COEXISTENCE BETWEEN MALARIA AND DIARRHOEA IN SOUTHERN MALAWI USING MULTILEVEL ANALYSIS METHODS

BY

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DECLARATION OF AUTHOR'S RIGHTS

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DEDICATION

This thesis is dedicated to my three children, Mphatso, Tiwonge, and Chiphaka

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ABSTRACT

This thesis is in applied statistics and provides an overview of the factors relating to self reported malaria and diarrhoea illnesses with a focus on their coexistence at community and household levels using multilevel statistics. The objective of this research is to assess prevalence and to provide an understanding of factors related to knowledge, resources and care practices for the two diseases which can be used as a basis for policy formulation, planning and implementation. Malaria and diarrhoea constitute a major disease burden on poor people in Malawi. Recent national sample survey reported that the prevalence of fever and diarrhoea was 44 and 22% respectively. Malaria and diarrhoea are also known to cause 14 and 18% of overall under-five childhood mortality. Chikwawa district is among the worst affected areas in Southern Malawi with 53% of fever morbidity mostly due to malaria and 24% of diarrhoea morbidity. Face-to-face interviews with matriarchal figures in systematically selected households were conducted in 33 stratified communities. Information for a total of 6,789 individuals was obtained. Various multilevel models were fitted and compared using deviance information criterion. Inference was Bayesian and was based on Markov Chain Monte Carlo simulation techniques in MLwiN 2.10 software. The models showed strong association and correlation between the two diseases at household level and in individuals. There were significant variations in both malaria and diarrhoea prevalence at household and community levels. Common prevalence factors included individual age, family size, and malaria or diarrhoea endemicity. There were strong hierarchical structured patterns in overall maternal knowledge and distribution of resources revealing hidden and unobserved community factors that directly influence both maternal knowledge and distribution of resources. Maternal age, formal education levels, nearest health facility and existence of health surveillance assistant had strong influences on maternal knowledge while community density, literacy levels, and household size had strong influence on the distribution of resources. Most families use oral rehydration solutions (ORS) to treat diarrhoea and normally visit health facilities to treat malaria. In both cases health surveillance assistants and village health committees had strong influences. The thesis recommends improvement in joint control and prevention strategies against the diseases through more effective and relevant educational campaigns, increased number of community workers and committees and targeted interventions to communities that need help most. More research including direct longitudinal studies is needed in the communities to identify behavioural characteristics associated with the persistence of diseases, especially malaria, and how these may be addressed.

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ACRONYMS

ACT	Artemisinin combination therapy
AIDS	Acquired Immune Deficiency Syndrome
CDD	Control of Diarrhoeal Disease programme
CHAM	Christian Association of Malawi
CI	Confidence interval or credibal interval
DC	Distric Commissioner
DDT	Dichlorodiphenyltrichloroethane
DHO	District Health Officer
DHS	Demographic Health Surveys
DIC	Deviance information criterion
EPI	Expanded Programme of Immunisation
GoM	Government of Malawi
HIV	Human Immunodefiency Virus
HLM	Hierarchical Linear Modelling
HMIS	Health management information system
HSA	Health surveillance assistant
HSAs	Health surveillance assistants
IGLS	Iterative generalised least-squares
IMCI	Integrated Management of Childhood Illness
IMF	International Monetory Fund
IPT	Intermittent preventive treatment
ITNs	Insecticide treated nets)
MCMC	Markov Chian Monte Carlo
MDG	Millenium Development Goal
MDGs	Millenium Development Goals
MTCM	Multilevel thresholds of change model
NGO	Non Governmental organisation
NSO	National statistical office
OLS	Ordinary least squares
OR	Odds ratio
ORS	Oral rehydration solution
ORT	Oral rehydration therapy
PQL	Penalised quasi-likelihood
PSI	Population Services International
RBM	Roll Back Malaria Cabinet Project
SCHI	Scotland Chikwawa Health Initiative
SP	Sulfadoxine-pyrimethamine
TA	Traditional Authority
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VHC	Village health committee
VHCs	Village health committees
WHO	World Health Organisation
WPC	Water point committee

CHAPTER 1

INTRODUCING THE THESIS

1.1 Context

Malaria and diarrhoea are among the biggest sources of mortality and morbidity in the Sub-Saharan Africa including Malawi. The National Statistical Office in Malawi estimates that fever and diarrhoea prevalence are at 44 and 22% respectively and that these diseases are increasingly becoming a public concern [NSO, 2004; WHO, 2005a; Kazembe and Namangale, 2007; Malawi Government, 2007, 2008]. Often these illnesses occur simultaneously because of common risk factors, overlaps between multiple risk factors, or because one disorder creates increased risk for the other [Fenn et al., 2005; Kazembe et. al., 2007b]. The complexity of coexistence of diseases is exacerbated by the HIV epidemic whose prevalence is estimated between 12% and 17% [Bell et al., 2006]. Failure to classify and analyse simultaneous occurrence of diseases has led to many problems in medical statistics [Feinstein, 1970 in Groot 2003] because co-morbidity of diseases can affect the moment of detection, prognosis, therapy, and outcome.

There are potential advantages and opportunities for combined attention in the fight against diseases. Joint evaluation of the pattern of malaria and diarrhoea, for example, can help explain common risk factors. This, in turn, can facilitate appropriate health delivery response leading to an integrated management strategy of the diseases and initiation of combined efforts in household and community management of malaria and diarrhoea [Kolstad et al., 1997; Perkins et al., 1997; Kazembe et al., 2007b]. Joint analysis can further correct for confounding, and thus, improve the internal validity of studies. Coexistence measure is also needed for reasons of statistical efficiency [Groot et al., 2003]

The thesis employs various models within the multilevel modelling framework to investigate problems relating to the prevalence of malaria and diarrhoea and to examine factors related to knowledge, resources and care practices. The multilevel modelling approach is preferred because it quantifies the effects of unobserved environmental, socioeconomic, or institutional factors that are represented by administrative structures such as region, district and community, and each of these has some influence on the health outcome [Kazembe and

Namangale, 2007]. Increasingly, efforts in disease studies are recognising the importance of multilevel analysis in identifying clusters of high risk for targeted, cost-effective application of limited resources [Carter et al., 2000]. An administrative location is, therefore, a proxy of socioeconomic, environmental, or institutional factors that affect the disease prevalence. When these are estimated and quantified they may be compared to known random patterns of possible explanatory factors, or they may provide leads for further epidemiological investigations [Diez-Roux, 2000; Rasbash et al., 2004].

In this thesis, an overview of the factors relating to self reported malaria and diarrhoeal illnesses with a focus on their coexistence at community and household levels are reported. The objective is to assess prevalence and to provide an understanding of factors related to knowledge, resources and care practices for the two diseases which can be used as a basis for policy formulation, planning and implementation.

A hierarchical quantitative research approach is employed to examine the coexistence of malaria and diarrhoea and various multilevel models are fitted and compared using deviance information criterion (DIC). Inference is Bayesian and is based on Markov Chain Monte Carlo (MCMC) simulation techniques in MLwiN 2.10 software.

1.2 The rationale for the study

The choice of malaria and diarrhoea has been prompted due to the fact that these diseases are of epidemiological importance in Malawi because they are the leading causes of childhood mortality and morbidity. Malaria and diarrhoea cause 14 and 18% respectively of overall under-five childhood mortality in Malawi [World Health Statistics, 2006]. These diseases share common risk factors, in particular, they are associated with behavioural and environmental factors of which family units and geographical locations of the communities form important examples, thus plausible for hierarchical analysis.

Intervention programmes for various health problems being carried out in various districts in Malawi lack well articulated research findings that can assist in efficient allocation of scarce healthcare resources. More often such programmes use poorly researched decisions or follow political dictates in the distribution of resources which creates a number of problems. It is common, for example, to find two or more organisations in one area or community providing

health services when other communities do not have even a single organisation to assist. Yet the areas with no health providers may have problems similar or even greater than those being patronised by more healthcare providers.

Accurate empirical evidence is essential for adequate disease control and prevention. Effective disease control requires prompt and adequate action towards the reduction of predisposing factors toward disease acquisition and transmission. Such actions can only be made if correct information reaches those required to take action timely. This has been difficult to achieve in Malawi partly because of lack of proper analytical information on disease pattern and variation in the communities. This hampers strategic planning at respective levels of health service delivery. Without proper scientific information that provides the right indicators, the fight against disease can be difficult.

Another important reason for this study is that in Malawi few studies have employed hierarchical techniques in making inferences and decisions about diseases and health outcomes. The 'hidden' assumption, when hierarchical models are not used, is that individual or household health outcomes are independent of family units or community influences. This, in essence, means that only the characteristics of the individuals are responsible for any health outcomes. This notion disregards the fact that different communities are exposed to different unaccounted socioeconomic, institutional, and natural environments that may influence health outcomes in varying proportions [Diez-Roux, 2000]. Individuals or households from the same community may have correlated health outcomes because of common factors in their individual communities. Using traditional non-hierarchical techniques may produce inefficient parameters and may further underestimate standard errors [Rasbash et al., 2004] which may result in misleading conclusions.

Various studies that have been conducted, have looked at a general national picture using data from national surveys [Kandala et al, 2006; Kazembe et al, 2007b] or have used health facility data [Sullivan et al., 1999; Vaahtera et al., 2000; MacArthur et al., 2001; Kublin et al., 2003; Verhoeff et al., 2004; Hamel et al., 2005]. The limitation of national surveys data is that it may conceal important household and community information within districts [Kandala et al, 2006; Masangwi, 2008]. Moreover, what may apply as risk factors of malaria at a district level may not necessarily be associated with the disease at sub-district, community, or household level. Health facility data contains information only for those that

report at the facilities. Data for those that are treated at home or elsewhere or those that do not seek any medical attention is missed out [Mulholland, 2005]. This study, therefore, contributes to existing knowledge by examining the properties of malaria and diarrhoea at community and household levels within a district.

Finally, this thesis was inspired by the Scotland Chikwawa Health Initiative (SCHI), the major sponsors of a survey conducted between September and October 2007. SCHI is a Scottish non-governmental organisation under the auspices of the University of Strathclyde and is funded mainly by the Scottish Government. The SCHI is carrying out a number of health interventions in Chikwawa, a district in Southern Malawi. These include the provision of clean water at source and household level, improving sanitation, improving health facilities and access to health facilities, training of health surveillance assistants (HSA), traditional birth attendants and voluntary community members who form village health committees (VHC) and water point committees (WPC).

1.3 Study area

Chikwawa is a district in Southern Malawi (Figure 1.1). It has a surface area of 4,755 Km^2 and an elevation of only 100m above sea level. Out of a population of about 470,000 about twenty two percent are women of child bearing age (see Table 1.1).

Table 1.1: Demographic data for Chikwawa (NSO Projections)

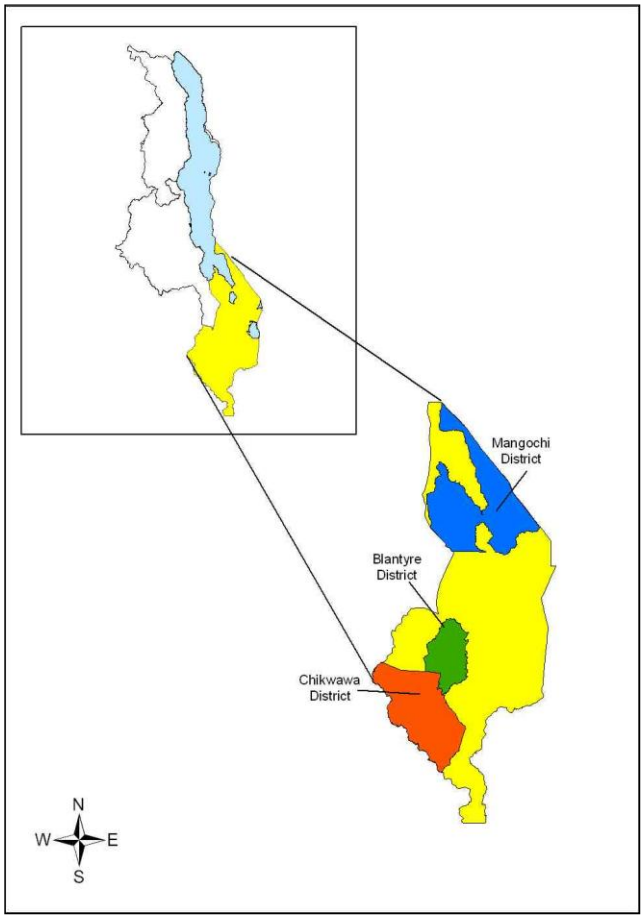
1.	Total population for Chikwawa	477,524
2.	Expected pregnancies	23,876
3.	Expected under 1 children	23,876
4.	Expected under 5 children	81,179
5.	Expected under 15 years	229,212
6.	Women of child bearing age	109,831

Courtesy of SCHI

Chikwawa's climate is subtropical. The rainy season runs from November through April. There is little to no rainfall throughout most of the district from May to October. Chikwawa has an average monthly temperature of 28.4^0 C with a minimum of 15.2^0 C and a maximum

of 45.6^{0}C (NSO, 2005). It is normally hot and humid in the months of November to April and hot, dusty and very dry in the months of July to November. Average rainfall in Chikwawa is around 915 mm/year mostly falling in November–March (NSO, 2005). Malawi's biggest river, which drains Lake Malawi and is characterised by big marshes, passes through this district. Chikwawa is also home to Malawi's biggest sugar plantation and two national game reserves.

a. *Map of Malawi and its location in Africa*



b. *Map of Southern Malawi and the location of Chikwawa District (Morse, 2006)*

Figure 1.1: *Maps of Malawi showing the Southern Region and the location of Chikwawa District (Morse, 2006)*

Because of these climatic and geographical features, Chikwawa is faced with a number of environmental and socioeconomic problems. Almost every year, Chikwawa is faced with

floods from the Shire River and others that feeds into it. The flooding sweeps away crops and livestock thereby creating food insecurity responsible for malnutrition to many children.

Floods also sweep away human dwellings, displacing hundreds of people. Floods leave behind marshes from which mosquitoes responsible for malarial illness bleed. Marshes can also be unsafe water sources (to poor families without access to improved water sources) that are subject to contamination from both point sources (e.g. indiscriminate faecal littering of the environment by humans who either do not have access to a latrine or would prefer not to use a latrine and domestic animals which roamed freely) and diffuse pollution (e.g. surface run-off from land into rivers, streams etc.) during the rainy season and flooding events [Muirhead et al., 2004]

The climatic and ecological conditions in Chikwawa are those that favour high malaria transmission potential. Its mean temperature value of 28.4^0C provides optimal conditions that lengthen the life-span of mosquitoes and increase the frequency of blood meals taken by the female anopheles mosquitoes. The rainfall of 915mm/year and the humid conditions offer favourable breeding places and are conducive to the survival and activity of Anopheles mosquitoes.

Currently fever (mostly due to malaria) and diarrhoeal morbidity in the district are estimated at 52.9% and 24.4% respectively [Kandala et al., 2005]. These are statistically higher than the national averages of 41.7% for fever and 17.2% for diarrhoea morbidity. Chikwawa is one of the districts with the worst health and economic indicators in Malawi with doctor population ratio of 1: 119,381; nurse to population ratio of 1: 5,135; and HSA to population ratio of 1: 1,319.

1.4 Research questions and structure of the thesis

This thesis provides an overview of the factors relating to self reported malaria and diarrhoea illnesses with a focus on their coexistence at community and household levels using multilevel modelling techniques with Bayesian estimation. The main objective of this research is to assess specific and joint prevalence of malaria and diarrhoea and to provide an understanding of factors related to knowledge, resources and care practices for the two diseases which can be used as a basis for policy formulation, planning and implementation.

The first chapter introduces the thesis followed by a Chapter 2 on literature review which outlines the burden of malaria and diarrhoea together with the theoretical framework, definition and aetiology of the diseases. Chapter three gives detailed methods that were used to conduct a survey in Chikwawa. The chapter explains sampling frame, sampling designs and survey methodologies that were deployed to obtain data for this thesis.

Chapter 4 examines the validity of models that are used to analyse and interpret survey data. The chapter looks at outcome and predictor variable selection, statistical analysis, and estimation. Normal plots are used to check model assumptions so that residuals at each level of hierarchy follow Normal distribution while DIC with Markov Chain Monte Carlo (MCMC) simulation techniques in MLwiN 2.10 are used to estimate model fit and complexity. This chapter is able to answer the following questions:

(a) *Which models provide the best fit, and what is the trade-off between fit and complexity?*
(b) *Do the normal plots to the models validate normal distribution assumptions at each hierarchical level?*
(c) *What are the effect of adding random effects to the parameters and standard errors of outcome predictors?*
(d) *What are the effects of adding random effects to the significance of the models?*

Chapter 5 investigates the pattern and relationship of prevalence between malaria and diarrhoea. First, a model with diarrhoea prevalence as an outcome variable and malaria prevalence as a predictor variable is examined. This is followed by a model with malaria prevalence as an outcome variable with diarrhoea prevalence as a predictor variable. The aim was to determine distinct patterns of malaria and diarrhoea prevalence and to establish if any relationship existed between the two reported diseases in the communities. The chapter concludes with a model that jointly analyses malaria and diarrhoea to determine common risk factors and to measure the degree of correlation between the two diseases. In general, therefore, this chapter answers the following set of questions:

(a) *What are the prevalence for malaria and diarrhoea in Chikwawa?*
(b) *To what extent does prevalence between diarrhoea and malaria affect and vary between households and different communities in Chikwawa?*
(c) *What are the individual, household, and community risk factors associated with malarial and diarrhoeal prevalence?*

(d) *Is there any significant relationship or correlation between malaria and diarrhoea in the communities?*

Chapter 6 assesses the pattern of knowledge and resource distribution with corresponding factors and further explores policy implications. The aim is to scrutinize existing gaps in knowledge and resource distribution and to determine if any relationship exists between knowledge and resource distribution gaps for malaria and diarrhoea. The following questions are, therefore, answered in this chapter:

(a) *To what extent do knowledge and resource distribution for malaria and diarrhoea vary at household and community levels in Chikwawa?*

(b) *What are the factors that affect the pattern of knowledge and resource distribution in households and communities in Chikwawa?*

(c) *Are there any relationships in pattern and predictor variables between malaria and diarrhoea?*

(d) *What policy implications can be drawn from the pattern of knowledge and resource distribution existent in Chikwawa?*

Chapter 7 examines care practices for malaria and diarrhoea and their corresponding risk factors. The objective is to investigate how families and communities make choices for treatment, reasons for such choices, and how choice of malaria treatment compares with choice of treatment for diarrhoea. The following questions are answered in this chapter:

(e) *To what extent does care-seeking behaviour vary across the communities in Chikwawa?*

(f) *What are the household and community factors that influence such behaviour?*

(g) *To what extent does care-seeking behaviour relate to occurrence of malaria and diarrhoea?*

(h) *Is there any relationship between malaria and diarrhoea treatment choices?*

Lastly, Chapter 8 discusses the general picture of the results and makes recommendations that are focused on improving joint control and prevention strategies against diseases. The chapter also explores areas of possible research in educational campaigns, capacity building, and targeted interventions to communities that need help most.

The recommendations are focused on improving joint control and prevention strategies against the diseases and further research to examine factors that were not captured by this thesis. These include more educational campaigns, increased number of community workers and committees and targeted interventions to communities that need help most.

CHAPTER 2

LITERATURE REVIEW

2.1 The burden of malaria and diarrhoea

It is well documented that malaria and diarrhoea are among the major causes of morbidity and mortality in developing countries especially among young children. It is estimated that out of 73% of 10.6 million yearly deaths in children in the years 2000 to 2003, 18% were due to diarrhoea and 8% malaria accounting for 26% of all deaths [Bryce et al., 2005]. Bryce et al. further estimated that out of all childhood deaths in Africa 16% were due to diarrhoea and 18% malaria, thus accounting for 34% of all deaths in African children. In Malawi malaria and diarrhoea cause 14 and 18% of overall under-five childhood mortality [World Health Statistics, 2006]

The problem of high malaria and diarrhoea mortality and morbidity in Africa is due to its climatic, geographic, nutritional, maternal, socioeconomic, and other conditions that favour high malaria transmission potential and viruses, bacteria, and parasites that cause diarrhoea [Woldemical, 2001; Reither et al., 2007]. The area of potential transmission of malaria is controlled by climatic factors such as temperature, humidity, and rainfall, which regulate the biology of development of both mosquito and parasite [Martin and Lefebvre, 1995]. Temperature affects the survival of the parasite and modifies the vectorial capacity of the *Anopheles* mosquito. Optimal temperature values, ranging from 22 to 30C, lengthen the life-span of the mosquitoes and increase the frequency of blood meals taken by the females, to up to one meal every 48 hours [Martin and Lefebvre, 1995]. Rainfall generally means new breeding places. The interaction between rainfall, evaporation, runoff, and temperature modulates the ambient air humidity which in turn affects the survival and activity of Anopheles mosquitoes. To survive, they need at least 50 or 60 % relative humidity.

Climatic and land-use changes and depletion of fresh water resources have implications on diarrhoea prevalence. Poor unsustainable land-use and changes in temperature and rainfall can cause floods that may affect the distribution and incidence of diarrhoea [Haines, et al., 2006]. In flood conditions, for example, there is potential for increased faecal-oral transmission of disease, especially in areas where the population does not have access to

clean water and sanitation [Ahern et al., 2005]. A study in Bangladesh, for example, found that diarrhoea was the most common illness after flooding and that watery diarrhoea was the most common cause of death for all age groups [Siddique et al., 1991].

2.2 Definition, Aetiology and perception of malarial and diarrhoeal diseases

2.2.1 Malaria

Plasmodium falciparum is the predominant parasite species that causes malaria in the sub-Saharan Africa including Malawi. It is associated with high virulence, severe morbidity and high mortality. It is transmitted by infected blood-feeding female anopheles mosquito [WHO, 1996; UNICEF 2000]. The clinical features of uncomplicated malaria are mild symptoms such as headache, muscular-ache, abdominal pain and fever while severe malaria clinical manifestations include severe anaemia, convulsions, kidney and renal failure, acute pulmonary oedema, metabolic acidosis and coma.

In Malawi the vernacular name used to identify malaria is *malungo* although most people, especially the youth and more educated use the name 'malaria'. However, the term *malungo* has several meanings and refers to different types of ailments with fever as a symptom. In actual fact fever is synonymous with malaria to most people in Malawi. Previous studies on perception and knowledge concerning malaria have observed that the term malaria is associated mostly with high fever, shivers and vomiting of yellow stuff [Munthali, 2005; Launiala and Kulmala, 2006]. This perception is reinforced by the tendency by health personnel to give presumptive malaria treatment whenever fever is reported due to scarcity of laboratory facilities for analysis of blood specimens to determine the presence of Plasmodium species. This affects the way families or parents seek treatment whenever members of their family, especially children have fever. Such misconceptions can also be a source of erroneous information when collecting information on morbidity.

2.2.2 Diarrhoea

Diarrhoea is associated with increased excretion of watery stools sometimes mixed with blood. It is caused by pathogenic agents such as viruses, bacteria and protozoa [WHO, 2004]. Considering that diarrhoea is often defined differently in various studies and countries

making inter-study comparison of morbidity and estimation of burden of disease difficult an internationally accepted standard definition of a diarrhoea-day is where a subject experiences three or more loose or watery stools in 24 hours or any number of loose or watery bloody stools [Baqui et al., 1991; Wright et al., 2006]. Acute diarrhoea lasts less than 14 days and the stools do not contain visible blood. Dysentery is diarrhoea with visible blood in the stool. Persistent diarrhoea is diarrhoea that begins acutely and continues for at least 14 days. These conditions differ with regard to pathogenesis, treatment, and risk of death [WHO, 2004].

In Malawian vernacular language diarrhoea is known as *'kutsegula m'mimba'* literally meaning opening up of bowels which is associated with defecation of watery stools especially in young children. However 'bloody stools' or dysentery, are known as *'kamwazi'* assumed to be a different disease from diarrhoea. This also affects treatment of family members and can be a source of erroneous information when collecting data.

2.3 Theoretical framework

A large proportion of malarial and diarrhoeal illnesses are entirely avoidable or treatable with existing medicines or interventions [Stevens, 2004]. However, these depend on a number of factors that involve host, agent, and environmental factors [Wallace, 1998].

2.3.1 Infectious diseases due to stress on the host factors:

Some of the factors that contribute to infection are due to the persons (hosts) infected. Stress in a host is among important factors that influences infection. Stress can either suppress or boost the immune system of a person [Suzanne and Gregory, 2004]. Short-term stress, for example, prompts the immune system to ready itself for infections resulting from measurable instantaneous challenges to the integrity of the body while chronic, long-term stress shifts the immune system from the adaptive changes as those resulting from short-term stress to more negative changes.

Stressors[1] are generally thought to influence the pathogenesis of physical disease by causing negative affective states, which in turn exert direct effects on biological processes or behavioural patterns that increase disease risk [Cohen and Williamson, 1991; Leventhal et al.,

[1] Agents, conditions, or other stimuli that cause stress to people, i.e. stress that seems beyond a person's control or seems endless.

1998]. Cohen and Williamson identified plausible routes through which stress might influence *susceptibility to infectious* disease and these include (i) altering biologic susceptibility and hence predisposing persons exposed to a pathogen to infection, (ii) *initiating or triggering a process* that allows a pathogen that is already in the body to reproduce, and (iii) *contributing to maintenance* of an ongoing pathogenic process.

These routes may relate to immunity whose strength depends on factors like genetics and the physical and mental state of the person. Lack of proper dietary food, for example, triggers stress due to malnutrition which, in turn may weaken the immune system especially in young children and old people. This increases the risk of illness and death from diseases, including malaria and diarrhoea [WHO, 2005]. Pregnant women are also particularly vulnerable to infection as stress due to pregnancy reduces a woman's immunity [WHO, 2003; Yartey, 2006]. The immune systems of the elderly are also subjected to stress-related changes [Suzanne S.C., Gregory M.E., 2004].

Lifestyles used to fight stress such as heavy drinking, smoking, and less sleep may also affect immunity [Cohen & Williamson, 1988]. They may do so directly by reducing the immunity of the host agent to infectious diseases or they may increase susceptibility through increased interaction with others in the same lifestyle category resulting in greater probability of exposure to infectious agents and consequent infection.

Ill health due to other diseases may also weaken the immune system, hence, subjecting the host agent to disease susceptibility [Suzanne S.C., Gregory M.E., 2004]. HIV, for example, invades critical cells of the immune system, which are essential for the body to mobilize the assorted armies needed to ward off any number of foreign invaders. HIV weakens the immune system's ability to do its job so that the host succumbs eventually to any number of infectious diseases. [Bruce Fife, 2006] some of which may coexist. For example, in areas where malaria is endemic, a child with fever may be suffering from malaria, pneumonia, diarrhoea, measles, or a combination of these, in addition to malnutrition [WHO, 2007a].

2.3.2 Infectious diseases due to agent factors:

Stress cannot result in infection without the presence of an infectious agent. The course of illness due to infectious diseases may also be influenced by factors related to the virulence of a disease agent, dose and frequency of exposure. Virulence may depend on transmission rate

i.e. by extracting more resources from the host; the diseases agent is able to make more transmissible forms per unit time. Malaria virulence, for example, depends on parasite clearance rate: the slower the parasite clearance rate the longer the infection from which to transmit. Thus there is a trade-off between 'how fast' and 'how long' the parasite transmits [Mackinnon and Read, 2004]. Diarrhoea depends on the frequency of exposure from agents. This is a function of the degree to which individuals may be exposed to environments that may cause the diseases. In the case of diarrhoea this depends on the frequency of drinking, or eating contaminated water or food respectively [Osumanu, 2007]. In cholera this may depend on overcrowded living conditions which result in increased interaction frequency and proximity with those that are infected [Yamada and Palmer, 2007]. Another important characteristic of an agent is its ability to survive outside the human body. The environments through which the disease agents survive is of paramount importance to the prevention and control of these infectious diseases.

2.3.3 Infectious disease due to environmental factors

Infectious diseases can be transmitted because of a number of environmental factors such commonly shared preventive/ curative services (including health seeking practices, healthcare utilisation, hygiene and sanitation practices), commonly shared dietary and nutrition intake, lifestyles such as smoking and alcohol, water sources and sanitation, health services, and ecological factors [Dahlgren and Whitehead, 1991; Turrell et al., 1999]. Other factors include household financial capital such as income expenditure and assets, household human capital such as knowledge, literacy, and education, household characteristics such as size, gender, and age, household physical setting in relation to health services, household or community geography setting, social capital, health service provision in relation to pricing and quality, health finance in relation to public health facilities and projects, and supply in relation to infrastructure.

2.3.3.1 Health seeking behaviour and healthcare utilisation

Infectious diseases can be influenced by lack of proper and timely health care resources and information available to the households or communities. Early diagnosis and prompt treatment are fundamental to infectious disease control more especially in malaria [WHO, 1995]. Timely treatment with professional diagnosis shortens disease duration and may

prevent the development of complications and death. The problem of drug resistance to infectious diseases such as malaria [Kublin et al., 2003; Hamel et al., 2005] highlights the importance of appropriate health facility diagnosis and prescription of right drugs. The fact that a large proportion of people in rural areas heavily depend on health facility personnel for the large part of their health information [Masangwi, 2007; 2008; 2009] signifies the importance of proper and effective health system.

Health service delivery system in Malawi is in four categories (see Figure 2.1) that include community, primary, secondary and tertiary care levels [GoM, 2002; Ezere, 2007]. At the community level, service is provided through health surveillance assistants (HSAs) and village health committees (VHCs). The focus is on preventive interventions. Primary care is delivered through clinics and health centres. District and central hospitals provide secondary and tertiary care services respectively. Other non-profit making organisations are also playing a vital role in service provision especially at community and primary levels [Masangwi, 2007; Morse et al., 2008].

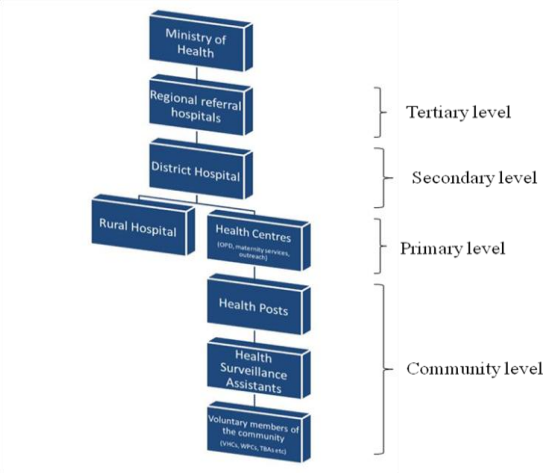


Figure 2.1: *Health service delivery system in Malawi*

Information on health seeking behaviour and health care utilization has important policy implications in health systems development. Factors which influence which treatment sources people seek when symptoms occur include social, economic, environment, proximity to a health care facility, and the severity of the disease [Okojie, 1994; Haddad and Fournier, 1995; Uzochukwu and Onwujekwe, 2004; Masangwi, 2008a]. The introduction of user fees and cost of treatment are also determinants of health seeking behaviour [Gilson et al., 1994; Moses et al., 1992; McCombie, 1996; Masangwi, 2008b].

2.3.3.2 A contextual and neighbourhood perspective

Existence of infectious diseases may, in addition to being associated with individual factors, also be associated with community and neighbourhood variations. Apart from within community effects, such as population at risk, individual or household characteristics, etc., it is important, therefore, to distinguish the likely effects on the variation of disease due to hierarchical and neighbourhood effects. Variation due to hierarchical effects may come because of differences in healthcare/healthcare resources, cultural, economic, disease endemicity, or ecological/environmental issues [Nosten et a., 2004; Kazembe et al., 2007a]. Communities may, for example, differ in the provision of and proximity to safe water sources, health infrastructure, and particular environmental features. Chikwawa, the district under study, has a variety of natural and man-made environmental features that may favour the occurrence of disease in the communities. Some of the communities are near big rivers characterised by marshes caused by floods during the rainy season, and yet others are near game reserves or irrigated sugar plantations. All these may have varying underlying degrees of influence on the incidence of malaria and diarrhoea in the communities.

2.4 Malaria and diarrhoea control and prevention strategies

The historical response by the international public health bodies and aid agencies to the burden of five common and preventable and easily treatable diseases that include malaria and diarrhoea was to develop disease-specific vertical control programmes such as the Expanded Programme of Immunisation (EPI) and the Control of Diarrhoeal Disease programme (CDD) [Moy, 1998]. Although these programmes were successful in reducing mortality rates Gove [1997] noted that the vertical approach had limited effectiveness in overcoming the major child health problems in developing countries. It was observed, for example, that many sick children had multiple symptoms or that their symptoms may not have been specific for one disease. An integrated approach to managing sick children was, therefore, required which would assess the whole child and combine therapies for several conditions rather than concentrating on individual diseases [Amaral et al., 2008]. The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) therefore developed a strategy entitled "Integrated Management of Childhood Illnesses" (IMCI) in 1993. The objective is to reduce mortality and morbidity associated with these diseases, as well as to contribute to children's healthy growth and development. The strategy has three key components of

performance of health professionals, health system organization, and family and community practices [Tulloch, 1999]. These components involve capacity building of health professionals, improvement of health system organisation and household and community activities on health support practices [Vidal et al., 2003; Amaral et al., 2008]

In Malawi notable activities aiming to reduce malaria and diarrhoea morbidity and mortality and to compliment the IMCI have been launched since 1999. These also compliment the Millennium Development Goals (MDGs) and include the introduction of ITNs (Insecticide Treated Nets) and IPT (Intermittent preventive treatment) to fight malaria; ORS (oral rehydration solution), WaterGuard (a water treatment product), improved drinking water sources, and improved sanitation to combat diarrhoea [WHO, 2005]. These initiatives were started with government programmes and other international organisations such as the United Nations Children's Fund (UNICEF), WHO (through the Roll Back Malaria Programme), United States Agency for International Development (USAID) and Population Services International (PSI) [WHO, 2005].

2.4.1 Malaria control and prevention using ITNs

Insecticide-treated nets (ITNs) are an effective intervention for the prevention of morbidity and mortality caused by malaria. They have been observed to be cost effective and to reduce the number of childhood illnesses and deaths in Sub-Saharan Africa including Tanzania, Kenya, and Malawi [Sexton et al., 1990; Beach et al., 1993; Goodman et al., 1999; Holtz, 2002; Wiseman et al., 2003; Hanson et al., 2003]. For example, a study to evaluate the use of ITNs and the effectiveness of social marketing in Malawi observed that living in a household without a bed net was significantly associated with lower mean haemoglobin levels, higher prevalence of malaria parasitaemia, a higher rate of clinically significant malaria parasitaemia, and a higher likelihood of having had fever within the past 2 weeks [Holtz et al., 2002]. WHO estimates that if insecticide-treated materials were used on a wide scale in sub-Saharan Africa, up to 340,000 child deaths per year could be averted [Lengeler, 2000; Holtz et al., 2002].

There is a social marketing programme in Malawi that has been distributing subsidised nets and insecticides since 1998. By 2004 the programme had distributed 2,557,412 ITNs representing 35% of overall bed net coverage in the country [Mathanga et al., 2005;

Mathanga and Bowie, 2007]. In addition to the social marketing programme initiative, there are other projects such as the Scotland-Chikwawa Health Initiative (SCHI) that are involved in the distribution of either free or subsidised ITNs in rural areas [Masangwi et al., 2008a]. However, current figures of ITNs coverage are far below the target of 60% that should have been achieved by the end of 2006 with rural families faring worse than urban residents [Kazembe et al., 2007c]. This is also affected by the short life span of many of these mosquito nets as they tear easily [Kumwenda, 2009].

2.4.2 Intermittent preventive treatment for prevention of malaria

More than 25 million women become pregnant in malaria endemic areas such as the sub-Saharan Africa each year. Between 75,000 and 200,000 infants die due to malaria infection in pregnancy [Steketee, 2001; WHO, 2004c]. Maternal anaemia which is responsible for maternal deaths and low birth are also linked to malaria especially in the sub-Saharan Africa [Steketee, 1996]. Intermittent preventive treatment of Malaria (IPT) involves the administration of a single curative dose of an efficacious anti-malarial drug at least twice during pregnancy – regardless of whether the woman is infected or not. It was introduced to fight malaria in infants and pregnant women. Sulphadoxine-pyrimethamine (SP) is the drug currently recommended by the WHO [WHO, 2004c]. 24 countries in the sub-Saharan Africa adopted this intermittent preventive treatment policy with SP as the control drug [WHO, 2005]. Out of these countries five of them, including Malawi, have achieved widespread programme of implementation [Hill and Kazembe, 2006]. Malawi was the first country to adopt this policy in 1993 [Kublin et al., 2003]. In 2004, eleven years after adopting this policy Malawi had achieved 78 % coverage for one dose and 47% for two doses. The Abuja Declaration requires that 60% of all pregnant women who are at risk of malaria, especially those in their first pregnancies have access to IPT [WHO, 2000]

2.4.3 Diarrhoea control and prevention strategies in Malawi

Lack of improved water sources and sanitary infrastructure is a high burden of diarrhoea diseases in developing countries which result in two and half million deaths in a year [Parashar et al., 2003; Garrett et al., 2008]. A 2004 World Bank Report [Fewtrell and Colford, 2004] reported that water supply, water quality, sanitation, hygiene or multi-factorial interventions have significantly reduced diarrhoea morbidity globally while in developing

countries factors that have significantly contributed to the decrease of diarrhoea are water point-of-use treatment, household connections without household storage, hand-washing, and sanitation. A study on household drinking water in developing countries [Wright et al., 2004] observed that the bacteriological quality of drinking water significantly declines after collection in many settings. They, thus, recommended safer household water storage and treatment together with point-of-use water quality monitoring. A systematic review and meta-analysis of interventions to improve water quality for preventing diarrhoea by Clasen et al. [2007] observed that interventions to improve the microbiological quality of drinking water, particularly at the household level, are more effective in preventing diarrhoea in endemic settings.

In Malawi statistics show that the proportion of improved water sources coverage has increased from 40% in 1990 to 73% in 2004 and of basic sanitation from 47% in 1990 to 61% in 2004 [NSO and Macro, 2005]. These are remarkable figures when compared to the MDGs targets. MDG 7 for water and sanitation requires that 70% of the Malawi population should have access to improved water coverage and 74% should have access to improved sanitation by 2015 [UNICEF, 2006]. Statistics from the Malawi Demographic Health Surveys [NSO and Macro, 2005] show that in 2004, 36% of the children under the age of five were taken to a health facility when they had diarrhoea, 61% were given oral rehydration therapy (ORT), 36% were given increased fluids, 70% were given ORT or increased fluids, 27% were given pills and syrup, 13% used home remedies, while 18% did not receive any form of treatment. This shows a general improvement of 8% for those that were taken to a health facility, 13% for those that received ORT, and 8% for those that received either ORT or increased fluids since 2000 [NSO and Macro, 2000, 2005]. The number of those that did not receive any form of treatment also declined from 18% to 12% from 2000 to 2004.

Lastly, a national survey conducted in Malawi [Stockman et al., 2007] to determine awareness and use of a socially marketed water treatment product, WaterGuard, showed a lot of mothers (64%) were aware of the product, however, there were very few (7%) that were using it. Currently there are some organisations such as the SCHI that are involved in the distribution of free and subsidised WaterGuard product in rural communities with the aim of increasing the proportion of families using the product to treat their drinking water in rural homes [Masangwi, 2009]

CHAPTER 3

RESEARCH SURVEY

3.1 Introduction

The survey was conducted in Chikwawa, a district in Southern Malawi (Figure 3.1). Chikwawa has a total of more than 400 villages (communities). The thesis used a survey methodology similar to that used in national surveys [NSO & UNICEF, 2008] to produce a district representative sample of communities, households and individuals. Enumeration maps from the Malawi National Statistical office were used as a guide in sampling the villages. These enumeration maps are used for professional national surveys such as the Demographic Health Surveys (DHS) [NSO and Macro, 2005]. The survey was carried out under the umbrella of the Scotland-Chikwawa Health Initiative (SCHI), a Scottish funded non-profit organisation under the Malawi Millennium Project at the University of Strathclyde and the major sponsors of the survey.

Ten enumerators were recruited amongst those that had already been involved in national surveys at the National Statistical Office in Malawi. The SCHI provided a supervisor who is an experienced health surveillance assistant in Chikwawa district and was previously involved in a number of surveys and data collection.

The enumerators were given one week intensive training on the questionnaire and had two days of a pilot study in order to (a) acquaint themselves with the questions, (b) afford them an opportunity to ask questions, seek clarifications, and make general questions where necessary, (c) accustom them with survey, interviewing, and house selection techniques. The exercise also sought to familiarise them with the problems they were going to encounter in the field and at the same time share their previous experiences in such exercises. Since the questionnaire was translated in a local language, the pilot study was also meant to clear any ambiguities and problems in its interpretation and administration.

Permission to conduct the survey was received from the Malawi National Health Sciences Research Committee (MNHSRC), the District Commissioner for Chikwawa District, and traditional leaders. Dissemination of findings was to be provided to the District Assembly on completion.

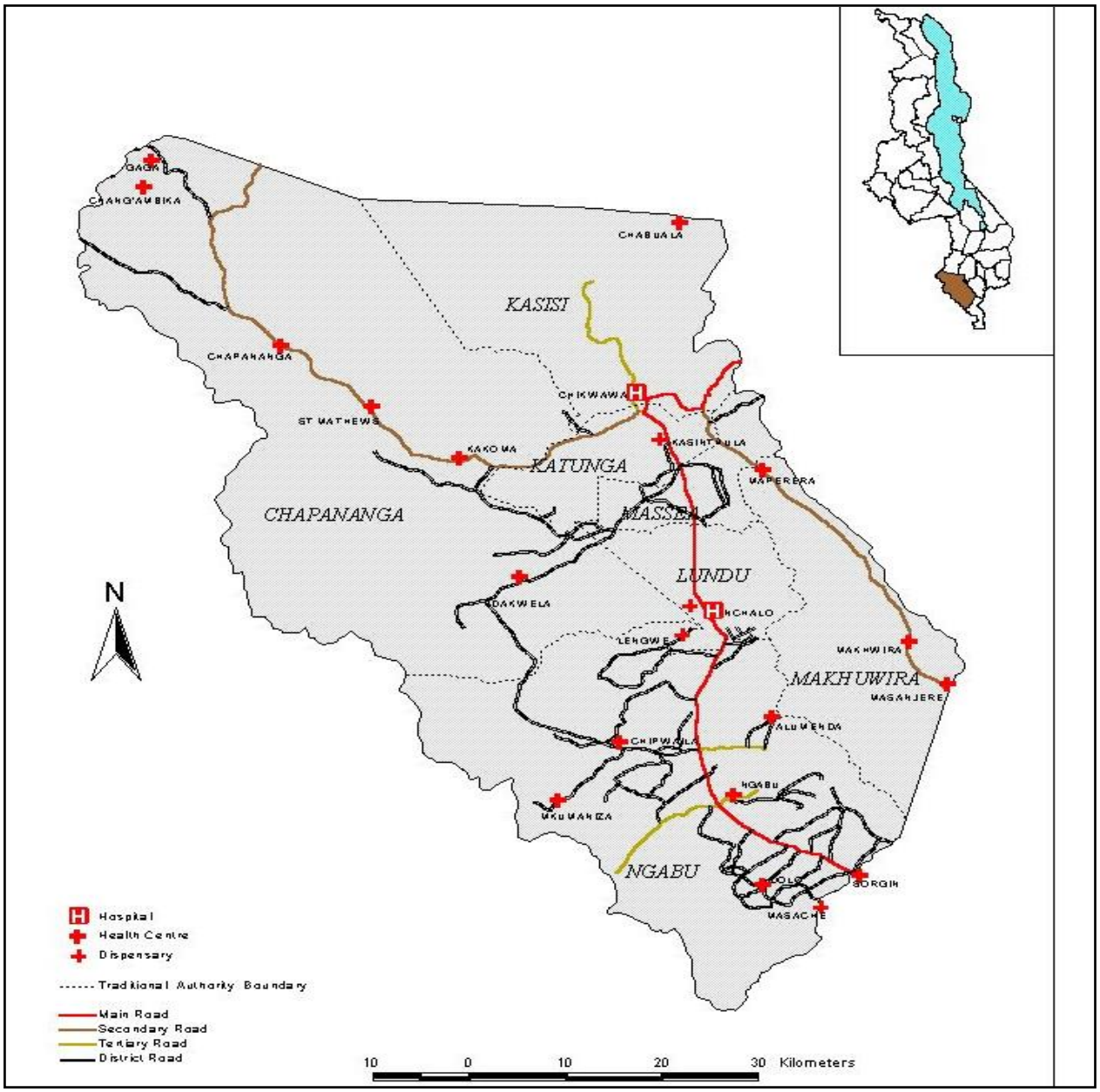


Figure 3.1: *Map of Chikwawa District and its location in Malawi (Courtesy of the SCHI)*

3.2 Survey methodology

Since one of the objectives of the 2007 survey was to determine the pattern of infectious diseases at community and household levels in Chikwawa using multilevel models and for purposes of this thesis, the author adopted a two-stage survey methodology. This was discussed with the author's supervisor and the University of Strathclyde and later at a working committee of Scotland-Chikwawa Health Initiative.

The survey in Chikwawa was a cross-sectional village-based survey which employed a two-stage cluster sample design to produce a district representative sample of households in 33

villages. Household in this thesis is defined as all persons who share earned income and farm produce and eat from the same cooking pot. Normally households share the same house, although at times teenage boys or other dependents would have their own house while remaining a member of the economic family unit. Village data were obtained from enumeration maps that were supplied by the National Statistical Office in Malawi.

