000 masl and in households with poor housing condition.
- Low household ITN ownership (28.5%) was observed. Logistic regression in Complex Samples Analysis showed household ITN ownership was determined by factors such as illiteracy (no

education), male-headship, ownership of two or more beds, absence of source reduction, and absence of main water body.

- Households having observed ITN hanging, ≥2 ITNs owned, no source reduction, low wealth status, and those within <1 km distance from main water body were more likely to use ITN.
- CareStart™ Malaria RDT was suitable in detecting *P. falciparum* and *P. vivax* and support parasites.
- CareStart™ Malaria RDT showed lower PPV (*P. falciparum*) and higher false positives, implying unnecessary treatment imposed; and lower NPV (*P. vivax*), higher false negative indicates missed cases for treatment.

- Malaria RDT quality control system should be introduced in the health systems especially in highlands with low endemicity, where *P. falciparum* and *P. vivax* co-exist.
- CareStart™ RDT could be used for epidemiological studies and results interpreted cautiously by considering its seasonal variation.
- Future research targeted to RDT evaluation should consider the use of a more sensitive reference standard such as PCR.

8. RECOMMENDATIONS

The following recommendations were forwarded to be accounted at different levels. These include policy matters, programmatic issues at health care delivery system, and future research.

8.1 Policy matters

First, in the past the threshold for transmission of endemic malaria has been considered as 2,000 masl. The present finding supported the recent notion of a recent suggestion by the Ministry of Health of Ethiopia to local epidemiological data and evidence-based decision in inclusion of areas above 2,000 masl (19). Thus, in designing malaria control program combination of altitude and health facility-based data should be considered to target ITN distribution. Second, countrywide periodic surveys targeted to evaluation of malaria control performance should emphasize on highland-fringe areas with established transmission like in Butajira area.

8.2 Malaria control programme

- Malaria interventions must prioritize children below nine years in order to successfully reduce malaria infection in light of the country's elimination strategy,
- Teaching households to maintain their houses with locally available materials appears helpful in reducing malaria infection,
- Household ITN coverage should be based on local epidemiological data,
- Orienting and ensuring hanging of ITNs is helpful in effective utilization,
- Strengthening malaria surveillance at high altitudes, and
- Establish malaria RDT quality control system in the health system.

8.3 Future research

- Conduct follow up survey with more frequent like weekly or two-week-based for better estimation of malaria burden,
- Apply advanced software that perform three-levels multilevel analysis that more inform targeted malaria interventions, and
- Consider the use of a more sensitive reference standard such as PCR in RDT evaluation.

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11. APPENDICES

11.1. Original Papers (I-IV)

This thesis is based on the following papers which will be referred to in the text by their Roman numbers (i-iv).

i. Prevalence of malaria infection in Butajira area, south-central Ethiopia. Malar J. 2012, **11**: 84. http://www.malariajournal.com/content/11/1/84.

ii. Evaluation of CareStart™ malaria Pf/Pv combo test for *Plasmodium falciparum* and *Plasmodium vivax* malaria diagnosis in Butajira area, south-central Ethiopia. Malar J. 2013; **12**: 218. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3700775/pdf/1475-2875-12-218.pdf.

iii. Malaria risk factors in Butajira area, south-central Ethiopia: a multilevel analysis. Malar J. 2013,**12**:273. http://www.malariajournal.com/content/12/1/273.

iv. Ownership and use of long-lasting insecticidal nets for malaria prevention in Butajira area, south-central Ethiopia: complex samples data analysis. BMC Public Health; 2014,**14**:99. http://www.biomedcentral.com/1471-2458/14/99.

11.2. Household interview data collection tool

11.2.1. Household questionnaire (English version)

Section 1. Socio-demographic characteristics of the respondents

No.	Questions and filters	Coding categories	Skip to
1	Sex of the respondent:	Male 1 Female 2	
2	Head of the household:	Male 1 Female 2	
3	Status of the respondent in the household:	Head of the household 1 Spouse of the head of the household 2 Son or daughter 3 Other (specify) _____ 4	
4	What is your age in years?	Year [___|___]	
5	What is your religion?	Islam 1 Orthodox Christian 2 Catholic Christian 3 Protestant Christian 4 Other (specify)_____ 5	
6	What is your ethnic group?	Guraghe 1 Siltie 2 Amhara 3 Oromo 4 Other (specify)_____ 5	

7	What is your current marital status? ***[If the respondent is a woman and her husband has currently more than one wife, the answer for this question is 2].***	Married (monogamous) 1 Married (polygamous) 2 Never married (single) 3 Divorced 4 Widowed 5 Separated 6	
8	What is the highest level of school or grade you attended or completed?	No education or attended school 0 Can only read and write 1 Elementary school 1st cycle (1-4) 2 Secondary school 1st cycle (5-8) 3 Secondary school 2nd cycle (9-10) 4 Preparatory (11-12) 5 Other (specify)_____ 6	
9	What is the highest level of school or grade your spouse attended or completed?	No education or attended school 0 Can only read and write 1 Elementary school 1st cycle (1-4) 2 Secondary school 1st cycle (5-8) 3 Secondary school 2nd cycle (9-10) 4 Preparatory (11-12) 5 Other (specify)_____ 6	

10	What is your current **main** work/occupation? • ***Chose only one response***	Job less 1 Housewife 2 Farmer 3 Pastoralist 4 Student 5 Daily labourer 6 Government/NGO employee 7 Trader 8 Other (specify)_____ 9	
11	What is your spouse's current main work/occupation? • ***Chose only one response***	No Spouse 0 Jobless 1 Housewife 2 Farmer 3 Student 4 Daily labourer 5 Government/NGO employee 6 Trader 7 Other (specify)_____ 8	
12	How many people generally live in this household, including you?	Total No. [____] No. of children below 5 years [___] No. of pregnant women [___]	
13	How many member of this household slept in this house in the previous night [including slept outdoors]?	Total No. [____] No. of children below 5 years [___] No. of pregnant women [____]	

14	What is the health care facility that is nearest to you?	Health post 1 Health center 2 Public/private hospital 3 Private clinic 4 Other (specify)_____ 5 Don't know -99	
15	How long does it take you from your home to reach the nearest public health care facility in minute?	Minute [_____]	
16	Is the primary living house shared with livestock during night?	Yes 1 No 2	
17	Average family/household monthly income of the household?	Birr [_____]	
18	How many sleeping places (beds, mats, etc) does your household have indoors and outdoors	Total [_____] Indoor [_____] Outdoor [_____]	

Section 2. Knowledge and perceptions about malaria transmission and treatment

No.	Questions and filters	Coding categories	Skip to
19	What are the three most important health problems in this area? • ***Don't read the list*** • ***Circle only three responses that apply***	Malaria 1 Diarrhea 2 Respiratory diseases including TB 3 Gastro-intestinal diseases 4 Malnutrition 5 HIV/AIDS 6 Skin diseases 7 Other (specify) _____ 8	

		Note sure/don't know 9	
20	Do you consider malaria a major health problem in this community?	Yes 1 No 2	
21	Can malaria be transmitted from one person to another?	Yes 1 No 2 Don't know -99	
22	How can a person acquire malaria? • ***Don't read the list*** • ***Circle all responses that apply***	By breathing 1 By mosquito bite 2 By sleeping with a malaria patient/ body contact 3 By drinking dirty water 4 Being exposed to cold air 5 Exposure to dirty swampy areas 6 Other (specify) _____ 7 Don't know -99	
23	When do mosquitoes usually bite a person?	Day 1 Evening 2 Night 3 Day and night 4 Don't know -99	
24	What are the main signs and symptoms of malaria? • ***Don't read the list*** • ***Circle all responses that apply***	**Yes** **No** Fever 1 2 Shivering/chills 1 2 Sweating 1 2 Headache 1 2 Vomiting 1 2 Diarrhea 1 2 Loss of appetite 1 2	

		Bitterness in the mouth 1 2 Weakness/tiredness 1 2 Splenomegally 1 2 Backache 1 2 Anemia 1 2 Convulsion 1 2 Thirsty 1 2 Joint pain 1 2 Other (specify)_____ Don't know -99	
25	To which group of the population malaria is more serious? • ***Circle only one response***	Adults 1 Children 2 Pregnant women 3 Elderly 4 Pregnant women/children 5 Equally serious for all 5 Don't know/ not sure -99	
26	Is malaria a curable disease with treatment?	Yes 1 No 2 Don't know/ not sure -99	
27	What is the name of the currently used new anti-malarial drug? • ***Circle only one response***	Coartem® 1 Chloroquine 2 Fansidar 3 Quinine 4 Other (specify)_____ 5 Don't know -99	

Section 3. Knowledge and practices about malaria prevention

No.	Questions and filters	Coding categories	Skip to
28	Is malaria a preventable disease?	Yes 1 No 2 Don't know 3	
29	What are the different malaria preventive measures that you know? • ***Don't read list.*** • ***Circle all responses that apply***	To eat good food 1 To keep house clean 2 Remain indoors at night 3 To sleep under a mosquito net 4 To spray house with insecticide (DDT) 5 To spray house with aerosols ("flit") 6 Smoking in the house (fumigation) 7 Apply ointment/repellents on the skin 8 Drain mosquito breeding sites 9 Window screening 10 Other (specify)_____ 11 Don't know -99	
30	What do you or your family members currently do to prevent mosquito biting? • ***Don't read the list*** • ***Circle all responses that apply***	Use aerosols to spray the house to kill mosquitoes 1 Close doors and windows on time before evenings 2 Use mosquito nets 3 Block mosquito entry holes to houses 4 Burn dung or leaves to keep mosquitoes away 5 Drainage of mosquito breeding sites nearby the house 6 Did nothing 7	

		Others(specify)_____ 8	

Section 4. Mosquito net knowledge, possession and utilization

No.	Questions and filters	Coding categories	Skip to
31	Have you heard the name "***mosquito net***"?	Yes 1 No 2	
32	Can sleeping under "***mosquito net***" protect a person from mosquito bite?	Yes 1 No 2	
33	Can sleeping under "***mosquito net***" protect a person from the bite of other nuisance insects?	Yes 1 No 2	
34	Can "***treated mosquito net***" kill mosquitoes?	Yes 1 No 2 Don't know -99	
35	Can sleeping under "***mosquito net***" protect a person from malaria?	Yes 1 No 2	
36	In your opinion, what is the average duration of "***mosquito net***" service years?	Year [____]	
37	Where do you obtain nets? • ***Circle all that apply***	Government hospital 1 Government health center 2 Woreda Health Office 3 Health post/station 4 Private health care facility 5 Pharmacy/drug store 6 Shop 7 Market 8 Other (specify) _____ 9	

38	Does your household currently possess any mosquito nets to sleep under?	Yes 1 No 2	**Skip to** **→58**
39	How many mosquito nets do you currently possess [both used and unused]? ***[Enumerator: Please ask the respondent and observe the number and condition of functioning of the nets to fill the following questions].***	_____	
40	How many of the nets the household possess are hanged over the bed/mat during the interview?	_____	
41	How many of the nets the household have are currently used by household members while sleeping?	_____	
42	Did any member of your household (including you) sleep under mosquito net last night?	Yes 1 No 2	→**58**
43	Did you sleep under a treated net during the previous night?	Yes 1 No 2	
44	How many of the people who slept in this household in the previous night slept under a net, including you?	Total No. [_____] No. of children below 5 years [___] No. of pregnant women [___]	
45	How long ago did your household obtain the most recent mosquito net?	Year [___] , month [___]	
46	Where did you obtain the most recent net you currently own?	Provided by health facility 1 Provided by Woreda Health Office 2 Provided by NGO 3 Bought from market/shop 4 Other (specify) _____ 5 Don't know -99	

	Questions 47-51 should be filled through observation		
47	How many of the nets the household have are **rectangular**?	_____	
48	How many of the nets the household have are **conical**?	_____	
49	How many of the nets the household have are **white**?	_____	
50	How many of the nets the household have are **green**?	_____	
51	How many of the nets the household have are **blue**?	_____	
52	How many of the nets the household have are with holes or torn that allow mosquito entrance?	_____	
	The following questions are supposed to be filled through interview		
53	What **shape** of the net do you most prefer?	Rectangular 1 Conical 2 Rectangular/conical 3 Any shape 4 Don't know -99	
54	What **cooler** of the net do you most prefer?	White 1 Green 2 Blue 3 Green and blue 4 Any colour 5 Other (specify) _____ 6	

55	If you have only one "**mosquito net**", to whom would you give priority using it? • ***Circle only one answer***	Husband 1 Wife 2 Husband and wife 3 Wife with youngest child 4 Young children 5 Elderly/grand parents 6 Pregnant women 7 Other (specify)_____ 8 Don't know -99	
56	Have you ever experienced any problems when using "***mosquito nets***"?	Yes 1 No 2	→**Stop**
57	If **Yes** to **Q61**, what problems have you or your family members experienced? • ***Circle all that apply***	It gives too warm to sleep under it 1 Mosquitoes still bite you through it 2 Inconvenient to easily get up during night 3 Tucking the net every night is boring 4 It gives you skin irritation 5 Other (specify)_____ 6 Don't know -99	**Stop**
	Q58 and Q59 will be completed for households without any mosquito net		
58	If your household possess currently no mosquito net, have your household ever had it before?	Yes 1 No 2	

59	If your household possess no mosquito net, what are the reasons for not having it? • ***Don't read the list*** • ***Circle all responses that apply***	Not convenient while sleeping 1 Not aware of its use 2 Not know where to get it 3 It is unavailable 4 It has a side effect since treated 5 Does not prevent malaria 6 Has become old or lost 7 Not adequate space to hang it in the house 8 Other (specify) _____ 9 Don't know -99	

Section 5. Description of Household Services

No.	Questions and filters	Coding categories	Skip to
60	What is the main type of fuel you use for cooking? • ***Don't read the list*** • ***Circle all responses that apply***	Animal dung 1 Collected firewood 2 Charcoal 3 Crop residue 4 Other (specify)_____ 5 Don't know -99	

61	What is the main source of water supply for the household? • ***Don't read the list*** • ***Circle all responses that apply***	Piped (tap) 1 Open well 2 Protected well 3 Open spring 4 Protected spring 5 River 6 Lake or pond 7 Other (specify)_____ 8 Don't know -99	
62	What kind of toilet facility does the household have?	Open field or no facility 1 Pit latrine (functional) 2 Pit latrine (non-functional) 3 Other (specify)_____ 4 Don't know -99	

Section 6. Household Assets

No.	Questions and filters	Coding categories	Skip to
63	What is the ownership status of dwelling?	Owned 1 Given by relative or other to use 2 Provided by government 3 Rented 4 Other (specify)_____ 5	

64	Does your household have a: Radio? Bicycle? Motor cycle? Car/truck? Kerosene lamp? Television? Phone including mobile? Cart? Grain-mill? Refrigerator? Sewing machine Electricity supply?	1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [non-functional] 1. No 2. Yes [functional] 3. Yes [nonfunctional] 1. No 2. Yes [functional] 3. Yes [nonfunctional]	
65	What is the sleeping place option in your household?	Ground (Animal skin or other) 1 Platform/Medeb 2 Bed frame 3	
66	Does your household own the following? (Quantify each of the items in appropriate measurement)	Farming land _____hectare, Cow_____(with calf) Cow_____(without calf), Ox_____, Horse_____ Mule_____ Donkey_____, Sheep ____Goat____	

67	What type of crops do you usually produce for household consumption? *(Consider this year harvest season and circle all that apply).*	Maize or sorghum 1 Wheat 2 Barley 3 Teff 4 Pepper 5 Enset 6 Kchat 7 Other (specify): _____ 8	

Section 7. Description of dwelling (Interviewer's observation)

No.	Questions and filters	Coding categories	Skip to
68	The walls are made mainly of:	Wood only 1 Wood and mud 2 Mud bricks 3 Cement blocks 4 Sticks 5 Thatch 6 Other (specify)_____ 7	
69	The floor is made mainly of:	Earth/mud 1 Cement 2 Cement tiles 3 Other (specify)_____ 4	

70	The roof is made mainly of:	Thatch/grass 1 Corrugated iron sheets 2 Other (specify)_____ 3	
71	Does the house have windows?	No 1 Yes 2	
72	If Q 71 is "**yes"**, do they are they screened and/or covered by Curtains or others?	No 1 Yes 2	
73	Are the eaves open enough/holes in the walls allowing mosquito entrance?	No 1 Yes 2	
74	What is the distance of permanent water body such as river, stream, or irrigation scheme (estimated in meters)	_____meter	
75	What is the observed structural condition of the main dwelling?	Seriously dilapidated 1 Needs major repair 2 Sound structure 3	

That is the end of our interview. Thank you very much for taking time to answer our questions. We appreciate your help.

Checklist for completing the questionnaire correctly and confirmation by supervisors.