The survey targeted only women of childbearing age. The women had to be the owners or the most senior responsible women in the households (matriarchal figures). Such women were targeted because they are the custodians of household information of each and every member of the household. In Malawi women of child bearing age can, at times, be below the age of 15 years. Other households are simply managed by young women due to the scourge of HIV/AIDS epidemic. For this reason the questionnaire did not give a lower limit of the responsible women in the household. As long as the woman was in charge of a household, she was eligible for the interviews.

3.3 The questionnaire

The questionnaire was a modification of a 2004 DHS questionnaire and the 2006 SCHI questionnaire (Appendix 3A). Additional questions not yet covered in the two questionnaires were added to capture relevant information to this thesis. The questionnaire had sixteen sections and only questions from the identification, household information, socioeconomic data, health access, malaria, diarrhoea, water sources and sanitation sections are relevant to this thesis. The rest of the questions were designed for the SCHI who were the major sponsors of the research survey.

The questionnaire was translated into Chichewa, the national language of Malawi which is used for communication in Chikwawa. Translations were checked by SCHI members, and enumerators. Some ambiguities in translation were dealt with after the pilot survey.

3.4 Sample description

The ‘first-stage’ sampling frame consisted of villages in seven traditional authorities in Chikwawa District (Figure 3.2). There are eleven traditional authorities and seven were included in this study. Villages from each of the selected traditional authorities were

strategically selected with a probability proportional to the number of enumeration areas in each traditional authority. Thirty six villages were selected for the survey (see Table 3.1).

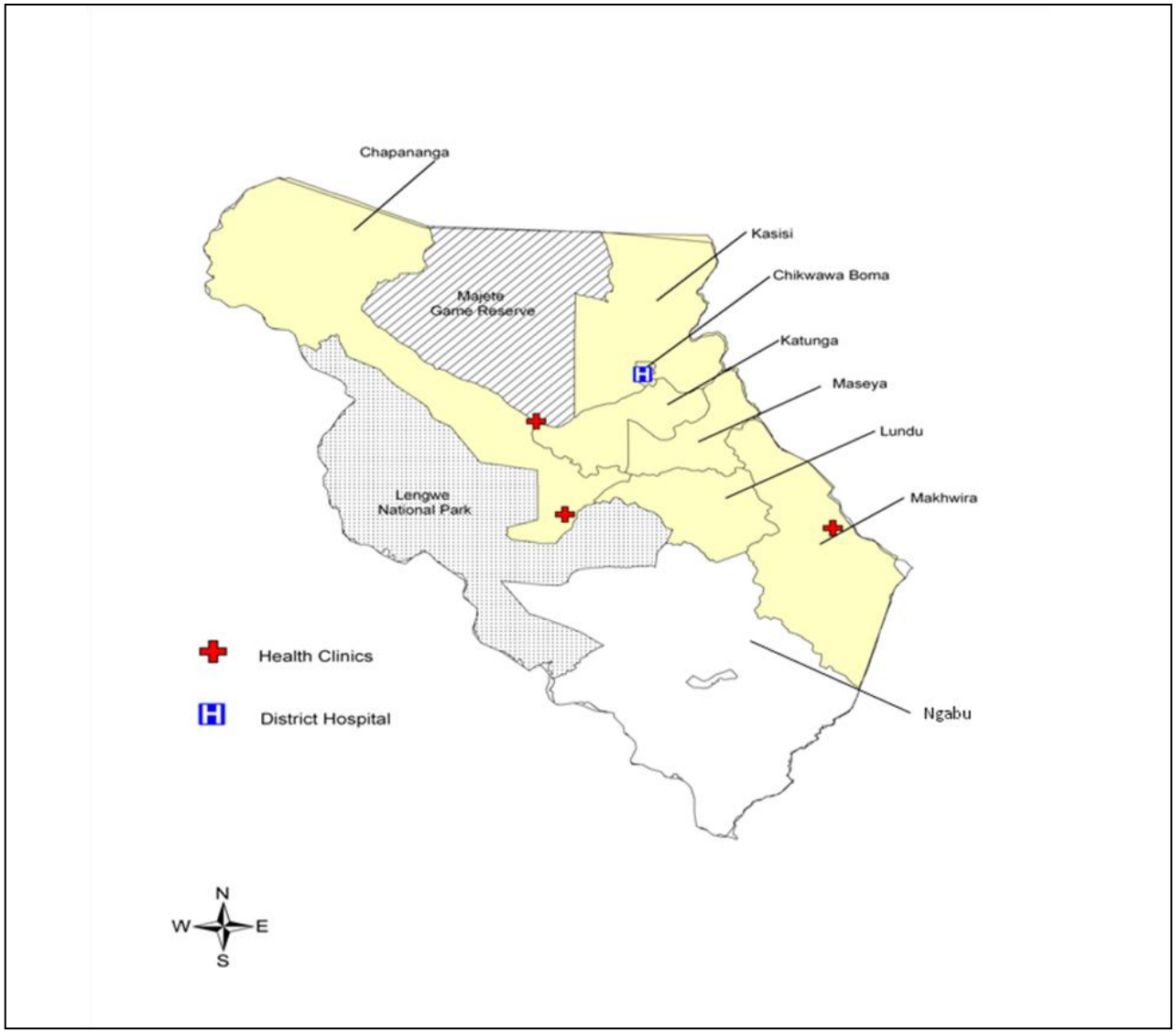


Figure 3.2: *Map of Chikwawa District showing the seven traditional authorities that were sampled (Courtesy of SCHI)*

The second sampling stage took place on the day of interviews. Sampling of households was systematic from a chosen point to all directions in each village. This heavily relied on trust that the interviewers would indeed follow the prescribed systematic sampling. An experienced HSA was recruited as a supervisor and together with the principal investigator made rounds checking each enumerator to ensure that they maintained the standards as

required of them. Starting points were selected at random by each interviewer. Only women were eligible for interviews and all other members of the households were asked to leave the interviewing premises to avoid interference.

3.5 Sampling design

In this multilevel model there are two major sample sizes: the household number size and the village number size. Both of these have influence on model parameters. Currently, the conventional wisdom suggests samples of at least 30 at level one and at least 30 at level two in order to get adequate statistical power with respect to estimates of all model parameters and their standard errors [Kreft, 1996; Maas and Hox, 2002; Huang and Lu, 2007]. Maas and Hox went even further by suggesting that bootstrapping or other simulation-based methods [Goldstein, 2003; Hox, 2002] may also be useful to assess the sampling variability even if the sample is as small as 10 groups of five units, provided we are interested only in the regression coefficients. The robustness issue and the choice of sample size and power in multilevel modelling have been studied by several authors [Maas and Hox, 2004; Hox, 2002; Snijders and Bosker, 1993; Leyland and Goldstein, 2001; Raudenbush and Liu, 2001; Bingenheimer and Raudenbush, 2004; Atkins, 2005; Maas and Hox, 2005, Shieh and Fouladi, 2003; and Dickinson and Basu, 2005] . In his simulation techniques using Monte Carlo methods to assess the impact of misspecification of the distribution of random effects on estimation of and inference about both the fixed effects and the random effects in multilevel logistic regression models Austin [2005] concluded that estimation and inference concerning the fixed effects were insensitive to misspecification of the distribution of the random effects. However, he established that estimation and inferences concerning the random effects were affected by model misspecification. More simulation studies showed that a larger number of groups are more important than a larger number of individuals per group [Hox, 2002; Maas and Hox, 2004]. The estimates of the standard errors and the variance components tend to be underestimated when the number of level 2 units is less than 30 [Maas and Hox, 2004; 2005]. Many methodologists have argued that the second-level sample size is much more important for the performance of parameter estimation than the first-level sample size. They suggest the first-level sample size can be reduced to 15 given the same number of the total observations. However, in their more recent simulation study, Huang and Lu [2007] argues that the 30/30 rule is still a better principle. Based on their simulation studies they found that reducing first-level size performs far worse than the 30/30 rule. They concluded, therefore, that multilevel

models should stick to the 30/30 rule unless the analytical purpose is focused on testing a well-elaborated macro-level theory. Considering that most simulation studies cited above have shown that convergency rates of the regression parameters at 95% confidence intervals improved considerably with groups of 30 and group sizes of 30 and that the bias in group-level variance components was reasonable although improvements to group level of 50 helped, this study decided to adopt a 30/30 rule with the following additional reasons: (i) most models in this study were going to be two level models, i.e. household and community levels and (ii) minimum number of communities and households were required due to the limitation of financial resources. However, the actual sample size comprised 33 villages with 30 of them with at least 30 households as shown in Table 3.1. The sponsors of this study insisted on large number of samples from their four pilot communities (Mwanayaya, Mwalija, Sekeni and Namila communities). They actually demanded a total sample of not less than 500 households. In total, therefore, 1,410 households were sampled in 33 communities. The number of individuals whose information was sought is 6,847.

Table 3.1 Sampled villages and their sample sizes

Code	Village	HHNO	Code	Village	HHNO
1	Chikwawa Boma	36	18	Beleu	30
2	Jombo	34	19	Mwanayaya	95
3	Mose	31	20	Makhula	42
4	Chindoko	15	21	Mafunga	30
5	Mbwadzi	34	22	Matimati	24
6	Julius	32	23	Machokola	33
7	Ngalu	35	24	Tombondera	30
8	Ngabu Trading	32	25	Tembenawo	31
9	Changamuka	31	26	Sekeni	198
10	Chipwepwete	38	27	Ndirande	34
11	Kabona	32	28	Tomali	36
12	Phonde	30	29	Bester	30
13	Njuzi	32	30	Biliati II	31
14	Maluwati	31	31	Thomo/Moda	32
15	Salumeji	39	32	Thembeta	25
16	Ntondeza	31	33	Mwalija	102
17	Namila	95			

HHNO = number of households sampled; Total number of households sampled = 1,410;
Total number of individuals whose information was sought = 6,847

3.6 Data collection

A day before the interviews the author and a supervisor[2] would visit local leaders in the selected villages. They (local leaders) would be handed with a letter from the District Commissioner that authorised the interviews. The local leaders would then be asked to publicise the impending interviews and that only matriarchal figures would be required to remain in their homes until the interviews were complete. Generally this did not pose any problem and response rates were almost 100%.

Plate 3.1: *An interview in the process. A senior woman in a household (right) taking questions from an enumerator (left)*

The questionnaires were administered by the enumerators to matriarchal figures in each selected household (see Plate 3.1). Survey procedures were designed to guard against collaboration with other members of the household (especially husbands). There were ten interviewers. Five interviewers were assigned to one village at a time. From each village a starting point was randomly picked. Each interviewer was asked to choose a random starting point and direction for his/her interviews. The interviews by each interviewer were done

[2] This was a locally recruited experienced interviewer who was made in-charge of all other interviewers. He acted as a link between this author and the other interviewers.

systematically (i.e. each interviewer picked every 5th household in their respective directions).

3.7 Challenges faced with the survey

The challenges in the survey were in two categories. Those involving the conduct of the survey and those associated with some methodological, ethical, and taboo issues in researching rural communities. This survey was motivated by the SCHI who were the main sponsors. The SCHI primary interest was to obtain household data for four communities of Namila, Mwalija, Sekeni and Mwanayaya. SCHI has ongoing projects in these four communities and wanted the survey results to evaluate its activities. This was at variance with the goals of the thesis which were to determine the pattern and variation of morbidity in the whole district. The total prepared budget for the whole (Chikwawa) project was about £5,000.00 and the SCHI offered a limit of £3,000.00. This meant the author hard to source the remaining £2,000.00. Fortunately, the Polytechnic College of the University of Malawi offered about £340.00 from its research fund. The author provided remaining costs by using own transport (see Plate 3.2) to cut costs and by providing the remaining required funds from own sources.

(a) vehicle with enumerators on the way to the field

(b) Front view of the vehicle

Plate 3.2: *A vehicle hired for the survey.*

Apart from ethical clearance issues which were already obtained under the SCHI, each district in Malawi has a District Commissioner (DC) and a hierarchy of local traditional

authorities. Before any survey was carried out these authorities had to be consulted and the surveys could only go ahead with their consent. There was no problem with the DC but local traditional authorities. On occasions local authorities could not be found in their headquarters and the author had to make a number of repeated trips until contact with the village chief was made and consent obtained. This proved costly in terms of fuel, time, and exhaustion considering that most of these places are in remote areas and are difficult to access.

Since the communities in each enumeration area were randomly selected, some villages in one particular traditional authority (Chapananga) were located in hilly and stony areas very difficult to reach. This was compounded with the problems of the car which started developing frequent problems towards the end of the survey exercise and the heat wave during this summer period. As a result some three villages in Traditional Authority Chapananga were abandoned. This meant surveying 33 villages instead of 36 originally included for this purpose. This was considered a bearable anomaly considering that a minimum of 30 villages was required for the whole exercise.

The aim of the survey was to target matriarchal figures as custodians of detailed household information. During the course of interview some men (heads of households) insisted on attending the interviews themselves. Since letters of consent from the DC were shown to the village heads a day before the interviews, rumours swept fast through the village that government officials were coming to obtain information that might assist with developmental projects in the communities. This raised expectations. Probably due to lack of trust on matters of this nature, most men wanted to be included in the exercise. Some insisted to remain within the earshot of the interviews and more often interfered with the responses. However, the interviewers were trained to only take those views coming from the intended respondents.

Some of the questions, especially those that relate to sex, sexual organs, and HIV/AIDS are considered a taboo to some tribes within the communities. As such it was very difficult to obtain straight and trustworthy information in such topics and sometimes no responses were given. In some rare occasions interviews had to be abandoned immediately the topics were introduced. Interviewers were advised to introduce such topics at the end of each exercise so that in case of abandonment most of the information would have already been sought.

The reporting of household information was based on retrospective reporting by senior women in each household. This had possible result of biases due to incomplete responses and unrepresentative individual data. Furthermore, only information from surviving women was recorded implying that no data was available for households without matriarchal figure which may create bias. During the survey mothers were not given a precise definition of what constitutes an episode of childhood malaria or diarrhoea. Therefore, questions relied on the mother's perception of the diseases other than clinical or actual definitions. This may create variations among different households and villages because perception of an illness episode is not the same across different groups of people. Further most mothers identified malaria from fever which may be a symptom for other diseases other than malaria. To reduce the effect of these methodological limitations, questionnaires from each enumerator were carefully audited after each day's survey and the data was screened to ensure consistency of approach to questioning and responses and to determine if the data conformed to expected patterns.

Respondents were also required to explain in detail why they thought a member's illness constituted malaria rather than just fever. This thesis used the Malawi Ministry of Health guidelines to health workers that fevers without another identifiable cause should be treated as malaria if accompanied by one of the following symptoms: headache, chills, shivering, or loss of appetite [Malawi Government Ministry of Health, 2002]. Thus any information on additional symptom of malaria to fever as indicated above or information of a test at a health facility, or if antimalarial drugs cured an ailment was desirable to confirm a malaria episode. Also considering that diarrhoea is often defined differently in various studies and countries [Wright et al., 2006], a standard definition of a diarrhoea-day was used in this study i.e. one where a subject experiences three or more loose or watery stools in 24 hours or any number of loose or watery bloody stools [Baqui et al., 1991 in Wright et al., 2006]. As already explained in chapter 2, in Malawian vernacular language diarrhoea is taken as a different disease from dysentery, interviewers were advised to use both vernacular definitions of diarrhoea and dysentery when collecting data on diarrhoea illness.

CHAPTER 4

MODEL VALIDATION

4.1 Introduction

Some of the problems associated with the prevention and control of infectious diseases may be due to the fact that the epidemiology of these diseases is not properly researched. The pattern and variation of morbidity and co-morbidity due to infectious diseases and how these relate to behavioural, environmental and socioeconomic factors at different hierarchical levels in the communities may not be fully understood. Accurate epidemiologic data are essential for adequate disease control and prevention. Effective disease control requires prompt and adequate action towards the reduction of predisposing factors toward disease acquisition and transmission. Such actions can only be made if correct information reaches those required to take action promptly. This has been difficult to achieve in Malawi partly because of lack of proper analytical information on disease pattern, variation and risk factors in the communities. This hampers communication between the respective levels of health service delivery and planning, monitoring of results, and evaluation at district and national levels. Without proper professional information which provides the right indicators, the fight against controllable and preventable diseases can be difficult.

Some epidemiological studies of diseases in Malawi have concentrated on national patterns and geographical variations using data collected by the national demographic and health surveys [Kandala et al, 2005; Kazembe et al, 2007b; Kazembe and Namangale, 2007]. The problem with this approach is that national classifications may conceal important community information within districts and may result in misallocation of scarce resources. Kandala and others [2005] successfully illustrated this in their study on childhood diarrhoea and fever when they showed that regional classifications do mask important district variations. This may result in ill-suited interventions that may translate into misplacement of scarce resources in the communities. In turn this may make it difficult for households to ably sustain the control and prevention of various diseases in their communities. Efforts are needed to determine district-specific disease epidemiologic profiles to be used for planning of specific appropriate interventions. It is important, therefore, that research focuses on common disease prevalence, their prevention, and public health impact at different epidemiologic profiles.

This chapter explores various multilevel modelling techniques and selects appropriate models for the interpretation of results in the subsequent chapters. A conceptual framework of health outcomes being investigated is shown in Figure 4.1 and Figure 4.2. These figures derive from the organisational paradigm in the socio-economic determinants of health and disease [Dahlgren and Whitehead, 1991; Turrell et al., 1999]. It is important to understand that Figure 4.1 and Figure 4.2 do not represent casual path diagrams in any formal sense. However, they suggest potentially testable structural relationships among the variables comprising outcome and indicator factors at different levels of a district health system. The diagrams are inherently multilevel.

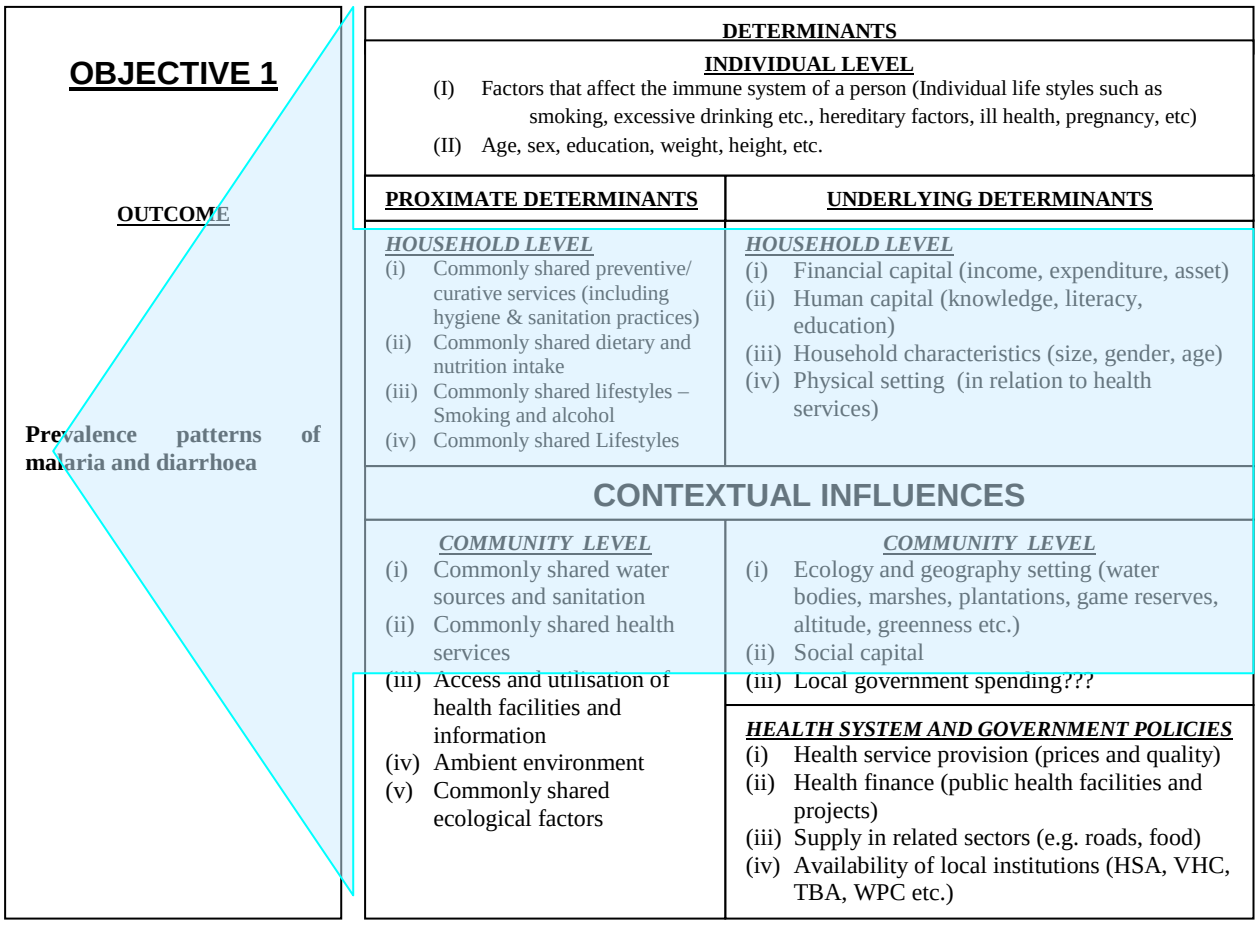


Figure 4.1: *Conceptual framework for a 3-level model*

There are mainly four types of multilevel models employed in this thesis and these include binary, unordered and ordered multinomial, and bivariate regression models. The chapter starts with the exploration of binary logistic model for diarrhoea prevalence. It shows how each predictor variable was selected and how each potential model was diagnosed and compared to other models. Since the mode of selecting variables and vetting the candidate

model for final analysis is the same, the remaining sections are only preoccupied with model assumptions and why each model is selected as opposed to other potential choices.

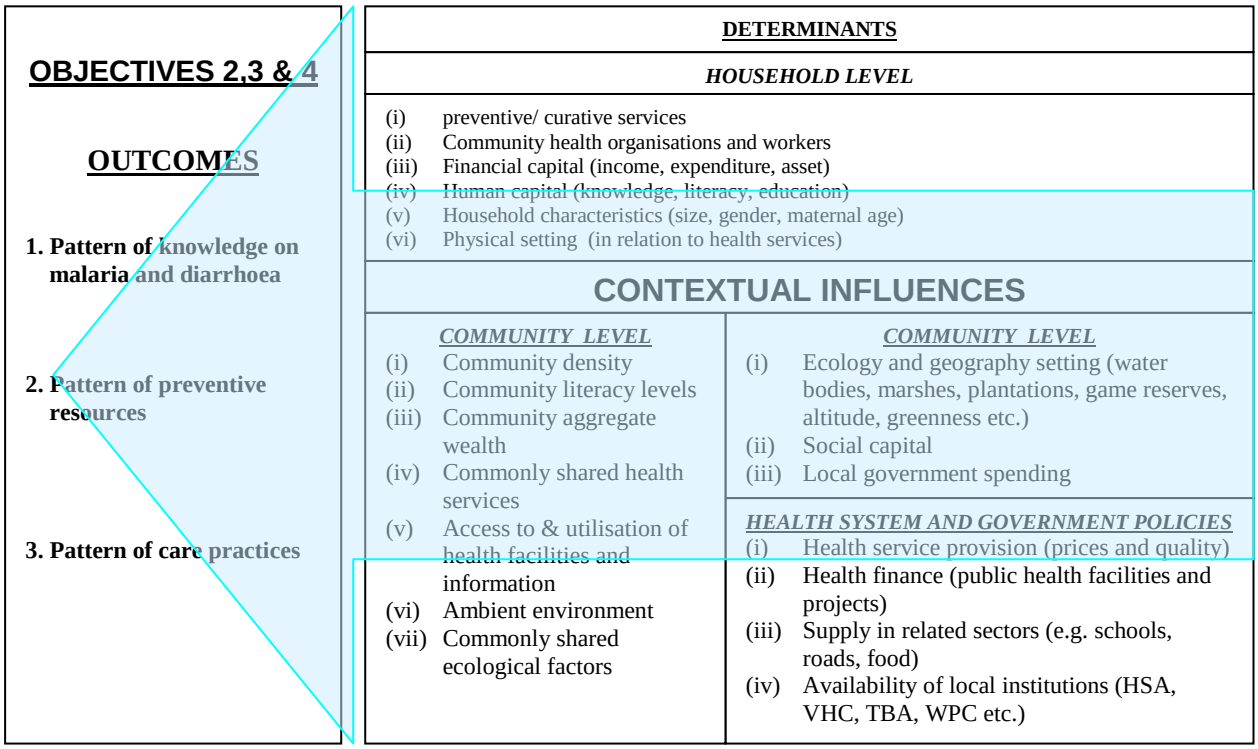


Figure 4.2: *Conceptual framework for a 2-level model*

Estimation of the models is performed using Markov Chain Monte Carlo (MCMC) procedures in MLwiN 2.10 software [Browne, 2003]. MCMC procedures are used because the models being considered are complex and high-dimensional, making it difficult to find solutions analytically. Starting values for each parameter for the MCMC procedures are derived using second-order penalised quasi-likelihood (PQL) procedures with Iterative generalised least-squares (IGLS) estimation in MLwiN 2.10. Stability of all model parameters is monitored by observing the Raftery-Lewis diagnostics [Browne, 2003

Model comparison is based on the Deviance Information Criterion (DIC) [Spiegelhalter et al., 2002] such that $DIC = \overline{D} + pD$. As Manda and Meyer [2005] observed the use of DIC is particularly useful in situations involving complex hierarchical models in which the number of parameters used is not known. The deviance $\overline{D}$ represents goodness-of-fit and is evaluated at the posterior mean of the parameters, while pD is the effective number of parameters and provides a penalty for increasing model complexity. The effective number of parameters is

defined as $pD = \overline{D} - D(\bar{\theta})$, where $D(\bar{\theta})$ is the deviance evaluated at the posterior expectations. Small values of DIC are an indication of a good model. Differences of more than 7 in DIC were taken to indicate a statistically significant difference [Spiegelhalter et al., 2002].

Various software packages are available for multilevel analysis including MLwiN, HLM, SAS, VARCL, STATA, and SPSS. However, the scope for model specification in some of these packages is currently more limited than that of MLwiN [Zhou et al., 1999]. While most of the packages allow for estimation of covariates at each level of hierarchy and for estimation of the covariates to be unit specific as in random coefficient models, MLwiN has an option to perform second order approximations, has ability to perform Bayesian inference using MCMC and has more analytical as well as estimation methods a clear advantage for nonlinear analysis required in this thesis.

Normally when data is large as is the case in this thesis (6,847 individuals nested in 1,410 households nested in 33 communities) classical and Bayesian parameter estimates are usually very close [Paap, 2002]. The choice of Bayesian estimation in this thesis is motivated by the fact that the results of this study are meant for decision making in Chikwawa. Bayesian estimation, therefore, provides a more convenient way of dealing with parameter uncertainty i.e. using the results to make inferences about malaria and diarrhoea and random effects at individual, household and community levels within Chikwawa District. MLwiN software has facilities for Bayesian estimation using MCMC making the whole exercise easy.

The first step in the analysis of the data was to examine the pattern of the outcome variable with (i) individual level, (ii) individual and household levels, and (iii) individual, household and community level without and predictor variable. DIC is used to measure the fitness of the models at each stage.

The second step investigated the simple relation between each potential explanatory (indicator or predictor) variable and the outcome variable of interest ignoring all other variables. Only indicator variables that were significant at $p \leq 0.2$ with a DIC reduction of at least 7 were selected for the final model. Then after this a stepwise regression analysis [Altman, 1997] of the variables was performed as follows:

(a) A variable with the strongest association with the outcome variable was entered

(b) A variable among those not included in the model that, when added to the model reduced the DIC by more than 7 or explains the largest amount of the remaining variability was entered.

(c) Step (b) was repeated until the addition of an extra variable was not statistically significant at $p \leq 0.10$

The third step was to inspect whether assumptions of normality and linearity are met. In multilevel regression analysis it is assumed that variance of the residual errors is the same in all groups [Hox, 2002]. This can be inspected by plotting standardised residuals against their normal scores. If the residuals are normally distributed the plot should show a fairly straight diagonal line. The best models were selected for final interpretation of results on malaria and diarrhoea.

4.2 Statistical modelling of diarrhoea prevalence

4.2.1 Outcome variable

Each household member's reported diarrhoea prevalence was used as the outcome variable. Respondents were asked if a member of their household had diarrhoea since January of 2007 to the time of the survey (September 2007). The response was dichotomised with 1 representing yes and 0 representing no. A binary logistic regression hierarchical model was proposed for this type of data.

4.2.2 Indicator variables

Age, an individual's highest level of school attended, gender, frequency of malaria episodes per individual, and whether a person was pregnant or not, were all included as individual (level one) predictor variables after satisfying condition of the stepwise regression analysis.

Household size, employment status of head of household, drinking water source, sanitation, distance to the nearest river[3], type of nearest health facility and wealth status were included as

[3] *Notice that distance to the nearest river and nearest health facility were included as household variables because households from the same community could have different proximities to the same nearest river or would have different nearest rivers and they could report to different health facilities based on distances and socioeconomic preferences.*

household (level two) predictor variables. Community's proximity to the nearest active trading centre was included as a community level predictor.

Individual age variable was categorised as: 1: 0-5 years, 2: 6-18 years, 3: 19-40 years, 4: 41-60 years, and 5: above 60 years. The categories were selected based on observed clusters on a scatter plot as shown in figure 4.3.

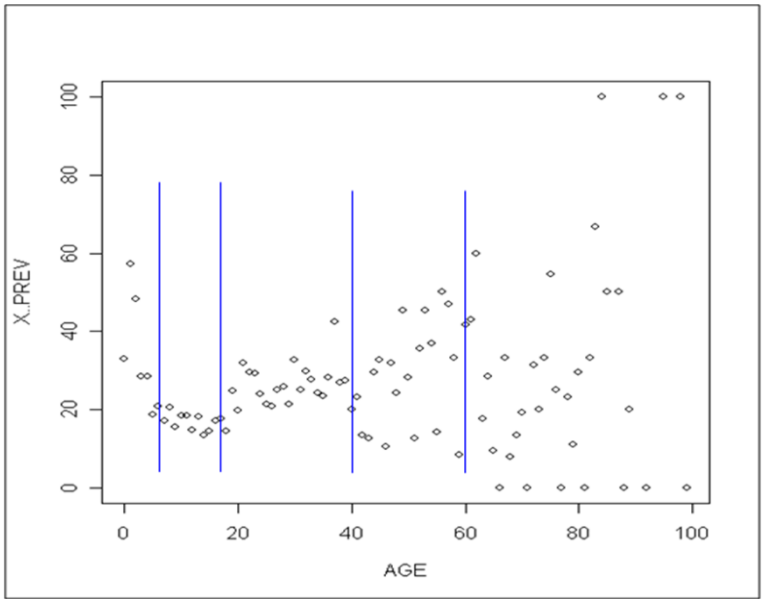


Figure 4.3: *Diarrhoea prevalence~(X..PREV) by individual age showing cut-off points for selected categories*

Individual highest levels of school were categorised as: 1: no school, 2: primary school education, 3: secondary and tertiary education. Gender was classified as 1: male and 2: female. Existence of an expectant woman was scored 1 otherwise 0. Individual malaria episodes predictor was included as a continuous variable.

Household size was included as continuous quadratic variable based on scatter plots in Figure Figure 4.5.

A household head was scored 1 if he/she was employed and 0 otherwise.

Water sources variables that were considered in this study were: (1) private piped water or private water tanks, (2) public piped water, (3) other safe water sources such as boreholes, protected wells, and springs, and (4) unsafe water sources such as rivers, streams, or ponds.

A sanitation variable was measured through categories of: (1) own toilet facility, (2) shared toilet facility, (3) no toilet facility. Health facility variable was considered as: (1) local private clinic, (2) government hospital, (3) health centre, (4) Christian Association of Malawi (CHAM) hospital, and (5) health post or local clinic.

Distance to the river was also categorised as: 1: 0 to < 1 km, 2: 1 to 2 km, 3: more than 2 km.

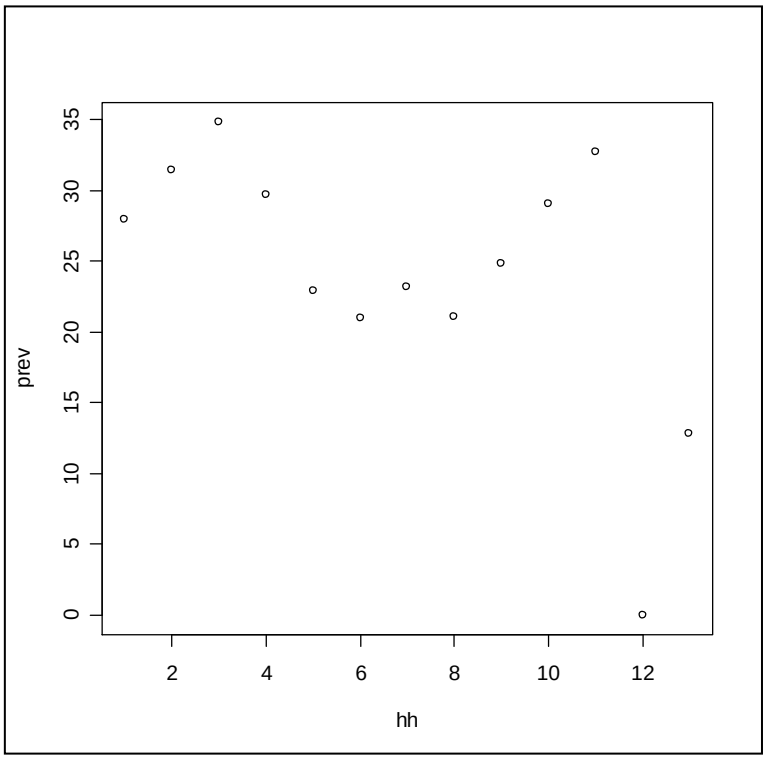


Figure 4.5: *A scatter plot of the percentage of diarrhoea prevalence (prev) against household number (hh)*

Household wealth index was derived by analysing household possessions, quantity of animals and birds and type and quality of house. The method of 'variations' [Gwatkin et al., 2000] that assigns weights to indicator variables and uses the inverse of the proportion of number of households with an asset or service as the weight for the indicator was used. The principle behind this procedure is that the costlier an item, the wealthier a household needs to be to possess one, giving the highest weights to the least possessed assets. Caution was taken to ensure that problems arising with this weighting scheme in certain assets, such as motorcycles, that are rare, but are not as costly as a car, were either excluded or were included amongst items closer in function and quality. A categorical variable was derived by grouping the wealth index distribution into three distinct segments. These segments are based on observed clusters such that the first segment is from households with indices 0 to less than

0.003; the second segment is from 0.003 to less than 0.01, the third segment is from 0.01 and above.

4.2.3 Diarrhoea prevalence statistical analysis

Binary logistic regression base models (without any predictor variables) were fitted first and were assessed based on their diagnostics and random effects. Since the data were clustered at household and community levels, single-level, two-level and three-level models were tested. These models were extended to incorporate fixed and random covariates. The model with the best fit was used for final analysis on diarrhoea prevalence.

The binary regression model [Collet, 1994; Souza et al., 2004; Leyland and Goldstein, 2001; Fielding et al., 2003; Rasbash et al., 2004] was used to explain the probability of binary diarrhoea prevalence outcomes for individuals. If the i_{th} individual from the j_{th} household from the k_{th} village was reported to have had diarrhoea illness. Then a response would be written

$$y_{ijk} = \begin{cases} 1 \; if \quad i_{th} individual \quad from \quad j_{th} household \quad in \quad k_{th} village \quad was \quad reported \quad ill \\ 0 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad otherwise \end{cases}$$

such that

$y_{ijk} \left| \boldsymbol{\pi}_{ijk} = Ber(\boldsymbol{\pi}_{ijk}) \right.$, and $\log it(\boldsymbol{\pi}_{ijk}) = \boldsymbol{x_{ijk}\beta} + \boldsymbol{z_{ijk}u_{jk}} + \boldsymbol{z_{ijk}v_k}$ is a general random components model. $i = 1,...., I_j$ individuals; $j = 1,\ldots,J$ households; and $k = 1,\ldots.K$ villages, with π_{ijk} as the probability that the i_{th} individual in the j_{th} household belonging to k_{th} community reported sickness. The vector $\boldsymbol{\beta}$ is a Φ set of fixed regression coefficients corresponding to a set of individual covariates x_{ijk}. Random effects at the household and community level are respectively modelled through u_{jk} and v_k such that $u_{jk} \sim N(0, \sigma_u^2)$ and $v_k \sim N(0, \sigma_v^2)$. Where household and community level covariates are available, these are captured by z_{ijk}, which may or may not be equal to covariate x_{ijk}. Base models (i.e. models without covariates) are obtained when $x_{ijk} = z_{ijk} = 1$. When $v_k = 0$ we have a two-level model and when $v_k = u_{jk} = 0$ we have a single-level model.

4.2.4 Diagnostics for a binary logistic multilevel model

Table 4.1 shows base models (with no predictors) that are used to determine estimates for comparison with subsequent models. Model 1 is without random effects, model 2 includes household random effects only, and model 3 includes both household and community random effects. Model 1 is the least complex but fits poorly. Model 2 is more complex but with improved fit that lowers the DIC substantially by over a 1,000 units. Model 3 is also more complex and improved the DIC from model 2 with over 47 units suggesting this is the best model of the three. Thus the inclusion of household and community random effects leads to significantly improved models although their model complexity has increased.

Table 4.1: Diagnostics and random effects at household and community levels for the null models

	Model 1		Model 2		Model 3	
	β	SE	β	SE	β	SE
Constant	-1.070	0.028****	-1.488	0.076****	-1.477	0.103****
Community and household effects:						
σ_u^2 (household)	—	—	2.786	0.403****	2.703	0.243****
σ_v^2 (community)	—	—	—	—	0.204	0.094**
Model diagnostics:						
$\overline{D}$	7716.08		5639.88		5608.01	
$D(\overline{\theta})$	7715.08		4814.02		4797.55	
pD	1.00		825.86		810.46	
DIC	7717.08		6465.74		6418.46	

$*p \leq 0.10$; $**p \leq 0.05$; $***p \leq 0.01$; $****p \leq 0.001$

Household random effects for base models 2 and 3 are highly significant ($p<0.001$) indicating significant variation in diarrhoea prevalence at household level. Model 3 adds community effects which are also significant ($p<0.05$) and they explain about 5% of the variation. This again suggests significant variation in diarrhoea prevalence at community level.

Models with predictor variables at individual, household, and community levels are given in Table 4.2. Models 4 and 5 are less complex than models 2 and 3 in spite of increased parameters. Their (models 4 and 5) DIC are lower by over 260 units each when compared to models 2 and 3 indicating they are better models. The difference in DIC between models 4 and 5 is over 102 signifying model 5 is a better model. Household random effects for models

Table 4.2: Diagnostics, random effects and estimated coefficient summaries fitted to data on diarrhoea prevalence.

	Model 4		Model 5		Model 6	
Risk factors	β	SE	β	SE	β	SE
Constant	-1.81	0.560***	-1.770	0.547***	-2.449	1.041**
INDIVIDUAL LEVEL:						
Categorical variables						
Individual age						
Age 6-18 (ref)	0.000		0.000		0.000	
Age 0-5	0.893	0.130****	0.904	0.131****	1.087	0.188****
Age 19-40	0.468	0.100****	0.477	0.101****	0.512	0.174***
Age 41-60	0.688	0.149****	0.730	0.149****	0.560	0.261**
Age >60	-0.294	0.22	0.314	0.225**	0.387	0.337
Individual School						
None (ref)	0.000		0.000		0.000	
Primary	-0.144	0.098	-0.159	0.101	-0.270	0.150*
secondary	-0.753	0.173****	-0.779	0.174****	-0.946	0.271****
Continuous variables						
Frequency of malaria episodes	0.482	0.029****	0.488	0.031****	0.627	0.049****
HOUSEHOLD LEVEL:						
Categorical variables						
Employment -Head Household						
Not employed (ref)	0.000		0.000		0.000	
Employed	-0.466	0.196**	-0.536	0.212**	-0.595	0.276**
Health Facility						
Private clinic (ref)	0.000		0.000		0.000	
Government Hospital	-0.539	0.235**	-0.252	0.256	0.008	0.334
Health centre	-0.278	0.236	-0.084	0.235	0.227	0.303
CHAM hospital	-0.463	0.240*	-0.405	0.275	-0.537	0.329
Local clinic	-1.246	0.435***	-1.036	0.476**	-1.123	0.676*
Distance to nearest river						
< 1 km (ref)	0.000		0.000		0.000	
1 to 2 km	0.240	0.118**	0.217	0.147	0.187	0.189
>2 km	0.500	0.141****	0.415	0.168**	0.492	0.212**
Household water source						
Other safe water sources5(ref)	0.000		0.000		0.000	
PPWOPWT[4]	-0.598	0.268**	-0.491	0.274*	-0.494	0.385
Public piped water	-0.223	0.194	-0.164	0.203	-0.132	0.323
Unsafe water sources[5]	0.819	0.248****	0.789	0.271***	0.682	0.375*
Household wealth index						
Lower category (ref)	0.000		0.000		0.000	
Middle category	-0.111	0.131	-0.158	0.151	-0.255	0.180
Higher category	-0.342	0.152**	-0.345	0.166**	-0.316	0.226
Continuous variables						
Household density: x	-0.389	0.135***	-0.428	0.090****	-0.515	0.178***
x^2	0.028	0.012**	0.031	0.008****	0.032	0.031
VILLAGE LEVEL:						
Categorical variable						
Proximity to trading centre						
>2 km radius (ref)	0.000		0.000		0.000	
$\leq$ 2km radius	0.631	0.162****	0.540	0.190***	0.859	0.424**
Community and household effects:						
σ_u^2 (household)	1.900	0.546****	2.108	0.398***	4.383	1.150****
σ_v^2 (community)	—	—	0.067	0.059	0.600	0.693
Model diagnostics:						
$\overline{D}$	5475.44		5454.69		4576.51	
$D(\bar{\theta})$	4753.52		4614.09		3323.15	
pD	721.92		740.60		1253.37	
DIC	6197.35		6095.29		5829.88	

$*p \leq 0.10$; $**p \leq 0.05$; $***p \leq 0.01$; $****p \leq 0.001$

4 and 5 are highly significant indicating more unobserved activity at household level in spite of added household predictors to the models.

4.2.5 Model assumptions for the binary regression model

Figure 4.6, Figure 4.7, and Figure 4.8 are normal plots for the residuals for individual, household and community levels respectively. They show reasonable marginal normal plots distributions validating the assumptions of linearity in the models.