Name	Signature	Date
Data collector: **Supervisor:**		

11.2.2. Household questionnaire (Amharic version)

ክፍል 1፡ አጠቃላይ የመረጃ ሰጪው ግለሰብ ሁኔታታ

ተ.ቁ.	መጠይቅ	መልስ	ይለፍ
1	የመረጃ ሰጪው ጸታታ	ወንድ 1 ሴት 2	
2	የቤተሰቡ ኃላፊ፡	ወንድ 1 ሴት 2	
3	መረጃ ሰጪዉ በቤተሰቡ ዉሰጥ ያለዉ የዝምድና ግንኙነት ምንድን ነዉ?	የቤተሰቡ አባወራ 1 የቤተሰቡ እማወራ 2 የቤተሰቡ ወንድ ወይም ሴት ልጅ 3 ሌላ (ይገለጽ) _____ 4	
4	እድሜዎ ስንት ነው (በዓመት)?	ዓመት [_____]	
5	የየትኛዉ ሐይማኖት ተከታይ ነዎት-?	እስላም 1 ኦርቶዶክስ ክርስቲያን 2 ካቶሊክ ክርስቲያን 3 ፕሮቴስታንት ክርስቲያን 4 ሌላ (ይገለጽ) _____ 5	
6	የየትኛው ብሔረሰብ አባል ነዎት?	ጉራጌ 1 ስልጤ 2 አማራ 3 ኦሮሞ 4 ሌላ (ይገለጽ) _____ 5	

7	የአሁኑ ጊዜ የጋብቻዎ ሁኔታ እንዴት ነው? (*መረጃ ሰጪዉ ሴት ከሆነችና ባሉዎ በአሁኑ ጊዜ ከአንድ ሚስት በላይ ካለዉ የዚህ ጥያቄ መልስ ምርጫ ቁጥር 2 ይሆናል*)	ያገባ (ባል አንድ ሚስት ብቻ ያለዉ) **1** ያገባ (ባል ከአንድ ሚስት በላይ ያለዉ) **2** ፈጽሞ ያላገባ **3** የተፋታ/ች **4** ባል/ሚስት የሞተበት **5** የተለያዩ **6**	
8	ትምህርት ቤት ገብተዉ ያዉቃሉ?	አዎ **1** የለም **2**	 →**10**
9	የ8ኛ ጥያቄ መልስ "**<u>አዎ</u>**" ከሆነ የትምህርት ደረጃዎና ያጠናቀቁት የትምህርት ክፍል ስንት ነዉ?	ማንበብና መፃፍ የሚችል **1** አንደኛ ደረጃ (1-4) **2** መለስተኛ ሁ/ደረጃ (5-8) **3** ከፍ/ሁ/ደረጃ (9-12) **4** ሌላ (ይገለጽ) _____ **5**	
10	ቤተሰብዎ(ባልዎ/ምስትዎ) ትምህርት ቤት ገብተዉ ያዉቃሉ?	አዎ **1** የለም **2**	 →**12**
11	የ10ኛ ጥያቄ መልስ "**<u>አዎ</u>**" ከሆነ የትምህርት ደረጃቸውና ያጠናቀቁት የትምህርት ክፍል ስንት ነዉ?	አሁን ባል/ሚስት የለኝም 0 ማንበብና መፃፍ የሚችል **1** አንደኛ ደረጃ (1-4) **2** መለስተኛ ሁ/ደረጃ (5-8) **3** ከፍ/ሁ/ደረጃ (9-12) **4** ሌላ (ይገለጽ) _____ **5**	
12	በአሁኑ ጊዜ እርስዎ ሥራ ይሠራሉ?	አዎ **1** የለም **2**	 →**14**

13	የጥያቄ 12 መልስ "<u>አዎ</u>" ከሆነ፡ የአሁኑ ጊዜ **ዋና** መተዳደሪያ ሥራዎ ምንድን ነው? • **አንድ መልስ ብቻ ያክብቡ**	ሥራዐጥ 1 የቤት እመቤት 2 ገበሬ 3 አርብቶ አደር 4 ተማሪ 5 የጉልበት (የቀን) ሠራተኛ 6 የመንግስት ወይም መ.ያ.ድ ሠራተኛ 7 ነጋዴ 8 ሌላ (ይገለጽ) _____ 9	
14	ቤተሰብዎ(ባልዎ/ምስትዎ) **ዋና** መተዳደሪያ ሥራቸው ምንድን ነው?	አሁን ባል/ሚስት የለኝም 0 ሥራዐጥ 1 የቤት እመቤት 2 ገበሬ 3 አርብቶ አደር 4 ተማሪ 5 የጉልበት (የቀን) ሠራተኛ 6 የመንግስት ወይም መ.ያ.ድ ሠራተኛ 7 ነጋዴ 8 ሌላ (ይገለጽ) _____ 9	
15	እርስዎን ጨምሮ የዚህ ቤተሰብ ጠቅላላ አባላት ስንት ናቸዉ? • ***መልሱን ከጠቅላላ የቤተሰብ አባላት በተጨማሪ ለህጻናትና ለነፍሰ ጡር ሰቶችም ለይተዉ ይሙሉ፤***	ጠቅላላ ብዛት |____| ከ5 አመት በታች ብዛት |____| ነፍሰ ጡር ሴቶች |____|	
16	ያለፈው ሌሊት ስንት የቤተሰብዎ አባላት በዚህ ቤት አደሩ [እቤት ዉጪ ያደሩትን ጨምሮ]? • ***መልሱን ከጠቅላላ የቤተሰብ አባላት በተጨማሪ ለህጻናትና ለነፍሰ ጡር ሰቶችም ለይተዉ ይሙሉ፤***	ጠቅላላ ብዛት |____| ከ5 አመት በታች ብዛት |____| ነፍሰ ጡር ሴቶች |____|	

17	ከሚከተሉት የጤና ተቋማት መካከል ለቤተሰብዎ በጣም የሚቀርበዉ የትኛው ነው? • **አንድ መልስ ብቻ ያክብቡ**	የመንግስት ጤና ኬላ 1 ጤና ጣቢያ 2 የመንግስት (የግል) ሆስፒታል 3 የግል ክሊኒክ 4 ሌላ (ይጠቀስ) _____ 5 አላውቅም -99	
18	በቅርብ የሚገኘዉን የመንግስት ጤና ተቋም ለመድረስ ከቤትዎ ምን ያህል ጊዜ ይወስዳል?	በደቂቃ [_____]	
19	በዋና መኖሪያ ቤትዎ ዉስጥ ከብቶች (ጥጃ፡ ፍዬል፡ በግ፡ ላም፡ ወዘተ) ያድራሉ?	አዎ 1 የለም 2	
20	የቤተሰብዎ አማካይ ጠቅላላ የወር ገቢ ስንት ብር ይሆናል?	ብር [_____]	
21	ቤተሰብዎ ከቤት ዉስጥና ከቤት ዉጪ ያለዉን ጨምሮ ስንት የመኝታ ቦታዎች (አልጋ፡ መደብ፡ ወዘተ) አለዉ?	ጠቅላላ ድምር [_____] ቤት ዉስጥ [_____] ከቤት ዉጪ [_____]	

ክፍል 2፡ ስለ ወባ በሽታ መተላለፊያ መንገድና ሕክምና ግንዛቤና አመለካከት

ተ.ቁ.	መጠይቅ	መልስ	ይለፍ
22	በዚህ አካባቢ በብዛት የሚታዩት 3 ዋና ዋና የጤና ችግሮች (በሽታዎች) ምንድን ናቸዉ? • **ምርጫዎቹን አያንብቡ** • **ሶስት መልስ ብቻ ያክብቡ**	ወባ 1 ተቅማጥ 2 የመተንፈሻ አካላት በሽታዎች (ሣንባ ነቀርሳን ጨምሮ) 3 የአንጀትና የሆድ ጥገኛ ተህዋስያን 4 በምግብ እጥረት ሳቢያ የሚመጡ በሽታዎች 5 ኤች. አይ. ቪ / ኤድስ በሽታ 6 የቆዳ በሽታ 7 ሌላ (ይጠቀስ) _____ 8 አላውቅም (እርግጠኛ አይደለሁም) -99	
23	በዚህ አካባቢ የወባ በሽታ የህብረተሰቡ ዋና የጤና ችግር ነው ሠቀው ያስባሉ?	አዎ 1	

		የለም 2	

4	የወባ በሽታ ከአንድ ሰው ወደ ሌላ ሰው ሊተላለፍ ይችላል?	አዎ **1** የለም **2** አላውቅም **-99**	
25	አንድ ሰው በወባ በሽታ የሚያዘው በምን አማካኝነት ነው? • **ምርጫዎቹን አያንብቡ** • **መረጃ ሰጪዉ የሰጡትን መልስ በሙሉ ያክብቡ**	በትንፋሽ አማካኝነት **1** በወባ ትንኝ ንክሻ **2** ከወባ በሽተኛ ጋር አብሮ በመተኛት/በመነካካት **3** ንጽህና የጎደለውን ውሃ በመጠጣት **4** ለቀዝቃዛ አየር በመጋለጥ **5** ረግረግማ በሆኑ ቆሻሻ ቦታዎች ሽታ **6** ሌላ (ይጠቀስ) _____ **7** አላውቅም **-99**	
26	የወባ ትንኞች በአብዛኛዉ የሚናደፉት ጊዜ መቼ ነዉ?	ቀን **1** ማታ **2** ሌሊት 3 ቀንና ሌሊት **4** አላዉቅም **-99**	
27	የወባ በሽታ ዋና ዋና ምልክቶች ምንድን ናቸው? • ***ምርጫዎቹን አያንብቡ*** • ***መልስ ሰጪው የጠቀሱትን መልሶች*** ***ቁጥር 1፥ ያልመለሱትን ደግሞ ቁጥር 2*** ***ያክብቡ***		

	<u>አዎ</u>	**<u>የለም</u>**
ትኩሳት	**1**	**2**
ማንቀጥቀጥና ብርድ ብርድ ማለት	**1**	**2**
ማላብ	**1**	**2**
የራስ ምታት	**1**	**2**
ትውከት	**1**	**2**
ተቅማጥ	**1**	**2**
የምግብ ፍላጎት ማጣት	**1**	**2**
የአፍ ዉስጥ መራራነት	**1**	**2**
የድካም ስሜት	**1**	**2**
የጣፊያ ማበጥ	**1**	**2**
የጀርባ ህመም	**1**	**2**

		የደም ማነስ 1 2 ማንዘፍዘፍ/ራስን መሳት 1 2 የዉሃ ጥማት 1 2 የአካል መገጣጠሚያዎች ህመም 1 2 ሌላ (ይጠቀስ) _____ አላውቅም 1 2	
28	የወባ በሽታ በይበልጥ የሚያጠቃዉ የትኛዉን የህብረተሰብ ክፍል ነዉ? • **አንድ መልስ ብቻ ያክብቡ**	ለአቅመ አዳም/ሄዋን የበቁትን ሰዎች 1 ህጻናትና ልጆችን 2 ነፍሰ ጡር ሴቶችን 3 በዕድሜ የገፉና ያረጁ ሰዎችን 4 ነፍሰ ጡር ሴቶች/ ህጻናት/ልጆች 5 ለሁሉም እኩል አደገኛ ነው 6 አላውቅም (እርግጠኛ አይደለሁም) -99	
29	የወባ በሽታን በህክምና ማዳን ይቻላል?	አዎ 1 የለም 2 አላውቅም (እርግጠኛ አይደለሁም) 3	
30	በአሁኑ ጊዜ በጥቅም ላይ ያለዉ አዲሱ የፀረ-ወባ መድሓኒት ስሙ ምን ይባላል? • **አንድ መልስ ብቻ ያክብቡ**	ክሎሮክዊን 1 ፋንሲዳር 2 ኮአርተም 3 ኩዊኒን 4 ሌላ (ይጠቀስ) _____ 5 አላውቅም -99	

ክፍል 3: ስለ ወባ በሽታ መከላከያ ዘዴዎች ግንዛቤና ተግባር

ተ.ቁ.	መጠይቅ	መልስ	ይለፍ
31	የወባ በሽታ እንዳይዘን መከላከል እንችላለን?	አዎ 1 የለም 2 አላውቅም 3	
32	እርስዎ የሚያዉቋቸዉ የወባ በሽታ የተለያዩ የመከላከያ ዘዴዎችን ብነግሩኝስ? • ምርጫዎቹን አያንቡ • መረጃ ሰጪዉ የሰጡትን መልስ በሙሉ ያክብቡ	ጥሩ ምግብ መብላት 1 የመኖሪያ ቤትን በንጽህና መያዝ 2 ሌሊት (ስጨልም) ቤት ዉስጥ መሆን 3 በአልጋ አጎበር/ላንዝራ ሥር መተኛት 4 ቤትን በፀረ-ወባ ኬሚካል (DDT) መርጨት 5 ቤትን በፀረ-ነፍሳት (ፊሊት፡ ሞቢል) መርጨት 6 ኩበት፡ ወይም እንደ ቅጠላ ቅጠል ያሉትን በቤት ዉስጥ ማጨስ 7 በሰዉነት ላይ የተለያዩ ፀረ-ትንኝ ቅባቶችን መቀባት 8 የትንኝ መራቢያ ቦታዎችን ማሰወገድ 9 መስኮቶች ትንኝን እንዳያስገቡ ማድረግ 10 ሌላ (ይጠቀስ) _____ 11 አላውቅም -99	
33	የወባ ትንኝ ንክሻን ለመከላከል እርስዎ ወይም የቤተሰብዎ አባላት በአሁኑ ጊዜ ምን እያደረጉ ነዉ? • ምርጫዎቹን አያንቡ • መረጃ ሰጪዉ የሰጡትን መልስ በሙሉ ያክብቡ	ትንኝን ለመግደል ቤቱን በፀረ-ነፍሳት (ፊሊት፡ ሞቢል) እንረጫለን 1 በሮችና መስኮቶችን ሳይጨልም በጊዜ እንዘጋለን 2 የአልጋ አጎበር/ላንዝራን እንጠቀማለን 3 የወባ ትንኝ መግቢያ ቀዳዳዎችን እንዘጋቸዋለን 4 ኩበት፡ እበት ወይም ቅጠላ ቅጠል በቤት ውስጥ እናጨሳለን 5 በቤት አከባቢ ያለውን የትንኝ መራቢያ ቦታዎችን እናስወግዳቸዋለን 6 ምንም አናደርግም 7 ሌላ (ይጠቀስ) _____ 8	

ክፍል 4፡ ስለ አልጋ አጎበር እዉቀት፡ ባለቤትነትና አጠቃቀም

ተ.ቁ.	መጠይቅ	መልስ	ይለፍ
34	እርስዎ **"አጎበር/ዛንዝራ"** የሚባለዉን ሰምተዉ ያዉቃሉ?	አዎ 1 የለም 2	
35	በ**"አጎበር/ዛንዝራ"** ሥር መተኛት ከወባ ትንኝ ንክሻ ይከላከላልን?	አዎ 1 የለም 2	
36	በ**"አጎበር/ዛንዝራ"** ሥር መተኛት ከሌሎች ነፍሳት ንክሻ ይከላከላልን?	አዎ 1 የለም 2	
37	በኬሚካል የተነከረ **አጎበር/ዛንዝራ** የወባ ትንኝን መግደል ይችላልን?	አዎ 1 የለም 2 አላዉቅም 3	
38	በ**"አጎበር/ዛንዝራ"** ሥር መተኛት በወባ በሽታ እንዳንያዝ ይከላከላልን?	አዎ 1 የለም 2	
39	በርስዎ ግምት አንድ "**አጎበር/ዛንዝራ**" በአማካይ ለስንት ዓመት ያህል ያገለግላል ብለዉ ያስባሉ?	ዓመት [____]	
40	"**አጎበር/ዛንዝራ**" ከየት ማግኘት እንደሚቻል ያዉቃሉ?	አዎ 1 የለም 2	→43
41	የጥያቄ 40 መልስ **"አዎ"** ከሆነ፡ ከየት ነዉ ማግኘት የሚቻለዉ? • **መረጃ ሰጪዉ የሰጡትን መልስ በሙሉ ያክብቡ**	ከመንግስት ሆስፒታል 1 ከመንግስት ጤና ጣቢያ 2 ከወረዳ ጤና ጥበቃ ጽ/ቤት 3 ከመንግስት ጤና ኪላ/ክሊኒክ 4 ከግል ጤና ተቀማት 5 ፋርማሲ/መድሃኒት መደብር 6 ሱቅ 7 ገበያ 8 ሌላ (ይገለጽ) _____ 9	