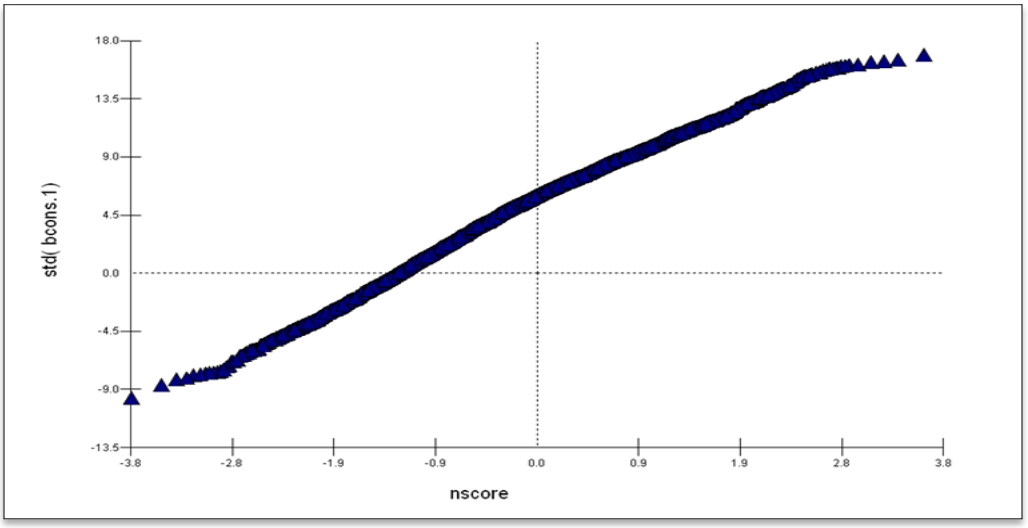


Figure 4.6: *Standardised residuals (std(bcons.1) by normal scores (nscore) at individual level*

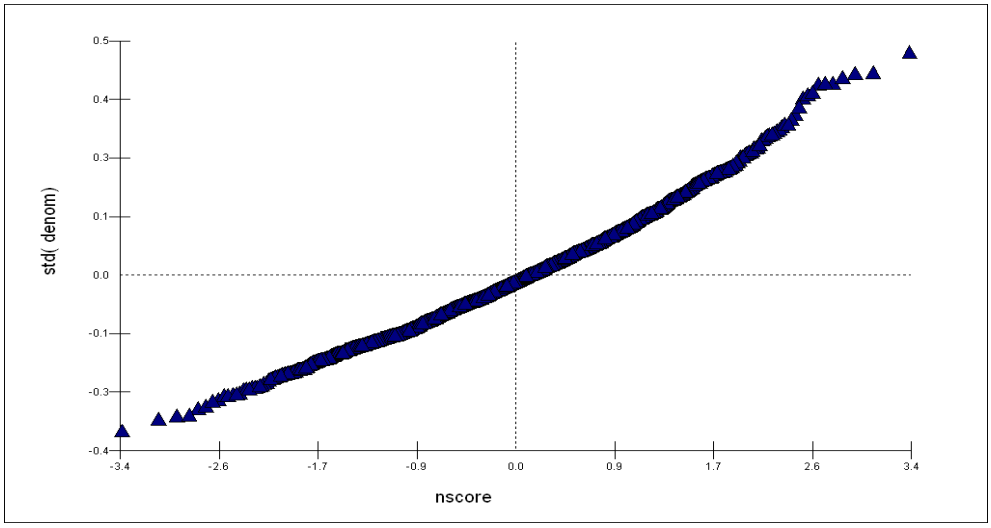


Figure 4.7: *Standardised residuals (std(denom) by normal scores (nscore) at household level*

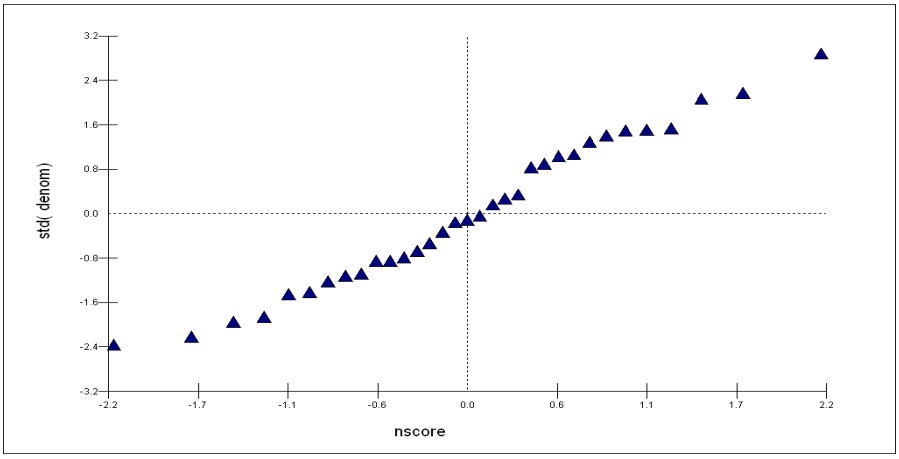


Figure: 4.8: *Standardised residuals (std(denom) by normal scores (nscore) at community level*

Table 4.3: Covariance structures at household and community levels[§]

Household covariance matrix

	$u_{0\,jk}$	$u_{1\,jk}$	$u_{3\,jk}$	$u_{4\,jk}$	$u_{5\,jk}$	$u_{6\,jk}$	$u_{7\,jk}$	$u_{8\,jk}$
$u_{0\,jk}$	σ_u^2 4.383 (1.150)***							
$u_{1\,jk}$		$\sigma_u^{2(1)}$ 0.946 (0.525)*						
$u_{3\,jk}$			$\sigma_u^{2(3)}$ 1.529 (0.686)**					
$u_{4\,jk}$				$\sigma_u^{2(4)}$ 2.842 (1.373)**				
$u_{5\,jk}$					$\sigma_u^{2(5)}$ 1.636 (1.066)			
$u_{6\,jk}$						$\sigma_u^{2(6)}$ 0.773 (0.285)***		
$u_{7\,jk}$							$\sigma_u^{2(7)}$ 1.029 (0.613)*	
$u_{8\,jk}$	$\sigma_u^{(0,8)}$ -0.568 (0.210)***							$\sigma_u^{2(8)}$ 0.355 (0.085)***

Community covariance matrix

	v_{0k}	v_{10k}	v_{11k}
v_{0k}	σ_v^2 = 0.600 (0.693)		
v_{10k}		$\sigma_v^{2(10)}$ = 0.152 (0.098)	
v_{11k}			$\sigma_v^{2(11)}$ = 0.031 (0.008)***

$*p \leq 0.10$; $**p \leq 0.05$; $***p \leq 0.01$

§Only variances (diagonal) and significant covariance terms (off-diagonal) have been included in the covariance matrices. Numbers in brackets are standard errors)

4.2.6 Diagnostics for a random coefficient model

Model 6 has included random coefficient effects and is simply an extension of model 5. Its covariance structure both at household and community levels is shown in Table 4.3. Model 5 underestimates most of the error terms when compared to model 6. The DIC for the random coefficient model is much lower by at least 260 units. This is the best model so far and it was adopted for final interpretation of diarrhoea morbidity in Chikwawa.

4.3 Statistical modelling of malaria prevalence

4.3.1 Outcome variable

Each household member's reported malaria prevalence was used as the outcome variable. Respondents were asked to mention the number of malaria episodes each member of their household had since January of 2007 to the time of the survey (September 2007). The response is summarised in Table 4.4. The mean number of episodes is 1.074 with a standard deviation of 1.295 episodes.

Table 4.4: Number of malaria episodes per individual in 8 months in Chikwawa, Malawi 2007

Number of episodes	Frequency	Percent	Cumulative Percent
0	3146	46.3	46.3
1	1583	23.3	69.7
2	1035	15.2	84.9
3	624	9.2	94.1
4	239	3.5	97.6
5 or more	162	2.4	100.0
Total	6,789	100.0	

While a number of models are possible, an unordered multinomial model was fitted for this data. The response was categorized in three groups of 1: no malaria episode, 2: one malaria episode, and 3: two or more malaria episodes. Advantages of this model are that: (i) it offers a separate treatment of the single and multiple malaria episode categories in relation to a no malaria episode category, (ii) the interpretation of the fixed effects is straightforward since effects of each variable on each category of episodes is compared with the category of no episode, (iii) the model is able to distinguish individuals who experienced one episode of

malaria from those who experienced two or more malaria episodes thereby providing a rare opportunity in studying factors specific to those individuals who had either a single or multiple episodes of malaria within the study period.

4.3.2 Indicator variables

After satisfying conditions for stepwise regression analysis individual age, highest level of school attended, and gender were included as level one predictor variables. Also included, as individual level variables, were diarrhoea episodes and expectant mothers.

Household size, number of mosquito-nets to household size ratio, distance to the nearest stagnant water body, distance to the nearest health facility, distance to the nearest irrigated land, and wealth status were included as household (level two) predictor variables. Community endemicity, community literacy levels, community density, and area of residence were included as community predictor variables.

Household size, distance to the nearest stagnant water body, and distance to a health facility were included as continuous variables. Based on the scatter plot in Figure 4.9 household size variable was assumed to be linear. Individual and maternal school were categorised as: 1: no school, 2: primary school, 3: at least secondary school education. Gender was classified as 1: male and 2: female. A pregnant woman was scored 1 and 0 otherwise. Diarrhoea episodes were categorised as: 1: no episode, 2: one episode, 3: two or more episodes.

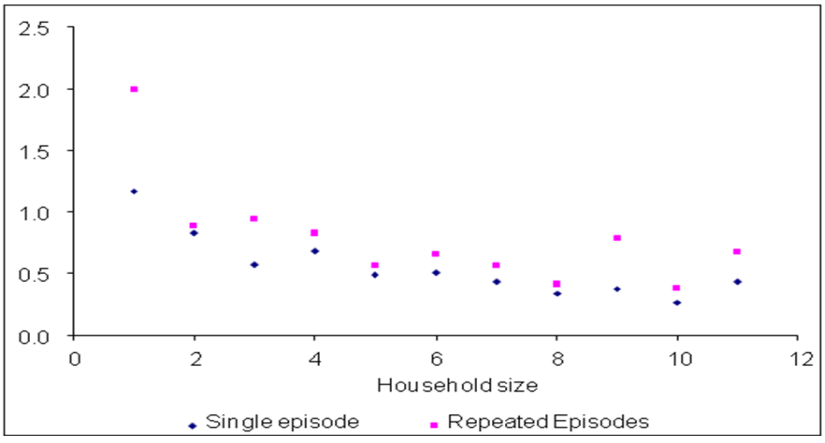


Figure 4.9: *A scatter plot of proportions of 'single' and 'repeated' ML episodes to 'no' ML episode versus household size*

Household wealth index was derived using the method of 'variations' [Gwatkin et al., 2000] just like in the diarrhoea prevalence model (Section 4.2.2).

4.3.3 Malaria prevalence statistical analysis

Since the data were clustered at household and community levels, single level, two level and three-level models were tested. Treating the first group of no malaria episodes as a reference category, unoerdered multinomial logistic regression model [Rasbash et al., 2004] is written:

$$log\left(\frac{\pi_i^{(s)}}{\pi_i^{(1)}}\right) = X_i^T \beta^{(s)}, s = 2,3;$$

where the probability of the individual being in one of the response categories is $\pi_i^{(s)}, s = 1,2,3$, where $\sum_{s=1}^{3} \pi_i^{(s)} = 1$. There are $i = 1,\ldots.6,727$ individuals. A separate intercept and slope parameters are estimated for each of the two contrasts as indicated by the *s* superscripts. The vector $\beta^{(s)}$ is a Φ set of fixed regression coefficients corresponding to a set of individual level covariates in vector $X_i^T = (x_{i1},.....,x_{i\Phi})$.

Taking into account the clustering of individuals nested within households, a two-level multinomial model is written:

$$\log\left(\frac{\pi_{ij}^{(s)}}{\pi_{ij}^{(1)}}\right) = X_{ij}^T \beta^{(s)} + u_j, s = 2,3.$$

The probability of the individual being in one of the response categories is $\pi_{ij}^{(s)}, s = 1,2,3$, and $\sum_{s=1}^{3} \pi_{ij}^{(s)} = 1$. Random effects at the household level are modelled through $u_j^{(s)}$ such that $u_j^{(s)} \sim N(0, \sigma_u^{2(s)})$. The random effects are contrast-specific because different unobserved household-level factors may affect each contrast. The random effects may be correlated across contrasts hence: $Cov(u_j^{(2)}, u_j^{(3)}) = \sigma_u^{(2,3)}$. Correspondingly, $r_u^{(2,3)} = r_u^{(3,2)} = \frac{\sigma_u^{(2,3)}}{\sqrt{\sigma_u^{2(2)} \sigma_u^{2(3)}}}$ gives a measure of correlation between single episode and repeated episodes contrasts. Correlation would arise if there are unobserved household-level factors that affect the occurrence of both single and multiple malaria episodes within the same household.

A three-level multinomial logistic regression model is considered when community effects are taken into account. The model is written as:

$$\log\left(\frac{\pi_{ijk}^{(s)}}{\pi_{ijk}^{(1)}}\right) = X_{ijk}^{T}\beta^{(s)} + u_{jk}^{(s)} + v_{k}^{(s)}, s = 2,3.$$

This time household and community effects are modelled through $u_{jk}^{(s)}$ and $v_{k}^{(s)}$ respectively such that $u_{jk}^{(s)} \sim N(0, \sigma_{u}^{2(s)})$ and $v_{k}^{(s)} \sim N(0, \sigma_{v}^{2(s)})$. The probability of the individual being in one of the response categories is $\pi_{ijk}^{(s)}, s = 1,2,3$, where $\sum_{s=1}^{3}\pi_{ijk}^{(s)} = 1$. $Cov(u_{jk}^{(2)}, u_{jk}^{(3)}) = \sigma_{u}^{(2,3)}$ and $Cov(v_{k}^{(2)}, v_{k}^{(3)}) = \sigma_{v}^{(2,3)}$ are the covariance between contrasts at household and community levels respectively . The measure of correlation between single and multiple episode categories at community level is given by $r_{v}^{(2,3)} = r_{v}^{(3,2)} = \frac{\sigma_{v}^{(2,3)}}{\sqrt{\sigma_{v}^{2(2)}\sigma_{v}^{2(3)}}}$.

4.3.4 Diagnostics and model assumptions for multinomial regression model

A multinomial regression model was fitted to a three-category response variable and assessed the effect of fixed covariates (Model 1). The model was extended to incorporate extra-multinomial heterogeneity variation. Since the data were clustered at household and community levels, two more random effect structures were considered. Household level random effects were fitted first as unstructured heterogeneity effects (Model 2). Similar model formulation was repeated using community and household level random effects (Model 3). As a result, the following set of models was analysed:

Model 1: $\eta = X_{i}^{T}\beta^{(s)}$

Model 2: $\eta = X_{ij}^{T}\beta^{(s)} + u_{j}$

Model 3: $\eta = X_{ijk}^{T}\beta^{(s)} + u_{jk}^{(s)} + v_{k}^{(s)}$

Where $\eta = \log\left(\frac{\pi_{ijk}^{(s)}}{\pi_{ijk}^{(1)}}\right)$ is the $\log it$ link relative to category 1, the no malaria episode and $s = 2,3$.

Table 4.5: Measures of model fit and complexity and estimates of random effects at household and community levels for the malaria episode models

	Model 1	Model 2	Model 3
Model fit and complexity			
Deviance ($\overline{D}$)	13401.28	10533.53	10523.91
pD	38.15	1264.94	1250.03
DIC	13439.43	11798.46	11773.94
Variance components [a]			
$\sigma_u^{2(2)}$		2.038 (0.207)***	1.964 (0.210)***
$\sigma_u^{2(3)}$		4.014 (0.336)***	3.789 (0.328)***
$\sigma_u^{(2,3)}$		2.519 (0.229)***	2.410 (0.226)***
$\sigma_v^{2(2)}$			0.123 (0.067)*
$\sigma_v^{2(3)}$			0.141 (0.082)*
$\sigma_v^{(2,3)}$			0.265 (0.124)**

[a] Standard errors (*se*) are given in brackets; $*p \leq 0.10$; $**p \leq 0.05$; $***p \leq 0.01$;
$\sigma_u^{2(s)}, \sigma_u^{(s,r)}$ = household random effects; $\sigma_v^{2(s)}, \sigma_v^{(s,r)}$ = community random effects

Measures of model fit and complexity and estimates of random effects at household and community levels for the malaria episode models are shown in Table 4.5. Model 1 was the least complex ($\mathrm{pD} = 38.15$) and fitted poorly ($\mathrm{DIC} = 13439.43$). Model 2 provided an improved fit ($\mathrm{DIC} = 11798.46$), but at an increased complexity ($\mathrm{pD} = 1264.94$), i.e including household random effects in the model improved the fit of the model and substantially reduced the DIC by over 1,600 units. In addition, the random effects at household level ($\sigma_{\mathrm{u}}^{2(2)} = 2.038, \mathrm{se} = 0.207$; $\sigma_{\mathrm{u}}^{2(3)} = 4.014, \mathrm{se} = 0.336$; $\sigma_{\mathrm{u}}^{(2,3)} 2.519, \mathrm{se} = 0.229$) are highly significant implying a random effects model is better than a model with fixed covariates only. Adding community random effects (Model 3) improves both model fit ($\mathrm{DIC} = 11773.94$) and model complexity ($\mathrm{pD} = 1250.03$). Random effects at household level have also slightly been reduced. This means part of the variation in Model 2 is now explained by community random effects in Model 3. Model 3 was, therefore, adopted for the final analysis of malaria episodes.

Figure 4.11 and Figure 4.12 are respectively probability plots of household and community residuals. They all fairly lie on a straight line thus satisfying the condition for normally distributed residuals at these levels.

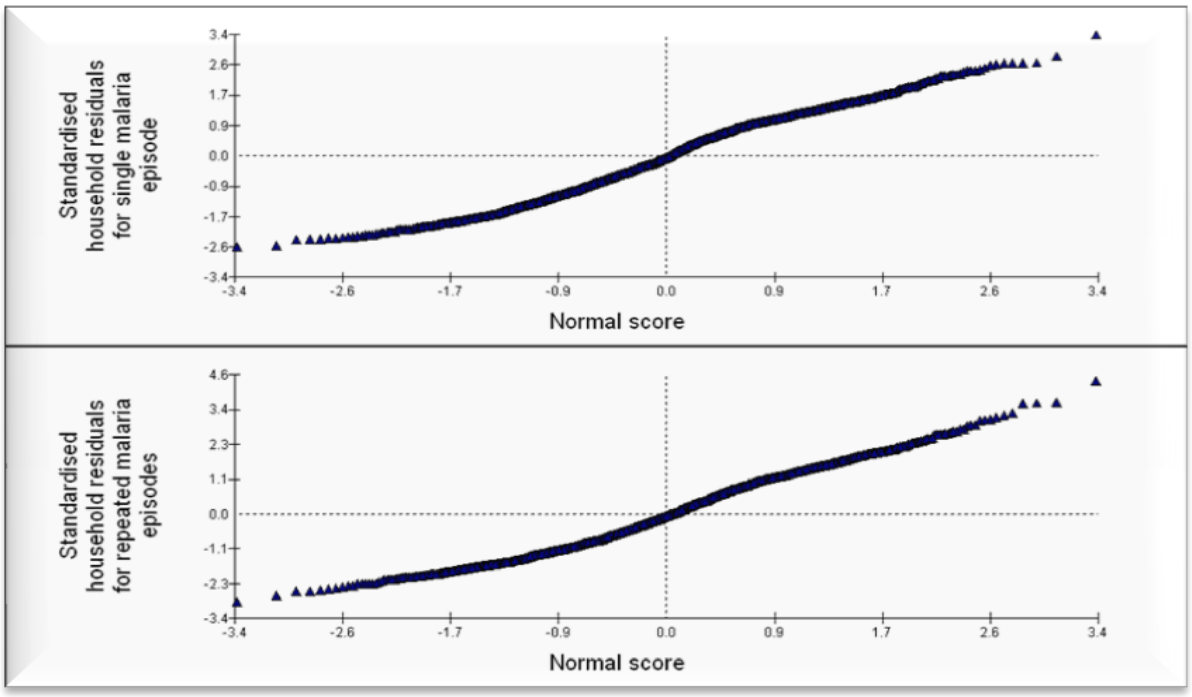


***Figure 4.11**: Normal probability plot of household residuals for ML episodes*

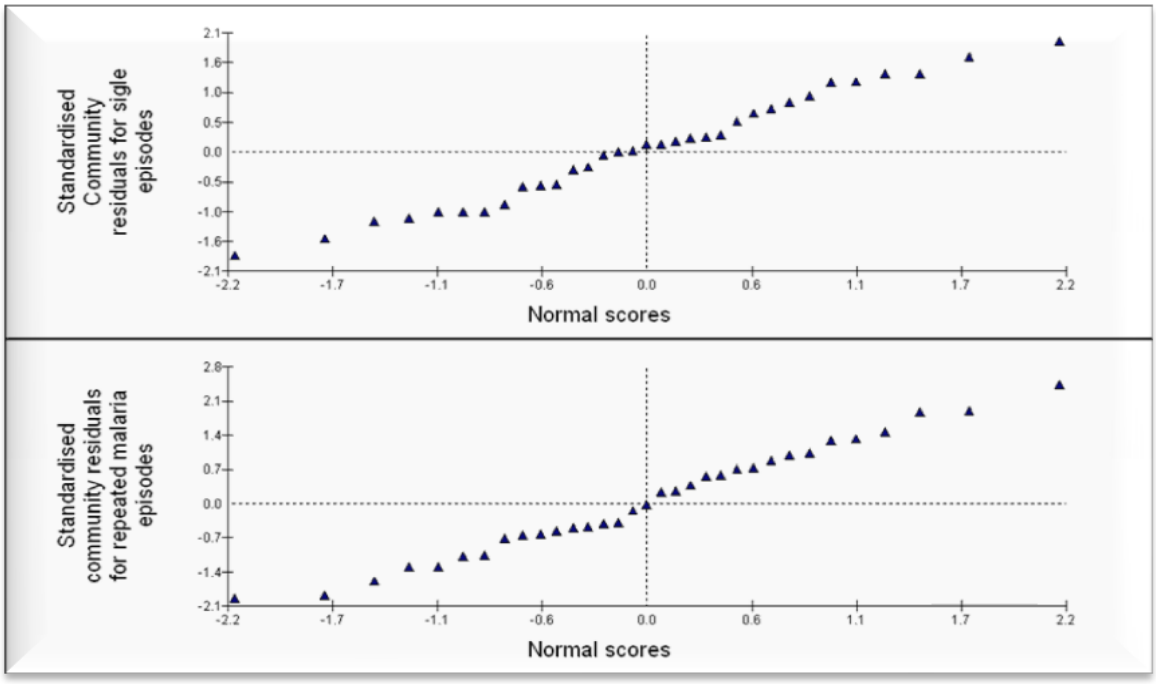


***Figure: 4.12:** Normal probability plot of community residuals for ML episodes*

4.4 Statistical modelling of a joint malaria and diarrhoea prevalence

4.4.1 Outcome variables

Each household member's reported malaria and diarrhoea prevalence were used as the outcome variables. If an individual was reported to have malaria since January he was scored 1 otherwise 0. The same scoring applied to those reported to have diarrhoea.

4.4.2 Indicator variables

After a stepwise regression analysis individual age, individual school level, expectant mothers, and gender were included as individual (level one) predictor variables. Household size, head of household employment status, drinking water source, distance to the nearest river[4], nearest health facility, household mosquito-net ratio, distance to the nearest stagnant water body, and household wealth status were included as household (level two) predictor variables. Community's malaria and diarrhoea endemicity were included as community (level three) predictor variables.

Household size and diarrhoea or malaria endemicity were continuous variables. Based on sections 4.2 and 4.3 household size was included as a quadratic variable for the diarrhoea contrast and as a linear variable for the malaria contrast.

4.4.3 Joint statistical analysis of malaria and diarrhoea prevalence

The bivariate regression model [Leyland and Goldstein, 2001; Fielding et al., 2003; Rasbash et al., 2004] was used to explain the joint probability of binary malaria and binary diarrhoea outcomes for individuals.

To explain the joint probability of malaria and diarrhoea, assume y_{ijkq} is the response of malaria $(q=1)$ and diarrhoea $(q=2)$ for individual i $(i=1,\ldots,6727)$ in household j $(j=1,\ldots,1380)$ and community k $(k=1,\ldots,33)$ such that

[4] Notice that distance to the nearest river and nearest health facility were included as household variables because households from the same community could have different proximities to the same nearest river or would have different nearest rivers and they could report to different health facilities based on distances and socioeconomic preferences.

$$y_{ijkq} = \begin{cases} 1 & if \quad disease \quad q \quad exist \\ 0 & no \quad disease \quad q \end{cases}$$

then the bivariate 3-level hierarchical model for presence of malaria and diarrhoea is given by

$$\begin{pmatrix} probit(p_{ijk1}) \\ probit(p_{ijk2}) \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + X_{ijkq}^{T} \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} + \begin{pmatrix} u_{jk1} \\ u_{jk2} \end{pmatrix} + \begin{pmatrix} v_{k1} \\ v_{k2} \end{pmatrix}$$

Where $\alpha_q = (\alpha_1, \alpha_2)$ is the intercept for disease q, in individual i found in household j residing in community k. The term $\beta = (\beta_1, \beta_2)^T$ is a vector of regression parameters corresponding to a set of covariates X_{ijkq}. The components u_{jkq} and v_{kq} are the unstructured heterogeneity variation terms at the household and community levels respectively. Since the outcomes may be dependent then their error terms may be correlated such that if $\text{cov}(e_{ijk1}, e_{ijk2}) = \sigma_e^{(1,2)}$, $\text{cov}(u_{jk1}, u_{jk2}) = \sigma_u^{(1,2)}$, and $\text{cov}(v_{k1}, v_{k2}) = \sigma_v^{(1,2)}$ are the covariance at individual, household and community levels respectively and $\text{var}(e_{ijkq}) = \sigma_{eq}^2$, $\text{var}(u_{jkq}) = \sigma_{uq}^2$, and $\text{var}(v_{kq}) = \sigma_{vq}^2$ are their corresponding variances then $r_e^{(1,2)} = \frac{\sigma_e^{(1,2)}}{\sqrt{\sigma_{e1}^2 \sigma_{e2}^2}}$, $r_u^{(1,2)} = \frac{\sigma_u^{(1,2)}}{\sqrt{\sigma_{u1}^2 \sigma_{u2}^2}}$, and $r_v^{(1,2)} = \frac{\sigma_v^{(1,2)}}{\sqrt{\sigma_{v1}^2 \sigma_{v2}^2}}$ are the correlations between malaria and diarrhoea at individual, household and community levels respectively.

Three models were fitted. Model 1 was fitted without random effects, Model 2 was fitted with household effects and Model 3 was fitted with household and community effects.

The maximum number of iterations performed in each model to reach stabilisation using MCMC was 50,000.

4.4.4 Diagnostics and model assumptions for the bivariate regression model

Since ignoring clustering in hierarchical data structures normally causes standard errors of regression coefficients to be underestimated [Rasbash et al., 2008], Figure 4.13 and Figure 4.14 respectively were used to compare standard errors and precision values for different models. Standard errors for Model 1 appear to be generally lower and precision contrasts appear to be higher especially in the diarrhoea contrast than those of Model 2 and Model 3.

This is an indication that ignoring household and community level affects leads to underestimation of standard errors and hence overrating the significance of the regression coefficients in the process. Table 4.6 shows existence of random effects at household and

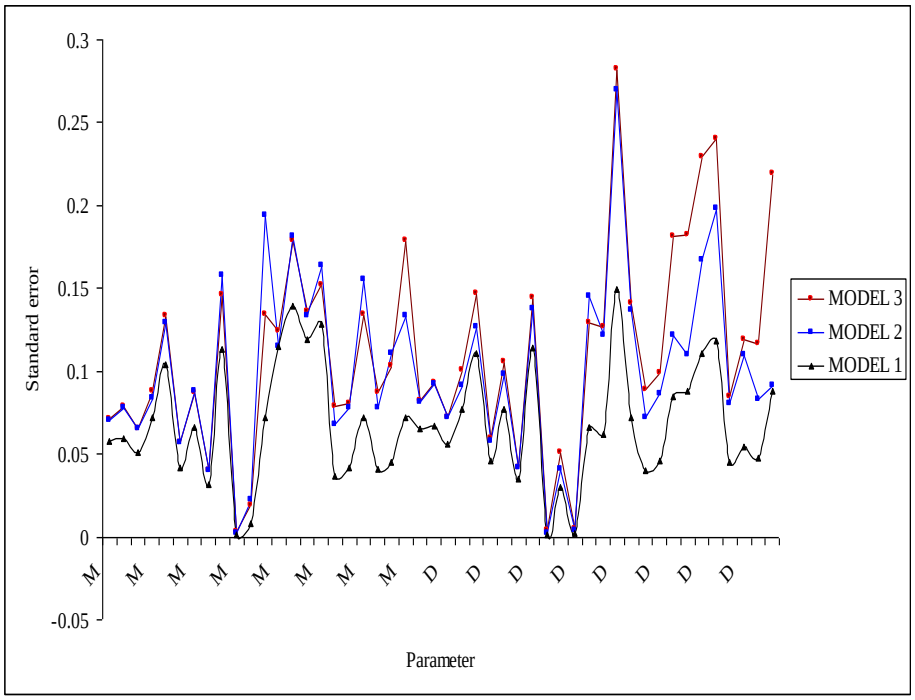


Figure 4.13: *A comparison of standard error values for different models of a bivariate regression analysis*

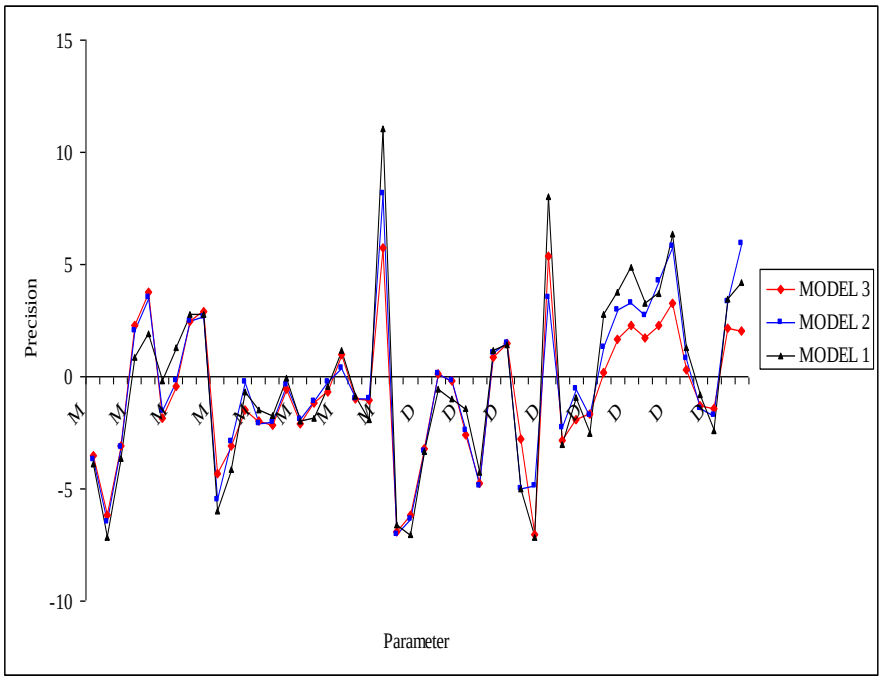


Figure 4.14: *A comparison of precision values for different models of a bivariate analysis (M= ML contrast; D= diarrhoea contrast)*

community levels for Model 3. Household effects explain 48% of malaria illness residual variation and 46% of diarrhoea illness residual variation. Community effects explain 5% of malaria residual variation and 3% of diarrhoea residual variation. Figure 4.15 and Figure 4.16 show household and community-level probability plots for the malaria and diarrhoea contrasts.They are all fairly linear validating model assumptions for multilevel models. A model incorporating household and community level effects is, therefore, adopted for final analysis of joint malaria and diarrhoea illnesses.

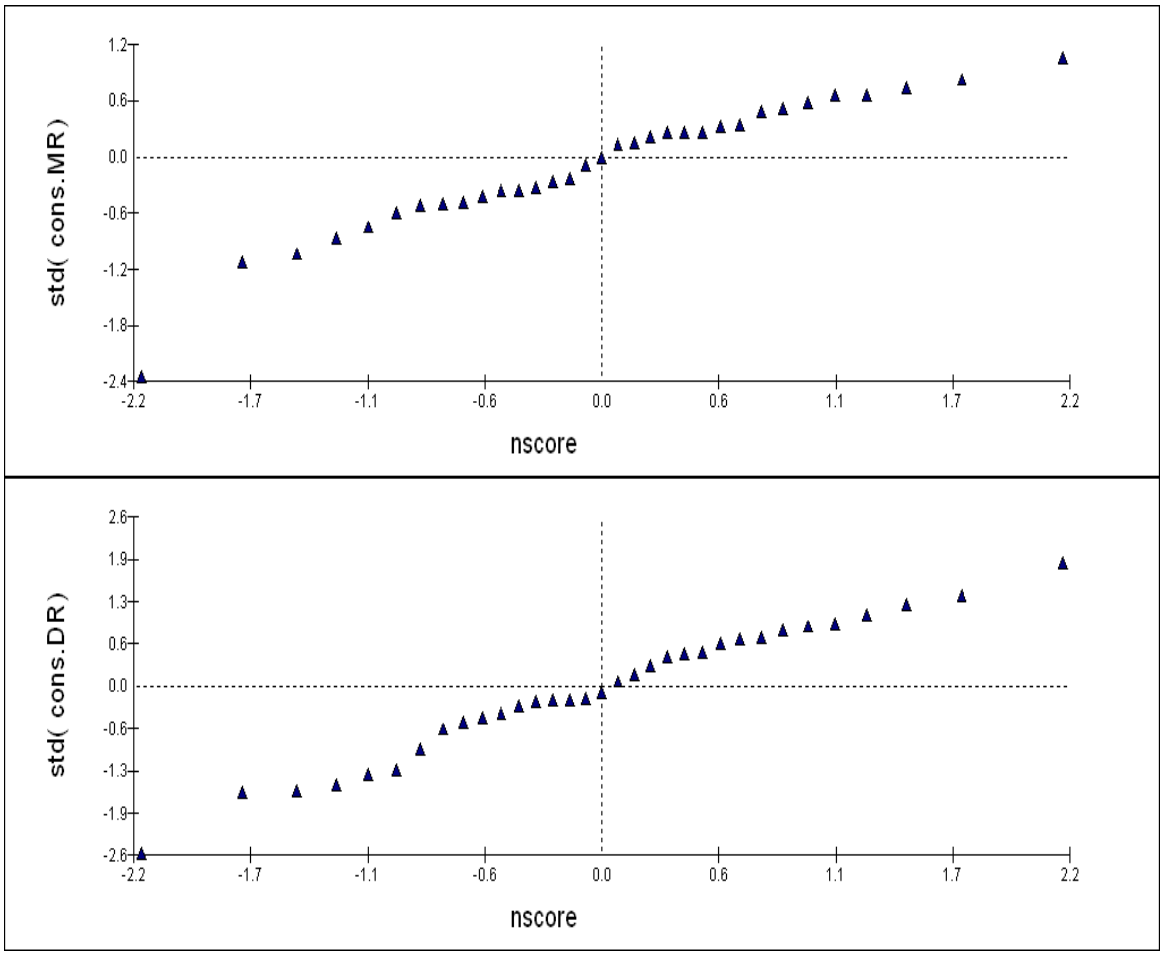


Figure 4.15: *Normal probability plot of joint community residuals for ML (cons.MR) and diarrhoea (cons.DR)*

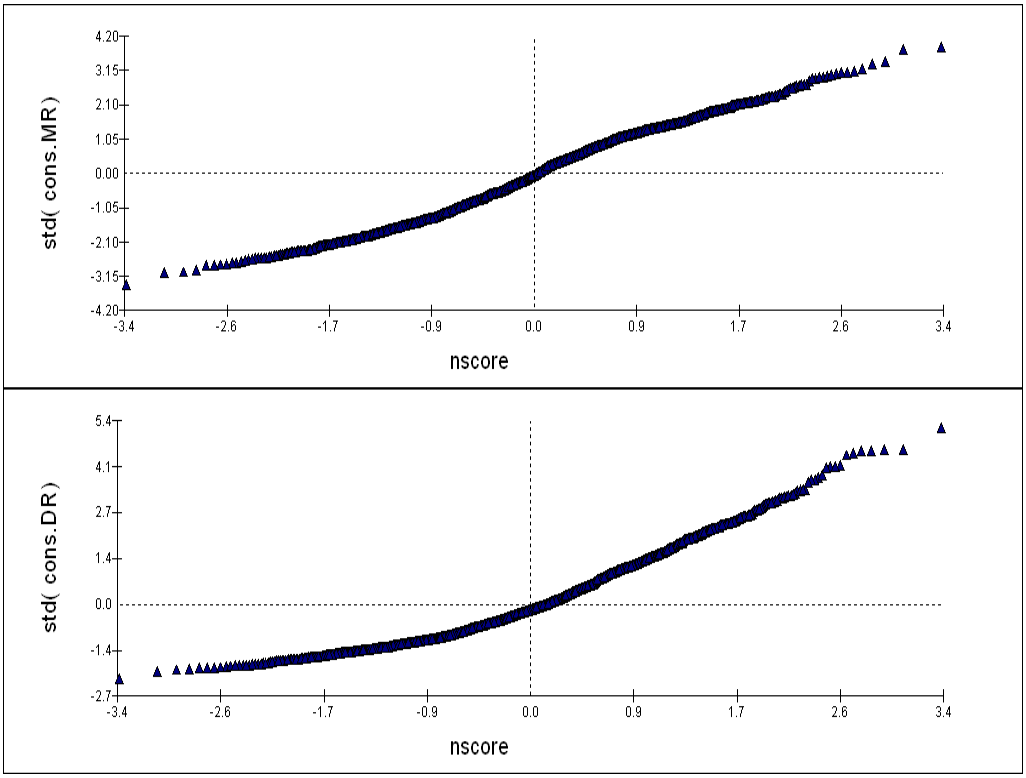


Figure 4.16: *Normal probability plot of joint household residuals for ML (cons.MR) and diarrhoea (cons.DR)*

Table 4.6: Random effects from a joint model of malaria and diarrhoea in Chikwawa 2007[§]

		Malaria	Diarrhoea
	Malaria	$\sigma^2_{e1} = 1$	
Model 3	Diarrhoea	$\sigma_e^{(1,2)} = 0.243;\ (0.182,0.304)$	$\sigma^2_{e2} = 1$
	Household level		
	Malaria	$\sigma^2_{u1} = 1.021;\ (0.858,1.184)$	
	Diarrhoea	$\sigma_u^{(1,2)} = 0.556;\ (0.456,0.656)$	$\sigma^2_{u2} = 0.910;\ (0.753,1.067)$
	Community level		
	Malaria	$\sigma^2_{v1} = 0.104;\ (0.031,0.176)$	
	Diarrhoea	$\sigma_v^{(1,2)} = 0.039;\ (-0.002,0.080)$	$\sigma^2_{v2} = 0.053;\ (0.018,0.088)$

[§] 95% credible intervals in parentheses level.

4.5 Statistical modelling of knowledge on diarrhoea using multilevel thresholds of change analysis.

4.5.1 Outcome variables

A mother in each household was asked to mention (i) the symptoms of; (ii) causes of, and (iii) preventive measures taken against diarrhoea. These questions were open ended to avoid any bias. A series of binary responses were formed by coding 1 if a mother mentioned a required symptom, prevention method, or cause and 0 otherwise. Categories were derived from these responses as follows: (a) three categories for the symptoms category and these are: (1) zero or one symptom mentioned, (2) two symptoms mentioned, and (3) three or more symptoms mentioned; (b) four categories each were formed for prevention method and causes of diarrhoea as follows: (1) no single cause or no single prevention method mentioned; (2) one cause or one preventative method mentioned; (3) two causes or two prevention methods mentioned; and (4) three or more causes or three or more prevention methods mentioned.

A fourth response variable was formed by taking the total scores for each woman in all the three response categories. This outcome variable was called the overall knowledge on diarrhoea. Its categories are: (1) zero to three points scored, (2) four to five points scored, (3) six to seven points scored, (4) eight or more points scored. Note that the cut-off points for the categories are arbitrary and are guided only by the distribution of mothers in the knowledge profile. Table 4.7 shows a summary of descriptive statistics for the outcome variables.

Considering that diarrhoea is often defined differently in various studies and countries [Wright et al., 2006], a standard definition of a diarrhoea-day was used in this study i.e. one where a subject experiences three or more loose or watery stools in 24 hours or any number of loose or watery bloody stools [Baqui et al., 1991 in Wright et al., 2006]. In Malawian vernacular language diarrhoea is known as ‘kutsegula m’mimba’ literally meaning opening up of bowels which is associated with defecation of watery stools especially in young children. However ‘bloody stools’ or dysentery, are known as a different disease and are known as ‘kamwazi’. On causes and preventative measures, interviewers were advised to use both ‘kutsegula m’mimba’ and ‘kamwazi’ in their interviews.

Since the category scores on maternal knowledge are arbitrary, ordered and hierarchical, in order to retain category values, determine the extent to which each predictor variable contributes to maternal knowledge, and account for the hierarchical structure the analysis was performed using multilevel thresholds of change. Notice that the number of responses given to each question on outcomes is meant to test the extent of knowledge and flexibility in expressing such knowledge.

4.5.2 Explanatory variables

Maternal age, highest maternal schooling (or highest level of formal education), relative wealth, health facility, HSA, and NGO were included in this model as indicator variables after satisfying a stepwise regression analysis.

4.5.3 Statistical Analysis and estimation

The ordered multinomial response model [Hedeker and Mermelstein, 1998; Fielding, 1999; Leyland and Goldstein, 2001; Fielding et al., 2003; Rasbash et al., 2004] is used to explain the probability of ordered scores on diarrhoea knowledge. The response variable is the number of answers correctly given by each mother in a household on symptoms, causes or prevention of diarrhoea. The response on symptoms has three categories s such that $s = 1,2,3$. The responses on causes, prevention and overall knowledge have four categories s each such that $s = 1,2,3,4$. The last category in each case is taken as a reference.

Suppose that the probability of a woman from household i in community j of having a score in category s is $\pi_{ij}^{(s)}$ and the probability that household i in community j will obtain a score higher than that represented by category s is $\gamma_{ij}^{(s)}$. Then the cumulative response probabilities are defined as

$$E(y_{ij}^{(s)}) = \gamma_{ij}^{(s)} = \sum_{h=1}^{s} \pi_{ij}^{(h)}, \qquad (1)$$

where $s = 1,2$ on the symptoms outcome and $s = 1,2,3$ on causes, prevention and overall knowledge outcomes. For the symptoms response variable $0 < \gamma_{ij}^{(1)} < \gamma_{ij}^{(2)} < \gamma_{ji}^{(3)} = 1$ and for the other response variables $0 < \gamma_{ij}^{(1)} < \gamma_{ij}^{(2)} < \gamma_{ij}^{(3)} < \gamma_{ij}^{(4)} = 1$. Notice that the probabilities for the scores are cumulated downwards for convenience in interpretation of the results.

Table 4.7: Descriptive statistics for response variables on diarrhoea knowledge

Variable	*Mean*	*Median*	*Min.*	*Max.*	N=1389	%
What are the symptoms of diarrhoea?						
1. Watery stools					1171	84.3
2. Increased number of stools					183	13.2
3. Loose stools					383	27.6
4. Loose stools and vomiting					175	12.6
5. Bloody stools					183	13.2
6. Stomach-ache					492	35.4
What are the causes of diarrhoea						
1. Contaminated water					765	55.1
2. Contaminated food					619	44.6
3. Flies					376	27.1
4. Poor hygiene and sanitation practices					703	50.6
5. Poor sanitation practices					*111*	*8.0*
What action do you take to prevent diarrhoea?						
1. Add disinfectant (water guard, chlorine, etc) to water					421	30.3
2. Good water hygiene or management					357	25.7
3. Good food hygiene or management					78	5.6
4. Proper cleaning of cooking and eating utensils					332	23.9
5. Good sanitation					278	20.0
6. Hands washing					307	22.1
Number of Symptoms identified	*2*	*2*	*0*	*5*		
Zero or one symptom					351	25.3
Two symptoms					672	48.4
Three or more symptoms					366	26.3
Number of Causes identified	*2*	*2*	*0*	*5*		
No single cause mentioned					61	4.4
One cause mentioned					590	42.5
Two causes mentioned					365	26.3
Three or more causes mentioned					373	26.9
Prevention methods identified	*1*	*1*	*0*	*6*		
No prevention method					435	31.3
One prevention method					404	29.1
Two prevention methods					338	24.3
Three or more methods					212	15.3
Overall knowledge	*5*	*5*	*0*	*14*		
Zero to three points					305	22.0
Four to five points					498	35.9
Six to seven points					438	31.5
Eight or more points					148	10.7

A proportional odds model with a $\log it$ link is, therefore, given by:

$$\log it(\gamma_{ij}^{(s)}) = \log\left(\frac{\gamma_{ij}^{(s)}}{1-\gamma_{ij}^{(s)}}\right) = \alpha^{(s)} + X_{ij}\beta + u_{0j} \quad (2)$$

with α^{s} as threshold values for the scores. X_{ij} is the covariate vector and β is a vector of unknown fixed regression parameters. Also, u_{0j} is a design vector of random effects. Fixed and random effects operate linearly on thresholds and hence indirectly on the probabilities over the ordered scores. For the *j* th community establishment there is a single random effect u_{0j} which is normally distributed with mean 0 and variance σ_u^2.

In our model (2) we have assumed that fixed cut-point thresholds do not vary across observations. However, if tests of parallel lines for different predictor variables on their respective outcomes show that some slope coefficients are not the same across response categories, then model (2) can be extended to accommodate this scenario [Hedeker and Mermelstein, 1998]. Hence, equation (2) is rewritten as:

$$\log it(\gamma_{ij}^{(s)}) = \log\left(\frac{\gamma_{ij}^{(s)}}{1-\gamma_{ij}^{(s)}}\right) = \alpha^{(s)} + \omega^{(s)}t_{ij} + X_{ij}\beta + u_{0j} \qquad (3)$$

where t_{ij} is a predictor variable whose slope coefficients, $\omega^{(s)}$, are not the same across response categories and hence allowing fixed cut-point thresholds to vary across observations. Thus

$$\log it(\gamma_{ij}^{(s)}) = \log\left(\frac{\gamma_{ij}^{(s)}}{1-\gamma_{ij}^{(s)}}\right) = \alpha_{ij}^{s} + X_{ij}\beta + u_{0j}$$

with

$$\alpha_{ij}^{s} = \alpha^{(s)} + \omega^{(s)}t_{ij},$$

α_{ij}^{s} is now our threshold value while $\alpha^{(s)}$ is defined as a baseline threshold. Model (3) which includes multilevel random effects is known as the ***multilevel thresholds of change model*** (MTCM) [Hedeker and Mermelstein, 1998]

4.5.4 Diagnostics and model assumptions for the MTCM

A technical advantage in the use of ordered multinomial models lies in the fact that they do not require strong scaling assumptions, merely the existence of an ordering. They are also not subject to estimation problems arising from grouped observations of an assumed continuous response scale. Ordered multinomial models only require assuming that the effect of the indicator variables is the same for each level of the response. Further, they do not require a basic normality assumption over the scale as with the other earlier models in this thesis [Fielding et al., 1999, 2003]. They only require that a "test of parallel lines assumption" used to test that slope coefficients for fixed effects variables are the same across response categories, is satisfied. If some fixed effect variables are not the same across response categories then MTCM becomes handy since it allows fixed effects coefficients to vary with cut-offs of the response variable while preserving the ordered multinomial model properties and assumptions for those fixed effect variables that are the same for each level of the response [Harrell et al., 1998].

Each predictor variable that qualified through the stepwise regression analysis was, therefore, tested for a test of parallel lines with relevant outcome variables included in this section. All predictor variables that individually satisfied the parallel line test i.e. if $p \geq 0.20$ for a given outcome variable were included in the proportional odds model. All those that did not satisfy the test i.e. if $p < 0.2$ were allowed to vary across different cut-off points, thus contributed to the baseline threshold point of different categories. Table 4.8 gives results of tests of parallel lines for each outcome variable. In the symptoms knowledge outcome variable relative wealth, HSA, and NGO satisfied proportional odds model conditions while mother's age, mother's educational level and health facility variables failed the test of parallel lines and were, therefore, included such that they varied with cut-offs of the response variable. In the causes knowledge outcome mother's age mother's educational level, health facility and NGO passed the test of lines. In the prevention outcome variable only mother's age and mother's educational level satisfied the test of parallel lines. Lastly in the overall diarrhoea knowledge outcome variable all the variables satisfied the test except mother's age which was allowed to vary with cut-offs of the response variable.