42	ቤተሰብዎ በአሁኑ ጊዜ **አጎበር/ዛንዝራ** አለዉ?	አዎ 1 የለም 2	→62
43	በአሁኑ ጊዜ የሚጠቀሙትንና የማይጠቀሙትን ጨምሮ በአጠቃላይ ቤተሰብዎ ስንት **አጎበር/ዛንዝራ** አለዉ? ***መረጃ ሰጪዉን በመጠየቅና አጎበሩን በማየት ብዛቱን ያረጋግጡ***	ብዛት_____	
44	ይህ መጠይቅ በሚደረግበት ጊዜ በአልጋ (መኝታ ቦታ) ላይ የተሰቀሉ **አጎበሮች** ስንት ናቸዉ?	ብዛት _____	
45	ቤተሰብዎ ካለዎት ጠቅላላ **አጎበሮች** መካከል በአሁኑ ጊዜ ስንቶቹን እየተጠቀማችሁ ነዉ?	ብዛት _____	
46	እርስዎን ጨምሮ በዛሬ ሌሊት ከቤተሰብዎ አባላት መካከል **አጎበር/ዛንዝራ** ሥር ያደረ ሰዉ ነበር?	አዎ 1 የለም 2	→62
47	እርስዎ በትላንትናው ሌሊት **አጎበር/ዛንዝራ** ሥር/ውስጥ ነው ተኝተው ያደሩት?	አዎ 1 የለም 2	
48	እርስዎን ጨምሮ በዛሬ ሌሊት በአጠቃላይ ስንት የቤተሰብዎ አባላት **አጎበር/ዛንዝራ** ሥር አደሩ? • ***መልሱን ከጠቅላላ የቤተሰብ አባላት በተጨማሪ ለህጻናትና ለነፍሰ ጡር ሰቶችም ለይተዉ ይሙሉ፤***	ጠቅላላ ብዛት |____| ከ5 አመት በታች ብዛት |___| ነፍሰ ጡር ሴቶች |____|	
49	በቅርብ ጊዜ ለቤተሰብዎ ያመጡት **አጎበር/ዛንዝራ** ምን ያህል ጊዜ ሆኖታል?	ዓመት|____| ከ|_____|ወር	
50	በቅርብ ጊዜ ለቤተሰብዎ ያመጡትን (የወሰዱትን) **አጎበር/ዛንዝራ** ከየት አገኙት?	ከጤና ተቋም የተሰጠን 1 በሕዝብ ጤና ተጠሪዎች የተሰጠን 2 መንግስታዊ ባሆልነ ድርጅት የተሰጠን 3 ከገበያ/ሱቅ ገዛን 4 ሌላ (ይጠቀስ) _____ 5 አላውቅም 6	
	ከጥያቄ 51-56 ያሉት ጥያቄዎች ቤተሰቡን በመጠየቅና የአልጋ አጎበሩን በማየት የሚመለሱ ናቸዉ		
51	ቤተሰቡ ካለዉ ጠቅላላ **አጎበር/ዛንዝራዎች** መካከል፡ **<u>የአራት ማዕዘን</u>** ቅርጽ ያላቸዉ ስንት ናቸዉ?	ብዛት_____	
52	ቤተሰቡ ካለዉ ጠቅላላ **አጎበር/ዛንዝራዎች** መካከል፡ **<u>የክብ ቅርጽ</u>** ያላቸዉ ስንት ናቸዉ?	ብዛት_____	

53	ቤተሰቡ ካለዉ ጠቅላላ **አጎበር/ዛንዝራዎች** መካከል፡ **<u>ነጭ</u>** ስንት ናቸዉ?	ብዛት_____	
54	ቤተሰቡ ካለዉ ጠቅላላ **አጎበር/ዛንዝራዎች** መካከል፡ **<u>አረንጓዴ</u>** ስንት ናቸዉ?	ብዛት_____	
55	ቤተሰቡ ካለዉ ጠቅላላ **አጎበር/ዛንዝራዎች** መካከል፡ **<u>ሰማያዊ</u>** ስንት ናቸዉ?	ብዛት_____	
56	ቤተሰቡ ካለዉ ጠቅላላ **አጎበር/ዛንዝራዎች** መካከል፡ የወባ ትንኝ ሊያስገባ የሚችል **<u>ቀዳዳ</u>** ያላቸዉ ስንት ናቸዉ?	ብዛት_____	
	ከዚህ በታች የተመለከቱት ጥያቄዎች መልስ ሰጪዉን በመጠየቅ የሚመለሱ ናቸዉ።		
57	እርስዎ በይበልጥ የሚመርጡት የ"**አጎበር/ዛንዝራ**" **<u>ቅርጽ</u>** የትኛዉን ነዉ? ***(ይህ ጥያቄ ለመልስ ሰጪዉ ይብራራላቸዉ)***	ባለ አራት ማዕዘን 1 ክብ ቅርጽ 2 አራት መዕዘንና ክብ ቅርጽ 3 ማንኛዉንም ቅርጽ 4 አላውቅም 5	
58	እርስዎ በይበልጥ የሚመርጡት የ"**አጎበር/ዛንዝራ**" **<u>መልክ</u>** የትኛዉን ነዉ? ***(ይህ ጥያቄ ለመልስ ሰጪዉ ይብራራላቸዉ)***	ነጭ 1 አረንጓደ 2 ሰማያዊ 3 አረንጓደና ሰማያዊ 4 ማንኛዉንም ዓይነት መልክ 5 ሌላ (ይጠቀስ) _____ 6	
59	አሁን አንድ **አጎበር/ዛንዝራ** ብቻ ቢኖርዎት፡ ከቤተሰቡ አባላት መካከል ማን እንድተኛበት ይፈቅዳሉ? • **አንድ መልስ ብቻ ያክብቡ፡**	የቤቱ አባወራ (ባል) 1 የቤት እማወራ (ሚስት) 2 ባልና ሚስት 3 እናት ከልጅ ጋር 4 ሕጻናትና ልጆች 5 በዕድሜ የገፉ ሰዎች 6 ነፍሰ ጡር ሴቶች 7 ሌላ (ይጠቀስ) _____ 8 አላውቅም 9	

60	**"አጎበር/ዛንዝራ"** በሚጠቀሙበት ጊዜ አጋጥሞት የሚያዉቅ ችግር አለ?	አዎ 1 የለም 2	 →ቁም
61	የጥያቄ 60 መልስ **"<u>አዎ</u>"** ከሆነ፡ ችግሩ ምንድን ነዉ? • **ከአንድ መልስ በላይ ይቻላል**	በጣም ይሞቃል 1 በአጎበሩ ዉስጥ የወባ ትንኞች ይናከሳሉ 2 ሌሊት ቶሎ ለመነሳት አይመችም 3 አጎበሩን ሁልጊዜ መስቀልና ፍራሽ ሥርማሰገባት ይሰለቻል 4 የሰዉነት ቆዳ ያሳክካል 5 ሌላ (ይጠቀስ) _____ 6 አላውቅም 7	 ቁም
	ጥያቄ 75 እና 76 አጎበር/ዛንዝራ ለሌላቸዉ ቤተሰቦች ብቻ የሚሞላ ነዉ።		
62	ቤተሰብዎ በአሁኑ ጊዜ ምንም ዓይነት **አጎበር/ዛንዝራ** ከሌለዉ፡ ከዚህ በፊትስ ኖሮዎት ያዉቃል?	አዎ 1 የለም 2	
63	ቤተሰብዎ በአሁኑ ጊዜ ምንም ዓይነት **አጎበር/ዛንዝራ** የሌለዉ ከሆነ፡ ምክንያቱ ምንድን ነዉ? • ***ምርጫዎቹን አያንቡ*** • **መረጃ ሰጪዉ የሰጡትን መልስ በሙሉ ያክብቡ**	በመኝታ ጊዜ ሚቹ ስላልሆነ 1 ስለ አጎበር/ዛንዝራ ጥቅሙን ስለማናዉቅ 2 አጎበሩ ከየት እንደሚገኝ ስለማናዉቅ 3 አጎበሩ ስለማይኖር 4 ኬሚካል ስላለዉ ችግር ያስከትላል ስለሚባል 5 የወባ በሽታን አይከላከልም ብለን ስለሚናስብ 6 አርጅቶ ያለቀብን ወይም የጠፋብን ስለሆነ 7 በቤታችን ዉስጥ የሚንሰቅልበት በቂ የመኝታ ቦታ ስለሌለን 8 ሌላ (ይጠቀስ) _____ 9 አላውቅም 88	

5. የቤተሰብ መገልገያዎች መለጫ

ተ.ቁ.	መጠይቅ	መልስ	ይለፍ
64	ለምግበ ማብሰያ የሚጠቀሙት የሃይል ምንጭ ትኛወን ነው?	ኩበት 1 ማገዶ 2 ከሰል 3 ገለባ 4 ሌላ (ይጠቀስ) _____ 5	
65	የመጠጥ ውሃ በዋናነት ኬት ታገኛላችሁ?	ኩሬ 1 ያልተጠበቀ (ያልተከደነ) የጉድጓድ ውሃ 2 የተጠበቀ (የተከደነ) የጉድጓድ ውሃ 3 የጎለበተ የምንጭ ውሃ 4 ያልጎለበተ የምንጭ ውሃ 5 የቧንቧ ውሃ 6 የወንዝ ውሃ 7 የመስኖ አርጂን 8 ሌላ (ይጠቀስ) _____ 9	
66	መጸዳጃ ቦታ ውይም ዓይነት የትኛው ነው አለዉ?	የለንም/ሜዳ ላይ 1 የተቆፈረ ጉድጓድ 2 የተቆፈረ ጉድጓድ (የማይሰራ) 3 ሌላ (ይጠቀስ) _____4 አላውቅም -99	

6. የቤተሰብ ይዞታዎች ሀብት

ተ.ቁ.	መጠይቅ	መልስ	ይለፍ
67	ከሚከተሉት ቤተሰብዎ ምን አለው?		
	ሬድዮ	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ብስክለት	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ሞት ሳይክል	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	መኪና/የጭነት	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ማሾ	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ቴሌቭዥን	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ስልክ (ሞባይልንም ጨምሮ)	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ጋሪ	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	የእህል ወፍጮ	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	ማቀዝቀዣ	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	የስፌት መኪና	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
	የኤሌክትሪክ መስመር	1.አይደለም 2.አዎ (ይሰራል) 3. አዎ (አይሰራም)	
68	የመኝታ ቦታችሁ ምን ዓይነት ነው?	መሬት(ቁርበት/ከገለባ የተሰራ ፍራሽ ላይ) 1 መደብ ላይ 2 መደበኛ የእንጨት አልጋ ላይ 3 ሌላ (ይጠቀስ) _____ 9	
69	ከሚከተሉት የትኞቹን አላችሁ? ምን ያህል? ወይም ስንት?	የእርሻ መሬት__ሄክታር፣ ላም__(ጥጃ ያላት)፣ላም__(ጥጃ የሌላት)፣በሬ___ፈረስ____በቅሎ___አህያ___ በግ____ፍዬል___	

70	የሚከተሉትን ምርቶች ለቤታችሁ ታመርታላችሁ?	በቆሎ ወይም ዘንጋዳ 1 ስንዴ 2 ገብስ 3 ጤፍ 4 በርበሬ 5 እንሰት 6 ጫት 7 ሌላ (ይጠቀስ) _____8 አላውቅም -99	

7. የመኖሪያ ቤት ሁኔታ (ጠያቂው ራሱ በማየት የሚሞላው)

ተ.ቁ.	መጠይቅ	መልስ	ይሰፍ
71	የዚህ ቤት ይዞታው የማና ነው?	የግሌ 1 ከዘመድ በስጦታ ያገኘሁት 2 ከመንግስት በስጦታ ያገኘሁት 3 የኪራይ ቤት 4 ሌላ (ይጠቀስ) _____5	
72	የቤቱ ግድግዳ የተሠራው	ከእንጨት ብቻ 1 ከእንጨትና ጭቃ 2 ከጭቃ ብሎኬት 3 ከስምንቶ ብሎኬት 4 ከቀጫጭን እንጨት/አገዳ 5 ከሰንበለጥ/ሳር 6 ሌላ (ይጠቀስ) _____ 7	
73	የቤቱ ወለል የተሠራው	የተደመደመ/ጭቃ 1 ስምንቶ 2 የስምንቶ ታይልስ 3	

		ሌላ (ይጠቀስ) _____ 4	

74	የቤቱ ጣራው የተሠራው	ሳር/ሰንበለጥ 1 ቆርቆሮ 2 ሌላ (ይጠቀስ) _____ 3	
75	ቤቱ መስኮት አለው?	አዎ 1 የለም 2	
76	የጥያቄ ቁጥር 74 መልስ አዎ ከሆነ መጋረጃ ወይም ሌላ መሸፈኛ አለው?	አዎ 1 የለም 2	
77	የግድግዳውና ጣራ (ክፈፍ) የወባ ትንኝ ለማስገባት ምቹ ነው?	አዎ 1 የለም 2	
78	የቤቱን ሁኔታ እንዴት ይገልፁታል?	ከፍተኛ ጥገና የሚስፈልገው 1 ግድግዳው ቀዳዳዎች አሉት 2 በጣም ጥሩ ደረጃ ላይ ያለ ቤት 3	

ይህ የመጠይቁ ማጠቃለያ ነው። ጊዜዎን ሰዉተዉ ጥያቄያችንን ስለመለሱልንና

በአጠቃላይ ላደረጉልን ትብብር በጣም እናመሰግናለን። ሁሉም ጥያቄዎች በትክክል መሞላታቸውን ያረጋግጡ።

	መሉ ስም	ፊርማ	ቀን
የመረጃ ሰብሳቢው	_____	_____	_____
የተቆጣጣሪው	_____	_____	_____

11.2.3. Participant's Consent and Information Sheet (English version)

Household Questionnaire for the Infected Host Population Study, Ethiopian Malaria Prediction System, Butajira area, October 2008 (Tikimte 2001E.C)

Zone_____Woreda_____Kebele_____

Village Name _____House Number (DSS) _____

Informed Consent

[*Interviewer: Read the following introductory statement to the prospective respondent]*.

Greetings!

My name is _____ and I am working with Addis Ababa University. We are doing a survey on malaria risk factors, magnitude of morbidity and mortality, how people feel and perceive about malaria burdens, and what people do to protect themselves and family against malaria. We are interviewing, investigating your blood for malaria and give treatment for people detected to have the parasite. We are interviewing many different communities and households in Butajira area (show an Institutional Ethical Clearance from the Faculty of Medicine, if necessary). We would very much appreciate your participation in this survey. The interview will take less than an hour.

Whatever information you provide us will be kept strictly confidential. Your name and address will remain anonymous. Participation in this survey is voluntary and you can choose not to answer any individual question or all of the questions. However, we hope that you will participate in this survey since your views are important. This information will help health authorities to design and improve interventions related to malaria.

At this time, do you want to ask me anything about this survey?

Name and signature of interviewer: _____Date:___/___/_____

N.B. Interviewer: Please put all years in Ethiopian Calendar. *DD/MM/YYYY*

Would you be willing to be interviewed? 1. No (Stop the interview) 2. Yes

If "No", please state the reason: _____

Start time**: _____End** time**: _____Total Time (Minutes) _____**

11.2.4. Participant's Consent and Information Sheet (Amharic version)

በአዲስ አበባ ዩኒቨርስቲ የሕክምና ፋኩልቲ የሕብረተሰብ ጤና ት/ቤት

Study of highland malaria and its impact on sickness in Butajira, south-central Ethiopia.

[*መረጃ ለመሰብሰብ የተዘጋጀ የቤት ለቤት ቃለ መጠይቅ ቅፅ (ጥቅምት 2001 ዓ.ም)*]

<u>የፈቃደኝነት ማረጋገጫ ቅፅ</u>

ወረዳ_____ ቀበሌ _____ የመንደር ስም _____

የመጠይቁ መለያ ቁጥር_____ መጠይቁ የተካሄደበት ቀን _____

[ጠያቂው፡- የሚከተለው አንቀጽ የፈቃደኝነት ማረጋገጫ ስለሆነ ለመልስ ሰጪው በትክክል በማንበብና በማስረዳት ፈቃደኝነታቸውን ካረጋገጡ በኋላ መጠይቁን ይቀጥሉ]

እንደምን ነዎት? ስሜ _____ ሲሆን፡ አሁን ከአዲስ አበባ ዩኒቨርስቲ ጋር በወባ በሽታ አጠቃላይ ሁኔታ በዚህ አከባቢ ጥናት እያካሄድን እንገኛለን፡፡ የዚህ ጥናት ዋና አላማ በወባ በሽታና በመከላከያ ዜዴዉ ዙሪያ የሕብረተሰቡን ግንዛቤ፥ እውቀትና አመለካከት ለማወቅ እንዲሁም ለበሽታው የሚያጋልጡ ሁኔታዎችን የሚረዳ መረጃ ለመሰብሰብና ለወደፊት ተገቢና ቀጣይነት ያለውን የቅድመ-ትንበያ ሥርዐት ለመዘርጋት ነው፡፡ በዚህ ወረዳ ዉስጥ የተለያዩ የህብረተሰብ ክፍሎችን እየጠየቅን ስለሚንገኝ እርስዎም በዚህ ጥናት ተሣታፊ ቢሆኑ ምስጋናችን የላቀ ነዉ፡፡ እእርስዎ የሚሰጡን መረጃ ለዚህ ዓለማ መሳካት ወሳኝ ከመሆኑም በላይ ለሕብረተሰቡ ትልቅ ለወደፊት አስተዋፅዖ አለው፡፡

ከዚህ ቀጥሎ አንዳንድ ጥያቄዎችን በወባ ላይ እጠይቅዎታለሁ፡፡ መጠይቁ እንደ ሁኔታው ከ40-45 ደቂቃ ሊወስድ ይችላል፡፡ በመጠይቁ ላይ ስምዎ በምንም ዓይነት ሁኔታ አይጻፍም፡፡ መልስ መስጠት የማይፈልጉት ጥያቄ ካለ በሙሉ ወይም በከፊል ላለመለስ ይችላሉ፡፡ ሆኖም ግን የሚሰጡን መረጃ ወደፊት ለሚቀደውና ለሚ ሠራው የወባ ቁጥጥር ሥራ ጠቀሜታው የጎላ ስለሆነ በቅድሚያ ለምታደርጉልን ትብብር ምስጋናችን ከልብ የመነጨ ነው፡፡

በዚህ አጋጣሚ ስለዚህ ጥናት የሚጠይቁኝ ጥያቄ አለ?