Table 4.8: Test of parallel lines for outcomes on diarrhoea knowledge

Outcome Variable	Fixed effect variable	Test of parallel lines (*p*)
Knowledge on symptoms	Mother's age	0.000
	Mother's educational level	0.045
	Health facility	0.053
	NGO	0.423
	HSA	0.458
	Relative wealth	0.759
	Relative wealth, HSA, NGO included together	0.831
Knowledge on causes of diarrhoea	Mother's age	0.880
	Mother's educational level	0.550
	Health facility	0.367
	NGO	0.896
	HSA	0.165
	Relative wealth	0.171
	When mother's age, mother's educational level, health facility and NGO are included together	0.708
Knowledge on prevention methods	Mother's age	0.335
	Mother's educational level	0.930
	Health facility	0.020
	NGO	0.013
	HSA	0.143
	Relative wealth	0.074
	Mother's age and mother's educational level are included together	0.834
Overall knowledge on diarrhoea	Mother's age	0.021
	Mother's educational level	0.138
	Health facility	0.629
	NGO	0.824
	HSA	0.668
	Relative wealth	0.230
	All above included except mother's age	0.502

4.6 Statistical modelling of water consumption and sanitation: Analysing household drinking water sources and availability of toilets/latrines using multinomial logistic regression models

4.6.1 Outcome variables

A mother in each household was asked to mention (i) the main source of drinking water for members of their household; (ii) the kind of toilet facilities their house has; (iii) reasons for lack of a toilet if they did not have one. Responses for the first question were grouped into

three categories of (a) piped water; (b) other safe water sources thus comprising boreholes, protected wells, and springs; and (c) unsafe water sources comprising rivers, streams, ponds, unprotected wells. Responses to the second question were also categorised into three groups: (a) own toilet/latrine, (b) shared/public toilet/latrine, and (d) no toilet/latrine. The third question had a total of six categories. Hierarchical multinomial logistic regression models were fitted to the first two questions with other safe water sources and own toilet/latrine as reference categories respectively.

4.6.2 Indicator variables

A total of seven variables satisfied stepwise regression analysis this requirement and these are existence of a health surveillance assistant, existence of a village health committee (VHC), existence of an NGO, household relative wealth, community literacy level, community density, and community relative wealth.

Aggregated community literacy level was a continuous variable derived by dividing the total number of highest school levels for all individuals in the community by the total number of individuals.

Community density per household was a continuous variable derived by dividing the total number of household sizes by the total number of households in each community
Community relative wealth was a continuous variable derived by dividing the total number of household wealth by the total number of households in each community.

4.6.3 Statistical Analysis and estimation

Considering that water sources and sanitation outcomes are in unordered categories multinomial models are considered appropriate. For toilet/latrine distribution response the categories are: 1: own toilet/latrine, 2: shared/public toilet/latrine, and 3: no toilet/latrine. The water source response has the following categories: 1: piped water, 2: other improved/safe water sources (boreholes, protected wells, and springs), and 3: unsafe water sources (rivers, streams, ponds, unprotected wells etc.).

Treating the second category in each response variable as a reference category, a two level multinomial logistic regression model [Rasbash et al., 2008] with a logit link is written: $\log\left(\frac{\pi_{ij}^{(s)}}{\pi_{ij}^{(2)}}\right) = X_{ij}^{T}\beta^{(s)} + u_j, s = 1,3$. The probability of a household being in one of the response categories is $\pi_{ij}^{(s)}, s = 1,2,3$, and $\sum_{s=1}^{3}\pi_{ij}^{(s)} = 1$. Random effects at the community level are modelled through $u_j^{(s)}$ such that $u_j^{(s)} \sim N(0, \sigma_u^{2(s)})$. The random effects are contrast[5]-specific because different unobserved community-level factors may affect each contrast. The random effects may be correlated across contrasts hence $Cov(u_j^{(1)}, u_j^{(3)} = \sigma_u^{(1,3)})$. Correspondingly, $r_u^{(1,3)} = r_u^{(3,1)} = \frac{\sigma_u^{(1,3)}}{\sqrt{\sigma_u^{2(1)}\sigma_u^{2(3)}}}$ gives a measure of correlation between first and second contrasts. Correlation would arise if there are unobserved community-level factors that affect the occurrence of both first and second contrasts.

Since the data are assumed to be clustered at community level, two models for each outcome were considered as follows:

Model 1: $\eta = X_i^T \beta^{(s)}$ single level model

Model 2: $\eta = X_{ij}^T \beta^{(s)} + u_j$ two (community) - level model

Where $\eta = \log\left(\frac{\pi_{ij}^{(s)}}{\pi_{ij}^{(2)}}\right)$ is the $\log it$ link relative to category 2, and $s = 1,3$.

4.6.4 Diagnostics and model assumptions for the two level multinomial regression models

Table 4.9 shows measures of model fit and complexity and estimates of random effects at community level for the distribution of toilets/latrines and drinking water sources. Although random effects at community level are not significant, the DIC for the two-level sanitation model is lower (92677) when compared to a single-level sanitation level DIC (2740). The community level model was, therefore, preferred to a single level model. The drinking water sources community level model is by much better (DIC = 1190) than the corresponding

[5] There are two contrasts for each model. With respect to shared toilet category, the first contrast for the latrine/toilet model is the own toilet/latrine category and the second contrast is the no toilet/latrine category. With respect to the other safe water sources category, the first contrast for the water sources model is the piped water category and the second contrast is the unsafe water category.

single level model (DIC = 2034). This is also reflected in its community level random effects which are highly significant. Community level model for drinking water sources was, therefore, adopted for final interpretation of results. Figure 4.17 and Figure 4.18 can be said to lie fairly on a straight line thus fairly authenticating multilevel model assumptions for normally distributed errors at community level

Table 4.9: Measures of model fit and complexity and estimates of random effects at community levels for the sanitation and water sources models

	Sanitation models			Water sources models	
	Single level	2-level model		Single level	2-level model
Model fit and complexity					
Deviance ($\overline{D}$)	2723.97	2623.18		2023.01	1145.76
pD	15.74	53.71		11.16	44.77
DIC	2739.71	2676.89		2034.16	1190.53
Variance components [a]					
$\sigma_u^{2(1)}$		0.20 (-0.05,0.45)			21.52 (4.40,38.63)**
$\sigma_u^{2(3)}$		0.52 (-0.03,1.07)*			1.73 (0.22,3.25)**
$\sigma_u^{(1,3)}$		0.10 (-0.25,0.44)			1.79 (-1.56,5.14)

[a] 95 Credible Intervals (CI) are given in brackets; $*\ p \leq 0.10$; $**p \leq 0.05$; $\sigma_u^{2(s)}, \sigma_u^{(s,r)} =$ community random effects

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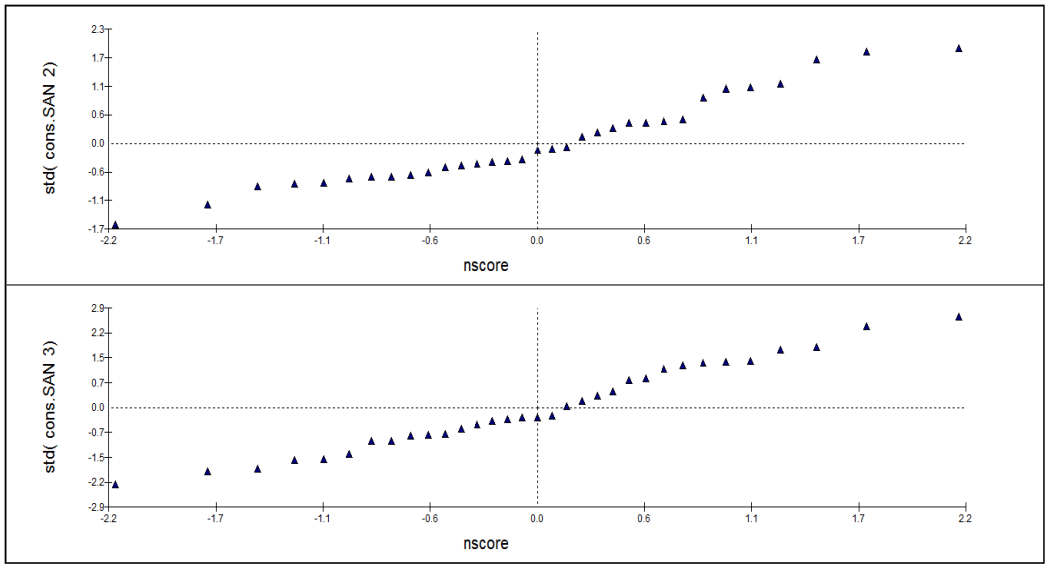

Figure 4.17: *Normal probability plot of standardised community residuals against normal scores for shared versus own toilet facility (std(cons.SAN2)) and no toilet versus own toilet facility (std(cons.SAN3))*

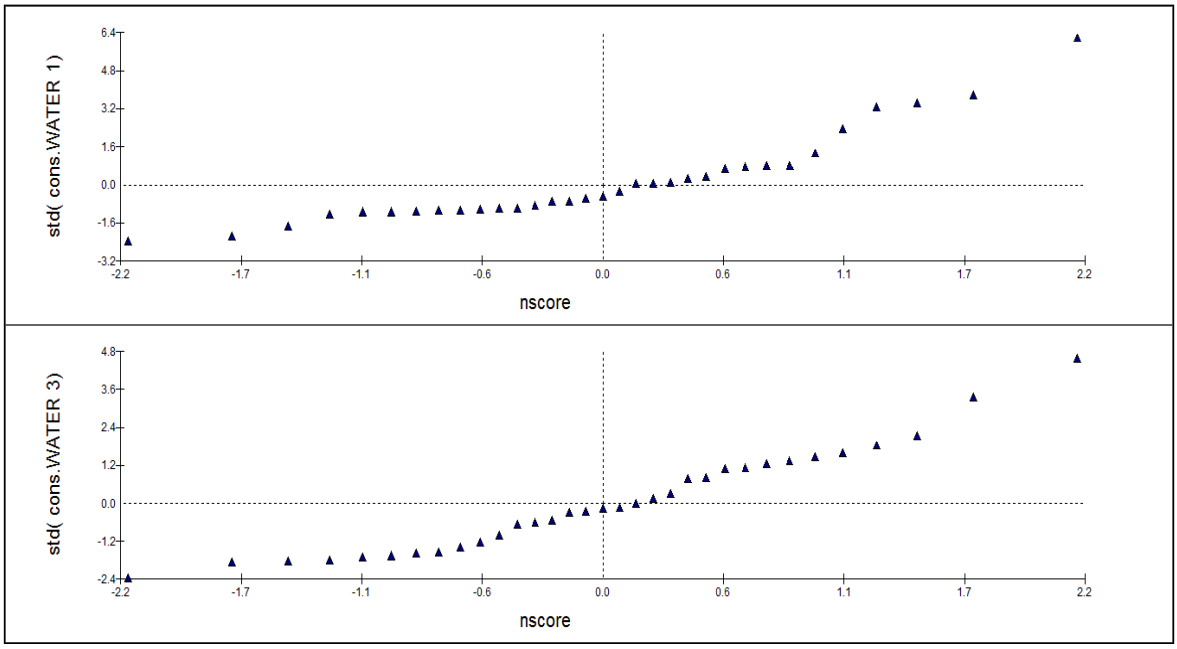

Figure 4.18: *Normal probability plot of standardised community residuals against normal scores for piped water versus other safe water sources (std(cons.WATER1)) and unsafe drinking water sources versus other safe water sources (std(cons.WATER3))*

4.7 Statistical modelling of malaria knowledge and care practices for diarrhoea and malaria.

4.7.1 Malaria knowledge outcome variables

Just like the diarrhoea knowledge response variables in section 4.4, the malaria knowledge variables could have been fitted to proportional odds or 'MTMC models since multinomial models are more efficient than binary models [Bender and Grouven, 1998]. Unfortunately and unlike in the diarrhoea knowledge response variables the majority of indicator variables could not pass the "test of parallel lines assumption" implying most slope coefficients for fixed effects variables were not the same across the malaria knowledge response categories. Simple binary models were, therefore used to interpret results. Following tests of normality as required in multilevel models, a sample of normality plots depicted in Figure 4.19, Figure 4.20, and Figure 4.21 show fairly straight line plots thus complying with normality assumptions. Similarly tests of best fit as shown in Table 4.10 favour two level models for the malaria knowledge response variables with two levels at household and community levels.

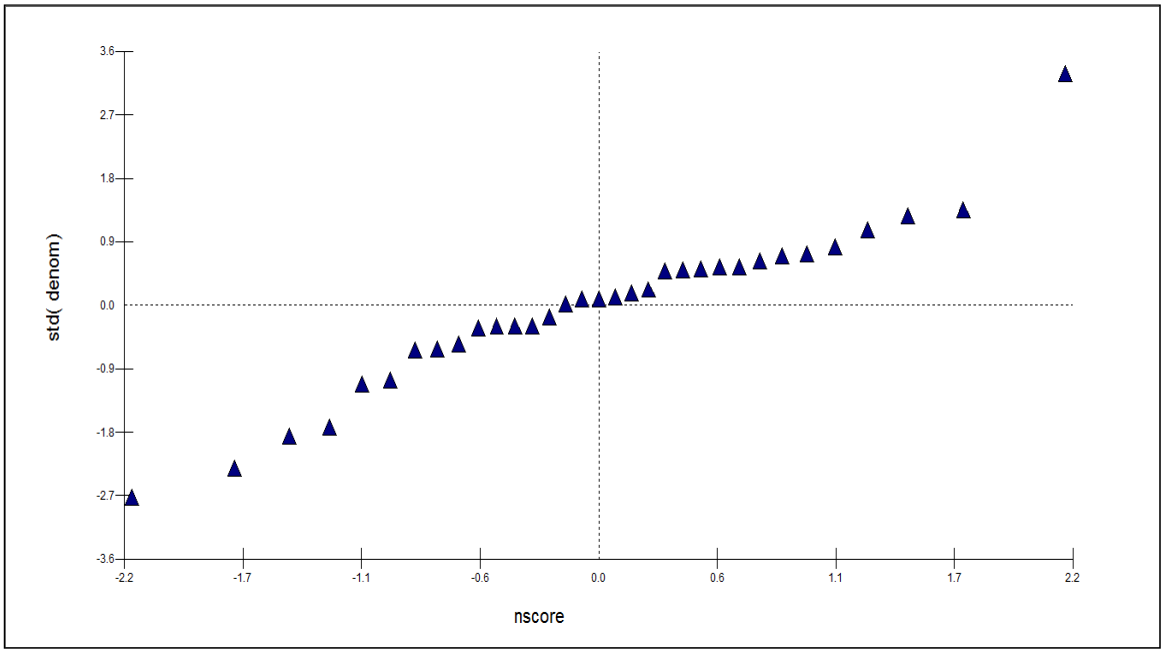

Figure 4.19: *Normal probability plot of standardised community residuals against normal scores for clearance of bushes/weeds residuals (std(denom))*

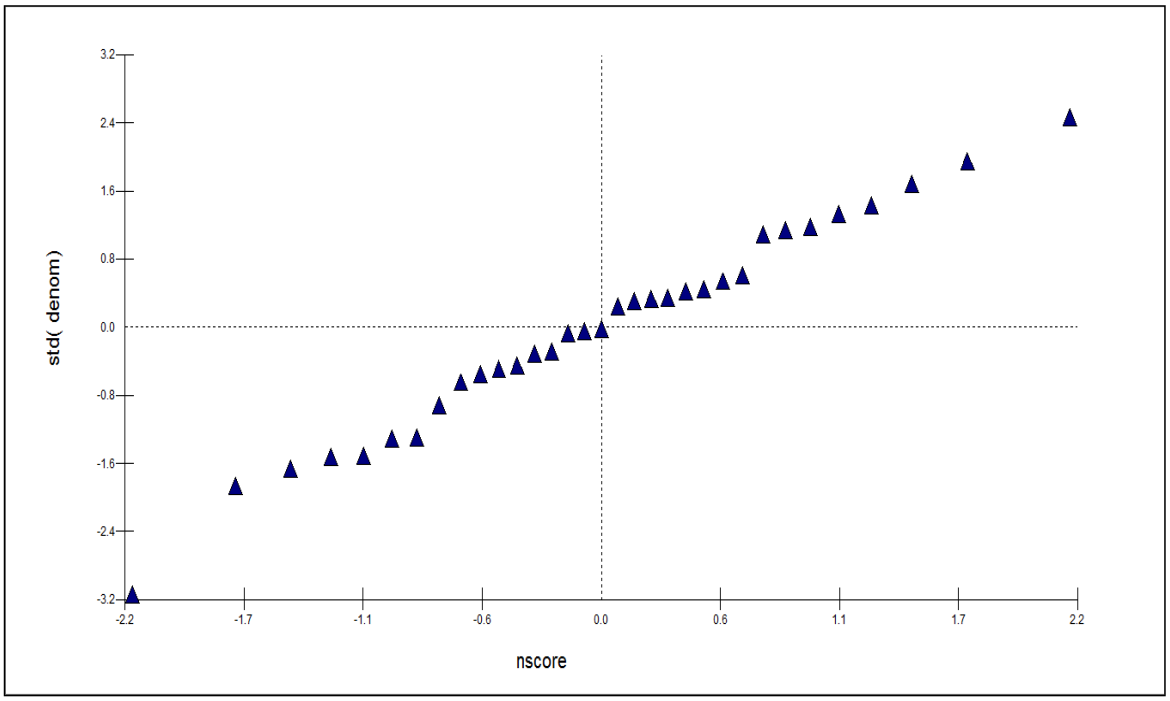

Figure 4.20: *Normal probability plot of standardised community residuals against normal scores for the use of bed nets residuals (std(denom))*

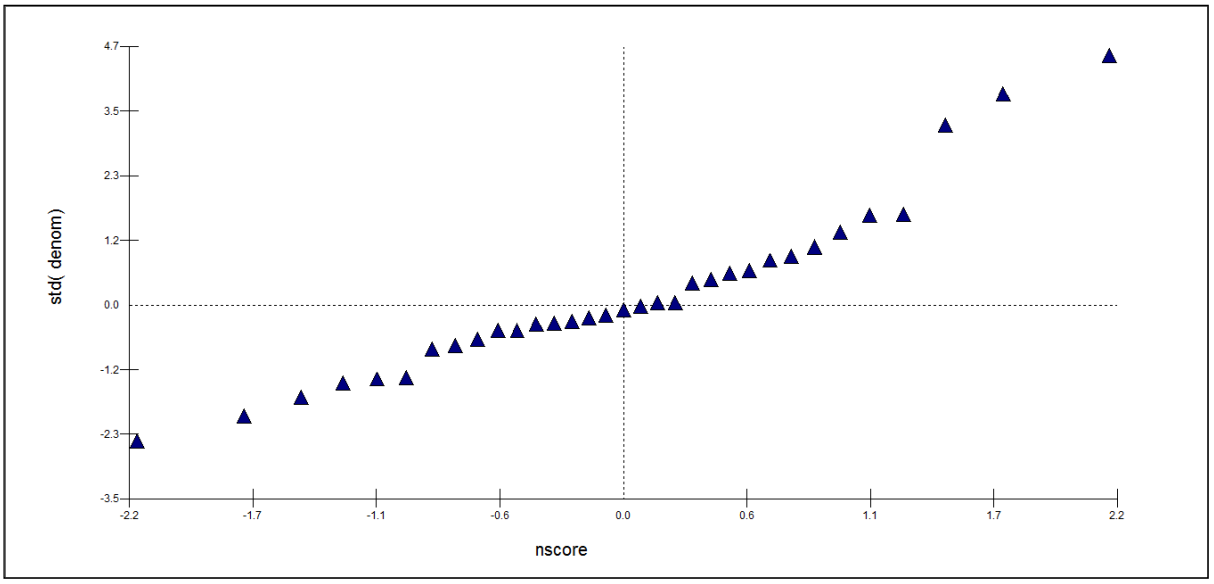

Figure 4.21: *Normal probability plot of standardised community residuals against normal scores for the distribution of bed nets residuals (std(denom))*

4.7.2 Care practice outcome variables

Care practice response variables for malaria and diarrhoea were each in three unordered categories. Since parameter estimates in multinomial models are more efficient than in binary models the former were, therefore, an obvious choice for analysis. Unfortunately stable estimations of both the malaria and diarrhoea practice response variables could not be obtained in the MLwiN 2.10. In actual fact some coefficient estimates were exploding after performing some finite number of iterations in the MCMC estimations. However, when binary responses were derived from the response variables, there were no problems experienced with iterations in MCMC. A sample of normality plots illustrated by Figure 4.22 and Figure 4.23 show reasonable agreement with the normality assumption of multilevel models. Table 4.11 and Table 4.12 show that two level models were fairly better than single level models. Two level binary logistic models at household and community levels were, therefore, adopted for final interpretation of results on care practices.

Table 4.10: Measures of model fit and complexity and estimates of random coefficient effects at community levels for household knowledge on malaria and bed-net ownership

	Identification of malaria symptoms									
	Rigors		Fever		Vomiting		Blood test at hospital			
	Single-level	Community-level	Single-level	Community-level	Single-level	Community-level	Single-level	Community-level		
Model fit and complexity										
Deviance ($\bar{D}$)	1449.35	1388.93	719.11	695.62	1767.06	1736.01	772.39	716.88		
pD	12.95	34.94	12.85	26.70	13.02	29.12	12.80	32.43		
DIC	1462.30	1423.88	731.96	722.32	1780.10	1765.13	785.19	749.32		
	Knowledge on malaria preventive measures				Bed-net ownership					
	Clear weeds/bushes		Use mosquito-net		Random components model		Random coefficients model			
Model fit and complexity										
Deviance ($\bar{D}$)	1642.29	1590.68	1671.50	1613.88	1675.98		1629.19			
pD	12.98	32.87	13.00	33.85	33.12		92.4			
DIC	1655.28	1623.48	1684.50	1647.73	1709.10		1721.72			
Random Coefficient components										
Primary school							0.42 (-0.01,0.84)*			
Secondary school							0.51 (-0.07,1.09)*			
Average wealth							0.37 (0.01,0.72)**			
Above average wealth							0.46 (-0.03,0.95)*			
Household size							0.12 (0.04,0.19)**			

[a] 95% credible intervals in parentheses; * significant at *p=0.10*; **significant at *p=0.05*

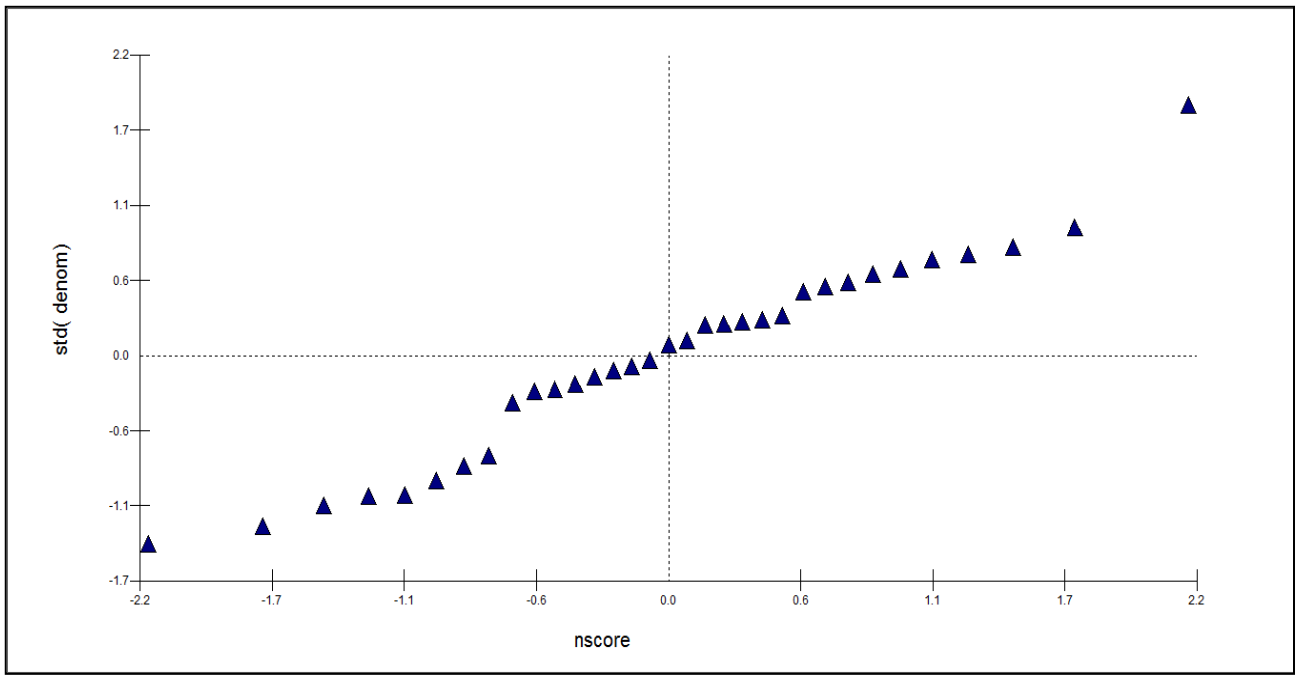

Figure 4.22: *Normal probability plots of standardised community residuals against normal scores for malaria care-seeking behaviour when a child is ill: Family uses hospital treatment for child malaria*

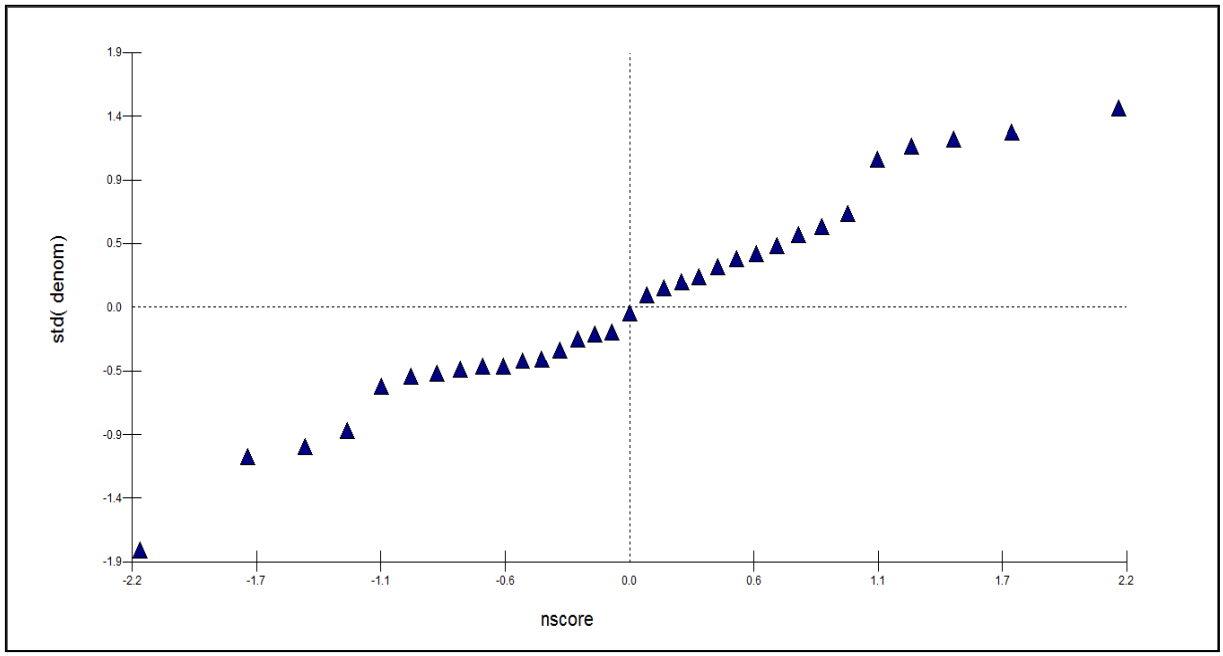

Figure 4.23: *Normal probability plots of standardised community residuals against normal scores for malaria care-seeking behaviour when a child is ill: Family uses hospital treatment for child malaria*

Table 4.11: Measures of model fit and complexity and estimates of random effects at community levels for household care-seeking practices for malaria illness

		Hospital treatment			Buy/Home drugs			Traditional or nothing	
		Single-level	Community-level		Single-level	Community-level		Single-level	Community-level
Childhood malaria	*Model fit and complexity*								
	Deviance ($\bar{D}$)	1286.05	1256.78		1201.30	1160.09		286.70	285.84
	pD	6.04	22.36		6.10	23.56		5.88	7.43
	DIC	1298.13	1279.15		1207.41	1183.65		292.58	293.27
	Community effects [a]								
	σ_u^2		0.255 (0.140)*			0.338 (0.178)*			0.093 (0.175)
Adulthood malaria	*Model fit and complexity*								
	Deviance ($\bar{D}$)	1512.40	1445.37		1435.29	1376.01		308.04	305.63
	pD	5.89	27.70		6.07	27.00		5.82	8.52
	DIC	1518.29	1473.07		1441.36	1403.01		313.87	314.15
	Community effects [a]								
	σ_u^2		0.497 (0.222)**			0.454 (0.211)**			0.146 (0.271)

[a] standard errors in parentheses; * significant at *p=0.10*; **significant at *p=0.05*

Table 4.12: Measures of model fit and complexity and estimates of random effects at community levels for household care-seeking practices for diarrhoea illness

		Hospital treatment			Home use ORS			Home use of other fluids			Nothing	
		Single-level	Community-level		Single-level	Community-level		Single-level	Community-level		Single-level	Community-level
Childhood diarrhoea	*Model fit and complexity*											
	Deviance ($\bar{D}$)	796.87	769.59		1299.43	1281.64		832.55	826.48		437.92	435.49
	pD	12.03	26.45		12.16	24.20		11.95	17.55		11.49	14.59
	DIC	808.90	795.05		1311.59	1305.84		844.50	844.03		449.34	450.08
	Community effects [a]											
	σ_u^2		0.35 (-0.11,0.82)			0.14 (-0.07,0.35)			0.09 (-0.14,0.32)			0.11 (-0.20,0.41)
		Hospital treatment			Home use of ORS from HP			Home use of bought ORS			Home use of fluids	
Family member diarrhoea	*Model fit and complexity*											
	Deviance ($\bar{D}$)	1768.67	1715.98		1205.11	1162.73		943.54	920.22		673.00	671.01
	pD	13.00	33.14		12.94	29.79		12.95	26.63		12.40	15.36
	DIC	1781.67	1749.12		1218.05	1192.52		956.49	946.85		685.41	686.38
	Community effects [a]											
	σ_u^2		0.28 (0.025,0.54)**			0.38 (-0.01,0.75)*			0.27 (-0.11,0.65)			0.053 (-0.11,0.22)

[a] 95% credible interval in parentheses; * significant at *p=0.10*; **significant at *p=0.05*

CHAPTER 5

THE PATTERN OF MALARIA AND DIARRHOEA PREVALENCE

5.1 Introduction

This chapter investigates hierarchical relationship between malaria and diarrhoea prevalence using three different approaches of analysis. First, a hierarchical binary logistic regression is used to analyse household and community influences on diarrhoea with individual malaria episodes as a predictor variable after controlling for all other relevant predictor variables. Then a multinomial modelling approach is employed to examine household and community-level influences on repeated malaria episodes with both individual diarrhoea episodes and community diarrhoea endemicity as predictor variables. In the end a bivariate analysis is used to investigate the joint pattern of variation between diarrhoea and malaria coexistence. The study shows high malaria and diarrhoea prevalence levels when compared to average national prevalence levels. The results also show that prevalence of malaria and diarrhoea has remained the same in Chikwawa over a period of three years in spite of massive programmes being executed under the MDGs such as the integrated management of childhood illness (IMCI), and the roll back malaria project (RBM). All three models show a strong relationship between reported malaria and diarrhoea illnesses. They also show strong malaria and diarrhoea variations between households and between communities. Strong common predictor variables shared between malaria and diarrhoea include individual age, household size, and community endemicity. The results reaffirm observations made in other scholarly articles and underscore the importance of early integrated interventions both at household and community levels to diagnose and treat malaria illness and stop their transmission. Strong household and community variations suggest more research is needed at these levels to determine the hidden predictor variables.

5.2 Household and community variations in diarrhoea illness: a binary multilevel modelling approach

5.2.1 Summary

This section examines malaria endemicity and household and community-level influences on diarrhoeal prevalence. A Bayesian multilevel modelling technique is used in the estimation of hierarchically built data from a survey of individuals nested within households nested within communities. Households have strong unobserved influence on diarrhoeal illness (σ_u^2 =4.383; 95% CI: 2.129, 6.637). A joint Wald test of significance shows that an individual's age [$\chi^2_{df=4}$ = 55.921, p = 0.000], and school [$\chi^2_{df=2}$ = 18.203, p = 0.000] have strong influence on individual's diarrhoeal prevalence. An individual's history of malarial-like illness also has a strong positive relationship with diarrhoeal prevalence [$\beta = 0.627,\ 95\%CI: 0.531, 0.723$]. Household factors that influence diarrhoea include employment status of head of household [$\beta = -0.595,\ 95\%CI: -1.136, -0.054$] and proximity to a trading centre [$\beta = 0.859,\ 95\%CI: 0.028, 1.690$]. The positive relationship between diarrhoea and malaria-like episodes highlights common risk factors hence the need for common approaches to combat the diseases. Significant household effects underline the importance of household considerations in policy issues.

5.2.2 Results and discussion

5.2.2.1 Descriptive statistics

This section uses results of model 6, the random coefficient effects model, from section 4.2.6 of chapter 4 which was found to be the best binary model. Table 5.1 shows summary measures for outcome and predictor variables in the models. There were 6,789 individuals nested within 1,403 households, clustered within 33 villages (communities) analysed in this study. A quarter of individuals were reported to have experienced diarrhoeal illness during the 8 month period. Eight in every ten people (n = 5,431) have access either to piped water or a borehole and a total of 94% have access to improved water sources[6]. Two-thirds (n = 4,520) have access to a toilet facility and out of these every 2 individuals in three (n= 3,028) use

[6] ***WHO definition of improved water source*****:** *there must be at least household piped water connections, public standpipes, boreholes, protected dug wells, protected springs or rainwater collection available to the household*

Table 5.1: Summary measures for variables in the diarrhoea prevalence model.

Variable	Number at risk	% at risk	% infected
Outcome variable	6789	100%	25.5%
Categorical variables			
Individual age			
Age 0-5 (ref)	1459	21.5	35.57
Age 6-18	1728	25.5	17.77
Age 19-40	1427	21.0	22.21
Age 41-60	1298	19.1	26.96
Age >60	877	12.9	27.48
Individual school			
None (ref)	2578	38.0	31.23
Primary	3612	53.2	22.76
Secondary	599	8.8	17.86
Individual Sex			
Male (ref)	3351	49.4	24.32
Female	3438	50.6	26.73
Employment of Head by Household			
Not employed (ref)	438	6.5	34.70
Employed	6351	93.5	24.91
Health facility by household			
Private clinic (ref)	1966	29.0	32.24
Government hospital	3336	49.1	22.43
Health centre	924	13.6	27.07
CHAM[7] hospital	104	1.5	24.57
Local clinic	459	6.8	14.42
distance to nearest river			
< 1 km (ref)	2499	36.8	22.57
1 to 2 km	2887	42.5	25.84
>2 km	1403	20.7	30.22
Water Source by household			
PPWOPWT (ref)	420	6.2	20.95
Public piped water	1043	15.4	28.19
Other safe water sources	4933	72.7	24.37
Unsafe water sources	393	5.8	38.17
Sanitation			
Own toilet	3028	44.6	24.4
Shared toilet	1492	22.0	24.5
No toilet	2269	33.4	27.8
Wealth index by household			
Lower category (ref)	4400	64.8	27.20
Middle category	1385	20.4	23.90
Higher category	1004	14.8	20.52
Villages near active trading centres			
>2 km	4421	1044	23.61
≤ 2km	2368	690	29.14
Continuous variables			
Household density	Mean = 5.59	Median = 5.00	Minimum = 1
(per household)	Std. Dev. = .05	IQR = 3.00	Maximum = 13
Malaria episodes	Mean = 1.07	Median = 1.00	Minimum = 0
(per person in 8 months)	Std. Dev. =.30	IQR = 2.00	Maximum = 5

[7] *CHAM = Christian Association of Malawi*

their own household toilet. One in three individuals shared a toilet facility. These figures are in line with the 2015 Millennium Development Goals (MDGs). To meet MDG 7 for water and sanitation this would mean that approximately 89% of the population should have access to improved drinking water sources and 74% access to improved sanitation[8] by 2015 [UNICEF, 2006].

A quarter of individuals (n = 1,734) reported to have experienced an episode of diarrhoea between January and September 2007. Approximately one in three children under five years of age were reported to have suffered from diarrhoea during this period and a slightly higher percentage (38%) of those without access to safe water sources reported that they had suffered from a diarrhoeal episode during this period. These findings are similar to other studies that also observed more episodes of diarrhoea among children less than five years of age without access to improved water sources and sanitation [Kosek et al., 2003; Bryce et al., 2005.

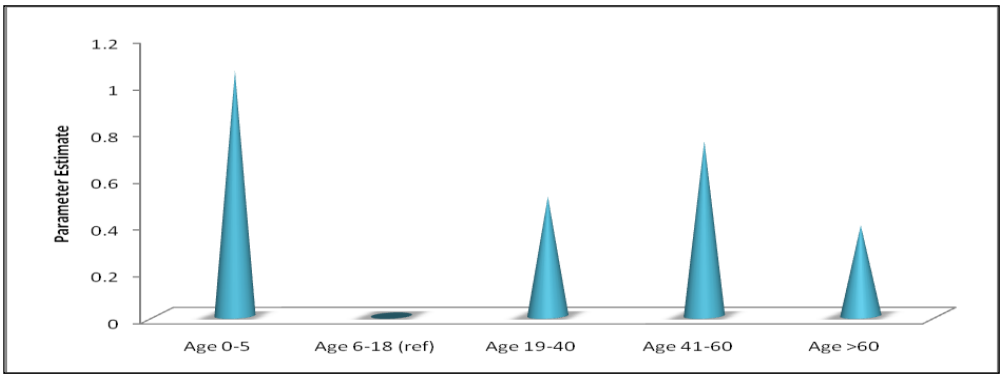

***Figure 5.1**: A Plot of age categories versus diarrhoea prevalence parameter estimate showing a cubical relationship.*

5.2.2.2 Binary multilevel modelling results

Based on model 6, Table 5.2 shows random effects and estimated coefficients fitted to data on diarrhoea prevalence. The results show a cubical relationship between age and diarrhoea prevalence as shown in figure 5.1. Infants and children of five or fewer years were likely to suffer from diarrhoea than children of 6 to 18 years of age [β = 1.087; 95% CI: 0.718, 1.455]. Similarly those in the 19 to 40 and those in the 41 to 60 age categories were more likely to have diarrhoea illness than those aged 6 to 18 years [β = 0.51; 95% CI: 0.171, 0.853] and [β = 0.56; 95% CI: 0.048, 1.072] respectively. However, the likelihood of diarrhoea prevalence

[8] ***WHO definition of improved sanitation*****:** *there must be at least a connection to a public sewer, a connection to a septic tank, a pour-flush latrine, a simple pit latrine or a ventilated improved pit latrine available to the household*

Table 5.2: Random effects and estimated coefficients fitted to data on diarrhoea prevalence.

Hierarchy	Variable	Parameter (β)	Standard error (se)
INDIVIDUAL-LEVEL	*Individual age*		
	Age 6-18 (ref)	0.000	
	Age 0-5	1.087	0.188****
	Age 19-40	0.512	0.174***
	Age 41-60	0.560	0.261**
	Age >60	0.387	0.337
	Individual School		
	None (ref)	0.000	
	Primary	-0.270	0.150*
	secondary	-0.946	0.271****
	Frequency of malaria episodes	0.627	0.049****
HOUSEHOLD-LEVEL	*Employment -Head Household*		
	Not employed (ref)	0.000	
	Employed	-0.595	0.276**
	Health Facility		
	Private clinic (ref)	0.000	
	Government Hospital	0.008	0.334
	Health centre	0.227	0.303
	CHAM hospital	-0.537	0.329
	Local clinic	-1.123	0.676*
	Distance to nearest river		
	< 1 km (ref)	0.000	
	1 to 2 km	0.187	0.189
	>2 km	0.492	0.212**
	Household water source		
	Other safe water sources5(ref)	0.000	
	PPWOPWT4	-0.494	0.385
	Public piped water	-0.132	0.323
	Unsafe water sources5	0.682	0.375*
	Household wealth index		
	Lower category (ref)	0.000	
	Middle category	-0.255	0.180
	Higher category	-0.316	0.226
	Household density: x	-0.515	0.178***
	x^2	0.032	0.031
COMMUNITY LEVEL	Proximity to trading centre		
	>2 km radius (ref)	0.000	
	$\leq$ 2km radius	0.859	0.424**
	σ_u^2 (household)	4.383	1.150****
	σ_v^2 (community)	0.600	0.693

$*p \leq 0.10$; $**p \leq 0.05$; $***p \leq 0.01$; $****p \leq 0.001$

for these groups was still lower than that of children of five years or lower. There was no statistical difference between 6 to 18 year olds and those above the age of 61 years.

The higher likelihood of diarrhoea prevalence amongst children below the age of five agrees with a number of studies, including those undertaken in Malawi [Morse, 2006; Kazembe, et al., 2007; Reither et al., 2007]. Studies have attributed this occurrence to underdeveloped immune systems in infants, poor breastfeeding practices, malnutrition, poor food preparation, mother's personal hygiene practices and lack of child health knowledge [Escobar et al., 1983; Nakao et al., 1992; Perera et al., 1999; Morse, 2006; IMF, 2007]. In this study it was observed that young children seldom wore shoes whilst playing in and around households and whilst seated on the ground often played with soil. Domesticated animals (chickens, goats, pigs etc.) were observed to roam freely and evidence was clearly visible of indiscriminate animal defecation (see plate 5.1). Children because of their *pica* and the potential for faecal-oral transmission of pathogens as a result of such practices in the absence of good hygiene are more susceptible to contracting diarrhoeal disease [Grimason et al., 2000; Burt et al., 2003; Taulo et al., 2009]. Other studies have reported faecal contamination of weaning foods with *Salmonella sp, E. Coli, Shigella sp, and Campylllobacter jejuni* [Steenberger et al., 1983; Molbak et al., 1989; Potgeither et al., 2005]. As Morse [2006] observed, it is possible to deduce from these reports that contamination of other child foods may occur during preparation, cooking and storage in the household. Other reports have also observed that some mothers do not wash their hands following defecation and subsequent disposal of child faeces and that only a small proportion of mothers were seen to wash their hands prior to feeding children [Omotade et al., 1995; Palamuleni 2002]. Proposed solutions include encouraging maternal breastfeeding (sometimes discouraged in young mothers), personal and household hygiene including proper handwashing, good food hygiene practices and proper faecal disposal. Village health committees should be encouraged to implement the World Health Organisation healthy village concept [Howard et al., 2002]

The significant gradual increase in diarrhoea prevalence likelihood from the ages of 19 to 60 years may be explained by the fact that most of those in this group are among the 14% in the age group 15 to 49 years that are infected with HIV/AIDS in Malawi [IMF, 2007]. These individuals may have weakened immunities that render them vulnerable to infection. Waning of immunity in the elderly may also be a factor [Agtini et al., 2005]. Low diarrhoea prevalence amongst those that are young (6 to 18 year olds) may explain the fact that this age

group is outside the HIV/AIDS vulnerable grouping. This may also be explained by their exposure to health education within the school curriculum. Erratic results for those above 60 years may be a reason for lack of evidence of any deference with those in the 6 to 18 year category.

Plate 5.1: *A picture showing domesticated animals roaming around and drinking near borehole soak-aways – Chikwawa 2007*

Individuals that have attended primary or secondary school were less likely to suffer from diarrhoea than those that had no formal schooling [β = -0.27; 90% CI: -0.517, -0.023] and [β=-0.95; 95% CI: -1.477, -0.415 respectively]. Those who attended school may have benefited from that part of the school curriculum which addresses the cause and prevention of disease. These findings are similar to those observed in other studies on the prevalence of diarrhoea [Pebly and Stupp, 1987; Hobcraft, 1993; Manda, 1999; Kandala et al., 2005; Morse, 2006; Pongou et al., 2006; Osuman, 2007; Masangwi 2008a].

The higher the number of malaria-like episodes an individual had the more likely they were to suffer from diarrhoeal illness during the same period ([β = 0.627; 95% CI: 0.531, 0.723]. This supports a study on the effect of malaria endemicity in childhood fever, diarrhoea and pneumonia in Malawi that observed marginal positive association between diarrhoea prevalence and high malaria endemicity levels relative to low malaria endemicity [Kazembe et al., 2007]. Other studies have explained the high risks associated with co-morbidity of malaria and diarrhoea likely to aggravate illness leading to death [Fenn et al., 2005].

While household possessions' categories were not significantly different from each other in diarrhoeal prevalence, families whose head of household was employed were less likely to suffer with diarrhoea than those whose head of household was not employed [β =-0.595; 95% CI: -1.136, -0.054]. Those that are employed are more likely to have a greater disposable income than the unemployed. They are also more likely to be in a position to afford the costs associated with accessing health facilities, the purchase of medicines, to obtain drinking water from safe water sources, to have access to improved sanitary facilities, better nutrition etc. This in turn will reduce exposure of these individuals to many of the factors associated with the onset and transmission of diarrhoeal disease. Indeed, a study by Veenstra [2000] showed that households with greater disposable income are positively related to better health.