በዚህ ጥናት ለመሳተፍ ፈቃደኛ ነዎት? 1. አዎ 2. የለም

መልሱ <u>«አዎ»</u> ከሆነ ወደ ሚቀጥለው ገጽ ይለፉ፡፡

መልሱ <u>«የለም»</u> ከሆነ አመስግነው መጠይቁን ያቋርጡ፡፡ ለጥናቱ ፈቃደኛ ያልሆኑበትን ምክንያት በመጠየቅና በማስታወሻዎ ላይ በመጻፍ ለተቆጣጣሪዉ ሪፖርት ያድርጉ፡፡

የመረጃ ሰበሳቢዉ ስምና ፊርማ_____ ቀን _____

መጠይቁ: የተጀመረበት ሰዓት_____ የተጠናቀቀበት ሰዓት_____ የፈጀው ሰዓት (ደቂቃ)፡___

11.3. Seasonal Blood Survey

11.3.1. Participant's Consent and Information Sheet (English version)

Informed Consent Form and Information Sheet

Study of highland malaria and its impact on sickness in Butajira, south-central Ethiopia.

Informed Consent Form and Information Sheet

District_____ Kebele_____ Village_____

Questionnaire Code _____ House No. _____Date _____

To the head of the Household:

Hello!

My name is _____. I am from Addis Ababa University, School of Public Health, conducting an investigation on malaria in your area. The objective of this study is to understand highland malaria and its impact in causing illnesses and deaths. Thus, we collect data through household head interview and seasonal blood survey. Ethical approval is provided by Institutional Review Board (IRB) of College of Health Sciences, Addis Ababa University. National Ethical approval is also obtained from the Ministry of Science and Technology of Ethiopia for this study.

In Ethiopia, malaria is one of the major public health problems. Two malaria transmission seasons are present in the country. The main peak transmission occurs from September to November following the cessation of the long rainy season, and the next minor transmission occurs during May and June after the short rainy season in March and April. Low land areas are highly malaria endemic and mid-highland areas are also at risk of moderate malaria transmission. In most cases malaria occurs in the form of epidemics causing significant illnesses and deaths. Moreover, the disease is the cause of socio-economic crises. In this study we are aiming at examining highland malaria to support in establishing malaria early warning system in the country.

Data will be collected from selected randomly collected houses using interview of household heads and seasonal blood survey. We request your willingness to participate in this study. If you are willing to

participate the information required is general concept in malaria (causes, signs and symptoms, prevention tools, and treatment seeking behavior, and blood specimen seasonally. We use blood film collection procedure which is routinely used in health facilities, pricking using blood lancets and collecting three drops of blood on microscope slide. The blood lancets are packed and open in front of you with single-use (or disposable type). Blood film collection will be done by trained and experienced health personnel. There is only a transient pain you might feel temporarily. In fact, if the blood collection is not done carefully and fast enough some blood loss can't be avoided. In order to overcome this problem we will give thorough theoretical and practical training to blood specimen collectors. Study participants will also be advised to present themselves accordingly. In this regard, we give much attention to children below 18 years during the data collection. First, we ask consents of the household head before recruiting children of below 18 years. Then, request assent of these children for the blood film collection. When we compare the minor risks aforementioned during blood film collection with the overall benefits of this study the latter outweighs. The study participants are not only contributing to the improvements of malaria control program in their area but also to similar areas of the same setting elsewhere.

People with fever history will immediately be screened their blood for malaria using RDTs. In case found positive to malaria, malaria treatment will be rendered by the study team free of charge.

The study team will also facilitate treatment of severe malaria through facilitating referral service to Butajira Hospital, the nearest facility for in-patient service.

We assure you any information we obtain through this study will be kept confidential. We also assure you that this questionnaire will be coded and the information you will give us will be analyzed using this code not by name. Participation in this study will be on your willingness. You are free at any time to withdraw from the study. You are free at any time to withdraw consent to further participation without prejudice in any way. You are neither required to give reason nor justification for such a decision.

Have you understood information presented to you? If you have any questions we are very happy to answer them.

I (the participant) have obtained enough information on the data collection methods and procedures. I agree to participate in this activity, realizing that I may withdraw at any time without reason and without

prejudice. This information sheet is read to me with my own language and understood correctly, thus consent to participate in this study willingly.

Are you willing to participate? 1. Yes 2. No

If the answer is “No”, say thank you and quiet the interview. Then, record reason for not willing to participate and report to the principal investigator.

The School of Public Health and Institutional Review Board of the College of health Sciences require that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the School of Public Health, and Ethical Committee, Addis Ababa University, P.O.Box 9086 Addis Ababa, Ethiopia (Phone +251-1- 5157701) In addition, if there is a need to contact the principal investigator of the study his mobile phone is +251 911 454349 and P. O. Box is 1242, Addis Ababa, Ethiopia

Name & signature of the data collector_____ Date _____

11.3.2. Participant’s Consent and Information Sheet (Amharic version)

Participant’s Consent Form and Information Sheet (Amharic version)

(የጥናቱ መግለጫና የፈቃደኝነት ማረጋገጫ ቅፅ)

የከፍተኛ ቦታዎች ወባ እና በህመምና ሞት ምክንያት የሚያስከትለው ጉዳት በቡታጅራ አከባቢ፥ ደቡብ-ማህከላዊ ኢትዮጵያ

የጥናቱ መግለጫና የፈቃደኝነት ማረጋገጫ ቅፅ

የወረዳው ስም_____ የቀበሌው ስም_____

የመንደሩ ስም _____የመጠይቁ መለያ ቁጥር_____

የቤት ቁጥር_____ መጠይቁ የተካሄደበት ቀን _____

[ለመረጃ ሰብሳቢው፡- የሚከተለው አንቀጽ የፈቃደኝነት ማረጋገጫ ቅፅ ስለሆነ ለመልስ ሰጪው በጥንቃቄ በማንበብና በትክክል በማስረዳት ፈቃደኝነታቸውን ካረጋገጡ በኋላ መጠይቁን ይቀጥሉ]

እንደምን ነዎት? እኔ ስሜ _____እባላለሁ፡፡ አሁን ከአዲስ አበባ ዩኒቨርስቲ ጋር በወባ በሽታ ላይ በዚህ አከባቢ ጥናት እያካሄድን እንገኛለን፡፡ የዚህ ጥናት ዋና ዓላማ የወባ በሽታ በከፍተኛ ቦታዎች (highland areas) የሚያስከትለውን የህመምና ሞት ጉዳት ለመረዳት ነው፡፡ ለዚህም የሚረዳ መረጃ የምናገኘው በቤተሰብ ደረጃ በመጠይቅ እና የደም ናሙና በመሰብሰብ ይሆናል፡፡ ለዚህ ጥናት የሥነ-ምግባር ማረጋገጫ በአዲስ አበባ ዩኒቨርሲቲ የጤና ሣይንስ ኮሌጅ የሥነ-ምግባር ራቭው ቦርድ ያገኘን መሆኑን እናረጋግጣለን፡፡ እንዲሁም ለዚህ ጥናት የብሔራዊ ሥነ-ምግባር ማረጋገጫ ከኢትዮድያ ሣይንስና ተክኖሎጂ ሚኒስተር አግኝተናል፡፡

የወባ በሽታ በኢትዮጵያ የሕብረተሰቡ የጤና ችግር ከሆኑት አንዱና ዋነኛው መሆኑ ይታወቃል::በአገሪቱ የክረምት ወራትን ተከትሎ መስከረም'ጥቅምትና ህዳር ከፍተኛ ወባ መከሰቻ ሲሆን ከበልግ ዝናብ ለጥቆ ግንቦትና ሴኔም የተወሰነ መጠን ያለው የበሽታው ስርጭት ይታያል:: ቆላማ አከባቢዎች በከፍተኛ ደረጃና ወይና ደጋ አከባቢዎች ደግሞ እንደ መልክዐ-ምድራዊ አቀማመጣቸው በመጠኑም ቢሆን ለበሽታው ተጋላጭ ናቸው:: በብዛት በሽታው በወረርሽ መልክ በመከሰት: በጣም ከፍተኛ ቁጥር ያለውን ሰው ለህመምና ሞት ይዳርጋል:: በተጨማሪም የማህበራዊና ኢኮኖሚያዊ ጉዳትን በማስከተል ከፍተኛ ድርሻ ያስከትላል::

በዚህ ጥናት የወባ በሽታ በወረርሽኝ ከሚከሰትባቸው ቦታዎች ዋነኛው ከፍተኛ ቦታዎች ስለሆኑ መስኤውን በማጥናት የቅድመ ትንበያ ስርዐትን በአገርቱ ለመዘርጋት ለማገዝ ነው፡፡

መረጃ የምሰበሰብባቸው በዕጣ ከተመረጡ ቤቶች ከአባወራው/እማውራዋ በመጠይቅና ከሁሉም የቤተሰብ አባላት የደም ናሙና በየወቅቱ በመሰብሰብ ይሆናል፡፡ እርስዎ በዚህ ጥናት እንዲሳተፉ ፈቃደኛነትዎን እንጠይቃለን:: ፈቃደኛ ከሆኑ የሚሰበሰቡት መረጃዎች፦ ስለወባ በሽታ አጠቃላይ ሁኔታ (መንስኤው፣ምልክቶች፣ የመከላከያ ዘዴ፣ ዘመናዊ ህክምና የመጠቀም ዝንባሌ) እና ከቤተሰብ አባላት የደም ጠብታ ናሙና በየሩብ ዓመቱ በተከታታይ መውሰድ ናቸው፡፡ የደም ናሙና አወሳሰዳችን በጤና ድርጅቶች የተለመደ ዓይነት ሲሆን ጣትን በትንሹ በ"ብለድ ላንሴት" በመውጋት ሶስት ጠብታ ደም በእስላይድ ላይ መውሰድ ይሆናል፡፡ ብሌድ ላንሴቱ የተሸገና ከጀርም ጥቃትም ነፃ ሲሆን አንዱ ለአንድ ሰው ብቻ ጥቅም ላይ የሚውልና ከዚያም በጥንቃቄ የሚወገድ ይሆናል፡፡ ደም የሚወስዱት የሰለጠኑና ልምድ ያላቸው የጤና ባለሞያዎች ናቸው፡፡ ደም ሲወሰድ የተለመደ ለአፍታ ብቻ የሚቆይ ህመም ካልሆነ ሌላ ጉዳት የለውም፡፡ በእርግጥ በጥንቃቄና በቅልጥፍና ካልተከናወነ የተወሰነ ደም መፍሰሱና መባከኑ የማይቀር ነው፡፡ ይሄንን ጉዳት ለመቀነስና ለማስቀረት ለደም ናሙና ሰብሳቢዎች በቂ የንድፈ-ሐሳብና የተግባር ሥልጠና ይሰጣል፡፡ ተመርማሪዎችም ለደም ናሙና አወሳሰድ በሚመች ሁኔታ በባለሞያው ጥያቄ መሰረት ራሳቸውን እንዲያዘጋጁ ይመከራሉ፡፡ በተለይ ከ18 ዓመት በታች ለሆኑ ሕፃናት ልዩ ጥንቃቄ ይደረጋል፡፡ በዚሁ መሠረት በመጀመሪያ የሕፃናት ወላጆች ፈቃደኝነት ማግኘትና የሕፃናት እሽታ ማግኘት ይሆናል፡፡ በደም አወሳሰድ ወቅት የሚከሰቱ ጉዳቶች ካለው የጥናቱ አጠቃላይ ጠቀሜታ አንፃር ሲታይ የጥናቱ ጥቅም ልቆ ይገኛል፡፡ ይሄም የሚለካው የጥናቱ ውጤት ለአከባቢው ህብረተሰብ የወባ ቁጥጥር ሥራ መሻሻል ብቻ ሣይሆን ለሌሎች ተመሣሣይ ቦታዎች ሥራ

ላይ መዋል አንዣር ጭምር ነው፡፡ ትኩሳት ላለባቸው ሰዎች ፈጣን የወባ መመርመሪያ (malaria RDT) በመጠቀም የወባ በሽታ መሆን አለመሆኑን ወዲያውኑ መለየት ስለምንችል ለተገኘባቸው አስፈላጊው ህክምና ወዲያው ያለክፍያ ይሰጣል፡፡ በወባ በሽታ በጣም የታመሙና ክፍተኛ ህክምና የሚያስፈልጋቸው ካሉ በአቅራቢያ ወዳለው ቡታጅራ ሆስፒታል እንዲደርሱና አስፈላጊውን ህክምና እንዲጀምሩ ሁኔታዎችን እናመቻቻለን፡፡

ከጥናቱ ጋር በተያያዘ የሚሰጡን መረጃ በሚስጢር የሚያዝ ሲሆን ለሶስተኛ ወገን ተላልፎ የማይሰጥ መሆኑን እናረጋግጣለን፡፡ የጥናቱ ግኝት ትንተና የሚቀርበው ባጠቃላይ ሲሆን በሥም የማይገለፅ መሆኑን እናሳውቃለን፡፡

በጥናቱ መሳተፍ በራስዎ ውሳኔና ፍላጎት ብቻ ሲሆን ከጀመሩም በኋላ ካልፈለጉ በማንኛውም ወቅት ማቋረጥ መብትዎ ነው፡፡ በጥናቱ ባለመሳተፍዎም ይሁን በማቋረጥዎ ምክንያት ሊያገኙት የሚገባውን ወይም የነበረውን የጤና አገልግሎት የማይከለከሉ መሆኑን እንገልፃለን፡፡

ከዚህ በላይ የቀረበውን ሀሳብ በትክክል ተገንዝበዋል? የትኛውንም ያልገባዎትን ሀሳብ መጠየቅና በቂ ማብራሪያ ማግኘት መብትዎ ነው፡፡ ትክክለኛና በቂ ማብራሪያም ያገኛሉ፡፡

ስለጥናቱ ዓላማ የምርመራ ሂደትና የሚፈለጉ መረጃዎች በሰፊው ተገልፀውልኛል፡፡ በቂ ምክንያት ማቅረብ ሳያስፈልገኝ በፈለግኩት ጊዜ ጥናቱን ማቋረጥ እንደምችል ተገንዝቤያለሁ፡፡ ይህ የፈቃደኝነት ማረጋገጫ ቅፅ በምገባኝ ቋንቋ ተነቦልኝና በትክክል ተገንዝቤ በፈቃደኝነት በጥናቱ ለመሳተፍ ሙሉ በሙሉ መስማማቴን አረጋግጣለሁ፡፡

በዚህ አጋጣሚ ስለዚህ ጥናት የሚጠይቁኝ ጥያቄ አለ?

በዚህ ጥናት ለመሳተፍ ፈቃደኛ ነዎት? 1.አዎ 2.አይደለም

መልሱ <u>"የለም"</u> ከሆነ አመስግነው መጠይቁን ያቋርጡ፡፡ ለጥናቱ ፈቃደኛ ያልሆኑበትን ምክንያት በመጠየቅና በማስታወሻዎ ላይ በመያዝ ለጥናቱ ተቆጣጣሪ ሪፖርት ያድርጉ፡፡

የህብረተሰብ ጤና ት/ቤት እና የህክምና ኮሌጁ ኢንስትቲዩሽናል ሪቪው ቦርድም በጥናቱ አካሄድ ላይ ቅሬታ ወይም የአሰራር ጉድለት ካለ በስልክ ቁጥር +251-1-5157701 እና በፖስታ ሳጥን ቁጥር 9086 አማካኝነት በመጠቀም ለት/ቤቱ መደወልና ጥያቀዎትን ማቅረብ እንደሚችሉ ማረጋገጫ መስጠት ይፈልጋል፡፡ በተጨማሪም ዋናውን አጥኚ ማግኘት ቢያስፈልግዎ በእጅ ስልክ ቁጥር +251 911 454349 እና በፖስታ ሳጥን ቁጥር 1242 አዲስ አበባ ማግኘት እንደሚችሉ እንገልፃልን፡፡

የመረጃ ሰብሳቢው ስምና ፊርማ_____ _____**ቀን**_____

12. LETTER OF DECLARATION (DISSERTATION WORK)

I, the under signed, declare that this work is my original work, has never been presented in this or any other University, and that all the resources and materials used for dissertation, have been fully acknowledged.

Name: _____

Signature: _____

Date: _____

Place: _____

Documents do not forget. [Brev. [og dokument] gløymer ikkje [Go 23]. Norwegian Proverbs. Accessed 7 th July 2016, New York, USA.