Type of health facility had no noticeable association with diarrhoea prevalence except with local clinics or health posts that were marginally associated with less likelihood of diarrhoeal prevalence when compared with local private clinics [β =-1.123; 90% CI: -2.235, -0.011]. Malawi's health service delivery system consists of community, primary, secondary and tertiary care levels [Zere et al., 2007]. Health posts are normally administered at community level where service is provided through health surveillance assistants (HSAs). The focus is on preventive interventions. Intervention programmes by non-governmental organisations (NGOs) and other non-profit organisations involved in healthcare delivery issues use these health posts to reach the local communities. The communities in turn benefit from frequent health initiatives including the provision of water disinfectants, safe water provision, and health education. Such organisations rarely use district hospitals, health centres or local private clinics. The reduced risk of diarrhoeal prevalence at local health posts may be a reflection of this scenario.

Households utilising unsafe water sources (i.e. rivers, streams, ponds, and other stagnant water bodies) were marginally more likely to have suffered from diarrhoea than those using safe water sources such as boreholes, protected wells or springs [β =0.682; 90% CI: 0.065, 1.299]. There was no evidence of difference in diarrhoeal prevalence between those using boreholes, protected wells, or springs and those drinking from piped water supplies. Unsafe water sources are usually only used by villagers for bathing and laundry purposes (see Plate 5.2) but occasionally people collected river water for drinking water purposes e.g. as a result of overcrowding around safe water sources or by personal preference. Unsafe water sources are subject to contamination from both point sources (e.g. indiscriminate faecal littering of

Plate 5.2: *A picture showing unsafe water source being used for bathing and laundry and a woman collecting water for home use – Chikwawa 2007*

the environment by humans who either do not have access to a latrine or would prefer not to use a latrine and domestic animals which roamed freely) and diffuse pollution (e.g. surface run-off from land into rivers, streams etc.) during the rainy season and flooding events [Muirhead et al., 2004; Sirajul Islam et al., 2006]. Animals were often observed drinking and cooling themselves in ponds of stagnated water e.g. caused by inadequate drainage at the end of poorly constructed borehole soak-aways (see plate 5.1). It was also noted that farmers brought their cattle to river sources for drinking both upstream and downstream of the location used by women and children for bathing and laundry purposes (see plate 5.3). Faecal contamination of such water resources exposes human beings to zoo-anthropoonotic sources of diarrhoeal disease. The use of river water for drinking purposes and other domestic chores was found to be a significant risk factor associated with the incidence of cryptosporidiosis in paediatric children in Chikwawa [Morse, 2006].

Diarrhoea risks were also associated with regards to the proximity of households to a river or stream after controlling for rivers and streams as drinking water sources. Households that live more than 2 kilometres from a river were significantly at a high risk of suffering from an episode of diarrhoea than those that lived within a 1 kilometre to the nearest river [β =0.492; 95% CI: 0.076, 0.907]. The distance to a safe water source, the quantities that can be collected and time and effort required for collection and transportation are important factors in water use and management within households. Some women preferred to recycle water

Plate 5.3: *Domesticated animals feeding and drinking near a location used by women and children for bathing and laundry purposes – Chikwawa 2007.*

that had previously been collected from a safe water source for cleaning kitchen utensils, rather than walk over a kilometre to obtain fresh water from a safe water source such as a borehole for the same task. Hands, food, floors, cooking surfaces, kitchen utensils, and children are less likely to be kept clean and hygienic when water from safe water sources has to be carried from distance, is in short supply, and requires valuable time, energy resources and effort to be devoted [Bartlett, 2003]. Studies in Papua New Guinea and Burkina Faso [Bukenya et al., 1991; Curtis et al., 1997] reported a significant reduction in diarrhoeal disease in communities who had access to safe water sources within their compounds compared with those that had to fetch safe water from outside their compounds. Communities who had access to abundant safe water sources within their compounds were more likely to adopt good hygiene practices such as handwashing after using a latrine.

Household size has a quadratic relationship with diarrhoea prevalence. Increasing sizes in households from one to six members had a negative relationship with diarrhoea prevalence [β=-0.515; 95% CI:-0.864, -0.166] while increasing household size from 7 and above had a non-significant positive relationship with diarrhoea prevalence [β =0.032; 95% CI: -0.029, 0.093]. Small households comprising of two or three people are mostly associated with young single mothers or newlywed couples who may be less experienced and not as prepared to deal with the challenges associated with child caring [Hobcraft, 1993; Pongou et al., 2006; Osuman, 2007]. The decreasing prevalence in diarrhoea may reflect increasing experience

with years as the family expands until this reaches a threshold of about six member family when the impact of overcrowding outweighs any gains from experience.

At community level, villages living within two kilometres of an active[9] trading centre were more likely to experience diarrhoea than those living more than two kilometres from an active trading centre [β =0.859; 95% CI: 0.028, 1690]. Factors that may have influenced this include the observed unhygienic practices associated with the preparation and presentation of foodstuffs for sale to the public in an unsanitary environment and unhygienic stalls. Vendors trade in the sale of live and dead animals in an open, dusty and overcrowded environment. Further work is required to improve the food hygiene practices operated by vendors and proprietors of trading centres through the implementation of proper licensing and inspection system which incorporates the provision for basic food hygiene training for those involved in the production and sale of foodstuffs.

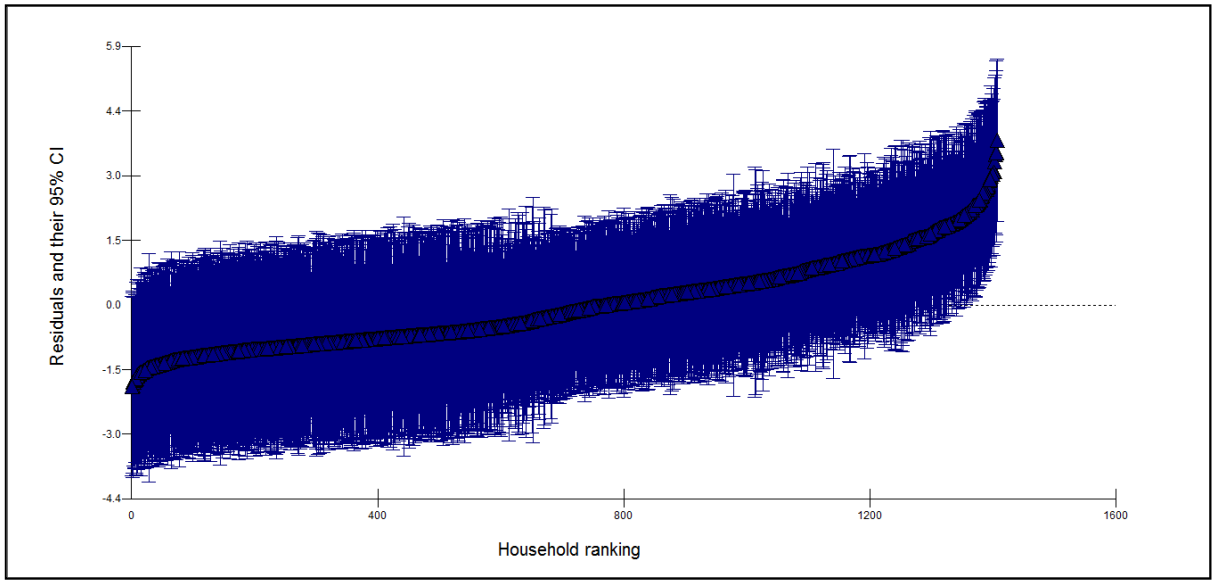

Figure 5. 2: *Caterpillar plot of ranked household residuals. The dotted line is the mean of the estimated (shrunken) residuals[10] which is equal to zero. The brushes represent 95% CI to the estimated residuals*

Figure 5.2 shows a caterpillar plot of household residuals (Appendix 5A). A number of households have their residuals significantly higher than a zero indicating significant

9 *Active trading centres are those that are busy and have large volumes of people on daily basis*

10 *Estimated or shrunken residual for group j is the residual obtained by multiplying the mean of the residuals of subjects in group j by a shrinkage factor. Shrinkage factor shrinks an observed group mean towards the centre of the population mean.*

differences between households and extreme vulnerability in such households. This is supported by the covariance structure in table 5.3 that shows significant variation in diarrhoea prevalence at household level [σ_u^2=4.383; 95% CI: 2.129, 6.637]. Prevalence of diarrhoea also varies across households amongst the age groups 0 to 5 years [$\sigma_u^{2(1)}$=0.946; 90% CI: 0.082, 1.810]; 19 to 40 years [$\sigma_u^{2(3)}$=1.529; 95% CI: 0.184,2.874]; and 41 to 60 years [$\sigma_u^{2(4)}$=2.842; 95% CI: 0.151,5.533]. Household variation is also observed amongst those that have primary school education [$\sigma_u^{2(6)}$=0.773; 95% CI: 0.214,1.331] and those that had varying degrees of malaria-like episodes [$\sigma_u^{2(8)}$=0.355; 95% CI: 0.188,0.522]. Those with varying degrees of malaria-like episodes show less variability in their pattern of diarrhoea prevalence [$\sigma_u^{(0,8)}$=-0.568; 95% CI: -0.980,-0.156].

Figure 5.3 shows a caterpillar plot of community residuals. No single community residual is significantly above zero indicating no difference in diarrhoea prevalence between communities and this is supported by community random term in Table 5.2. However, there is variation in diarrhoea prevalence based on household sizes of 7 or more members [$\sigma_u^{2(11)}$=0.031; 95% CI: 0.0153,0.047] indicating significant differences between communities in diarrhoea prevalence in bigger households.

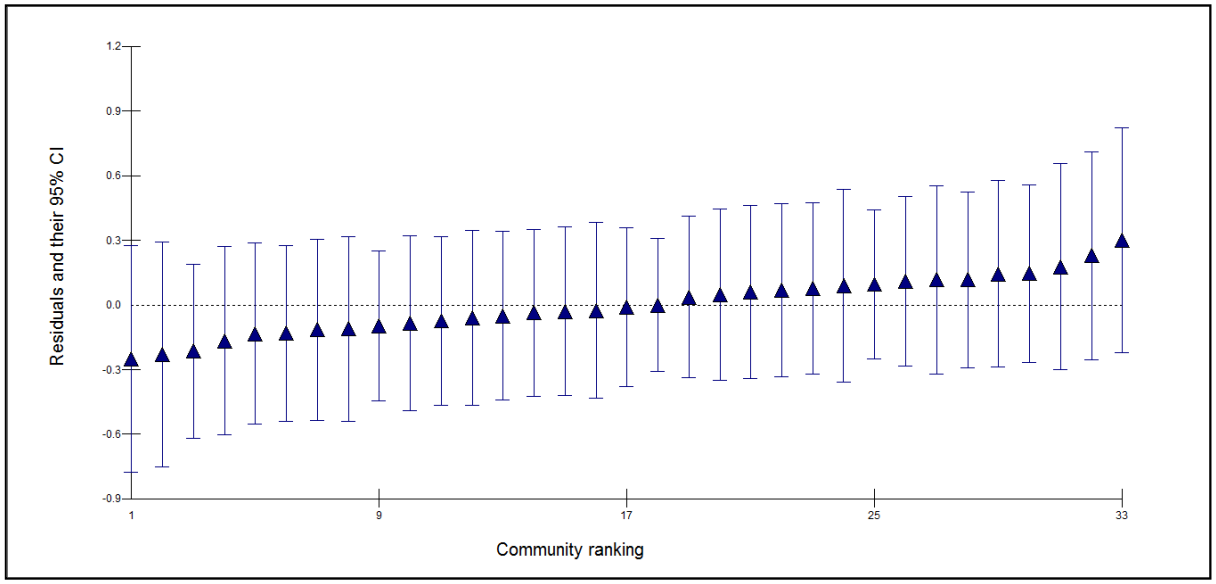

Fig 5.3: *A 95% credible interval caterpillar plot of ranked village residuals. The triangles indicate estimated (shrunken) community residuals.*

Table 5.4 shows community residuals ranked in ascending order. Communities with negative residuals were less likely to have diarrhoea prevalence when compared to those that are positive. Highlighted with asterisks are four communities under the SCHI. These have been targeted for some health interventions in Chikwawa. On average the communities were less likely to have diarrhoea prevalence when compared to most communities in Chikwawa that did not receive the same attention. This suggests that the relevant interventions against diarrhoea have some positive effect in the four villages.

Table 5.3: Covariance structures at household and community levels[§]

Household covariance matrix

	$u_{0\,jk}$	$u_{1\,jk}$	$u_{3\,jk}$	$u_{4\,jk}$	$u_{5\,jk}$	$u_{6\,jk}$	$u_{7\,jk}$	$u_{8\,jk}$
$u_{0\,jk}$	σ_u^2 4.383 (1.150)***							
$u_{1\,jk}$		$\sigma_u^{2(1)}$ 0.946 (0.525)*						
$u_{3\,jk}$			$\sigma_u^{2(3)}$ 1.529 (0.686)**					
$u_{4\,jk}$				$\sigma_u^{2(4)}$ 2.842 (1.373)**				
$u_{5\,jk}$					$\sigma_u^{2(5)}$ 1.636 (1.066)			
$u_{6\,jk}$						$\sigma_u^{2(6)}$ 0.773 (0.285)***		
$u_{7\,jk}$							$\sigma_u^{2(7)}$ 1.029 (0.613)*	
$u_{8\,jk}$	$\sigma_u^{(0,8)}$ -0.568 (0.210)***							$\sigma_u^{2(8)}$ 0.355 (0.085)***

Community covariance matrix

	v_{0k}	v_{10k}	v_{11k}
v_{0k}	σ_v^2 = 0.600 (0.693)		
v_{10k}		$\sigma_v^{2(10)}$ = 0.152 (0.098)	
v_{11k}			$\sigma_v^{2(11)}$ = 0.031 (0.008)***

$*p \leq 0.10$; $**\ p \leq 0.05$; $***p \leq 0.01$

§Only variances (diagonal) and significant covariance terms (off-diagonal) have been included in the covariance matrices. Numbers in brackets are standard errors)

Table 5.4: Community residuals for diarrhoea prevalence in ascending order

Community	Traditional Authority	Residual
Changamuka	Ngabu	-0.353
Tombondera	Chapananga	-0.342
Thomo	Ngabu	-0.31
Salumeji	Katunga	-0.247
Sekeni*	Lundu	-0.231
Ngalu	Ngabu	-0.221
Bester	Lundu	-0.204
Mwalija*	Kasisi	-0.17
Mwanayaya*	Makhuwira	-0.1
Matimati	Makhuwira	-0.086
Mbwadzi	Ngabu	-0.082
Biliati	Lundu	-0.068
Tomali	Lundu	-0.033
Jombo	Ngabu	-0.021
Kabona	Ngabu	-0.017
Ngabu Trading	Ngabu	-0.007
Namila*	Mlilima	0
Makhula	Makhuwira	0.044
Chipwepwete	Ngabu	0.052
Julius	Ngabu	0.053
Ntondeza	Maseya	0.068
Tembenawo	Chapananga	0.073
Thembeta	Ngabu	0.1
Machokola	Makhuwira	0.126
Mafunga	Makhuwira	0.153
Maluwati	Ngabu	0.162
Njuzi	Ngabu	0.165
Ndirande	Lundu	0.174
Beleu	Maseya	0.19
Chindoko	Ngabu	0.227
Phonde	Ngabu	0.237
Chikwawa Boma	Kasisi	0.299
Mose	Ngabu	0.322

** These communities have been targeted as pilot projects for the SCHI initiatives.*

The effect of diarrhoea endemicity on community variations in malaria illness: a multinomial multilevel modelling approach

5.3.1 Summary

Malaria is highly endemic in Southern Malawi. While efforts have been made to examine special characteristics associated with malaria risks, few studies have looked at highly endemic areas to examine patterns of malaria severity and their associated risk factors. This paper examines household and community-level influences on repeated malaria episodes using a multinomial modelling approach with Bayesian estimation. It demonstrates how the multilevel multinomial modelling approach allows the effects of explanatory variables to vary and be isolated hierarchically between categories of malaria episodes while treating individuals without any single malaria-like episode as a reference group. Results have shown that choice of treatment, proximity to stagnant water bodies, being female, expectant mothers, and community diarrhoea endemicity are specifically and strongly associated with repeated malaria attacks. There are strong household variations for both single and repeated malaria episode categories while community variations were marginal for the single episode contrast and strong for the repeated episode contrast. Strong household variations suggest more research is needed at household level to determine their cause. The results also demonstrate the need for early integrated interventions both at household and community levels to diagnose and treat malaria illness and reduce malaria transmission

5.3.2 Results

5.3.2.1 Descriptive statistics

Out of 6,727 individuals more than half (54%) experienced malaria-like (ML) episodes while a third (31%) experienced two or more ML episodes within the study period (Table 5.5). Of the 1,444 children under the age of five 61% suffered from ML illness. Similarly 62% of elderly people (above 60 years of age) suffered from ML illness. Eight in every ten of those that experienced 2 or more episodes of diarrhoea and seven in every ten of those that experienced a single bout of diarrhoea suffered from malaria during the previous 8 month period. This is proportionally higher when compared to those who did not suffer from diarrhoea but suffered from ML illness in the eight month period. Three in every five individuals from households that either use traditional methods (e.g. covering an ML patient with a wet cloth or administering traditional medicine) or used no method of treatment when

Table 5.5: Summary measures for variables in the ML multinomial model.

	Malaria episodes			
Risk factors	**0**	**1**	**≥ 2**	***n = 6727***
Outcome	46.3	23.3	30.5	6727
Categorical variables				
Individual age				
0-5	38.7	26.5	34.8	1444
6-10	49.7	26.5	23.8	1102
11-20	57.6	20.3	22.1	1344
21-40	44.9	21.9	33.2	2027
41-60	40.1	20.9	38.9	573
>60	38.0	22.8	39.2	237
Individual Sex				
Male	48.1	23.5	28.4	3318
Female	44.5	23.0	32.5	3409
Individual diarrhoea episodes				
No episode	53.7	26.6	23.7	500
One episode	29.0	30.4	40.6	941
Two or more episodes	12.6	19.1	61.3	786
Expectant?				
no	46.6	23.3	30.1	6583
yes	31.3	23.6	45.1	144
Is head employed?				
no	40.6	20.7	38.7	429
yes	46.6	23.5	29.9	6298
Care seeking behaviour				
Traditional or nothing	38.6	16.6	44.8	163
Home treatment (HTDHF)	47.3	22.6	30.1	4677
Home treatment (htDGSM)	47.7	25.8	26.5	287
Home treat then hospital	38.9	26.1	35.0	1139
Local clinic	55.3	24.5	20.2	461

Continuous variables	Mean & std. dev.	Median & IQR	Range
Distance to stagnant water body	$\bar{x} = 1.91$	$M = 2.00$	$Min = 1$
	$s = 0.897$	$IQR = 2$	$Max = 4$
Distance to hospital	$\bar{x} = 2.86$	$M = 3$	$Min = 1$
	$s = 1.006$	$IQR = 2$	$Max = 4$
Household size	$\bar{x} = 5.59$	$M = 5.00$	$Min = 1$
	$s = 2.054$	$IQR = 3$	$Max = 13$
Community diarrhoea endemicity	$\bar{x} = 0.4587$	$M = 0.4581$	$Min = 0.1560$
	$s = 0.1562$	$IQR = 0.2110$	$Max = 0.7805$

HTDHF = home treatment with drugs from health facility; HTDGSM = home treatment with drugs bought from grocery or market; Std. dev. = s = standard deviation; IQR = inter-quartile range;

a member of her household was ill had experienced ML episodes. Similarly seven of every ten expectant mothers had experienced ML episodes.

5.3.2.2 Fitting multinomial logistic multilevel model

Table 5.6 provides estimates for the fixed and random effects for the three -level model. The results show that infants and children under the age of five are more vulnerable to ML disease than those in the age categories of 6 to 40 years. Unlike in the diarrhoea prevalence outcome (section 5.2) where there was a cubical relationship between individual age and prevalence, there is a quadratic relationship between the log odds ratios for age categories and ML prevalence with the minimum prevalence occurring in the log odds ratio for age group 11 to 20 years of age (see figure 5.4). Notice that the multiple episodes series is showing a very steep gradient when compared to a single episode series highlighting strong differences between age groups with respect to multiple ML illness. Older people above 41 years of age were more likely to suffer from repeated ML episodes than children less than five years of age.

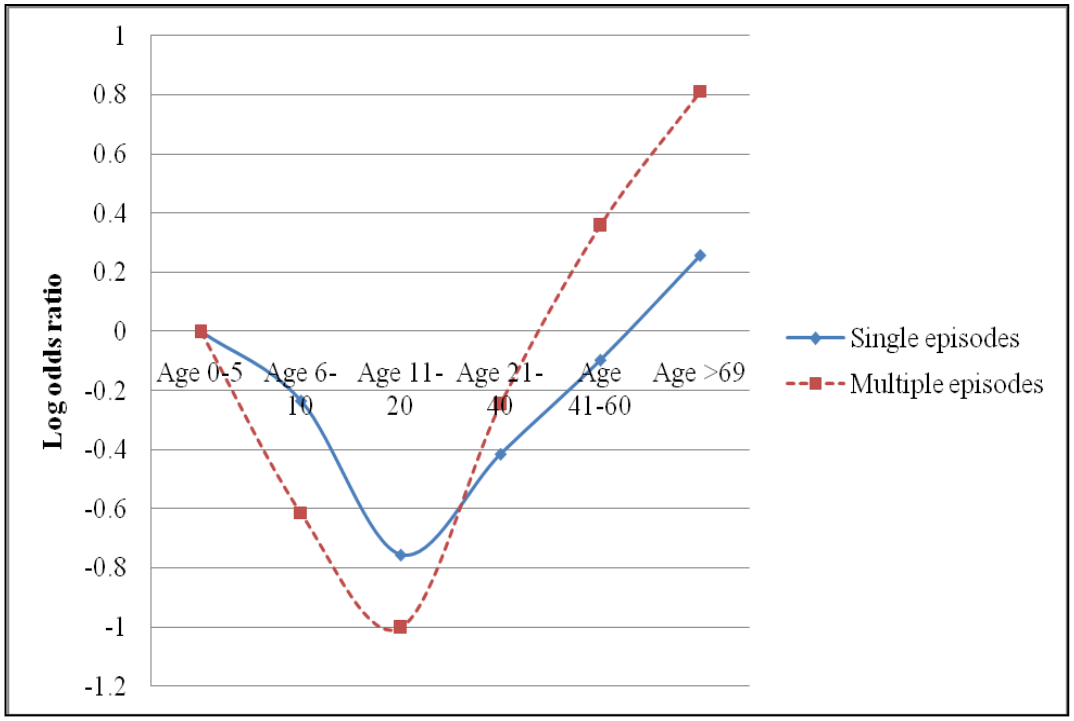

Figure 5.4: *A Plot of age categories versus ML episodes parameter estimates showing a quadratic relationship.*

Females were more likely to have experienced repeated ML episodes during the study period than their male counterparts ($\beta_6^{(2)} = 0.253,\ 95\%CI: 0.098,0.408$) although evidence of differences do not exist between the different genders for those that had experienced single bouts of ML episodes. Similarly expectant mothers were more likely to have suffered from both single ML illness ($\beta_7^{(1)} = 0.571,\ 95\%CI: 0.012,1.129$) and repeated ML illness than all other individuals ($\beta_7^{(2)} = 0.812,\ 95\%CI: 0.246,1.378$). Individuals that had at least an experience of diarrhoea were also likely to have experienced both single ($\beta_8^{(1)} = 0.845,\ 95\%CI: 0.618,1.072$ and $\beta_8^{(2)} = 1.09,\ 95\%CI: 0.853,1.33$) and multiple episodes of ML disease ($\beta_9^{(1)} = 0.796,\ 95\%\ CI: 0.506,1.086$ and $\beta_9^{(2)} = 1.856,\ 95\%CI: 1.576,2.136$).

Members from households (i) that seek medical care from health facilities ($\beta_{11}^{(2)} = -0.993,\ 95\%\text{CI}: -1.793,-0.193$), (ii) that treat their patients at home using hospital prescribed medication ($\beta_{12}^{(2)} = -1.115,\ 95\%\text{CI}: -2.167,-0.062$), or (iii) those that treat their patients first and then take them to hospital ($\beta_{14}^{(2)} = -1.422,\ 95\%\text{CI}: -2.386,-0.458$) were all less likely to have suffered from repeated ML illness in the eight month period than members from households that either use traditional methods or those that do nothing. However, there is no difference in single ML spells between these groups. The results also show no evidence that members from households that treat their relatives at home using medication bought from vendors, groceries or from the open market are different in their ML experiences from those that use traditional methods or do nothing.

Distance to the nearest stagnant water body is marginally associated with only multiple attacks of ML disease. The furthest the distance a household was to a stagnant water body the less likely that its members would have experienced repeated episodes of ML disease ($\beta_{15}^{(2)} = -0.132,90\%CI: -0.264,0.000$). Household size is also negatively associated with single bouts of ML episodes. The bigger the family size the less likely that its members were going to experience both single and multiple bouts of ML episodes ($\beta_{18}^{(1)} = -0.135,95\%CI: -0.192,-0.078$) and ($\beta_{18}^{(2)} = -0.105,95\%CI: -0.175,-0.034$ respectively)

Distance to hospital is positively and marginally associated with a single bout of ML illness ($\beta_{16}^{(1)} = 0.162,\ 95\%\text{CI}: 0.031,0.293$).

Table 5.6: Bayesian estimated coefficients fitted to three-level multinomial data on ML episodes

Variable	par	Cat	Model 3		Variable	par	Cat	Model 3	
Fixed effects			Estimate	Std. error	**Fixed effects**			Estimate	Std. error
Individual age					*Care seeking behaviour*				
Age 6-10	β_1	1	-0.234	(0.118)**	traditional	ref			
		2	-0.613	(0.130)***	*Health facility*	β_{11}	1	0.046	(0.366)
Age 11-20	β_2	1	-0.755	(0.119)***			2	-0.993	(0.408)**
		2	-1.000	(0.130)***	HTDHF	β_{12}	1	0.041	(0.442)
Age 21-40	β_3	1	-0.414	(0.103)***			2	-1.115	(0.537)**
		2	-0.244	(0.108)**	HTDGSM	β_{13}	1	0.332	(0.386)
Age 41-60	β_4	1	-0.096	(0.159)			2	-0.451	(0.448)
		2	0.360	(0.163)**	Home treat then hospital	β_{14}	1	-0.113	(0.409)
Age > 60	β_5	1	0.258	(0.231)			2	-1.422	(0.492)***
		2	0.812	(0.239)***					
Sex					*Distance to stagnant water*	β_{15}	1	-0.032	(0.065)
male	ref								
female	β_6	1	0.075	(0.074)			2	-0.132	(0.080)*
		2	0.253	0.079)***	*Distance to hospital*	β_{16}	1	0.164	(0.063)**
Expectant?	ref						2	-0.010	(0.079)
no									
yes	β_7	1	0.571	0.285)**	*Household size*	β_{18}	1	-0.135	(0.029)***
		2	0.812	(0.289)***			2	-0.105	(0.036)***
Diarrhoea episodes									
one	β_8	1	0.845	(0.116)***	*Community endemicity*	β_{19}	1	0.580	(0.538)
		2	1.090	(0.121)***			2	1.789	(0.735)**
Two or more	β_9	1	0.796	(0.148)***					
		2	1.856	(0.143)***	**Random effects**				
Is head employed?					$\sigma_u^{2(2)}$			1.964	(0.210)***
					$\sigma_u^{(2,3)}$			2.410	(0.226)***
yes	β_{10}	1	-0.025	(0.241)	$\sigma_u^{2(3)}$			3.789	(0.328)***
		2	-0.309	(0.294)	$\sigma_v^{2(2)}$			0.123	(0.067)*
					$\sigma_v^{(2,3)}$			0.141	(0.082)*
					$\sigma_v^{2(3)}$			0.265	(0.124)**

$* \; p \leq 0.10$; $** p \leq 0.05$; $*** \; p \leq 0.01$; Par = parameter; cat = category; ref = reference; std. error = standard error; $\sigma_u^{2(2)}$ = household random effects; $\sigma_v^{(s,r)}$ = community random effects

There is a significant variation at household level both for the single ML ($\sigma_u^{2(2)} = 1.964,\ 95\%CI: 1.552, 2.376$) and repeated ML categories ($\sigma_u^{2(3)} = 3.789, 9\ 5\%CI: 3.146, 4.432$) suggesting more unobserved activities for both categories at household level. There is also a strong significant correlation between the single ML and repeated ML categories ($\sigma_u^{(2,3)} = 2.410,\ 95\%CI: 1.967, 2.853,\ r_u^{(2,3)} = 0.883$). This was expected since the conditions under which single and multiple ML episodes occur are similar.

Community variation for the single ML category is only marginally significant ($\sigma_v^{2(2)} = 0.123, 90\%CI: 0.013, 0.233$) while variation for the repeated episode category is significant ($\sigma_v^{2(3)} = 0.265, 95\%CI: 0.022, 0.508$). These variations are much smaller when compared to those at household level indicating more unobserved factors at household level than at community level. Correlation between single ML episodes and repeated episodes at community level is also high as expected ($\sigma_v^{(2,3)} = 0.141, 90\%CI: 0.006, 0.276, r_v^{(2,3)} = 0.781$).

Figure 5.5 shows a caterpillar plot of ranked community residuals. Four communities highlighted in red are the worst affected of all other communities. Table 5.7 shows the ranked community residuals. The four worst affected communities are Mwalija, Tembenawo, Njuzi, and Tomali. Surprisingly, Mwalija and Tembenawo are among villages that have been targeted for free and subsidized mosquito nets and yet they rank highly on malaria prevalence. Tembenawo is under the Anglican Malaria Project while Mwalija is under the SCHI. Actually, all the four communities under the SCHI pilot phase are randomly scattered in Table 5.7 indicating current SCHI initiatives such as the distribution of bed nets are not having much impact in combating the problem of malaria the communities. Interestingly, this has also been noted by the Chikwawa District data through the health management information system (HMIS). More (direct and longitudinal) research is needed to investigate reasons for this observation.

5.3.2.3 Discussion and concluding remarks

This section contributes to research on the variation and risk factors associated with repeated ML episodes both at household and community levels in Southern Malawi.

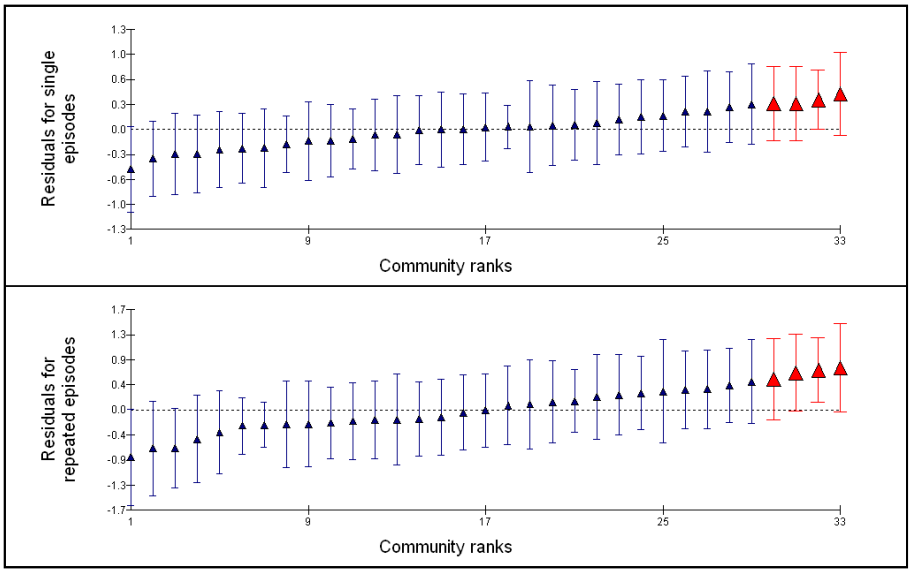

Figure 5.5: *95% credible interval caterpillar plot of ranked community residuals of single and repeated ML episodes*

The study adopts a Bayesian multinomial modelling approach with categorised malaria episodes as an outcome variable.

The advantage of this model is that it offers a separate treatment of the single and multiple ML episode categories in relation to a no episode category. As Kazembe and Namangale [2007] observed in their study on co-morbidity between fever, diarrhoea and pneumonia in Malawi, the interpretation of the fixed effects is easy since effects of each variable on each category of episodes is compared with the category of no episode. Another advantage is that this model is able to distinguish on 'severity' of malaria being measured by the number of episodes thereby providing a rare opportunity in studying factors specific to the 'severity' of the disease.

The multinomial modelling of ML illness (Table 5.2) has highlighted specific risk factors associated with both single and repeated ML attacks at all levels of hierarch in the communities. In particular the results have shown that choice of treatment, distance from stagnant water bodies, being female, and community diarrhoea endemicity are specifically and strongly associated with repeated ML attacks. Accessibility of a health facility in terms of distance is strongly associated with single malaria only. The remaining factors of age, expectant mothers and individual diarrhoeal episodes are strongly associated with both single and repeated ML episodes.

Table 5.7: Community residuals for ML episodes in ascending order

Community	Traditional Authority	Residual	
		Single episode	Multiple episodes
Phonde	Ngabu	-0.567	-1.023
Biliati	Lundu	-0.43	-0.771
Ngalu	Ngabu	-0.32	-0.277
Bester	Lundu	-0.29	-0.64
Mose	Ngabu	-0.288	-0.221
Makhula	Makhuwira	-0.264	-0.224
Jombo	Ngabu	-0.261	-0.281
Mwanayaya*	Makhuwira	-0.238	-0.327
Namila*	Mlilima	-0.207	0.072
Beleu	Maseya	-0.167	-0.717
Ndirande	Lundu	-0.111	-0.043
Matimati	Makhuwira	-0.095	-0.441
Ntondeza	Maseya	-0.061	-0.139
Maluwati	Ngabu	-0.008	0.08
Kabona	Ngabu	-0.002	0.045
Mafunga	Makhuwira	0.011	0.287
Chindoko	Ngabu	0.012	0.343
Mbwadzi	Ngabu	0.04	0.144
Chipwepwete	Ngabu	0.041	-0.073
Sekeni*	Lundu	0.048	-0.41
Salumeji	Katunga	0.061	-0.545
Thomo	Ngabu	0.11	0.183
Thembeta	Ngabu	0.129	0.35
Machokola	Makhuwira	0.138	-0.022
Ngabu Trading	Ngabu	0.197	0.318
Changamuka	Ngabu	0.236	0.493
Tombondera	Chapananga	0.249	0.088
Julius	Ngabu	0.258	0.48
Chikwawa Boma	Kasisi	0.284	0.608
Mwalija*	Kasisi	0.326	0.536
Tembenawo	Chapananga	0.333	0.57
Njuzi	Ngabu	0.417	0.779
Tomali	Lundu	0.51	0.918

** Communities under the SCHI pilot project.*

The association between stagnant water bodies and repeated ML episodes was expected. Most stagnant water bodies are habitats to malaria vectors. Being closer to such habitats means being exposed to increasing and repetitive transmission rates of mosquito bites which

in turn may translate to repeated malaria episodes especially to hosts that have weak immunities [Mackinnon and Read, 2004].

Expectant mothers and diarrhoeal community endemicity variables are related since each is associated with weakened immunities. Occurrence of diseases may weaken the immune system, hence, subjecting the victims to other infectious diseases [WHO, 2007b]. Similarly expectant mothers are also particularly vulnerable to infection as pregnancy reduces a woman's immunity [WHO, 2003; Yartey, 2006].

Those that use health facilities for diagnosis and treatment or those that use health facility drugs are exposed to the World Health Organisation (WHO) initiatives through the Roll Back Malaria Cabinet Project (RBM) [WHO, 2000]. These include intermittent preventive treatment (IPT), provision of insecticide treated nets (ITN), provision of vitamin A, civic education on malaria control, and proper diagnosis of malaria. IPT involves the administration of single curative doses of an efficacious anti-malarial drug to women, especially those that are pregnant. When compared with those that buy medication, use traditional methods or those who do nothing; this may explain why those that use health facilities and those that use drugs from health facilities mostly suffered from single as opposed to multiple bouts of malaria.

The result that children under the age of five are more likely to suffer from malaria than those in the age group 6 to 40 years is similar to the case in diarrhoea illness (Section 5.2) and confirms results from other studies [Murray et al., 2001; Bryce et al., 2005]. Weak antibodies in infants, poor breastfeeding practices, lack of proper dietary food, malnutrition and lack of child health knowledge are some of the factors that expose children to infection [Escobar et al., 1983; Nakao et al 1992; Perera et al., 1999; WHO, 2005a; Morse 2006].

Unlike in the diarrhoea illness, these results also show that elderly people above 60 years of age are more vulnerable than the other age groups including children under the age of five. Old age is closely associated with the waning of body immunity especially if there is lack proper dietary food which may trigger malnutrition [WHO, 2005a]. This result is significant and shows that elderly people in the communities also need special attention. Emphasis on malaria prevention is mostly on children and pregnant women. Elderly people are hardly included in malaria decisions and policy. The goals and targets of the President's Malaria

Initiative by 2010, for example, do not include elderly people [Agency for International Development, 2007]. Emphasis is on children under five years of age and pregnant women.

The quadratic relationship between log-odds ratios for ML episodes and age categories highlights the fact that old people are just as vulnerable as children. Reinforcements of public health education in both child and old age care and efforts in encouraging mothers to young breastfeed children may be appropriate. Increase in log odds coefficients in the quadratic pattern from the age of 21 above may explain the HIV/AIDS vulnerable group of 15 to 49 years [IMF, 2007]. Nearly seven in every fifty individuals in this age group in Malawi are infected with HIV/AIDS responsible for weak immunities.

ML episodes are also positively related both to individual diarrhoea illness and to community diarrhoea endemicity. Existence of diarrhoea in an individual has a positive effect on existence of both single and repeated malaria episodes. The degree of malaria endemicity in the communities has a positive effect only on multiple malaria episodes. High diarrhoea endemicity may signal extreme poor conditions in the communities that may be favourable to malaria vectors. These may include fertile breeding areas for mosquitoes that translate to repeated transmission rates of mosquito bites resulting to repeated malaria episodes. Examples of breeding places are clear stagnant water bodies (ponds) in the communities that may also be used as sources of drinking water.

Individual diarrhoea episodes may be a reflection of individual socioeconomic status. The number of diarrhoea episodes may simply mirror one's lifestyle in society based on one's socioeconomic status since diarrhoea is linked to poor sanitation and hygiene practices [Curtis et al., 2000].

The strong relationship between diarrhoea and malaria demonstrates that these two diseases coexist in the communities and have common risk factors. Relationship with more other infectious diseases has been illustrated in other studies [Mulholland, 2005; Kazembe and Namangale 2007]. This shows that integrated approaches that address coexisting infectious diseases are necessary. In the case of Chikwawa where malaria and diarrhoea morbidities are highest, combined efforts against the two diseases can be useful in reducing morbidity and mortality.

Large and significant household-level random effects show that the inclusion of the existing explanatory variables does not fully capture all the determinants of malaria prevalence at household level. This may signify the omission of factors on malaria occurrence that may have been difficult to measure, were not thought about, were unobservable or were less quantifiable but nevertheless cumulative. Examples include the presence of other ailments such as HIV/AIDS, unobservable and less quantifiable malnutrition, social, cultural, spatial and other environmental factors. More detailed longitudinal analysis may be important to capture some of these factors.

The presence of smaller variation at community-level than household-level is an indication that the models are more successful in explaining clustering at this level. The marginal significance at community-level demonstrates existence of some community-level variables not captured by this model. Examples may include environmental, institutional, and other relevant epidemiological measures such as average weather conditions at different points between different communities, the actual and average quality and quantity of healthcare and healthcare-resource funding available to each community; and a measure of average number of mosquito habitats available in each community.

5.3 The joint analysis of malaria and diarrhoea illnesses: a bivariate hierarchical modelling approach

5.4.1 Summary

This section estimates the joint pattern and variation of ML and diarrhoea coexistence in Chikwawa, a district in Southern Malawi using bivariate multilevel modelling with Bayesian estimation. A probit link was employed to examine hierarchically built data from a survey of individuals (*n=6,727*) nested within households (*n=1,380*) nested within communities (*n=33*). Results show significant malaria [$\sigma^2_{u1} = 1.021\ (95\%\ \text{CI}: 0.858, 1.184)$] and diarrhoea [$\sigma^2_{u2} = .910\quad (95\%\ \text{CI}: 0.753, 1.067)$] variations with a strong correlation between them [$r_u^{(1,2)} = 0.577$] at household level. There are significant malaria [$\sigma^2_{v1} = 0.104\ (95\%\ \text{CI}: 0.031, 0.176)$] and diarrhoea [$\sigma^2_{v2} = 0.053\quad (95\%\ \text{CI}: 0.018, 0.088)$] variations at community level but with a small correlation [$r_v^{(1,2)} = 0.525$] between them. There is also significant correlation between malaria and diarrhoea at individual level

[$r_e^{(1,2)} = 0.243$]. These results suggest a close association between reported malaria-like illness and diarrhoeal illness at community, household and individual levels in Southern Malawi.

5.4.2 **Results**

5.4.2.1 Descriptive statistics

Concentration in this section is on common risk factors between ML episodes of disease and diarrhoea illness and their corresponding pattern of variation at household and community levels. Table 5.8 provides descriptive statistics for hypothesised risk factors at individual, household and community levels along with prevalence of ML and diarrhoea. Slightly more than half and a quarter of the people in the sample had at least an episode of ML and diarrhoea respectively within the study period. The mean ratio for ML episodes per person per village during this period was 1.10 (range: 0.57 – 1.60) and of diarrhoea was 0.46 (range: 0.16 – 0.78).

There is similarity in the pattern of risk factors between ML and diarrhoeal illnesses at all levels. Figure 5.6, for example, shows independent curves, one for ML and the other for diarrhoeal prevalence, depicting a similar relationship between the two diseases and individual age groups. There were significant Pearson Chi-square variations in age groups with respect to both ML and diarrhoeal illness ($\chi^2_{df=5} = 124.4; p = 0.000$; and $\chi^2_{df=5} = 160.6; p = 0.000$ respectively). There was also significant variation in individual school level with respect to both ML ($\chi^2_{df=2} = 34.6; p = 0.000$) and diarrhoeal illness ($\chi^2_{df=2} = 78.1; p = 0.000$). The higher the level of school the less likely an individual was reported to have suffered from both diseases. Female individuals and expectant mothers had higher risks of suffering from both ML disease (68.8%) and diarrhoea illness (35.4%).

At household level, families with low wealth index were more likely to get sick than those that had higher wealth indexes. Families whose head of household had no job were more at risk of contracting both ML and diarrhoeal illness. On average there were 6 people (range: 1 – 13) per household.

Table 5.8: Descriptive estimates of risk factors of ML and diarrhoea in Chikwawa, Southern Malawi, 2007

Discrete variables Risk factor	Description	value	Number at risk	% infected malaria	diarrhoea
Individual level					
Age	0-5 yrs	1	1444	62.3	35.7
	6-10 yrs	2	1102	50.3	18.8
	11-20 yrs	3	1344	42.4	17.1
	21-40 yrs	4	2027	55.1	26.9
	41-60 yrs	5	573	59.9	29.0
	>60 yrs	6	237	62.0	26.6
School	No school	1	2552	58.2	31.4
	Primary school	2	3576	50.6	22.9
	≥Secondary	3	599	53.6	17.9
Sex	Male	1	3318	51.9	24.5
	female	2	3409	55.5	26.8
Expectant Woman	Yes	1	144	68.8	35.4
	No	0	6583	54.4	25.5
Household level					
OHH	No job	0	429	59.4	34.5
	Has a job	1	6298	53.4	25.1
Distance to river	1 km or less	1	2463	-	22.8
	1 km to 2 km	2	2871	-	25.8
	> 2 km	3	1393	-	30.4
Drinking water source	Public tap	1	1041	-	28.2
	Private tap	2	419	-	21.0
	OSDWS	3	4593	-	24.5
	UDWS	4	674	-	32.3
Continuous variables					
Risk factor	Description	Mean	Std. dev.	Median	Range
Household level					
Household size		6	2	5	12
Community level					
CDE		0.46	0.16	0.46	0.62
CME		1.10	0.24	1.05	1.02

OHH – Occupation of head of household; OSDWS – Other safe drinking water sources; UDWS – Unsafe drinking water sources; Relative wealth index; CDE – Community diarrhoea endemicity; CME – Community malaria endemicity

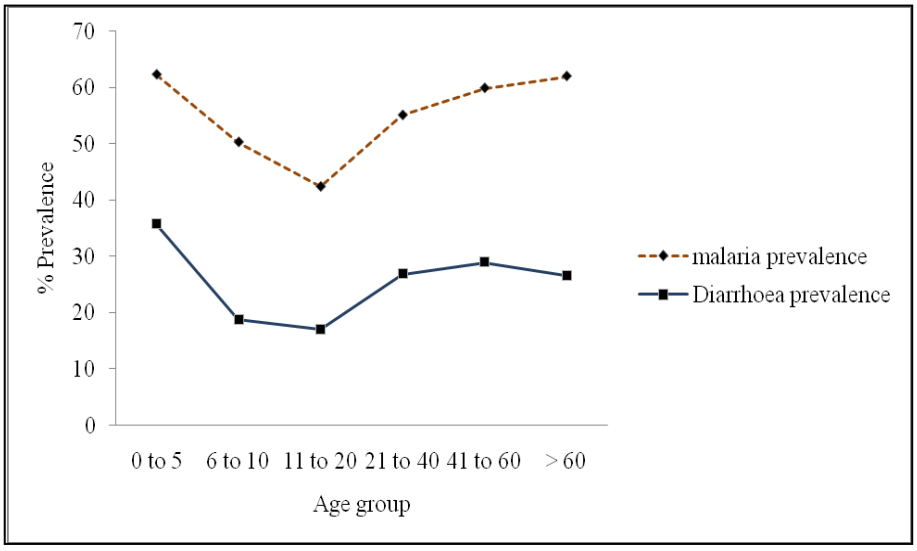

Figure 5.6: *Curves showing the relationship between malaria(ML) and diarrhoeal illnesses with respect to age groups.*

5.4.2.2 Fixed effects of ML and diarrhoea morbidities

Table 5.9 provides Bayesian estimates of a bivariate 3-level hierarchical model between malaria-like and diarrhoeal illness. Individuals aged 6-40 were less likely to suffer from both malaria-like and diarrhoeal illness compared to infants and young children aged 0-5 years. Those aged above 40 years were more likely to suffer from ML symptoms when compared to all other age groups. There was no difference in diarrhoeal illness between children under the age of five and those older than 40 years.

Expectant mothers were more likely to suffer from ML symptoms ($\beta = 0.453; 95\%\ CI: 0.159, 0.747$) and were marginally more likely to suffer from diarrhoea than all other individuals ($\beta = 0.233;\ 95\%\ CI: -0.047, 0.513; p < 0.11$). Females were more likely to suffer from ML than their male counterparts ($\beta = 0.101;\ 95\%\ CI: 0.023, 0.179$). There was no difference in diarrhoeal illness between females and males.

There was a negative linear relationship between malaria and family size indicating that members from bigger families were less likely to suffer from ML illness than smaller families ($\beta = -0.074;\ 95\%\ CI: -0.105, -0.043$). There was a quadratic relationship between diarrhoeal disease and family size with a turning point at family size of six (Table 5.9).

Employment status of a head of a family was a significant risk factor for diarrhoeal illness but not ML disease. Families that had an employed head of household were less likely to suffer from diarrhoea than those whose head of household was jobless $[\beta = -0.408;\ 95\%\ CI: -0.663, -0.153\ ]$.

Water source was a strong risk factor for diarrhoea sickness. Households that used unsafe water sources (rivers, streams, and ponds) as drinking water in their homes were more likely to suffer from diarrhoea than those that used private piped water $[\beta = 0.495;\ 95\%\ CI: 0.040, 0.950\ ]$. However, there was no difference in diarrhoeal prevalence between those that used public piped water, boreholes, springs, or protected wells and those that used private piped water.

At community level both ML and diarrhoeal endemicity were strong risk factors for both ML and diarrhoeal disease when placed in the model interchangeably. The higher the ML or diarrhoea endemicity the more likely members of that community were likely to suffer from either diarrhoea or ML disease. This observation shows that individuals from high malaria-like endemicity communities were likely to suffer diarrhoea illness and similarly for individuals from high diarrhoeal endemicity communities were likely to suffer from ML illness.

5.4.2.3 Random effects of ML and diarrhoea morbidities

The degree of group level effects is given in Table 5.10. Community variation was estimated as $\sigma^2_{v1} = 0.104\ (95\%\ CI: 0.031, 0.176)$ for ML illness and $\sigma^2_{v2} = 0.053\ (95\%\ CI: 0.018, 0.088)$ for diarrhoea. For household variation, I estimated $\sigma^2_{u1} = 1.021\ (95\%\ CI: 0.858, 1.184)$ for ML and $\sigma^2_{u2} = 0.910\ (95\%\ CI: 0.753, 1.067)$ for diarrhoeal disease. This demonstrates that there are significant differences in both ML and diarrhoeal prevalence at household as well as at community levels.

Table 5.9: Fixed effects estimates from the bivariate model of ML and diarrhoea coexistence in Chikwawa 2007

		Malaria		Diarrhoea	
		β	95% CI	β	95% CI
Fixed effects					
Individual age	0 to 5 years	Reference category			
	6 to 10 years	-0.262	(-0.403,-0.121)	-0.584	(-0.741,-0.427)
	11 to 20 years	-0.522	(-0.671,-0.373)	-0.612	(-0.781,-0.443)
	21 to 40 years	-0.198	(-0.337,-0.059)	-0.245	(-0.382,-0.108)
	41 to 60 years	0.126	(0.050,0.302)	0.062	(-0.236,0.112)
	60 years above	0.322	(0.083,0.561)	-0.174	(-0.429,0.081)
School level	None	Reference category			
	Primary	-0.091	(-0.203,0.021)	-0.145	(-0.261,-0.029)
	≥Secondary	-0.020	(-0.196,0.156)	-0.475	(-0.667,-0.283)
Sex	Male	Reference category			
	Female	0.101	(0.023,0.179)	0.039	(-0.051,0.129)
Expectant woman	No				
	Yes	0.453	(0.159,0.747)	0.233	(-0.047,0.513)
OHH	No job	Reference category			
	Has a job	-0.19	(-0.455,0.075)	-0.408	(-0.663,-0.153)
Household size	X	-0.074	(-0.105,-0.043)	-0.311	(-0.415,-0.207)
	X^2	-	-	0.022	(0.014,0.030)
CDE		1.004	(0.330,1.678)		
CME				1.737	(1.098,2.376)
Distance to river	<1 km	Reference category			
	1 to 2 km	-	-	0.183	(0.040,0.326)
	> 2 km	-	-	0.179	(-0.025,0.383)
Drinking water source	Public piped water	Reference category			
	Private piped water	-	-	0.204	(-0.123,0.531)
	Other safe water sources	-	-	0.286	(-0.065,0.637)
	Unsafe water sources	-	-	0.495	(0.040,0.950)

CI-Credible interval

The covariance and correlation associated with the variations between ML and diarrhoeal diseases at all levels are also presented in Table 5.10. At community level the covariance between ML and diarrhoeal illness is $\sigma_v^{(1,2)} = 0.039\ (95\%\ \text{CI}: -0.002, 0.080)$ with a correlation of $r_v^{(1,2)} = 0.0.525$; at household level the covariance is

$\sigma_u^{(1,2)} = 0.556$ (95% CI: 0.456,0.656) with a correlation of $r_u^{(1,2)} = 0.577$; and at individual level the covariance is $\sigma_e^{(1,2)} = 0.243$ (95% CI: 0.182,0.304) with a correlation of $r_e^{(1,2)} = 0.243$.

Figure 5.7a and Figure 5.7b show caterpillar plots of ML and diarrhoeal illness residuals at household and community levels respectively. A random sample of households and communities (lower, middle and upper sections of the graphs) as highlighted on the graphs shows similarities of the pattern of variation of ML and diarrhoeal illness. This demonstrates that there is a strong association between ML symptoms and diarrhoeal disease both at household as well as community levels. There is also a significant relationship between the two diseases at individual level as indicated by the correlation factor.

Table 5.10: Covariance structure from the bivariate model of ML and diarrhoea coexistence in Chikwawa 2007[§]

	Malaria (95% CI)	Diarrhoea (95% CI)
Hierarchy		
Individual level		
Malaria	$\sigma_{e1}^2 = 1$	$r_e^{(1,2)} = 0.243$
Diarrhoea	$\sigma_e^{(1,2)} = 0.243;\ (0.182,0.304)$	$\sigma_{e2}^2 = 1$
Household level		
Malaria	$\sigma_{u1}^2 = 1.021;\ (0.858,1.184)$	$r_u^{(1,2)} = 0.577$
Diarrhoea	$\sigma_u^{(1,2)} = 0.556;\ (0.456,0.656)$	$\sigma_{u2}^2 = 0.910;\ (0.753,1,067)$
Community level		
Malaria	$\sigma_{v1}^2 = 0.104;\ (0.031,0.176)$	$r_v^{(1,2)} = 0.525$
Diarrhoea	$\sigma_v^{(1,2)} = 0.039;\ (-0.002,0.080)$	$\sigma_{v2}^2 = 0.053;\ (0.018,0.088)$

[§] 95% credible interval in parentheses and correlation coefficients in the upper triangle of each level.

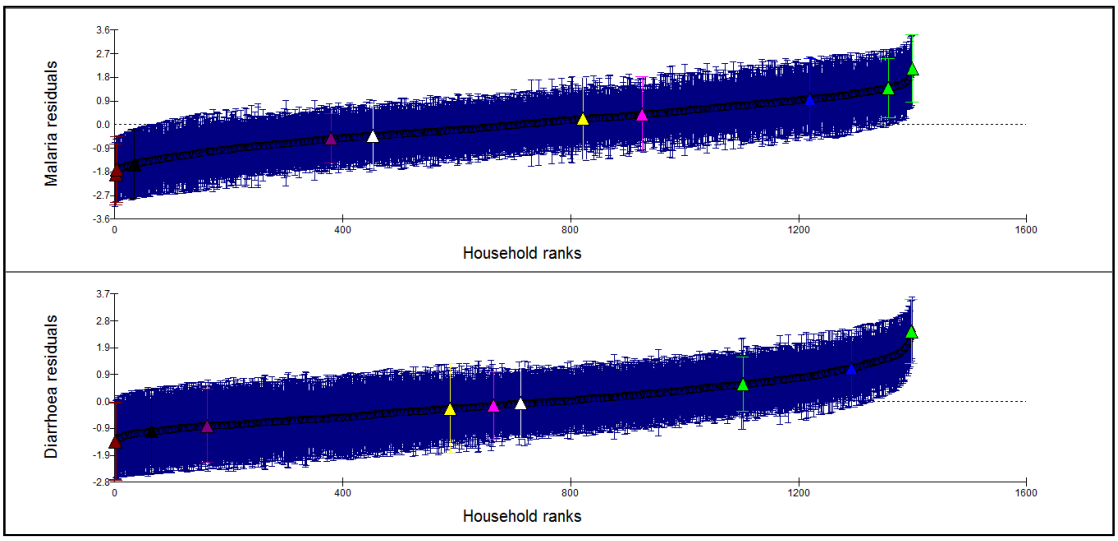

Figure 5.7a: *Caterpillar plot of household residuals for ML and diarrhoea prevalence. The dotted line is the mean of the estimated (shrunken) residuals*[11] *which is equal to zero. The brushes represent 95% CI to the estimated residuals*

5.4.2.4 Discussion and Conclusion

In this section the aim was to determine the concurrence of reported ML disease and diarrhoeal illness in Chikwawa by identifying patterns of variation and their common risk factors. This data accrued has shown significant variation both at community and household levels suggesting clustering of these two diseases in communities and families. The study also demonstrated significant correlation between reported ML disease and diarrhoeal illness within communities ($r_v^{(1,2)} = 0.525$), households ($r_u^{(1,2)} = 0.577$) and in individuals ($r_e^{(1,2)} = 0.243$), indicating that communities and households with more ML episodes also tended to have more diarrhoeal illness.

Similarly individuals who experienced ML disease were also likely to have suffered from diarrhoeal illness during the same period. The analysis further suggests association between community ML disease or diarrhoeal illness with individual ML symptoms or individual diarrhoeal illness. This implies that individuals in communities with more ML disease were likely to have suffered from diarrhoeal illness; likewise individuals from communities with more diarrhoeal illness were likely to have suffered from ML symptoms. These observations

[11] Estimated or shrunken residual for group j is the residual obtained by multiplying the mean of the residuals of subjects in group j by a shrinkage factor. Shrinkage factor shrinks an observed group mean towards the centre of the population mean.

are similar to other studies that have observed similarities in the variation in childhood fever, diarrhoea and pneumonia due to shared and overlapping risk factors that include malaria endemicity [Kazembe et al., 2007b].

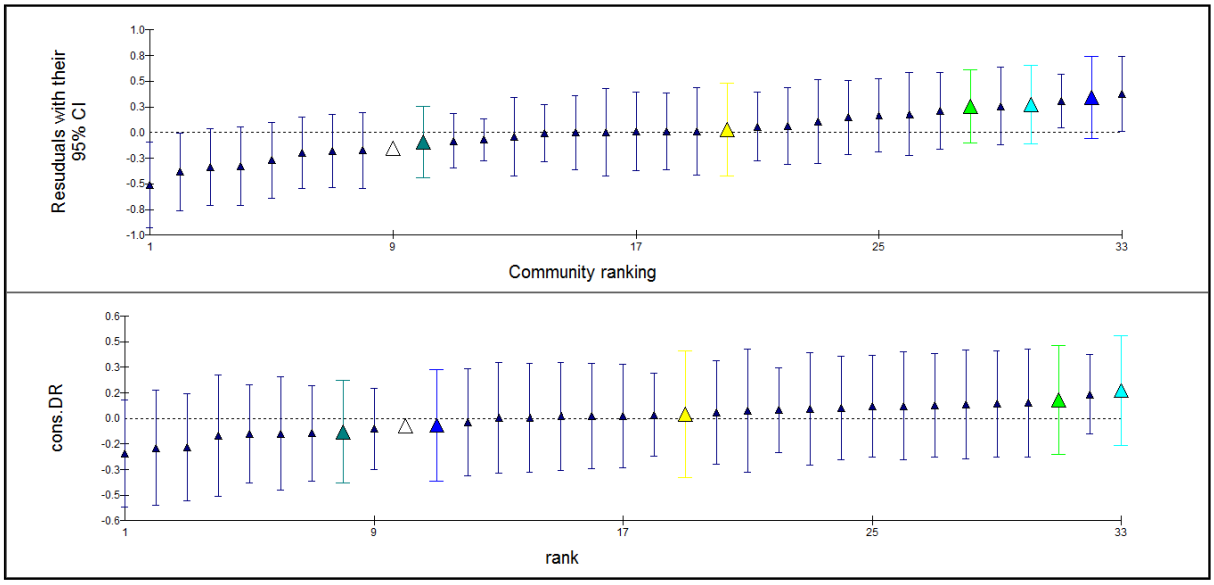

Figure 5.7b: *Caterpillar plot of community residuals for ML and diarrhoea prevalence. The triangles indicate estimated (shrunken) community residuals*

After controlling for unique risk factors to malaria and diarrhoea such as mosquito net ownership and drinking water sources respectively, other common risk factors between ML and diarrhoeal illnesses included age and pregnancy at individual level; family size at household level; and either ML or diarrhoeal endemicity at community level.

The effect of age on ML disease and diarrhoeal illness is of particular interest and has been discussed in detail in section 5.2. The increased likelihood of both ML disease and diarrhoeal illness in young children is attributed to underdeveloped immune systems in infants, poor breastfeeding practices, malnutrition and lack of child health knowledge [Escobar et al., 1983; Nakao et al 1992; Perera et al., 1999; Morse, 2006; IMF, 2007]. HIV/AIDS is prevalent in 14% of those between 15 and 49 years and waning of immunity in the elderly may explain the steady increase in risk of both malaria and diarrhoea for those above 41 years old [Agtini et al., 2005; IMF, 2007].

The low prevalence of ML and diarrhoeal disease amongst those that attended school may be due to the knowledge acquired from the school curriculum which addresses prevention and

control of diarrhoea and malaria [Morse, 2006; Masangwi, 2009] and provides increased awareness of existing healthcare resources [Pebly and Stupp, 1987; Hobcraft, 1993; Pongou et al., 2006]. The increased risk among female individuals may be due to induced stress brought about as a result of the heavy burden of household responsibilities placed upon women and young girls. The increased risk may also be due to greater exposure to mosquito's and gastro-enteric pathogens as they go about fulfilling daily household chores e.g. utilising stagnant and/or contaminated water sources for chores such as dish-washing, laundry and bathing [Cohen and Williamson, 1991; Leventhal et al., 1998].

Another significant risk factor to both ML disease and diarrhoeal illness in this study is pregnancy. The relationship between malaria and pregnancy has been a focus of research in Africa and it is a priority area in Roll Back Malaria strategy [Snow et al., 1999]. Pregnant women constitute the main adult risk group for malaria such that 80% of deaths due to malaria in Africa occur in pregnant women and children below 5 years. Immunity is normally low in pregnant women and their risk to infection is greater compared with women who are not pregnant living in the same area [Luxemburger et al., 1997].

Household size has a positive quadratic relationship with diarrhoeal prevalence and a negative linear relationship with ML prevalence. The decreasing prevalence of diarrhoea with increasing family size from 1 to 6 family members and the negative linear relationship between ML illness and family size may reflect increasing experience in family management as the family expands. However, the impact of overcrowding [Connolly et al., 2004] in families with more than 6 members overcomes all other factors and increases the chance of diarrhoeal illness.

5.4 General discussion on ML and diarrhoea prevalence

The contributions of this chapter are fourfold. First, it contributes to research on the variation of diarrhoea and malaria prevalence at household and community levels in the Southern Malawi by adopting hierarchical modelling approach with Bayesian estimation. Second, it contributes to the understanding of common risk factors for malaria and diarrhoea within the district of Chikwawa based on individual, household and community characteristics. Third it is able to quantify the correlation between relative risks for the diseases as well as enable the pattern of disease-specific residuals to be examined, while at the same time, examining the

influence of covariates on each disease. Lastly the chapter is able to assess the influence of both malaria and diarrhoea endemicity on the two diseases by adjusting for confounding individual and household level covariates.

The main finding of this chapter is that there is more significant variation in both diarrhoea and malaria prevalence between households and between communities. Excess variability for both diseases may be due to spatial variability both at household and community levels which has not been accounted for in these models. While multilevel models avoid important biases in estimates and standard errors for the risk factors by relying on space fragmented areas such as villages and households, spatial techniques use place indicators that continuously consider the space around the individual's place of residence thereby overcoming the fragmentation of the space into areas when formulating the correlation structure [Chaix et al., 2005]. However, in the absence of continuous space information multilevel techniques are the alternative. Marginal variation for diarrhoea at community level may be due to some unobservable factors that have not been captured by this study. Reported household hygiene practices and water management, for example, may not be the actual daily practices. They may only reflect what respondents perceive to be expected practices. Reported cases may also not reflect instances that may have been a source of diarrhoea contamination rather they may only reflect average social, cultural, and other environmental activities in the household. For example, environmental factors such as floods common in Chikwawa and other parts of Southern Malawi, may lead to food shortages resulting in malnutrition or overcrowding which are important risk factors of coexistence of diseases and mortality [Caulfield et al., 2004; NSO, 2005]. Direct longitudinal household and community studies may be appropriate to capture some practices missed by the cross-sectional data.

The patterns of malaria and diarrhoea prevalence with respect to individual age give an interesting observation and are confirmed in all three models. Children under 5 years require special attention. Reinforcements of public health education in child care and efforts in encouraging mothers to breastfeed may be appropriate. Reduced risks amongst those that have done at least primary school education points to the substance of education to all school going children especially girls.

The significant positive relationship between diarrhoea and malaria highlights common risk factors hence the need for common approaches to fighting the diseases. This also highlights

the role other diseases play in making individuals more vulnerable to other infections thus validating proposition 1 of chapter 1. Thus an episode of malaria may trigger other opportunistic diseases such as diarrhoea and vice versa.

More research is needed to unravel more risk factors associated with the coexistence between malaria and diarrhoea. As Kazembe and Namangale [2007] observed, a country with high HIV prevalence like Malawi the relationship between malaria and diarrhoea may be due to the fact that symptoms of HIV include fever and diarrhoea. Thus HIV may be a potential risk factor which may explain household and community structured residual variation in the coexistence between malaria and diarrhoea.

CHAPTER 6

THE PATTERN OF KNOWLEDGE AND RESOURCES IN THE FIGHT AGAINST MALARIA AND DIARRHOEA

6.1 Introduction

This chapter examines household and community factors that influence knowledge and availability of resources for fighting malaria and diarrhoea. It begins with a discussion on diarrhoea knowledge then patterns and factors that influence availability of improved water sources and sanitation. This is followed by a discussion on factors that influence knowledge on malaria together with the pattern and predictor variables for use of bed nets. The chapter concludes with a comparative analysis on knowledge and resources between malaria and diarrhoea. A multilevel threshold of change analysis is used to evaluate predictors of knowledge about diarrhoeal aetiology, clinical features, and prevention while a series of binary logistic regression models are used to determine influences of knowledge about malaria symptoms and prevention. Multinomial models are used on drinking water resources and sanitation while a random components model is used to determine factors that influence availability of mosquito nets. The results show that there are variations across communities in knowledge and resources both for malaria and diarrhoea. The results also show that existence of a health surveillance assistant is a significant predictor variable common to knowledge on and availability of resources for both malaria and diarrhoea. A lot of mothers are knowledgeable about one symptom for both malaria and diarrhoea. About nine in every ten women are able to mention fever as a symptom for malaria while eight in every tem women know watery stools as a symptom for diarrhoea. Other symptoms for malaria and diarrhoea are not well known by most families in Chikwawa. Prevention methods for both malaria and diarrhoea are also not well known among the majority of women in Chikwawa with the exception of use of bed nets to prevent malaria (68%). Four or more people have a single bed net in 60% of the families. Fifty eight percent of the families do not have their own toilet or latrine facility. More than one in every ten families cannot access safe drinking water sources. The results underscore the importance of community health workers in the fight against both malaria and diarrhoea and hence the need to increase their numbers and empowering them to effectively participate in healthcare delivery in the communities. The results also show lack

of adequate knowledge on the two diseases a problem that is clustered within the communities. Although figures show high bed net ownership (65%) across households, net ownership ratios are very poor a sign that more people sleep without the protection of a net. While more families are able to access safe water sources many more families are still vulnerable to diarrhoea infection due to lack of proper sanitary facilities such as a toilet or a latrine, handwashing, and hygienic household/food practices.

6.2 The pattern of maternal knowledge and its implications for diarrhoea control: multilevel thresholds of change analysis

6.2.1 Summary

Although diarrhoea morbidity can be reduced through improved water supply, water quality, sanitation, and hygiene, it has been shown that accelerated diarrhoea control depends on maternal knowledge on the underlying symptoms, causes and prevention methods against diarrhoea. This section examined the pattern of mothers' knowledge on diarrhoea and determined corresponding predictors. Multilevel thresholds of change analysis with Bayesian estimation was used to determine predictors of knowledge about diarrhoeal aetiology, clinical features, and prevention. The results show a strong hierarchical structured pattern in overall maternal knowledge $[\sigma_u^2 = 0.366;\ 95\%\ CI: 0.107, 0.625]$ revealing differences between communities. Mothers with primary or secondary school education were more likely to give more responses on diarrhoea knowledge than those without any formal education $[\beta = -0.289;\ 95\%\ CI: -0.554, -0.024$ and $\beta = -0.418;\ 95\%\ CI: -0.757, -0.079$ respectively]. Mothers from communities without a health surveillance assistant were less likely to give more responses $[\beta = 0.605;\ 95\%\ CI: 0.380, 0.830]$. The results have an important role to play in policy and the promotion of health education messages on diarrhoea in Malawi. The results show that differences in diarrhoeal knowledge do exist between communities and demonstrate that basic formal education is important in women's understanding of diseases. The results also reveal the positive impact health surveillance assistants have in the communities. Their role can be maximised by increasing their numbers and empowering them so that they are equipped and knowledgeable to disseminate relevant effective messages on diarrhoea and other diseases

6.2.2 Descriptive statistics

The distribution of response variables is summarised in Table 6.1. Almost all of the women interviewed mentioned watery stools as the likely symptom of diarrhoea. Very few women mentioned additional symptoms such as increased number of stools (13%), loose stools (28%), loose stools and vomiting (13%), bloody stools (13%), and stomach-ache (35%). One in every two women mentioned contaminated water as a means through which one can contract diarrhoea. Similarly one in every two women mentioned contaminated food and poor hygiene practices as a cause of diarrhoea. One in four (27%) mentioned flies while one in twelve (8%) mentioned poor sanitation practices as pathways through which people may contract diarrhoea. Few women knew how diarrhoea can be prevented. One in three (30%) women mentioned the use of water disinfectants, while one in every four women mentioned good water hygiene and management. One woman in every four mentioned proper cleaning of cooking and eating utensils. Good sanitation was mentioned by one in five (20%) women, hands washing by a similar ratio (22%), and good food hygiene or management by approximately one in seventeen women (6%). In general two thirds of the women interviewed mentioned at most one diarrhoea symptom, half mentioned at most one cause of diarrhoea, and two thirds of women mentioned at most one preventative method.

Table 6.2 shows descriptive statistics for predictor variables used in the models. Most households were nearer to either a government hospital (30%) or a health centre (48%). One in every seven households (14%) were near a CHAM hospital, one in every fifty households (2%) were near a local health post, and one in every fourteen households (7%) were near a private clinic. Almost half the households were in communities without an NGO and three in every ten households lived in communities without an HSA.

6.2.3 Multilevel Thresholds of Change Modelling of knowledge on diarrhoea

MTCM used to identify predictors of maternal knowledge on diarrhoea symptoms is given in Table 6.3. The baseline threshold parameters $[\alpha^{(1)} = -1.465;\ 95\%\ CI: -1.986, -0.944]$ and $\alpha^{(2)} = -1.053;\ 95\%\ CI: 0.508, 1.598]$ are significantly different from zero and, therefore, significantly contributed to the score values of probability in the different categories of the diarrhoea symptom outcome variable. Primary education increased women's probability of mentioning two or more diarrhoea symptoms when compared to those without any formal

Table 6.1: Descriptive statistics for response variables on diarrhoea knowledge

Variable	*Mean*	*Median*	*Min.*	*Max.*	N=1389	%
What are the symptoms of diarrhoea?						
7. Watery stools					1171	84.3
8. Increased number of stools					183	13.2
9. Loose stools					383	27.6
10. Loose stools and vomiting					175	12.6
11. Bloody stools					183	13.2
12. Stomach-ache					492	35.4
What are the causes of diarrhoea						
6. Contaminated water					765	55.1
7. Contaminated food					619	44.6
8. Flies					376	27.1
9. Poor hygiene and sanitation practices					703	50.6
10. Poor sanitation practices					*111*	*8.0*
What action do you take to prevent diarrhoea?						
7. Add disinfectant (water guard, chlorine, etc) to water					421	30.3
8. Good water hygiene or management					357	25.7
9. Good food hygiene or management					78	5.6
10. Proper cleaning of cooking and eating utensils					332	23.9
11. Good sanitation					278	20.0
12. Hands washing					307	22.1
Number of Symptoms identified	*2*	*2*	*0*	*5*		
Zero or one symptom					351	25.3
Two symptoms					672	48.4
Three or more symptoms					366	26.3
Number of Causes identified	*2*	*2*	*0*	*5*		
No single cause mentioned					61	4.4
One cause mentioned					590	42.5
Two causes mentioned					365	26.3
Three or more causes mentioned					373	26.9
Prevention methods identified	*1*	*1*	*0*	*6*		
No prevention method					435	31.3
One prevention method					404	29.1
Two prevention methods					338	24.3
Three or more methods					212	15.3
Overall knowledge	*5*	*5*	*0*	*14*		
Zero to three points					305	22.0
Four to five points					498	35.9
Six to seven points					438	31.5
Eight or more points					148	10.7

education $[\omega^{(2)} = -0.572;\ 95\%\ CI: -0.935, -0.209]$. Secondary education increased women's likelihood of mentioning more than two diarrhoea symptoms $[\omega^{(1)} = -0.364;\ 95\%\ \text{CI}: -0.795, 0.067; \text{p} = 0.10$ and $\omega^{(2)} = -0.534;\ 95\%\ \text{CI}: -0.975, -0.093]$. The probability of mentioning two symptoms increased for women that were nearer a health centre when compared to those nearer a government hospital $[\omega^{(2)} = 0.323;\ 95\%\ CI: -0.055, 0.701;\ p = 0.09]$. However, probabilities of mentioning more than two symptoms decreased for women nearer a CHAM hospital or a health post.

Table 6.2: Descriptive statistics for predictor variables on diarrhoea knowledge

Variable	*Mean*	*Median*	*Min.*	*Max.*	N=1389	%
School						
1. None					290	20.9
2. Primary					812	58.5
3. At least secondary					287	20.7
Health Facility						
1. Government hospital					417	30.0
2. Government health centre					672	48.4
3. Christian Association of Malawi (CHAM)					189	13.6
4. Local health post					21	1.5
5. Local private clinic					90	6.5
Non Governmental Organisation(NGO)						
1. Exists					611	44.0
2. Does not exist					778	56.0
Health Surveillance Assistant (HSA)						
1. Exists					951	68.5
2. Does not exist					438	31.5
Maternal age	*35*	*30*	*15*	*89*	*1389*	*100*

Increasing maternal age decreased the women's probability of obtaining one or no diarrhoea symptom i.e. increasing maternal age increased chances of mentioning more than one diarrhoea symptom $[\omega^{(1)} = -0.306;\ 95\%\ CI: -0.453, -0.159]$.

Existence of an NGO was the only significant predictor variable that obeyed proportional odds features. Women from communities without an NGO were more likely to mention fewer

Table 6.3: Partial proportional odds models to identify determinants of maternal knowledge on diarrhoea symptoms

Variable	Estimate	95% CI
Threshold		
$\alpha^{(1)}(no\ or\ one\ symptom)$	-1.465	(-1.986,-0.944)
$\alpha^{(2)}(two\ symptoms)$	1.053	(0.508,1.598)
No School	(Reference group)	
Primary school		
no or one symptom, $\omega^{(1)}$	-0.233	(-0.572,0.106)
two symptoms, $\omega^{(2)}$	-0.572	(-0.935,-0.209)
Secondary School		
no or one symptom, $\omega^{(1)}$	-0.364	(-0.795,0.067)
two symptoms, $\omega^{(2)}$	-0.534	(-0.975,-0.093)
Government hospital	(Reference group)	
Government Health centre		
no or one symptom, $\omega^{(1)}$	0.238	(-0.148,0.624)
two symptoms, $\omega^{(2)}$	0.323	(-0.055,0.701)
CHAM		
no or one symptom, $\omega^{(1)}$	0.684	(0.092,1.276)
two symptoms, $\omega^{(2)}$	1.331	(0.725,1.937)
Health Post		
no or one symptom, $\omega^{(1)}$	1.023	(0.049,1.997)
two symptoms, $\omega^{(2)}$	1.307	(-0.081,2.695)
Local private clinic		
no or one symptom, $\omega^{(1)}$	-0.063	(-0.806,0.680)
two symptoms, $\omega^{(2)}$	-0.170	(-0.781,0.441)
Age		
no or one symptom, $\omega^{(1)}$	-0.306	(-0.453,-0.159)
two symptoms, $\omega^{(2)}$	0.028	(-0.113,0.169)
NGO exists	(Reference group)	
NGO does not exist β	0.275	(-0.011,0.561)
HSA exists	(Reference group)	
HSA does not exist β	-0.091	(-0.328,0.146)
Community effects (u_{0j})	0.623	(0.219,1.027)

CI = Credible Interval

symptoms than those whose communities have the services of NGOs $[\beta = 0.275;\ 95\%\ CI: -0.011, 0.561;\ p = 0.06]$.

Table 6.4 shows partial proportional odds models to identify predictors of diarrhoea causes, prevention, and overall knowledge. All baseline thresholds for causes and prevention methods outcomes are significantly different from zero and, therefore, significantly contribute to outcome probabilities in different categories. Probabilities for mothers that mention no single cause, one cause, or two causes of diarrhoea significantly increases for communities without HSAs relative to those with HSAs $[\omega^{(1)} = 1.040;\ 95\%\ CI: 0.507, 1.573;$ $\omega^{(2)} = 0.571;\ 95\%\ CI: 0.320, 0.822;$ and $\omega^{(3)} = 0.611;\ 95\%\ CI: 0.323, 0.899$ respectively]. Nearest health facility and maternal age were the only significant predictors that obeyed proportional odds features. Respondents whose nearest health facility was a health centre, a CHAM hospital, or a local private clinic were likely to mention fewer causes of diarrhoea than those near a government hospital $[\beta = 0.625;\ 95\%\ CI: 0.307, 0.942;$ $\beta = 1.044;\ 95\%\ CI: 0.518, 1.569;$ $\beta = 0.844;\ 95\%\ CI: 0.276, 1.412$ respectively]. The older the women the more likely they were to mention fewer causes of diarrhoea $[\beta = 0.126;\ 95\%\ CI: 0.020, 232]$.

Probabilities for those that mention no single prevention method, one prevention method or two prevention methods decrease for households nearest to health centres than those nearest government hospitals $[\omega^{(1)} = -0.170;\ 95\%\ CI: -0.491, 0.151;$ $\omega^{(2)} = -0.583;\ 95\%\ CI: -0.902, -0.263;$ and $\omega^{(3)} = 0.357;\ 95\%\ \mathrm{CI}: -0.764, 0.051;$ $p = 0.09]$. However, threshold probabilities for those that mention no single prevention method, one prevention method or two prevention methods increase for households that do not have HSAs in their communities $[\omega^{(1)} = 0.617;\ 95\%\ \mathrm{CI}: 0.362, 0.872;$ $\omega^{(2)} = 0.466;\ 95\%\ CI: 0.217, 0.715;$ and $\omega^{(3)} = 0.578;\ 95\%\ CI: 0.225, 0.931$ respectively].

School level and maternal age were the only significant indicators that obeyed proportional odds features in the prevention methods outcome. Women with at least secondary school education were less likely to mention fewer prevention methods when compared to those who

Table 6.4: Partial proportional odds models to identify determinants of maternal knowledge on overall knowledge, causes and prevention of diarrhoea

	Causes of diarrhoea		Prevention methods		Overall knowledge on diarrhoea	
Variable	estimate	95% CI	estimate	95% CI	estimate	95% CI
Threshold $\alpha^{(1)}$	-4.122	(-4.782,-3.461)	-0.803	(-1.160,-0.446)	-1.653	(-2.235,-1.071)
$\alpha^{(2)}$	-0.756	(-1.211,-0.301)	0.737	(0.380,1.094)	-0.137	(-0.691,0.418)
$\alpha^{(3)}$	0.615	(0.158,1.072)	2.209	(1.750,2.668)	1.281	(0.601,1.961)
Primary school β or $\omega^{(1)}$	-0.069	(-0.339,0.201)	-0.090	(-0.349,0.169)	-0.289	(-0.554,-0.024)
$\omega^{(2)}$						
$\omega^{(3)}$						
Secondary School β or $\omega^{(1)}$	0.070	(-0.275,0.415)	-0.415	(-0.740,-0.090)	-0.418	(-0.757,-0.079)
$\omega^{(2)}$						
$\omega^{(3)}$						
Health centre β or $\omega^{(1)}$	0.625	(0.307,0.942)	-0.170	(-0.491,0.151)	0.199	(-0.118,0.516)
$\omega^{(2)}$			-0.583	(-0.902,-0.263)		
$\omega^{(3)}$			-0.357	(-0.764,0.051)		
CHAM β or $\omega^{(1)}$	1.044	(0.518,1.569)	0.220	(-0.237,0.677)	0.940	(0.436,1.444)
$\omega^{(2)}$			-0.211	(-0.652,0.230)		
$\omega^{(3)}$			-0.053	(-0.610,0.504)		
Health Post β or $\omega^{(1)}$	-0.244	(-1.085,0.597)	-0.092	(-1.127,0.943)	0.054	(-0.765,0.873)
$\omega^{(2)}$			-0.716	(-1.633,0.201)		
$\omega^{(3)}$			-0.019	(-1.366,1.327)		
Local private clinic β or $\omega^{(1)}$	0.844	(0.276,1.412)	0.247	(-0.312,0.806)	0.442	(-0.099,0.983)
$\omega^{(2)}$			0.127	(-0.412,0.666)		
$\omega^{(3)}$			0.150	(-0.558,0.858)		
Age β or $\omega^{(1)}$	0.126	(0.020,0.232)	0.180	(0.074,0.286)	0.002	(-0.008,0.012)
$\omega^{(2)}$					0.008	(0.000,0.016)
$\omega^{(3)}$					0.025	(0.009,0.041)
No NGO β or $\omega^{(1)}$	-0.030	(-0.297,0.237)	0.278	(0.002,0.554)	0.207	(-0.056,0.470)
$\omega^{(2)}$			0.142	(-0.117,0.401)		
$\omega^{(3)}$			-0.007	(-0.336,0.322)		
No HSA β or $\omega^{(1)}$	1.040	(0.507,1.573)	0.617	(0.362,0.872)	0.605	(0.380,0.830)
$\omega^{(2)}$	0.571	(0.320,0.822)	0.466	(0.217,0.715)		
$\omega^{(3)}$	0.611	(0.323,0.899)	0.578	(0.225,0.931)		
Community effects (u_{0j})	0.352	(0.085,0.619)	0.063	(-0.027,0.153)	0.366	(0.107,0.625)

had not attended any formal school [$\beta = -0.415;\ 95\%\ CI: -0.740, -0.090$] and older women were more likely to mention fewer prevention methods [$\beta = 0.180;\ 95\%\ CI: 0.074, 0.286$].

On overall knowledge, baseline threshold probability of having scored a total of four to five or six to seven points increased with maternal age [$\omega^{(2)} = 0.008;\ 95\% CI: 0.000, 0.016$ and $\omega^{(3)} = 0.025;\ 95\% CI: 0.009, 0.041$ respectively]. School level, nearest health facility, and existence of an HSA were significant predictors that obeyed proportional odds features in the overall knowledge outcome. Women that attended primary school and those that attended at least secondary school were less likely to score fewer points than those who did not attend any formal school education [$\beta = -0.289\ 95\% CI: -0.554, -0.024$ and $\beta = -0.418\ 95\% CI: -0.757, -0.079$ respectively]. Households whose nearest health facility was a CHAM hospital were more likely to score fewer points than those near a government hospital [$\beta = 0.940\ 95\% CI: 0.436, 1.444$]. Women in communities without HSAs were more likely to score fewer points than those in areas that have HSAs [$\beta = 0.605;\ 95\% CI: 0.380, 0.830$].

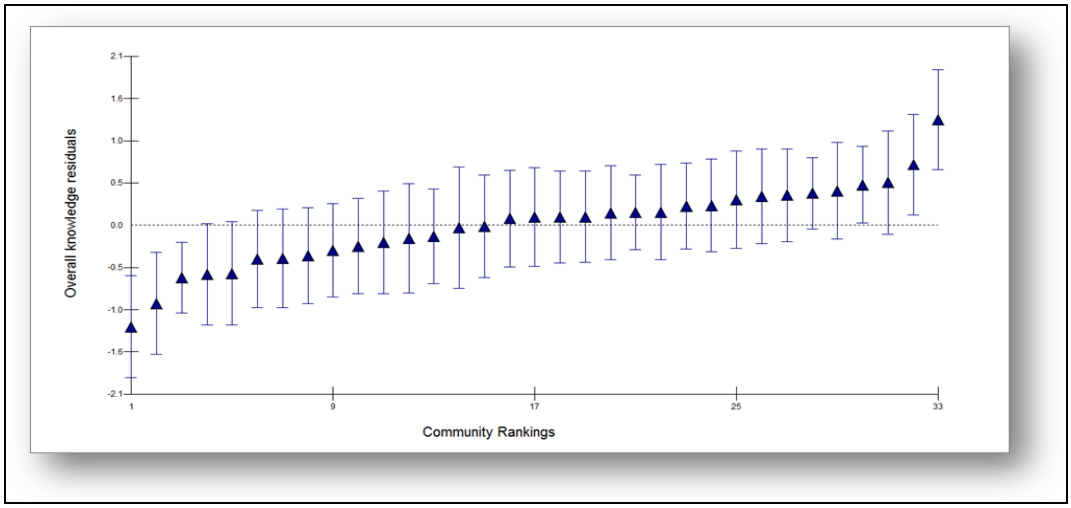

Figure 6.1: *Catapillar plot of diarrhoea knowledge residuals ranked by sampled communities. The dotted line is the mean of the estimated (shrunken) residuals[12] which is equal to zero. The triangles indicate estimated (shrunken) community residuals*

[12] *Estimated or shrunken residual for community j is the residual obtained by multiplying the mean of the residuals of households in community j by a shrinkage factor. Shrinkage factor shrinks an observed group mean towards the centre of the population mean.*

There is significant variation between communities on the symptoms outcome $[\sigma_u^2 = 0.623;\ 95\%\ CI: 0.219,1.027]$, causes outcome $[\sigma_u^2 = 0.352;\ 95\%\ CI: 0.085,0.619]$, and overall knowledge outcome $[\sigma_u^2 = 0.366;\ 95\% CI: 0.107,0.625]$ indicating differences between communities in those outcomes. This is evident in Figure 6.1 which shows residuals for some communities significantly below zero while others are significantly above zero revealing disparities in the way different communities understand issues related to diarrhoea.

6.2.4 Discussion

This section was undertaken to examine community variation and factors associated with mother's knowledge on causes of diarrhoeal illness, its symptoms and how to prevent the disease in rural villages in Chikwawa, Malawi. The majority of women in Chikwawa (84%) used the definition 'watery stools' to identify diarrhoea. Few women mentioned 'increased number of stools' or 'bloody stools'. Only 35% mentioned 'stomach-ache'. These results may be a consequence of a local Malawian definition of diarrhoea, '*kutsegula m'mimba*' which literally means opening up of bowels associated with defecation of watery stools especially in young children. The vernacular definition does not include the words 'increased' or 'bloody' stools. To avoid under reporting of causes and preventative measures the interviewers were advised to use both definitions of diarrhoea when seeking responses from matriarchal figures in the communities.

Less than a quarter or less of mothers mentioned each of the preventive measures while only half managed to mention half of the causes of diarrhoea. Clearly the results show inadequate knowledge amongst mothers both on causes and preventative measures against diarrhoea. While many mothers were able to identify diarrhoea (as watery stools) only a few could link diarrhoea to risks that go with it and many more were unaware of the actions they can take to avoid contracting the disease. The responses may be a reflection of health education awareness messages availed to mothers in the communities or lack thereof as is evident in the significant relationship between the location of the health facility and knowledge. Similarly the significant relationship between presence of an HSA within the village and knowledge explains the important role HSAs are playing in preventive health in the rural communities. As already explained in the methods section, HSAs are resident within communities where

they undertake and assist in the operation of health posts or clinics, outreach clinics and health surveillance within villages. They also carry out all water and sanitation development and regular village inspections to determine if acceptable standards of living are being met. They are also responsible as health educators [Morse, 2006]. Taking into consideration the results of this MTCM analysis, it is apparent that communities without an HSA or VHCs are less knowledgeable about the causes, symptoms, and prevention of diarrhoeal disease and they miss the services from HSAs and VHCs.

Maternal age and education were found to be significant predictors of maternal knowledge on diarrhoea symptoms. Education increased mothers' ability to mention more diarrhoea symptoms and preventative measures. It also increased chances of more overall knowledge on diarrhoea. Other earlier studies in Malawi [Ziba et al., 1994], Lao People's Democratic Republic [Uza et al., 2002], and Colombian Pacific [Nieto et al., 1999] agree with this finding and observed that higher literacy levels were positively related to knowledge on diarrhoea or malaria.

There are mixed results on maternal age and knowledge. There is a positive relationship between increasing age and knowledge of diarrhoeal symptoms. However, there is a negative relationship between increasing age and knowledge on causes. There is also a negative relationship between increasing age and knowledge on prevention methods. While it is easy to remember 'watery stools' as a symptom of diarrhoea through years of experience with the disease, remembering multiple causes or preventive measures may not be easy and may require cognitive reasoning. Studies have shown that aging has an important influence on cognitive performance and that factors representing memory and space/reasoning decrease with age [Verhaeghen and Salthouse, 1997; Schroeder and Salthouse, 2004].

The random effect variances for symptoms, causes, and overall knowledge are significant at the community level suggesting that there is unmeasured heterogeneity at the level of the community which is not captured by the predictor variables included in the model. This shows that there are substantial within-community clusters on diarrhoea knowledge which are not accounted for by the observed characteristics of maternal age and education, nearest health facility, existence of an HSA, VHCs or an NGO. This also shows that there are differences in maternal knowledge on diarrhoea between communities. In other words, there are hidden and unobserved factors that directly influence maternal knowledge on diarrhoea

within communities. Such differences may partly be due to different health education messages and/or policies between communities. Morse [2006] observed that there were different NGOs operating in Chikwawa. However, their projects were concentrated in particular areas and, therefore, only benefited those particular communities. Furthermore, different NGOs have different goals in their areas of operation and HSAs are required to carry out work on behalf of the NGOs based on the NGOs' terms of reference. This means there may be no uniformity in the type of projects being executed and health education messages being disseminated. Other reasons may include shared healthcare facilities, cultural, socioeconomic, or environmental experiences not accounted for in the models. Mothers living in the same community, for example, may be more likely to share beliefs on diarrhoea and other diseases through shared experiences.

Despite the limitations associated with cross-sectional data, these findings have an important role to play in policy and the promotion of health education messages in the district. While awareness campaigns are conducted in Chikwawa they are mostly done through hospital personnel [Morse 2006; Masangwi et al., 2008]. The observations in this study show that the involvement of HSAs has a positive impact which can be utilised by increasing the number of and empowering HSAs so that they are equipped and knowledgeable to effectively disseminate messages on diarrhoea and other diseases. It is important to standardise policies in relation to diarrhoea and other diseases. NGOs and all other health promotion players need to coordinate their activities within each district to ensure consistency. HSAs and VHCs must be increased and must cover all communities in Chikwawa. HSAs and VHCs must be given adequate training to ensure they are able to grasp not only the standards required but also the principles behind them to ensure effective and efficient services to the communities.

6.3 Water consumption, sanitation and their implications for diarrhoea control: Analysing household drinking water sources and availability of toilets/latrines using multinomial logistic regression models

6.3.1 Summary

Lack of improved water sources and sanitary infrastructure is a high burden of diarrhoea diseases in developing countries which result in millions of deaths. This section examines the pattern of drinking water sources and availability of toilet or latrine facilities as necessary

resources in the fight against diarrhoea. It further explores characteristics associated with use of different sources of drinking water and ownership of toilet or latrine facilities and then discusses policy implications of the results. Multinomial logistic regression models are used in the analysis. A total of 1,397 households clustered within 33 communities were analysed in this section. The estimated proportion of households with improved water sources was 88% while only 42% had an own toilet or latrine facility. Community density was the most important factor associated both with none availability of toilet or latrine facilities $[\beta = 0.39;\ 95\%\ CI : 0.06,0.73]$ and use of unsafe drinking water sources $[\beta = 1.03;\ 95\%\ CI : 0.55,1.50]$. Other important variables associated with unsafe drinking water sources were none exposure to health related NGOs $[\beta = -0.59;\ 95\%\ CI : -1.00,-0.17]$ and community literacy levels $[\beta = -0.79;\ 95\%\ CI : -1.17,-0.40]$. These findings indicate the necessity of health activities that are community-based. They also highlight the risks posed by densely populated communities and hence the need for targeted interventions in such areas.

6.3.2 Summary measures for the outcome and indicator variables included in the study

Table 6.5 shows summary measures for both outcome and indicator variables in the models. There were 1,397 households clustered within 33 villages (communities) analysed in this section. Nearly nine in every ten households (n =1,231) have access to protected water sources, i.e. piped water, boreholes, protected wells or springs. One in ten households had no access to improved drinking water sources[13]. Two-thirds (n = 901) have access to a toilet/latrine facility and out of these two in three households (n= 591) use their own family toilet/latrine facility. One in every three households shares a toilet/latrine facility. These figures are in line with the 2015 Millennium Development Goals (MDGs). To meet MDG 7 for water and sanitation this would mean that approximately 89% of the population should have access to improved drinking water sources and 74% access to improved sanitation14 by 2015 [UNICEF, 2006].

[13] ***WHO definition of improved water source*****:** *there must be at least household piped water connections, public standpipes, boreholes, protected dug wells, protected springs or rainwater collection available to the household*

[14] ***WHO definition of improved sanitation*****:** *there must be at least a connection to a public sewer, a connection to a septic tank, a pour-flush latrine, a simple pit latrine or a ventilated improved pit latrine available to the household*

Table 6.5: Distribution of variables included in the water sources and sanitation models

Variable	N=1397	%
Water sources		
Piped water	313	22.4
Other safe water sources (Boreholes, protected wells, springs)	918	65.7
Unsafe water (rivers, streams, ponds, etc.)	166	11.9
Sanitation		
Own a toilet/latrine	591	42.3
Shared/public toilet/latrine	310	22.2
No toilet/latrine	496	35.5
Reasons for lack of toilet/latrine (467 responded)		
Bad soil/collapses easily	241	51.61
No money for materials	27	5.78
No one to construct toilet	117	25.05
No place to construct toilet	24	5.14
Rented premises	15	3.21
Other (there is a public toilet, use nearby bush, etc)	43	9.21
Household (level-1) variables		
Is Health surveillance assistant available?		
No	436	31.2
Yes	961	68.8
Is Village Health Committee available? Sanitation		
No	451	32.3
Yes	946	67.7
Is there an NGO on health issues?		
No	778	55.7
Yes	619	44.3
Household relative wealth		
Low wealth	512	36.6
Average	456	32.6
High	429	30.7

Community (level 2) variables	*Mean*	*Median*	*Maximum*	*Minimum*
Community literacy per person	2.057	2.047	2.500	1.389
Community density per household	4.91	4.89	5.76	4.28
Community relative wealth per household	0.01340	0.01325	0.0227	0.0071

When asked for reasons for lack of a toilet/latrine facility one in every two households mentioned bad soil that lead to easy collapse of toilet/latrine structures. One in every four respondents said there was no one to construct the toilet/latrine and the rest mentioned cost of materials (6%), lack of land for the toilet/latrine (5%), and other various reasons (12%)

6.3.3 Multinomial logistic regression models for the distribution of drinking water sources and sanitation

Two-level multinomial logistic regression models to determine factors that influence availability/ownership of toilet/latrine facilities and water source usage are given in Table 6.6. Six predictor variables except for one were significant for the toilet/latrine model. When compared to own toilet facilities, households in communities without an HSA and a VHC were more likely to have shared toilet/latrine facilities [$\beta = 0.52,\ 95\%CI : 0.19,0.58$ and $\beta = 0.55,\ 95\%CI : 0.18,0.93$ respectively]; households exposed to health related NGOs in their communities were less likely to have shared toilet/latrine facilities [$\beta = -0.46,\ 95\%CI : -0.81,-0.10$] and were also less likely to have no toilet/latrine facility toilet/latrine facilities [$\beta = -0.59,\ 95\%CI : -1.00,-0.17$]. Clearly families exposed to health related NGOs were more likely to have their own toilet facilities.

Relative to own toilet facilities, households with average wealth were less likely to have no toilet/latrine facilities when compared households with low wealth [$\beta = -0.82,\ 95\%CI : -1.18,-0.45$], while households with above average wealth were more likely to have shared toilet/latrine facilities [$\beta = 0.67,\ 95\%CI : 0.31,1.03$] and were less likely to have no toilet/latrine facility [$\beta = -0.95,\ 95\%CI : -1.34,0.56$] when compared to families with low wealth.

More literate communities were marginally less likely to have shared toilet/latrines in relation to own toilet facilities [$\beta = -0.27,\ 95\%CI : -0.55,0.02,\ p = 0.07$] and were at the same time less likely to have no toilet/latrine than own toilet/latrine facilities [$\beta = -0.79,\ 95\%CI : -1.17,-0.40$]. Clearly more literate communities were more likely to have an own toilet facility.

When compared to own toilet facilities, densely populated communities were more likely to have shared toilet facilities [$\beta = 0.34,\ 95\%CI : 0.07,0.60$] and at the same time were more likely to have no toilet facilities [$\beta = 0.39,\ 95\%\text{CI} : 0.06,0.73$]. This implies highly populated

Table 6.6: Hierarchical multinomial logistic regression models to identify determinants of water source usage and availability of toilet facilities

Variables	Factors associated with availability of a toilet facility						Factors associated with water source usage					
	Shared vs. Own toilet			None vs. Own toilet			Piped vs. other safe water			Unsafe vs. other safe water		
	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*
Household (level-1) variables												
Any HSA?												
No			(Reference group)									
Yes	0.52	(0.19,0.85)	0.002**	0.15	(-0.20,0.51)	0.398						
Any VHC?												
No			(Reference group)									
Yes	0.55	(0.18,0.93)	0.004**	0.30	(-0.10,0.71)	0.145						
Any NGO?												
No			(Reference group)									
Yes	-0.46	(-0.81,-0.10)	0.011**	-0.59	(-1.00,-0.17)	0.005**						
Relative wealth												
Low			(Reference group)									
Average	0.15	(-0.20,0.50)	0.399	-0.82	(-1.18,-0.45)	0.000**						
High	0.67	(0.31,1.03)	0.000**	-0.95	(-1.34,-0.56)	0.000**						
Community (level-3) variables												
Literacy (LIT)	-0.27	(-0.55,0.02)	0.071*	-0.79	(-1.17,-0.40)	0.000**	1.93	(0.99,2.86)	0.000**	-0.35	(-0.80,0.11)	0.139
Density (DEN)	0.34	(0.07,0.60)	0.012**	0.39	(0.06,0.73)	0.022**	-1.12	(-2.26,0.02)	0.055*	1.03	(0.55,1.50)	0.000**
Wealth (WTH)							-2.47	(-3.42,-1.51)	0.000**	0.15	(-0.35,0.66)	0.556
WTH*DEN							-2.33	(-3.92,-0.73)	0.004**	-1.53	(-2.32,-0.74)	0.000**
LIT*WTH*DE							-4.92	(-7.65,-2.20)	0.000**	-1.73	(-2.79,-0.67)	0.001**
N												
Community random effects												

	Shared vs. Own toilets	No vs. Own toilets		Piped vs. other safe	Unsafe vs. other safe
Shared vs. Own toilets	0.20 (-0.05,0.45)		Piped vs. other safe	21.52 (4.40,38.63)**	
No vs. Own toilets	0.10 (-0.25,0.44)	0.52 (-0.03,1.07)*	Unsafe vs. other safe	1.79 (-1.56, 5.14)	1.73 (0.22,3.25)**

CI-Credible interval; *—$p \leq 0.10$; **—$p \leq 0.05$

communities were less likely to have their own toilet facilities. Lack of space to build toilet/latrine structures may explain shared as opposed to own toilet/latrine facilities in some more densely populated areas of Chikwawa especially in peri-urban areas.

There was marginal variation between communities whose households did not own toilet/latrine facilities indicating marginal clustering in such communities $[\sigma^2_{u2} = 0.52,\ 95\%CI : -0.03,1.07,\ \ p = 0.06]$.

The water sources model had three significant predictors and all were continuous community level variables. When compared to other safe water sources, more literate communities were more likely to use piped water sources$[\beta = 1.93,\ 95\%CI : 0.99,2.86]$; densely populated communities were marginally less likely to use piped water $[\beta = -1.12,\ 95\%CI : -2.26,0.02,\ \ p = 0.06]$ but were more likely to use unsafe water sources $[\beta = 1.03,\ 95\%\text{CI} : 0.55,1.50]$ and wealthier communities were less likely to use piped water sources $[\beta = -2.47,\ 95\%CI : -3.42,-1.51]$. This was expected considering that more literate people are employed and live in institutional houses with piped water or live in peri-urban areas where piped water is readily available.

The interaction effects between relative wealth and community density $(\text{relative wealth} \times \text{community density})$ indicate that while the probability of using piped water when compared to other safe water sources is only marginally less likely for highly populated communities and more unlikely for wealthier communities, it is highly unlikely for wealthier communities that are in densely populated communities to use piped water $[\beta = -2.33,\ 95\%\text{CI} : -3.92,-0.73]$. However, The interaction effects between wealthier and densely populated communities on unsafe water usage relative to other safe water sources indicate that wealthier communities that are also densely populated were less likely to use unsafe water sources $[\beta = -1.53,\ 95\%\text{CI} : -2.32,-0.74]$ in spite of the high likelihood for densely populated communities to use unsafe water sources and also in spite of lack of evidence of any differences on unsafe water usage between communities with different wealth levels. Although more literate communities are more likely to use piped water, the interaction term between literacy levels, relative wealth and community density

(literacy level × relative wealth × community density) shows that more literate communities that are also densely populated and wealthier are less likely to use piped water [$\beta = -4.92,\ 95\%CI: -7.65,-2.20$]. Similarly densely populated communities that are also literate and wealthier are less likely to use unsafe water sources [$\beta = -1.73,\ 95\%CI: -2.79,-0.67$] in spite of the observation that densely populated communities are more likely to use unsafe water sources.

There is significant variation between communities in the use of (i) piped water when compared to other improved water sources [$\sigma^2_{u1} = 21.52,\ 95\%CI: 4.40,38.63$] and (ii) unsafe water sources [$\sigma^2_{u2} = 1.73,\ 95\%CI: 0.22,3.25$] when compared to other improved water sources indicating clustering within communities on use of piped and unsafe water sources in relation to other safe water sources.

6.3.4 Discussion

The fact that one in every three households in Chikwawa is without a toilet facility has direct policy implications that need to be addressed. A toilet or a latrine is an element of sanitation that involves disposal of faecal matter. Lack of a toilet or latrine can facilitate the proliferation of diarrhoeal disease through various pathways. Previous studies in Sub Sahara Africa have identified poor sanitation and lack of latrines as a determinant for *Cryptosporidium* transmission [Gascon et al., 2000; Nizeyi et al., 2002; Morse 2006]. Traore et al [1994) and Morse [2006] further demonstrated that the risk of children contracting diarrhoeal illnesses was 35% higher in those who were living in households where human faeces were observed on the ground, and that reducing environmental contamination with faeces has been found to reduce the risk of diarrhoeal illness [van Derslice, et al., 1994]. Accumulated faecal matter can also attract large quantities of flies which in turn can help the transmission of diarrhoea within the population lying close to the faecal dumping sites. Flies are commonly thought of as a source of diarrhoea since they have been shown to carry pathogens on their feet, in their faeces, and in the digestive juices which they regurgitate onto foods [Oo Khin Nwe et al., 1989 and Esrey, 1991, Curtis et al 2000]. Floods and rainfall runoff can sweep indiscriminately disposed faeces to drinking water reservoirs which, if taken as drinking or bathing water without treatment or if other human beings simply come in

contact with it, can facilitate proliferation of diarrhoea in families and communities [Prüss et al., 2002].

While other studies have identified lack of funds and lack of technical expertise as major factors in toilet/latrine ownership [Grimason, et al., 2000; Palamuleni, et al., 2002] this study observed that one in every two women identified bad soil that lead to easy collapse of toilet/latrine structures as the reason for lack of toilet/latrine structures in their households. One in every four respondents said there was no one to construct the toilet/latrine and the rest mentioned cost of materials (6%), lack of land for the toilet/latrine (5%), and other various reasons (12%).

Regression results show that families that lack the services of an HSA and VHC are more likely to use shared toilets/latrines other than using their own facilities. Similarly households that are exposed to the services offered by NGOs are more likely to have their own toilet/latrine facilities. Further, more literate communities were more likely to have their own toilet/latrine facilities while densely populated communities were more likely to have no toilet facilities. These results clearly demonstrate (i) the positive role HSAs, VHCs, and NGOs are playing in the communities where they exist, (ii) the impact of formal education in valuing ownership of toilets or latrines, and (iii) the negative impact of large populations on sanitary matters. HSAs and VHCs are responsible for awareness, monitoring, and supervision of preventive measures against common diseases in the rural communities of Malawi while NGOs are involved in health education messages, distribution of healthcare resources, and surveillance of diseases [Ministry of Health, 2001].

Although the results show high proportions of families (88%) that are able to access improved water sources, quality is not the only key to the reduction of diarrhoeal disease. Other water sources comprise boreholes, protected wells, and springs. Table 6.5 shows that the majority of households (66%) use other safe water sources of which 78% are boreholes; 10% are protected wells and 12% are springs. Clearly boreholes are a common method of water delivery in Chikwawa. Boreholes can be unsafe due to microbiological contamination of aquifers, poor placement and the hydrology of the area. Borehole water may also prove to be unsafe if installed without due care and attention [Morse, 2006]. Earlier studies in Zimbabwe and Malawi demonstrated that faecal contamination of borehole water supplies was due to poor placement and quality of boreholes and sanitary facilities [Moran et al.,

1997; Stains 2002]. Although protected wells are classified as safe drinking water sources it has been observed that microbiological contamination of these wells is common [Morse, 2006]. For example, items used to collect water from wells such as buckets may provide a source of contamination to the wells.

Regression results in Table 6.6 show that highly densely populated communities are less likely to use piped water but are more likely to use unsafe water sources such as rivers, streams and ponds. Clearly density is a major factor in use of water sources. Density has a direct bearing on water demand and supply and is directly related to time and distance at a water source/supply. Curtis et al., [2000] observed that expenditure on improving the quantity of water available may have more impact on the common endemic diarrhoeas in developing countries than ensuring that supplies meet high standards of purity. Morse [2006] also observed that households collecting drinking water from boreholes are unlikely to collect large volumes of water due to time and distance of collection. Families may be nearer a safe water source but if demand for water from the source is very high then (i) households may have fewer quantities than is required for their household chores and (ii) time spent at the water source/supply may be long. Families, especially in densely populated communities, may opt for alternative sources/supply of water including those that are not safe but are in plentiful supply, in easy reach and not time consuming. Unfortunately, unsafe water reservoirs such as rivers, ponds, lakes, and streams are heavily contaminated with faecal coliforms and faecal streptococci [Staines, 2002]. They are also associated with cholera outbreaks in Malawi [Swerdlow, 1997; Morse, 2006]. Families in densely populated communities are, therefore, at greater risks of contracting diarrhoeal disease.

It is important to realise that improvement of water sources alone is not adequate in the provision of safe drinking water. Contamination can occur during collection, transportation, storage, and usage [Chemuliti et al., 2002; Gundry et al., 2004Trevett 2005; Morse 2006]. In Chikwawa water is normally collected and stored in homes using containers such as clay pots (56%), plastic buckets (19%), and metal buckets (15%). Contamination can occur if these are not covered properly or if handled with contaminated hands. Morse [2006] observed from a study in Honduras [Trevett et al., 2005] that hand contact was a source of contamination in containers with 44% of women's fingertips faecally contaminated during normal household duties.

The random effect variances for piped versus other safe water sources and unsafe versus other safe water sources are significant at the community level suggesting that there are substantial within-community clusters on water usage which are not accounted for by the observed characteristics. This was expected considering that piped water is mostly concentrated in peri-urban areas of Chikwawa where the more literate are located while other safe water sources and unsafe water sources are mostly used in rural communities.

Policy implications of the results are that:

(i) community health committees, workers, and NGOs are important in health delivery systems. Their empowerment through rigorous and relevant health promotion programmes such as refresher courses to update both their knowledge and their skills in communication and counselling on the importance of using safe water sources, good sanitation and hygiene practices is necessary;

(ii) provision and establishment of HSAs and VHCs respectively in areas that do not have them is essential;

(iii) health education messages on the importance and use of safe water sources, own household toilets/latrines, and general hygiene practices must be intensified;

(iv) more resources in the provision of more quantities of safe (improved) water sources must be allocated in highly densely populated areas of Chikwawa;

(v) Appropriate toilet/latrine technologies that will not easily collapse in sandy soils of Southern Malawi must be introduced to increase own accessibility ratios to toilets or latrines; and

(vi) Quantity and not just quality of drinking water could provide an important step in the provision of safe water to a greater number of households, including those in highly densely populated communities.

As with other cross-sectional surveys, the results must be treated with a degree of caution. The data was based on self-reported accounts by mothers. Self reported events suffer some limitations since the outcomes are dependent of respondent's recall and may lead to bias [Boerma et al., 1991]. Nevertheless, the strength of this study is significant. It is based on a large population with wide coverage within Chikwawa district. This paper is also able to draw some conclusions that may be helpful in policy development and planning, advocacy, resource allocation, implementation and monitoring and evaluation.

6.4 Pattern of knowledge, bed-net coverage and their implications for malaria control.

6.4.1 Summary

This paper estimates the pattern of knowledge, bed-net coverage, the role of a district healthcare system and their implications for malaria control in Southern Malawi using multilevel logistic regression modelling with Bayesian estimation. The results generally show lack of knowledge in understanding of symptoms of and preventative measures against malaria which, however, display significant variation between communities. Groups that are more knowledgeable on prevention and symptoms of malaria include young mothers, those that have attended school, the relatively wealthy, those nearest to government hospitals and health posts and those communities that have a health surveillance assistant. It is important that health officers at different levels of the Chikwawa district health system including health surveillance assistants (HSAs) and village health committees (VHCs) should be equipped with educational resources that can enhance their understanding and delivery of current knowledge in the prevention and control of malaria which, in turn, can effectively benefit the rural communities. Malaria health education messages must be intensified and distribution of bed nets must target the poorest households

6.4.2 Summary measures for the response variable included in the study

Distribution of response variables included in this study are summarised in Table 6.7. Most women interviewed (95%) had the correct knowledge about mosquito causing malaria. On how they determine that a member of their household has malaria most women identified fever (93%) followed by vomiting (34%), and rigors (22%). Only 8% mentioned blood test at a hospital and another 8% mentioned diarrhoea. On preventive measures 68% of the women mentioned use of bed nets followed by 29% who mentioned clearing of weeds or bushes. The rest of the categories on preventive measures received less than 7% recognition. Most women obtain their information on malaria from hospital personnel[15] (81%). 28% receive their information from HSAs and 21% from radio. All other health information sources were each mention by less that 6.5% of the women.

[15] This refers to health facility medical personnel such as nurses, clinical officers, and medical assistants.

Table 6.7: Distribution of household malaria knowledge outcome variables included in the study

Item	Variable	Category	N=1400	%
Malaria knowledge	Cause of malaria	Mosquitoes	1331	95.1
		other	69	4.9
	Symptoms	Fever	1295	92.5
		Diarrhoea	113	8.1
		Rigors	302	21.6
		Vomiting	469	33.5
		Blood test	114	8.1
		Other	119	8.5
	Preventive measure	Clear weeds/bushes	399	28.5
		Drain water	91	6.5
		Use net	956	68.3
		Indoor spraying	73	5.2
		Outdoor spraying	6	0.4
		Other (coils etc)	69	4.9
	Sources	Hospital personnel	1333	80.9
		Radio	297	21.2
		HSA	392	28.0
		VHC	84	6.0
		Traditional leaders	90	6.4
		TBA	36	2.6
		Drama	29	2.1
		Other	10	0.7
Net ownership	Any mosquito net	Yes	911	65.1
		No	489	34.9
	Ownership ratio *(mean=0.25; range= (0-3))*	Nets per person = 0	490	35.0
		0 <Nets per person ≤0.25	334	23.9
		0.25< Nets per person≤0.40	292	20.9
		Nets per person > 0.40	284	20.3
	Existence of holes	Yes	626	44.8
		no	773	55.2
	Source of nets	Health facility	921	65.8
		Community distributed	176	12.6
		Bought (shop or market)	231	16.5
		Other or don't know	71	5.1

Two thirds (65%) of the women admitted to having bed nets in their households and the mean ratio of net to household size was calculated to be 0.25 net per person per household i.e. an average of four people to one bed net. 1,399 bed nets were physically examined by enumerators and out of these 45% were found to have holes in them the size of a thumb. Most of the nets (66%) were obtained from a health facility, 17% were purchased, 13% were distributed within the communities and about 5% were obtained as gifts from relatives and other sources.

6.4.3 Binary logistic analysis of knowledge on malaria

Table 6.8 shows a series of hierarchical binary logistic regression results on the aetiology and clinical features of malaria. No single factor was found to associate with women's knowledge on the mosquito being the cause of malaria and there were no differences across the communities in women's knowledge on the mosquito being the cause of malaria [$\sigma_u^2 = 0.08;\ 95\%\ CI: -0.14, 0.31$]. The nearest health facility had the strongest association with fever. Women whose nearest health facility was either a health centre or CHAM were highly likely to have mentioned fever as a way of confirming malaria [$\beta = 0.86;\ 95\%\ \text{CI}: 0.28, 1.44$ and $\beta = 1.01;\ 95\%\ \text{CI}: 0.09, 1.93$ respectively]. The relatively wealthier in the communities were less likely to have mentioned vomiting and more likely to have mentioned rigors as clinical features of malaria. Those in relatively average and high wealth categories were less likely to have mentioned vomiting compared to those in the low wealth category [$\beta = -0.30\ 95\%\ \text{CI}: -0.59, -0.01$ and $\beta = -0.32;\ 95\%\ \text{CI}: -0.62, -0.01$ respectively]. Only those in the relatively high wealth category were more likely to have mentioned rigors [$\beta = 0.44;\ 95\%\ \text{CI}: 0.10, 0.78$].

Formal schooling level, HSA, and health facility were highly associated with use of a medical facility to confirm malaria illness. Those with at least secondary school education were more likely to have used health facilities to confirm malaria [$\beta = 0.81;\ 95\%\ \text{CI}: 0.17, 1.46$] than those who had not attended any formal schooling. Those who had no HSA in their communities and those whose nearest health facility was a health centre were less likely to

Table 6.8: Hierarchical binary logistic regression to identify determinants of household knowledge for detecting malaria illness

Predictors	Cause of malaria (%)			Symptoms (%)										
				Rigors			Fever			Vomiting			Blood test at HF		
	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*
Age group															
15-20								(Reference group)							
21-30				0.07	(-0.42,0.55)	0.785	0.63	(-0.03,1.29)	0.063**	0.01	(-0.38,0.39)	0.984	-0.53	-(1.22,0.16)	0.135
31-50				-0.07	(-0.58,0.44)	0.792	0.39	(-0.31,1.08)	0.277	-0.34	(-0.75,0.07)	0.103	-0.14	(-0.84,0.56)	0.694
Above 51				0.21	(-0.36,0.77)	0.473	0.30	(-0.49,1.08)	0.458	-0.29	(-0.77,0.20)	0.244	-0.15	(-0.96,0.66)	0.722
School															
None								(Reference group)							
Primary				0.28	(-0.10,0.66)	0.150	0.40	(-0.12,0.93)	0.134	0.21	(-0.11,0.53)	0.205	-0.13	(-0.69,0.43)	0.650
Secondary				0.31	(-0.15,0.76)	0.184	0.05	(-0.60,0.70)	0.871	0.32	(-0.07,0.71)	0.112	0.81	(0.17,1.46)	0.014**
Relative Wealth															
Middle								(Reference group)							
Low				0.26	(-0.09,0.61)	0.144	0.19	(-0.36,0.74)	0.496	-0.30	(-0.59,-0.01)	0.047**	-0.05	(-0.58,0.49)	0.867
high				0.44	(0.10,0.78)	0.012**	-0.21	(-0.75,0.34)	0.457	-0.32	(-0.62,-0.01)	0.040**	0.41	(-0.09,0.92)	0.110
Any HSA?															
Yes								(Reference group)							
No				0.17	(-0.14,0.46)	0.294	0.50	(-0.01,1.01)	0.06*	-0.26	(-0.53,0.01)	0.061*	-0.56	(-1.07,-0.05)	0.031**
Health facility															
Gov. Hospital								(Reference group)							
Health centre				-0.28	(-0.70,0.13)	0.181	0.86	(0.28,1.44)	0.004**	-0.30	(-0.66,0.05)	0.097*	-0.68	(-1.27,-0.08)	0.027**
CHAM				-0.59	(-1.21,0.03)	0.061*	1.01	(0.09,1.93)	0.032**	-0.37	(-0.88,0.13)	0.149	-0.27	(-1.16,0.62)	0.55
Health post				0.08	(-0.98,1.14)	0.884	-0.14	(-1.58,1.31)	0.853	-0.09	(-1.07,0.89)	0.860	-1.39	(-3.96,1.18)	0.289
Local private clinic				0.04	(-0.60,0.68)	0.898	-0.09	(-0.99,0.81)	0.848	0.23	(-0.33,0.79)	0.419	-0.73	(-1.73,0.27)	0.155
Community effects (u_{0j})	0.08	(-0.14,0.31)	0.713	0.46	(0.06,0.86)	0.025**	0.27	(-0.31,0.84)	0.359	0.14	(-0.02,0.29)	0.093*	1.12	(0.06,2.19)	0.039**

**—p≤0.10; **—p≤0.05; CI—Credible interval; HSA—Health surveillance assistant*

have used a health facility to verify malaria illness [$\beta = -0.56$ 95% CI : $-1.07, -0.05$ and $\beta = -0.68$; 95% CI : $-1.27, -0.08$ respectively]
Rigors and use of a health facility as a means of identifying malaria varied significantly between villages [$\sigma_u^2 = 0.46$ 95% CI : $0.06, 0.86$ and $\sigma_u^2 = 1.12$; 95% CI : $0.06, 2.19$]. Use of vomiting only marginally varied between villages [$\sigma_u^2 = 0.15$; $p = 0.09$]. There are no differences across villages in the use of fever as a means of identifying malaria.

Table 6.9 shows binary logistic regression models for clearing of weeds or bushes and use of mosquito nets as main preventive measures identified in the communities. Maternal age, school level, relative wealth, existence of an HSA and nearest health facilities were all strongly associated with use of bed net. Women in age groups 31 to 50 years and those above 51 years were less likely to have mentioned a bed net as a means of avoiding malaria than those in the 15 to 20 years age category [$\beta = -0.67$ 95% CI : $-1.12, -0.21$ and $\beta = -0.74$ 95% CI : $-1.26, -0.23$ respectively]. Those that attended primary school and those that attended at least secondary school education were more likely to have mentioned bed nets as a preventive measure [$\beta = 0.46$ 95% CI : $0.14, 0.77$ and $\beta = 0.48$ 95% CI : $0.07, 0.89$ respectively]. Those who did not have an HSA in their community were less likely to have mentioned use of bed nets [$\beta = -0.60$; 95% CI : $-0.87, -0.32$]. Similarly those whose nearest health facility is a health centre or CHAM were less likely to have mentioned use of bed nets to prevent malaria [$\beta = -0.46$ 95% CI : $-0.84, -0.08$; and $\beta = -0.78$; 95% CI : $-1.33, -0.22$ respectively] relative to those whose nearest health facility is a government or rural hospital. Those that use local private clinics were marginally less likely to have mentioned use of bed nets [$\beta = -0.61$; $p = 0.06$]. Those in the low wealth category were also less likely to have mentioned use bed nets as a preventive measure [$\beta = -0.38$; 95% CI : $-0.68, -0.08$] when compared to those in the average wealth category.

Maternal age, existence of an HSA and nearest health facility were strong predictors of those who mentioned clearance of weeds or bushes as a remedy against malaria. Those in the 31 to 50 age category were highly likely to have mentioned clearance of weeds or bushes than

Table 6.9: Binary logistic regression model to identify determinants of malaria prevention measures

Variable	Malaria preventive measure					
	Clear weeds/bushes			Use mosquito net		
	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*
Age group						
15-20			(Reference group)			
21-30	045	(-0.02,0.92)	0.059*	-0.38	(-0.83,0.07)	0.097*
31-50	0.64	(0.15,1.14)	0.010**	-0.67	(-1.12,-0.21)	0.004**
Above 51	0.23	(-0.33,0.80)	0.417	-0.74	(-1.26,-0.23)	0.005**
School						
None			(Reference group)			
Primary	0	(-0.34,0.34)	1.00	0.46	(0.14,0.77)	0.004**
Secondary	-0.02	(-0.44,0.41)	0.94	0.48	(0.07,0.89)	0.021**
Relative wealth						
Middle			(Reference group)			
Low	0.22	(-0.94,0.53)	0.172	-0.38	(-0.68,-0.08)	0.013**
High	0.20	(-0.11,0.51)	0.204	-0.05	(0.37,0.26)	0.731
Any HSA?						
Yes			(Reference group)			
No	-0.56	(-0.86,-0.26)	0.000**	-0.60	(-0.87,-0.32)	0.000**
Health facility						
Gov. Hospital			(Reference group)			
Health centre	0.01	(-0.37,0.38)	0.975	-0.46	(-0.84,-0.08)	0.017**
CHAM	-0.12	(-0.68,0.45)	0.688	-0.78	(-1.33,-0.22)	0.006**
Health post	-0.76	(-2.14,0.63)	0.284	0.35	(-0.85,1.54)	0.568
Local private clinic	0.61	(0.01,1.20)	0.046**	-0.61	(-1.24,0.02)	0.059*
Community effects (u_{0j})	0.24	(0.03,0.45)	0.025**	0.26	(0.02,0.50)	0.035**

**—p≤0.10; **—p≤0.05; CI—Credible interval; HSA—Health surveillance assistant*

those in the 15 to 20 years age category [$\beta = 0.64;\ 95\%\ \text{CI}: 0.15,1.14$] while those in the 21 to 30 years age category were marginally more likely to have mentioned clearance of weeds and bushes [$\beta = 0.45;\ \text{p} = 0.06$]. Those without an HSA in their communities were less likely to have mentioned clearance of weeds or bushes [$\beta = -0.56;\ 95\%\ \text{CI}: -0.86,-0.26$]. Those whose nearest health facilities are local private clinics were more likely to have mentioned clearance of weeds than those that are near government hospitals [$\beta = 0.61;\ 95\%\ \text{CI}: 0.01,1.20$].

Both clearance of weeds or bushes and use of bed nets as preventive measures varied significantly between communities [$\beta = 0.20;\ 95\%\ \text{CI}: 0.00,0.40;$ and $\beta = 0.26;\ 95\%\ \text{CI}: 0.02,0.50$ respectively].

Table 6.10 shows a binary random and coefficient components regression models to identify factors that affect ownership of bed nets and how the distribution of those nets vary between communities. Maternal school level, household wealth, and household size are strong factors that affect distribution of nets in the two level random components regression model. Households with mothers that have attended primary school and those that have attained at least secondary school education were more likely to have bed net ratios of more than 0.25, i.e. less than four members shared a bed net [$\beta = 0.39\ 95\%\ \text{CI}: 0.06,0.72;$ and $\beta = 0.70\ 95\%\ \text{CI}: 0.30,1.10$ respectively]. Similarly households with average wealth and those with relatively high wealth were more likely to have less than four of its members sharing a bed net [$\beta = 0.70\ 95\%\ \text{CI}: 0.40,0.99;$ and $\beta = 0.95;\ 95\%\ \text{CI}: 0.64,1.25$ respectively]. Households with large families were more likely to have four or more members to a single bed net [$\beta = -0.29\ 95\%\ \text{CI}: -0.37,-0.22$]. Households without an HSA were marginally less likely to have less than four members to a bed net [$\beta = -0.24; \text{p} = 0.07$]. The distribution of bed nets varies greatly from community to community [$\sigma_u^2 = 0.37;\ 95\%\ \text{CI}: 0.09,0.64$]. This is supported by Figure 6.2 which shows a couple of community residuals significantly below zero indicating significantly fewer distribution of bed nets in those communities and others significantly above zero a sign that those communities have better coverage of mosquito nets. Figure 6.2 also shows that four communities under a special Scotland

Table 6.10: Random components model to identify influences of mosquito net ownership

Variable	Mosquito net ownership								
	Two level fixed effects model			Two level random coefficient model					
	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	$\mathbf{u_{ij}}$	(95% CI)	*p-value*
Age group									
15-20				(Reference group)					
21-30	-0.24	(-0.65,0.16)	0.241	0.23	(-0.66,0.21)	0.302			
31-50	-0.10	(-0.54,0.35)	0.667	-0.12	(-0.59,0.36)	0.636			
Above 51	-0.30	(-0.80,0.20)	0.199	-0.27	(-0.81,0.27)	0.319			
School									
None				(Reference group)					
Primary	0.39	(0.06,0.72)	0.021**	0.39	(-0.06,0.83)	0.090*	0.42	(-0.01,0.84)	0.054*
Secondary	0.70	(0.30,1.10)	0.001**	0.75	(0.22,1.29)	0.006**	0.51	(-0.07,1.09)	0.088*
Relative wealth									
Low				(Reference group)					
Middle	0.70	(0.40,0.99)	000**	0.75	(0.34,1.15)	0.000**	0.37	(0.01,0.72)	0.043**
High	0.95	(0.64,1.25)	000**	1.06	(0.63,1.49)	0.000**	0.46	(-0.03,0.95)	0.065*
Any HSA?									
Yes				(Reference group)					
No	-0.24	(-0.50,0.02)	0.073*	-0.23	(-0.52,0.05)	0.110			
Household size	-0.29	(-0.37,-0.22)	0.000**	-0.36	(-0.51,-0.21)	0.000**	0.12	(0.04,0.19)	0.002**
Malaria endemicity	0.22	(-0.75,1.19)	0.653	0.69	(-0.87,2.25)	0.387			
Community effects ($\mathbf{u_{0j}}$)	0.37	(0.09,0.64)	0.009**	1.47	(-0.21,3.16)	0.087*			

**—p≤0.10; **—p≤0.05; CI—Credible interval; HSA—Health surveillance assistant*

Chikwawa Health Initiative (SCHI) are significantly leading in bed net coverage. SCHI is a Scottish funded project which is currently carrying a number of health programmes including distribution of bed nets to improve lives of people in four villages of Chikwawa.

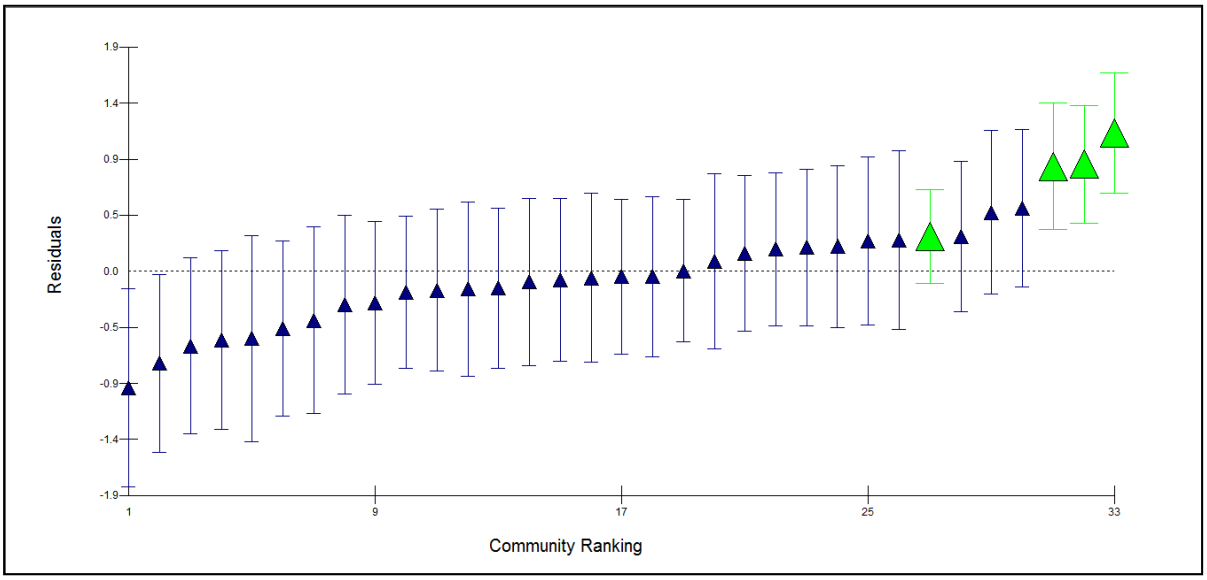

Figure 6.2: *A 95% Credible Interval Caterpillar plot showing residuals of mosquito net ownership ranked by their respective communities (villages under a special Scotland Chikwawa Health Initiative (SCHI) programme are highlighted in green)*

Maternal school, relative wealth, and household size have been allowed to vary across communities in a random components model shown in Table 6.10. The fixed part of the variables remains approximately the same. There is significant variation in the relationship between average wealth and bed net ownership across the villages [$\sigma^2_{u_{6j}} = 0.37$ 95% $CI : 0.01, 0.72$]. Similarly there is significant variation in the relationship between household size and bed net ownership across the communities [$\sigma^2_{u_{9j}} = 0.12$ 95% $CI : 0.04, 0.19$]. However, the relationship between maternal school and bed net ownership varies only at 10% significance level. The distribution of bed nets also varies from community to community only at 10% significance level

6.4.4 Discussion

The main goal of this study was to identify patterns of variation with corresponding factors of malaria related knowledge and bed net coverage in Southern Malawi. A multilevel modelling approach was adopted to distinguish the likely effects on the patterns of variation due to

hierarchical effects since the data comprised of women representing households that are nested within communities. Patterns of variation due to hierarchical effects may come due to unobserved differences in healthcare provision and resources, socioeconomic, or ecological/environmental issues in the communities [Nosten, 2004; Kazembe et al., 2007a]. A number of studies on knowledge on malaria transmission, prevention and control and use of bed nets have been carried out in Malawi [Schultz et al., 1994; Slutsker et al., 1994; Launiala and Kulmala, 2006]. However this study is the latest in Southern Malawi and the first to employ multilevel analysis in order to account for community effects.

The view that mosquitoes are the cause of malaria was found to be popular amongst the respondents. This view is similar elsewhere in the sampled communities since community variation parameter showed no evidence of any disparities. This may be the case considering that mosquitoes and the occurrence of malaria are so common in Chikwawa that almost everybody has been in contact with mosquitoes or had a malaria episode or they know somebody close who did.

The findings on methods used to identify malaria show that fever is the most common method of identifying malaria. Fever remains the best means by which malaria can be described since it is difficult to come up with a unique set of symptoms by which it can be recognized other than use of hospital diagnosis [Mwenesi, 2003]. Nearest health facility, representing nearest level of a district health system and existence of an HSA are major factors of influence common to household malaria diagnostic and preventative methods. Differences in basic health care interventions that are provided by different levels of the DHS including HSAs may explain differences in knowledge on these clinical features. The fact that most malaria clinical features had lower proportions only shows how poorly these are tackled in healthcare education messages at different levels of the Chikwawa health delivery system.

On preventative measures, clearance of weeds or bushes was the second most mentioned method by those interviewed. Clearance of weeds and bushes is commonly encouraged by some school teachers and health officers as a means of controlling malaria vectors around homes. Households in contact with HSAs were also more likely to mention clearance of weeds or bushes as a remedy. Some studies, however, have pointed out that this practice has no place in malaria vector control. Instead, dealing directly with and managing potential

mosquito breeding sites such as proper management of rubbish disposal sites, improvement of house structures to avoid mosquitoes, filling-up of man-made freshwater pools that are exposed to sunlight, chemical interventions, etc. may assist in controlling malaria vectors [Ribbonds, 1947 in Mwenesi, 2003]. Ignorance of these measures is an indicator that they are rarely or are not tackled in malaria health education messages at different levels in the Chikwawa DHS, this notwithstanding the fact that the majority of households receive their messages through hospital personnel (Table 6.7).

Use of bed nets was the most mentioned preventative measure against malaria. Young mothers were more likely to mention this method probably because of their contact with Ante-Natal Care (ANC) facilities through which most health education messages are conducted and bed nets distributed[16]. Figure 6.3 shows that young mothers are more likely to be expectant, hence more likely to attend ANC facilities from which they have high chances of learning about the use of mosquito nets. Similarly mothers in contact with an HSA have high chances of receiving or learning about a bed net. HSAs are specifically outlined in the Malawi Government RBM project as important contact points at the community level [WHO, 2004a].

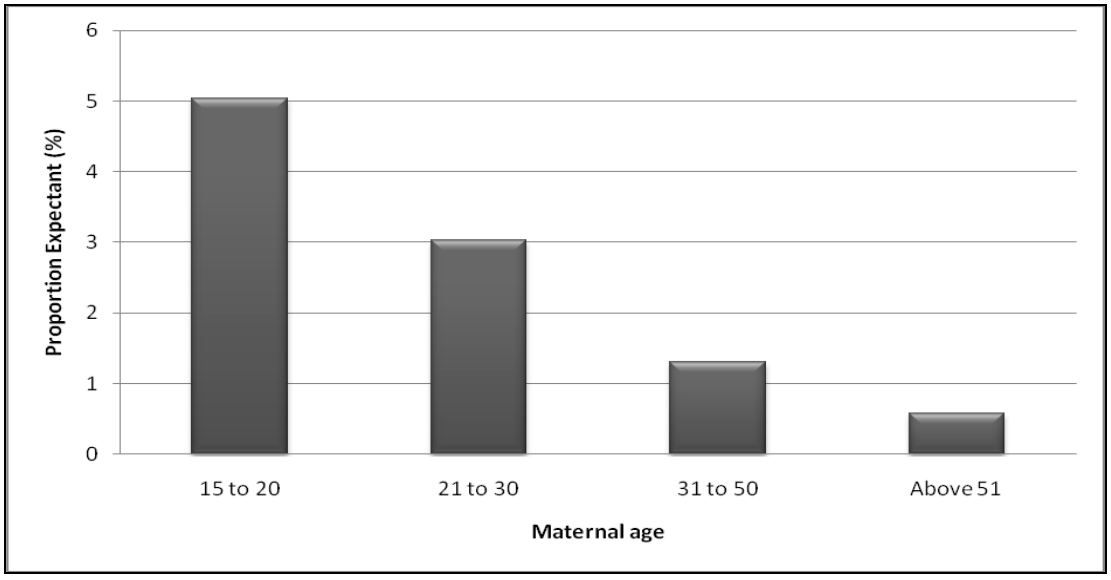

Figure 6.3: *Proportion of expectant women by age category in the sampled villages*

[16] *The Malawi Government receives funding from international donors through the RBM project partnership and uses Population Services International (PSI) to distribute them to district health authorities who in turn distributes them to health facilities for health facility-based distribution through Ante-Natal Care (ANC) visits and for Community-Based Distribution [WHO, 2004]*

Those whose nearest health facility is a government hospital and those that use a health post were also highly likely to mention use of bed nets probably because government distributes bed nets through district health authorities who are housed by district hospitals. District Health authorities are in charge of the distribution of healthcare resources within their districts. Similarly HSAs and VHCs utilise health posts as community-based distribution points. Those whose nearest facility is CHAM or a private clinic were less likely to mention use of bed nets because these facilities charge for their services and are not utilised as distribution points for free bed nets.

Although overall bed-net coverage was low, there was an improvement when compared to reports from other studies in Malawi [Holtz et al., 2002; Kazembe et al., 2007a; Mathanga and Bowie, 2007]. School level, relative wealth, existence of an HSA and household size are the main determinants of existence of bed nets within Chikwawa. School translates to better skills and knowledge that empower individuals in understanding and using existent healthcare resources [Pebly and Stupp, 1987; Hobcraft, 1993; Morse, 2006; Pongou et al., 2006; Osumanu, 2007; Masangwi 2008]. Severe Poverty and the expense of bed nets in shops, groceries, or markets may explain the impact of relative wealth. Apart from free bed nets that are distributed through health facilities some are also distributed through a social marketing program which, by implication, discriminates against the poor who may not have disposable income needed to afford health products [Mathanga and Bowie, 2007]. The role of HSAs in the distribution of healthcare resources may explain their impact on bed net coverage. Since each mother receives only one bed net it means more members from large families are likely to sleep without bed nets hence the negative relationship between bed net coverage ratio to household size also clearly shown in figure 6.4. This is made worse considering that a big proportion of households (45%) had bed nets with holes in them. This may explain absence of any relationship between the numbers of bed nets and prevalence of malaria in Chikwawa. Although there is an increase in the number of bed nets there is no decrease in the number of cases of malaria-like illness.

Significant variation of school level, relative wealth, and existence of an HSA explain the differences in impact that these variables have on bed net coverage between communities. Disparities also exist between bed net ownership across communities since the community random effect is evidently greater than zero. Figure 6.2 shows communities with NGOs

directly involved in the distribution of bed nets, for example the SCHI, have relatively high bed net coverage when compared to those that do not have such organisations.

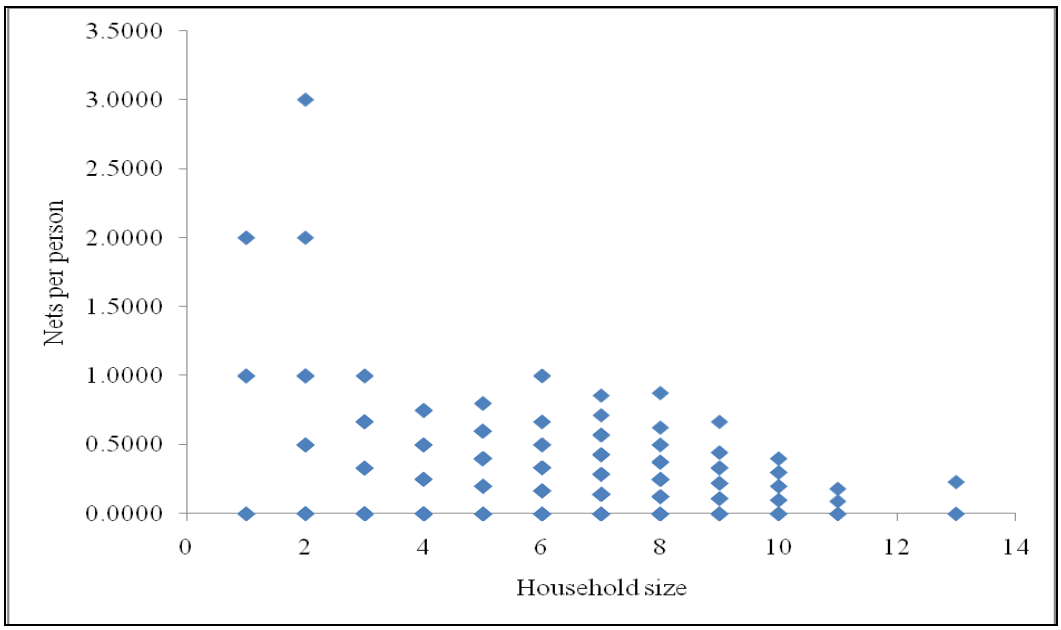

Figure 6.4: *A graph showing the distribution of bed-net ratios against household size*

Although malaria is very common in Southern Malawi, it is clear that people in this area do not have a clear understanding on most clinical features of and preventative measures against malaria infection. There are also inequalities in bed net coverage. This study further shows disparity in knowledge on clinical features and preventative measures between communities.

Policy implications of these results are that:

(i) health officers are important at different levels of the Chikwawa DHS including HSAs, VHCs, and NGOs. They should be equipped with educational resources that can enhance their understanding and delivery of current knowledge in the prevention and control of malaria so that the same can be uniformly imparted to the people in the communities. Malaria health education messages must be intensified and distribution of bed nets must target the poorest households;

(ii) government to ensure that HSAs and VHCs are provided for in all communities in Chikwawa. Special attention should be given to areas that currently do not have HSAs and VHCs;

(iii) households must be provided with long lasting bed nets to prevent tearing;

(iv) families must be encouraged to treat their bed nets with insecticides every six months to keep mosquitoes away even if they have developed holes;

(v) health education messages on the importance and use of insecticide treated nets and use of other available preventive measures must be intensified;

(vi) more resources in the provision quality bed nets and that bed nets must be distributed to households based on household sizes;

(vii) a genuine debate on the use of DDT for residual spraying in and around homes must be opened.

6.5 General discussion on knowledge and resource distribution in the fight against malaria and diarrhoea

The contributions of this chapter are twofold. First, it contributes to research on the pattern of knowledge and resource distribution for diarrhoea and malaria at household and community levels in Chikwawa using hierarchical modelling approach with Bayesian estimation. It contributes to the understanding of both common and rare risk factors for malaria and diarrhoea with the aim of providing knowledge of mothers' understanding of the two diseases and utilisation of resources meant to prevent infection from malaria and diarrhoea. Such knowledge can be used to bring about change of policy and can also assist bring about changes in attitudes and practices in the communities for better health.

Clearly most mothers' definition of diarrhoea is limited to watery stools and of malaria to fever. Most women cannot mention other symptoms of either diarrhoea or malaria. Similarly women's understanding of preventing malaria is limited to use of bed nets while little is known on any of the prevention methods for diarrhoea. Since knowledge about symptoms, prevention measures, and causes can be regarded as a proxy indicator for health education, it is not surprising that those who have gone to school were more knowledgeable both on diarrhoea and malaria than those who have not gone into a classroom. Primary school curriculum in Malawi covers health education subjects. Since the only source of health education information for those who may not have gone to school is health personnel and community health workers it is important that these should be properly trained to cover relevant and highly specific health education messages on the aetiology, prevention and

control of common diseases. Providing health education to mothers, particularly those who have not entered a formal classroom and young girls may be a key factor in increasing awareness about common diseases. As the rural poor usually have restricted access to mass media [Kazembe et al., 2007] efforts should also be made to educate mothers in rural poor communities through interpersonal communication by community health workers at the community and household levels.

Although Chikwawa surpasses MDGs and national targets for improved drinking water supply and sanitation, some households in Chikwawa still use unsafe and unprotected water and many more are without a toilet facility of their own. This is significantly prevalent in the densely settled, low-income, and low literate communities. Consequences of unsafe water use and poor sanitation are covered in international reports [WHO, 2005c] and these include diarrhoeal diseases, worm infections and other infectious diseases spread via contaminated water. Interestingly the results also found that densely populated, low-wealth, and maternal illiterate households had low bed net ratios.

Interventions that have been recommended include intensifying awareness and civic education on the importance of latrine/toilet ownership, particularly introducing cost effective, easy to adopt, and environmental friendly sanitary technology in low-income, densely populated, households; increasing the provision of safe portable water sources for domestic use by drilling more boreholes, extensive rehabilitation of broken boreholes, and expanding available piped water distribution systems to include low-income and densely populated rural communities; distribution of bed nets to take into consideration household size; introduction of chemicals to eradicate malaria including the use of DDT as is the case in other countries; increasing the number of community health workers and training them to be relevant to the challenges facing the fight against common diseases in the communities.

CHAPTER 7

THE PATTERN OF TREATMENT PRACTICES FOR DIARRHOEA AND MALARIA ILLNESSES

7.1 Introduction

This chapter examines household and community factors that influence choice of treatment knowledge on and availability of resources to fight malaria and diarrhoea. The primary strategy for control of diarrhoea and malaria is early diagnosis followed by prompt treatment with effective malaria drugs and administration of ORS for diarrhoea. Understanding the factors that influence decision making at household level, which has implications for implementing policies aimed at promoting healthcare practices and utilisation is important. This chapter examines and discusses the pattern of care-seeking behaviour with regard to attitude and practices and implications, first for diarrhoea and then for malaria control. Then the chapter concludes with a comparative analysis on the care-seeking behaviour between malaria and diarrhoea.

A series of binary logistic regression models were used to analyse factors that influence care practices and random factors from the models were used to investigate variability in behaviour between communities. Predictor variables that influence choice of treatment when a family member has diarrhoea include formal education, VHCs, mother's age, household size, household diarrhoea endemicity, and distance to the nearest health facility while predictors for malaria are existence of an HSA, whether the hospital belongs to CHAM or not, and distance to the nearest health facility. This implies the only common factor that determines choice of treatment between diarrhoea and malaria illnesses is distance to the nearest health facility. While the majority of families rush to the nearest hospital when a child has malaria, most of them administer ORS at home when a child has diarrhoea. Differences in predictor variables and case management for the two diseases highlight how differently malaria and diarrhoea sickness are regarded in the communities and reflects the type of health education awareness campaigns from health personnel and community health workers.

7.2 Care practices and implications for diarrhoea control: a two-level hierarchical modelling approach

7.2.1 Summary

This section examined the pattern of care-seeking behaviour and its associated risk factors for diarrhoea. After discarding missing and uncompleted data, information from 1,403 households nested within 33 communities were used for analysis in a series of two-level binary logistic regression models with Bayesian estimation.

The results show that families used oral rehydration solutions (ORS) when a child had diarrhoea (68%) in their families although their preferred mode of case management is taking diarrhoea patients to a health facility when they are perceived to have diarrhoea (67%). The most mentioned obstacle to reach their nearest health facility was long distance or transport costs (73%) and the most mentioned problem while at the hospital was long waiting time or absence of health workers (73%). The main predictor variables for actions take to treat a diarrhoea patients were maternal age, distance to the nearest health facility, existence of a village heath committee and a health surveillance assistant, school level, and relative wealth.

The results show that most households use ORS for the treatment of diarrhoea and that village health committees and health surveillance assistants play a significant role in this mode of treatment. Health education messages to the communities on use of ORS to ensure proper and prescribed handling are important. The role of HSAs and VHCs must be maximised by increasing their numbers and empowering them so that they are equipped and knowledgeable to disseminate relevant effective messages on diarrhoea and other diseases

7.2.2 Summary measures for outcome and predictor variables

Distribution of response variables used in this section is summarised in Table 7.1. When mothers were asked for normal actions they take when a family member has diarrhoea the majority of them (67%) said they visit a health facility and only 16% mentioned home administration of ORS previously obtained from hospital, 11% mentioned ORS bought from shops, market or from vendors and 7% said they administer other fluids at home. However, when asked for action that was taken on a child who most recently had diarrhoea in the family only 13% mentioned visiting a health facility, while the majority (68%) said they

administered either hospital or homemade ORS, 14% mentioned other fluids and 5.4% said they did nothing.

Table 7.1: Summary measures for response variables on diarrhoeal care seeking behaviour

Variable	N=1403	(%)
Problems to reach hospital		
Long distance or transport costs	1020	72.7
Too much work	91	6.5
Other	115	8.3
Problems at hospital		
Cost of medical services	174	12.4
Long waiting time or health workers don't show	1019	72.6
No drugs	496	35.4
Other	105	7.5
Time taken to treat a diarrhoea patient		
Same day	1190	84.8
One day	126	9.0
Two or more day	87	6.2
Action normally taken when a household member has diarrhoea		
Visits a health facility	940	67.0
Administers ORS obtained from health facility	220	15.7
Administers ORS bought from shop, market or vendors	151	10.8
Administers other fluids	92	6.6
Action that was taken when a child had last diarrhoea	*N=1059*	
Administered (ORS)	717	67.9
Administered other fluids	146	13.8
Visited health facility	136	12.9
None	57	5.4

When asked the time it takes for them to think of treating a diarrhoea patient in the family almost all women (85%) said the same day, while one in every ten women said after a day. And 6% of women said after two or more days.

On the problems they face to reach their nearest health facility, 73% of the respondents complained of long distance or transport costs, 7% mentioned too much work and 8.3% mentioned other problems. When asked about problems at the hospital 73% mentioned long

waiting time or none availability of health workers, 35% mentioned lack of drugs, 12% mentioned cost of medical services, and 8% mentioned other costs.

Table 7.2 shows descriptive statistics for predictor variables on diarrhoea knowledge. Slightly more than a third of families (35%) live within a kilometre from the nearest health facility, while two in every five families (42%) live 1 to 2 kilometres away and 23% live more than 2 kilometres away. The youngest respondent (mother) was 15 years old, the oldest was 89 years and on average the respondents were 35 years old.

Table 7.2: Summary measures for predictor variables on diarrhoeal care seeking behaviour

Variable	N=1403	(%)		
Categorical variables				
School				
None	558	39.8		
Primary	757	54.0		
At least Secondary	88	6.3		
Relative wealth				
Low	512	36.5		
Medium	458	32.6		
High	433	30.9		
Distance to nearest health facility				
<1 km	491	35.0		
1 to 2km	592	42.2		
> 2km	320	22.8		
HSA				
Yes	959	68.4		
No	444	31.6		
VHC				
Yes	944	67.3		
No	459	32.7		
Continuous variables	*mean*	*median*	*minimum*	*maximum*
Maternal age	35.00	31.00	15	89
Household diarrhoea endemicity	0.486	0.200	0.00	5.000
Household size	5.59	5	1	13

7.2.3 **Binary logistic regression results**

Multilevel binary logistic regression results of care-seeking behaviour when a member of the household is infected with diarrhoea are given in Table 7.3. School level, maternal age, household diarrhoea endemicity, and household size were the main predictor variables for those that visit a health facility when a member of their family has diarrhoea. Families with mothers that had attended primary or secondary school education were less likely to take diarrhoea patients health facilities when compared to those without any formal education [$\beta = -0.36;\ 95\%\ CI: -0.62,-0.09$; $\beta = -0.95;\ 95\%\ CI: -1.47,-0.43$ respectively]. Older mothers, large households, or families with high diarrhoea endemicity were less likely to take members of their households to a health facility when they had diarrhoea [$\beta = -0.01;\ 95\%\ CI: -0.02,0.00$; $\beta = -0.57;\ 95\%\ CI: -0.96,-0.17$; $\beta = -11;\ 95\%\ CI: -0.18,-0.03$ respectively].

Distance and household diarrhoea endemicity were the only two significant predictors for those that administered ORS obtained from a hospital when a member of their household had diarrhoea. Those that lived more than 2 kilometres away from the nearest health facility were less likely to use ORS than those that lived within a kilometre of a health facility [$\beta = -0.74;\ 95\%\ CI: -1.49,0.01;\ p = 0.053$]. High diarrhoea endemicity was positively related to the administration of ORS previously obtained from hospital [$\beta = 0.26;\ 95\%\ CI: 0.065,0.46$].

Use of ORS bought from shops or markets had two significant predictor variables: school level and relative wealth. Mothers who attended primary or secondary school were more likely to use bought ORS on their patients than mothers who had not attended any formal education [$\beta = 0.60;\ 95\%\ CI: 0.18,1.03$ and $\beta = 0.95;\ 95\%\ CI: 0.21,1.68$ respectively]. Households with relatively average wealth and the relatively wealthiest were more likely to use bought ORS than the poorest families in the communities [$\beta = 0.71;\ 95\%\ CI: 0.27,1.15$ and $\beta = 0.40;\ 95\%\ CI: -0.07,0.88;\ p = 0.097$ respectively]

Relative wealth, distance to the nearest hospital, maternal age, and household size were significant predictor variables for the administration of ‘other fluids’ or ‘solutions’ at home.

Table 7.3: Hierarchical binary logistic regression models to identify determinants of household care seeking behaviour when a family member has diarrhoea

Variables	Action after a member of household is infected with diarrhoea											
	Visit a health facility			Home use of ORS from hospital			Home use of bought ORS			Home use of solutions/fluids/other		
	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*
School												
None						(Reference group)						
Primary	-0.36	(-0.62,-0.09)	0.010**	-0.09	(-0.44,0.26)	0.603	0.60	(0.18,1.03)	0.005**	0.10	(-0.38,0.58)	0.674
Secondary	-0.95	(-1.47,-0.43)	0.000**	0.50	(-0.14,1.14)	0.124	0.95	(0.21,1.68)	0.012**	0.52	(-0.48,1.52)	0.308
Relative Wealth												
Low						(Reference group)						
middle	-0.10	(-0.38,0.19)	0.518	-0.14	(-0.51,0.23)	0.452	0.71	(0.27,1.15)	0.002**	-0.46	(-1.00,0.09)	0.100*
high	-0.07	(-0.37,0.23)	0.661	0.08	(-0.29,0.44)	0.686	0.40	(-0.07,0.88)	0.097*	-0.46	(-1.00,0.08)	0.098*
Any HSA?												
Yes						(Reference group)						
No	0.08	(-0.19,0.35)	0.565	-0.23	(-0.59,0.12)	0.202	0.15	(-0.26,0.55)	0.476	0.02	(-0.49,0.52)	0.947
Any VHC?												
Yes						(Reference group)						
no	-0.11	(-0.40,0.18)	0.452	0.01	(-0.38,0.39)	0.971	0.20	(-0.23,0.62)	0.362	-0.05	(-0.54,0.45)	0.855
Distance to nearest health facility												
<1 km						(Reference group)						
1 km to 2 km	-0.09	(-0.63,0.45)	0.740	-0.43	(-1.05,0.18)	0.168	0.40	(-0.23,1.04)	0.212	0.61	(0.01,1.20)	0.045**
>2 km	0.06	(-0.58,0.69)	0.863	-0.74	(-1.49,0.01)	0.053*	0.45	(-0.28,1.18)	0.230	0.55	(-0.13,1.22)	0.114
Maternal age	*-0.01*	*(-0.02,-0.00)*	*0.046***	*0.003*	*(-0.01,0.01)*	*0.617*	*0.00*	*(-0.01,0.01)*	*1.000*	*0.02*	*(-0.00,0.03)*	*0.061**
Household DRR	*-0.57*	*(-0.96,-0.17)*	*0.005***	*0.26*	*(0.065,0.46)*	*0.009***	*-0.03*	*(-0.28,0.23)*	*0.831*	*0.09*	*(-0.21,0.39)*	*0.574*
Household size	*-0.11*	*(-0.18,-0.03)*	*0.006***	*0.03*	*(-0.05,0.11)*	*0.435*	*0.02*	*(-0.08,0.11)*	*0.749*	*0.12*	*(0.01,0.23)*	*0.035***
*Age*HH size*	*0.09*	*(0.00,0.18)*	*0.039***									
Community effects (u_{0j})	0.28	(0.025,0.54)	0.031**	0.38	(-0.01,0.75)	0.053*	0.27	(-0.11,0.65)	0.161	0.053	(-0.11,0.22)	0.528

CI-Credible interval; HH-household; *—$p \leq 0.10$; **—$p \leq 0.05$

Households with relatively average wealth and the wealthiest were less likely to use other fluids or solutions when compared to very poor families [$\beta = -0.46;\ 95\%\ CI: -1.00, 0.09;\ p = 0.10$ and $\beta = -0.46;\ 95\%\ CI: -1.00, 0.08;\ p = 0.10$ respectively]. Families living 1 to 2 kilometres away from a hospital were more likely to use other fluids or solutions than those that lived within a kilometre from a hospital [$\beta = 0.61;\ 95\%\ CI: 0.01, 1.20$]. Similarly households that were more than 2 kilometres away from a hospital were marginally more likely to use other fluids or solutions than those within a kilometre from a hospital [$\beta = 0.55;\ 95\%\ CI: -0.13, 1.22;\ p = 0.11$]. Older mothers and large households were also more likely to use other fluids or solutions [$\beta = 0.02;\ 95\%\ CI: -0.00, 0.03;\ p = 0.06$ and $\beta = 0.12;\ 95\%\ CI: 0.01, 0.23$ respectively]

There was variation between communities for those that visited the hospital [$\sigma_u^2 = 0.28;\ 95\%\ CI: 0.025, 0.54$] and those that used ORS previously obtained from hospital [$\sigma_u^2 = 0.38;\ 95\%\ CI: -0.01, 0.75;\ p = 0.053$]. There was no statistical evidence at either 5% or 10% significance level of any variation between communities for those that administered bought ORS and those that administered other fluids or solutions.

Table 7.4 shows multilevel binary logistic regression results for care-seeking behaviour when a child had diarrhoea. Maternal age, distance to a hospital, and existence of a VHC were significant predictor variables for mothers who visited a health facility when a child had diarrhoea. Older mothers were unlikely to have visited a hospital [$\beta = -0.02;\ 95\%\ CI: -0.03, -0.00)$]. Mothers from communities that are more than 2 kilometres away from the nearest hospital were marginally likely to have visited a hospital [$\beta = 0.72;\ 95\%\ CI: -0.06, 1.50;\ p = 0.07$]. Similarly children from communities without a VHC were likely to have been taken to a hospital [$\beta = 0.41;\ 95\%\ CI: -0.05, 0.86;\ p = 0.08$].

Existence of a VHC, distance to hospital and household size were the predictor variables for those that administered ORS when a child had diarrhoea. Mothers in communities without a VHC were more unlikely to have administered ORS [$\beta = -0.35;\ 95\%\ CI: -0.68, -0.03$]. Similarly families living more than 2 kilometres away from the nearest hospital were unlikely

Table7. 4: Hierarchical binary logistic regression models to identify determinants of household care seeking behaviour when a child had diarrhoea

Variables	Action after a member of household is infected with diarrhoea											
	Visit a health facility			Home use of ORS			Home use of other fluids or solutions			Did nothing		
	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*	β	(95% CI)	*p-value*
School												
None						(Reference group)						
Primary	-0.36	(-0.79,0.07)	0.100*	0.21	(-0.09,0.51)	0.178	0.08	(-0.33,0.49)	0.708	-0.30	(-0.91,0.31)	0.333
Secondary	-0.58	(-1.51,0.35)	0.223	0.45	(-0.18,1.08)	0.162	0.20	(-0.63,1.04)	0.633	-2.33	(-4.96,0.31)	0.084*
Relative Wealth												
Low						(Reference group)						
middle	0.29	(-0.18,0.75)	0.230	-0.20	(-0.53,0.13)	0.246	0.23	(-0.20,0.65)	0.302	-0.25	(-0.93,0.43)	0.468
high	0.36	(-0.13,0.84)	0.148	-0.05	(-0.40,0.31)	0.801	-0.17	(-0.65,0.31)	0.496	-0.17	(-0.87,0.52)	0.626
Any HSA?												
Yes						(Reference group)						
No	0.17	(-0.26,0.60)	0.432	-0.15	(-0.46,0.16)	0.349	0.09	(-0.33,0.50)	0.685	0.02	(-0.60,0.64)	0.940
Any VHC?												
Yes						(Reference group)						
no	0.41	(-0.05,0.86)	0.081*	-0.35	(-0.68,-0.03)	0.035**	0.35	(-0.07,0.76)	0.104	-0.13	(-0.77,0.52)	0.706
Distance to nearest health facility												
<1 km						(Reference group)						
1 km to 2 km	0.29	(-0.43,1.00)	0.431	-0.30	(-0.77,0.18)	0.223	0.48	(-0.069,1.03)	0.086*	-0.55	(-1.26,0.16)	0.132
>2 km	0.72	(-0.06,1.50)	0.072*	-0.67	(-1.19,-0.14)	0.014**	0.75	(0.14,1.35)	0.015**	-0.71	(-1.56,0.15)	0.108
Maternal age	-0.02	(-0.03,-0.00)	0.018**	-0.01	(-0.02,0.00)	0.110	0.02	(0.00,0.03)	0.015**	0.02	(0.00,0.04)	0.046**
Household DRR	0.17	(-0.08,0.42)	0.188	-0.01	(-0.20,0.18)	0.927	-0.14	(-0.41,0.13)	0.324	-0.14	(-0.57,0.28)	0.513
Household size	-0.02	(-0.13,0.09)	0.689	0.07	(-0.01,0.14)	0.081*	-0.03	(-0.13,0.07)	0.505	-0.11	(-0.26,0.05)	0.178
Community effects (u_{0j})	0.35	(-0.11,0.82)	0.131	0.14	(-0.07,0.35)	0.205	0.09	(-0.14,0.32)	0.456	0.11	(-0.20,0.41)	0.498

CI-Credible intervals; HH-household; *—$p \leq 0.10$; **—$p \leq 0.05$

to have administered ORS at home [$\beta = -0.67$; 95% CI : $-1.19, -0.14$]. However, children from large households were marginally likely to have been given ORS at home when they had diarrhoea [$\beta = 0.07$; 95% CI : $-0.01, 0.14$; $p = 0.08$].

Mothers in communities 1 to 2 kilometres and more than 2 kilometres away from a hospital were more likely to have given their children other fluids or solutions when their children had diarrhoea [$\beta = 0.48$; 95% CI : $-0.07, 1.03$; $p = 0.09$ and $\beta = 0.75$; 95% CI : $0.14, 1.35$ respectively]. Older mothers were also more likely to have used other fluids or solutions to treat their diarrhoea children [$\beta = 0.02$; 95% CI : $0.00, 0.03$].

Formal education and maternal age were the only significant factors that influenced mothers' lack of action against diarrhoea when a child had diarrhoea. Mothers who attended at least a secondary school were marginally less likely to have done nothing [$\beta = -2.33$; 95% CI : $-4.96, 0.31$; $p = 0.08$] while older mothers were more likely to have done nothing when children in their households were sick [$\beta = 0.02$; 95% CI : $0.00, 0.04$].

There was no evidence of any community differences on visiting a hospital, using ORS, using other fluids or solutions and doing nothing when a child had diarrhoea.

7.2.4 **Discussion**

This section was developed to obtain pattern of variation and factors associated with care-seeking behaviour when a member of a household suffers from diarrhoea illness. Responses for a total of 1403 women were analysed in this study whose summary measures are included in table 7.1. Clearly there are discrepancies between reported action normally taken when a member of the family suffers from diarrhoea disease and the last action that was actually taken when a child suffered from diarrhoea illness. More women (67%) said they normally visit a hospital when a member of the family has contracted diarrhoea. Very few said they administer ORS or other fluids at home. However, the response changed drastically when asked to explain exactly what

they did last time a child had diarrhoea in the family. The majority (68%) administered ORS to the children while only13% actually visited the hospital and 14% administered other fluids or solutions at home. The most common and effective response to dehydration caused by diarrhoea in Malawi is the intake of oral rehydration therapy (ORT) which is promoted through commercially prepared ORS, facility-based provision of premixed ORS, and various home-made grain-based rehydration fluids [NSO, 2005]. ORS administered at home by families when a child or a member has diarrhoea is normally distributed free through health facilities or is distributed through VHCs and HSAs. When someone is perceived to have diarrhoea, families use their stock of ORS previously obtained from HSAs, VHCs or hospital i.e. ORS may be obtained from a health facility but its administration is done at home. This may explain the differences in responses between actions families normally take when one of their members has diarrhoea and actions actually taken when a child had diarrhoea. Overall, the statistics are not very different from national results of 2004 where 61% of the children with diarrhoea were given ORS [NSO, 2005].

There are more women that complained of long distance or transport costs (73%) in this study than the national averages (63%) of 2004 [NSO, 2005]. When compared to most parts of Malawi, Chikwawa is a low altitude area with bad roads or paths that are mostly impassable during the rainy seasons. Further, average reported distances are only perceptions of those interviewed and may be misleading. Actual distances may be much longer.

Complaints of long waiting time, health workers not showing, or shortage of drugs are common in Malawi. Chikwawa, as with other Districts in Malawi, suffers from a severe shortage of health workers at all levels, making access to treatment unreliable. In addition, the use of health facility staff for specific campaigns (e.g. measles vaccinations, cholera prevention etc.) often takes staff away from their general duties and can reduce their availability even further [Masangwi, 2007].

The regression results on actions normally taken when a family member has diarrhoea give interesting results. Mothers who attended at least primary school education were unlikely to take members of their family to a health facility for purposes of treating diarrhoea but, instead, were more likely to buy ORS. This confirms the observation

that educated people are equipped with skills and knowledge essential in understanding and using healthcare resources [Manda, 1999; Kandala et al., 2006; Pongou et al., 2006; Osumanu, 2007]. Those with at least formal basic education are able to appreciate the importance of prompt treatment of diarrhoea with ORS and would not wait until they visit a health centre to receive same prescription of ORS.

The relatively wealthier in the communities were more likely to purchase ORS and were less likely to use other fluids or solutions for the treatment of diarrhoea. Clearly and by implication the wealthier have disposable income which is used to purchase ORS instead of relying on handouts from health facilities.

Those that live long distances from hospitals were less likely to use hospital ORS and instead were more likely to use other fluids or solutions on their diarrhoea patients. Long distances mean less hospital visitations hence less opportunities in accessing healthcare resources including ORS.

Older mothers were less likely to visit health facilities but were more likely to use other fluids or solutions. Older mothers are more inclined to use traditional methods of treatment when a family member has diarrhoea. They may have problems of visiting health facilities due to advanced age. They may also rely on their years of experience in childcare and diarrhoea management hence less hospital visitations and more home-made fluids or solutions for treating diarrhoea. Similarly members from large households were less likely to visit hospitals but were more likely to be treated with home-made fluids or solutions. Large households may also have a lot of experience in the management of diarrhoea and may find it easier treating the disease using home-made resources. Large families mean high likelihood that the parents, especially the mother, are older people. This, therefore, may add on problems of transportation to the hospital which is normally through walking.

Household diarrhoea endemicity variable was included to examine if the magnitude of diarrhoea in the households has any bearing on care-seeking behaviour. High endemic households were less likely to visit hospitals but were more likely to use ORS previously obtained from a hospital. Frequent diarrhoea occurrences may compel

households to stock ORS from healthy facilities, which may later be used to treat diarrhoea cases at home.

Despite limitations of cross-sectional data, these results have an important role to play in policy and the promotion of health education messages in the district. While awareness campaigns are conducted in Chikwawa they are mostly done through hospital personnel [Masangwi 2007; Masangwi et al., 2008]. The observations in this study show that the involvement of HSAs and VHCs has a positive impact which can be utilised by increasing their numbers and empowering them so that they are equipped and knowledgeable to disseminate messages on diarrhoea and other diseases.

7.3 Care-seeking practices and implications for malaria control: Multilevel modelling approach

7.3.1 Summary

As has been explained in chapter 5, malaria is among the leading causes of mortality and morbidity in Southern Malawi. Although this is the case it remains a controllable and preventable disease. Among the important strategies for the control of malaria is early diagnosis and prompt treatment with hospital prescribed drugs and effective home management of malaria. These partly depend on understanding how households make their decisions to fight malaria. This section examines the pattern of care-seeking behaviour when a family member has malaria.

Using hierarchically built data and after ignoring missing and uncompleted data, 1400 data information nested within 33 communities was used for analysis in a series of two level logistic regression models with Bayesian estimation to determine predictors of care-seeking behaviour for malaria.

The results show that most families normally visit or use medication prescribed at health facilities both when an adult member (80%) and a child (86%) are perceived to have malaria. The main obstacle to reach their nearest health facility was long distance or transport costs (73%) and their two main problems at health facilities were long waiting time or absence of health workers (73%) and shortage of drugs (35%). Amongst the main predictor variables for choices of treatment for childhood malaria

was the absence of a health surveillance assistant for those that visited hospitals [$\beta = -0.56;\ 95\%\ CI: -0.86, -0.26$]; bought medication from open market [$\beta = 0.51;\ 95\%\ CI: 0.20, 0.82$]; and those that used other traditional methods or did nothing [$\beta = 0.70;\ 95\%\ CI: -0.04, 1.44; p = 0.06$].

The results have an important role to play in the control and prevention of malaria in Malawi. The results reveal the need for increased awareness about the dangers of buying drugs from non-medical and/or uncertified institutions by focusing attention in communalities that rely on shops, markets or vendors to purchase drugs for the treatment of their family members. They also show the important role community health workers are doing in the delivery of health systems such that their empowerment through rigorous and relevant health promotion programmes to update both their knowledge and their skills in communication and counselling are vital.

7.3.2 Descriptive statistics for outcome and predictor variables

Distribution of response variables used in this section is summarised in Table 7.5. Most households, 80%, either took their malaria patients to hospital or used hospital prescriptions for home treatment. Nearly one in every five households bought malaria drugs from shops, groceries, markets or vendors. Two in every hundred households used other traditional methods or did nothing. When a child was perceived to have malaria 86% of the households visited or used medication from health facilities, only 12% bought medication without prescription and two in every hundred used traditional methods or did nothing.

The majority of respondents, 73%, cited long distance or transport costs as the main obstacle to reach their nearest health facility. Very few mentioned too much work (7%) and other problems (6%). Similarly 73% mentioned long waiting time or absence of health workers as the main problem at the hospitals. However, slightly more than one third of the women cited lack of drugs while ten percent named cost of medical services as the main hitch at the hospitals. Seven percent of women mentioned other reasons.

Predictor variables are shown in Table 7.6. Seven in every ten households came from communities with an HSA while two thirds had a means of transport.

Table 7.5: Summary measures for response variables on malaria care-seeking behaviour (N=1400)

Variable	(%)
Action taken when an adult has malaria	
Visits or use medication from health facility	80.24
Use medication bought from shop/grocery/market/vendors	17.39
Use other remedies (i.e. traditional or do nothing)	2.36
Action taken when a child has malaria	
Visits or use medication from health facility	85.76
Use medication bought from shop/grocery/market/vendors	12.10
Use other remedies (i.e. traditional or do nothing)	2.15
Problems to reach hospital	
Long distance or transport costs	72.7
Too much work	6.5
Other	6.1
Problems at hospital	
Cost of medical services	12.2
Long waiting time or health workers don't show	72.7
No drugs	35.3
Other	6.6

Table 7.6: Summary measures for predictor variables included in the malaria care-seeking behaviour (N= 1400)

Variable	(%)
Distance to nearest health facility	
< 1 km	34.7
1 km - < 2km	42.4
≥ 2 km	22.8
Nearest hospital is CHAM	
No	86.0
Yes	14.0
Any HSA?	
Yes	68.2
No	31.8
Any form of transport? (bicycle, motorcycle, car, or oxcart)	
Yes	57.1
No	42.9

7.3.3 **Logistic regression results**

A series of binary logistic regression models to identify predictors of care seeking behaviour for adulthood and childhood malaria are given in Table 7.7 and Table 7.8 respectively. Distance to the nearest hospital, CHAM hospital, and existence of an HSA were the main significant factors that affect visitation to a health facility when an adult has malaria. When compared to those living within a kilometre, families living more than 2 kilometres away from nearest health facility were less likely to visit that facility when they had malaria [$\beta = -0.96;\ 95\%\ CI: -1.72,-0.20$] and instead opted to buy malaria drugs from shops, groceries, markets or from vendors [$\beta = 0.98;\ 95\%\ CI: 0.20,1.76$]. Similarly families living in a radius of more than 2 kilometres away from a health facility were less likely to take their children to hospital when they had malaria [$\beta = -0.88;\ 95\%\ CI: -1.52,-0.23$]; instead they chose to buy medication from open markets [$\beta = 0.92;\ 95\%\ CI: 0.18,1.65$ respectively].

Table 7.7: Hierarchical binary logistic regression model to identify determinants of care practices for adulthood malaria illness in Chikwawa, Malawi, 2007

Variables	Hospital treatment		Buy		Traditional or nothing	
	β	(95% CI)	β	(95% CI)	β	(95% CI)
Distance to nearest health facility						
< 1 km			(Reference group)			
1 - < 2 km	-0.38	(-1.06,0.31)	0.45	(-0.26,1.15)	-0.36	(-1.31,0.60)
≥ 2 Km	-0.96	(-1.72,-0.20)**	0.98	(0.20,1.76)**	0.28	-0.74,1.31)
Any HSA?						
Yes			(Reference group)			
No	-0.42	(-0.69,-0.13)**	0.35	(0.05,0.64)**	0.81	(0.09,1.52)**
CHAM hospital?						
No			(Reference group)			
Yes	-0.45	(-0.86,-0.04)**	0.61	(0.10,1.12)**	-0.05	(-1.18,1.08)
Any form of transport? (bicycle, motorcycle, car, or oxcart)						
No			(Reference group)			
Yes	-0.03	(-0.29,0.29)	0.15	(-0.12,0.12)	-0.67	(-1.39,1.39)*
Community effects						
$\sigma^2_{u_{0j}}$	0.50	(0.06,0.93)**	0.46	(0.04,0.88)**	0.15	(-0.38,0.68)

CI-Credible interval; *—$p \leq 0.10$; **—$p \leq 0.05$

Families in areas without an HSA were less likely to visit a hospital with adulthood malaria [$\beta = -0.42;\ 95\%\ CI: -0.69,-0.13$] but chose to either buy their medication from an open market [$\beta = 0.35;\ 95\%\ CI: 0.05,0.64$] or use traditional, other methods or do nothing [$\beta = 0.81;\ 95\%\ CI: 0.09,1.52$]. Similarly, families in communities without an HSA were less likely to take their children to a hospital [$\beta = -0.56;\ 95\%\ CI: -0.86,-0.26$]; instead they also preferred to either buy malaria drugs to treat the children [$\beta = 0.51;\ 95\%\ CI: 0.20,0.82$] or use traditional, other methods or do nothing [$\beta = 0.70;\ 95\%\ CI: -0.024,1.44\ \ p = 0.06$].

Table 7.8: Hierarchical binary logistic regression model to identify determinants of care practices for childhood malaria illness in Chikwawa, Malawi, 2007

Variables	Hospital treatment		Buy		Traditional or nothing	
	β	(95% CI)	β	(95% CI)	β	(95% CI)
Distance to nearest health facility						
< 1 km			(Reference group)			
1 - < 2 km	-0.50	(-1.08,0.08)*	0.58	(-0.06,1.21)*	-0.62	(-1.60,0.35)
≥ 2 Km	-0.88	(-1.52,-0.23)**	0.92	(0.18,1.65)**	-0.09	(-0.94,1.13)
Any HSA?						
Yes			(Reference group)			
No	-0.56	(-0.86,-0.26)**	0.51	(0.20,0.82)**	0.70	(-0.04,1.44)*
CHAM Hospital?						
Yes			(Reference group)			
No	-0.71	(-1.22,-0.21)**	0.86	(0.30,1.42)**	0.50	(-0.51,1.52)
Any form of transport? (bicycle, motorcycle, car, or oxcart)						
No			(Reference group)			
Yes	0.15	(-0.14,0.43)	-0.09	(-0.39,0.39)	-0.35	(-1.09,1.09)
Community effects						
$\sigma^2_{u_{0j}}$	0.25	(-0.02,0.52)*	0.33	(-0.01,0.67)*	0.08	(-0.23,0.39)

CI-Credible interval; *—$p \leq 0.10$; **—$p \leq 0.05$

Members from households close to CHAM hospitals were less likely to visit them when they had malaria [$\beta = -0.45;\ 95\%\ CI: -0.86,-0.04$]. Instead they preferred to buy drugs from an open market [$\beta = 0.61;\ 95\%\ CI: 0.10,1.12$]. Similarly members near CHAM hospitals were less likely to take their children there when they had

malaria [$\beta = -0.71;\ 95\%\ CI: -1.22,-0.21$] but chose to use drugs bought from an open market [$\beta = 0.86;\ 95\%\ CI: 0.30,1.42$].

Choice of treatment for adulthood malaria significantly varied between communities for those that visited hospitals [$\beta = 0.50;\ 95\%\ CI: 0.06,0.93$] and those that bought medication from an open market [$\beta = 0.46;\ 95\%\ CI: 0.04,0.88$]. However, these were only marginally significant for choice of treatment for childhood malaria [$\beta = 0.25;\ 95\%\ CI: -0.02,0.52;\ p < 0.07$ and $\beta = 0.33;\ 95\%\ \text{CI}: -0.01,0.67;\ p < 0.06$ respectively]. There was no evidence of any clustering within communities for those that chose to use other methods or do nothing for both adulthood and childhood malaria implying no significant differences between communities in those that used other methods or did nothing.

7.3.4 **Discussion**

A number of studies have looked at care-seeking behaviour for malaria both within Malawi and in neighbouring countries [Slutsker et al., 1994; Ruebush et al., 1995; Wirima, 1996; Oberlander and Elvardan, 2000; Holtz et al., 2003; Kazembe et al., 2007c]. While most of these studies analysed data from national surveys this paper analyses survey results within a district with the aim of determining the pattern and factors associated with care-seeking behaviour specific to a district. More than 80% of households either visited or used prescriptions from hospitals to treat malaria, less than 20% used malaria medication bought from shops or market and about 2% used other remedies. These rates are in contrast with other studies in Malawi [Holtz et al., 2003; Kazembe et al., 2007c] that calculated relatively lower rates for those visiting hospitals or using hospital medication and relatively higher rates for those that buy drugs. Currently the recommended first-line treatment for uncomplicated malaria at health facilities is artemisinin combination therapy (ACT), which was changed from sulfadoxine-pyrimethamine (SP) approved in 1993 by the Malawi Ministry of Health and Population. Regression results show that proximity to a health facility and availability of HSAs are important in accessing this drug. Those that leave furthest away from hospitals may not access hospital drugs and instead may be inclined to

purchase drugs from shops if they have the resources. The problem with buying drugs is that they are sold without prescription (i.e. without oral advice from medical experts). The only prescription is written down on the covers of drugs which may be meaningless to the illiterate communities in Chikwawa where almost half of the women interviewed had not attended any formal school. This may result in too many drugs being prescribed to patients, inadequate doses being prescribed, expired or fake drugs being purchased, or clinical guidelines not being followed or adhered to [WHO, 2004d]. More importantly is the fact that SP is still available for home and community use through general shops throughout Malawi. However, local scientific data has shown that the efficacies of SP and pharmaceutical tests of various SP formulations have deteriorated [Malenga et al., 2009]. This means SP is no longer a reliable weapon against malaria due to drug resistance.

Those that live far from government health facilities and do not have resources, cannot access free recommended malaria drugs and instead may chose to use traditional or other treatment methods or even do nothing. There are limited studies on the relationship between transport and healthcare utilisation in developing countries especially Africa. Studies that have been carried out have mainly looked at motorized transportation and healthcare utilization or programmes. Such studies have observed that distance and transportation are important in discussions of utilization [Aday and Anderersen, 1974; Joseph and Phillips, 1984; Ricketts and Savitz, 1994; Martin et al., 2002 all in Arcury et al., 2005] and that transportation is a big factor in accessing healthcare or involvement in health programmes [Arcury et al., 1998; Forti and Koerber, 2002; Gesler et al., 2001; Pasata et al., 1999 in all in Arcury et al., 2005]. Policy implications here include the need for carefully designed research to examine rural community transportation behaviour characteristics and their relationship to health care utilisation and programme in order to inform policy alternatives to address geographic barriers to health care in the rural communities. There is also need to increase awareness about the dangers of buying drugs from non-medical and/or uncertified institutions by focusing attention in communities that rely on shops, markets or vendors to purchase drugs for the treatment of their family members.

HSAs are responsible for teaching, monitoring, and even treating people in rural communities including their homes. In some cases they are responsible for running health care centres and community health posts and therefore directly involved in the distribution of healthcare resources including ACT. This is reflected in the regression results. Families that do not access an HSA were less likely to visit hospitals, and instead were more likely to purchase drugs. This shows that those in close contact with HSAs were more likely to visit hospitals or use hospital prescriptions and were unlikely to buy drugs from an open market. Policy implications of this result are that community health committees and workers are important in health delivery and there is the need for empowering them through rigorous and relevant health promotion programmes such as refresher courses to update both their knowledge and their skills in communication and counselling on the use and administration of drugs apart from their normal prevention strategies.

The regression results also show that families near CHAM hospitals were less likely to use hospitals and instead were more likely to buy malaria drugs from shops. Empirical data suggest that health-financing systems appear to influence patient behaviour for prescription and access to health care, especially some costly health care [Dong, 2003; Liu et al., 2006]. CHAM hospitals are private hospitals run on behalf of Christian organisations. They used to charge for their services including consultation and cost of medication. In relative terms this was more expensive for the poor communities who live off less than 1 US Dollar a day. However, CHAM now have a memorandum of understanding with the Government of Malawi to treat some patients for free and be reimbursed through the Essential Health Package (EHP), a minimum package of services to be provided free of charge at the point of delivery to all Malawians [Carlson, 2008]. This has increased the number of people now accessing CHAM facilities.

7.4 General Discussion on care practices for malaria and diarrhoea illnesses

The main findings of this chapter are that many families prefer home treatment of diarrhoea using ORS while using health facilities for treatment of malaria. Management of diarrhoea using ORS has been considered to be a simple intervention

and a convenient and important strategy for preventing dehydration and malnutrition especially in children [MICS, 2006]. Use of ORT was first introduced in Malawi to paediatric services in 1977 and to outpatient services in 1984. In 1990 a study reported decreased number of children admitted to paediatric wards with the diagnosis of diarrhoeal diseases and this was attributed to the introduction of ORS to outpatient services [Heymann et al, 1990]. While this is the case further efforts are needed to explore handling and management of ORS by mothers. Studies have shown that in spite of widespread awareness about ORS most mothers do not use it and do not know how to correctly prepare it for administration at home [Islam, 1996]. Mothers would, for example, use inadequate amount of water to prepare ORS. Mothers must be taught and be reminded to strictly adhere to guidelines for the preparation of ORS. Emphasis must also be put on hygiene practices in handling and preparing ORS. There is evidence that enteropathogenic bacteria survive and multiply in ORS and that ORS prepared in the developing countries is frequently contaminated with these pathogens [Black et al., 1981; Mathur and Reddy, 1983; Ahmad et al., 1985; Daniels et al., 1999].

In the case of malaria treatment, families use multiple sources of health care services as indicated in the results. However, their first reaction whenever a family member is perceived to have malaria is to treat the patient at home if they have malaria drugs in the home [Nyamongo, 2002]. This first reaction is normally based on problems associated with distance or transport costs to the nearest hospital as has been observed with reaction to CHAM hospitals in the results. Families would only go for treatment at health facilities when the illness gets worse. Thus perception on illness, distance and costs to the hospital, and persistence or magnitude of illness are the normal determining factors of treatment practices for malaria. However the additional factor of HSAs as a determining factor shows the positive work that these community workers are doing.

To achieve timely and effective care for both malaria and diarrhoea, families should be given information on home medication and must gain the capability to promptly recognize symptoms of complicated malaria and diarrhoea. Community education programs addressing practical methods of prevention and treatment are thus needed to

reduce the burden of these two diseases, especially in areas where health care is inaccessible.

CHAPTER 8

DISCUSSING AND CONCLUDING THE THESIS

8.1 Introduction

Malaria and diarrhoea constitute a major problem for Malawi. The country cannot afford to be complacent in the battle against these diseases, especially given the far-reaching and devastating effects that the two diseases have on the Malawi society. The question in relation to the scourge of malaria and diarrhoea is not whether we can control or even stop them but how much will-power (including political will-power) do we have as a nation to stop these two diseases. Malaria and diarrhoea can easily be prevented through simple and inexpensive methods. What is required is commitment and relevant education including relevant awareness campaigns. The people of Malawi must be made to understand the stakes involved in fighting the two diseases. This is the only way to guarantee that the necessary resources will be allocated in sufficient quantities and on time. All stakeholders, researchers, politicians, health professionals, the financial sector and the communities at large, must take the necessary bold steps forward.

The thesis has addressed the pattern of coexistence between malaria and diarrhoea in a rural district of Malawi. This chapter summarises the major findings obtained from the foregoing chapters, and draws some specific conclusions regarding the coexistence of malaria and diarrhoea. The objective of this study was to assess prevalence and to provide an understanding of factors related to knowledge, resources and care practices for the two diseases which can be used as a basis for policy formulation, planning and implementation

In spite of the shortfalls that come with the cross-sectional data, this study has shown that there is still high prevalence of both malaria and diarrhoea and that there are significant variations between communities and between households. The study has further shown that there is significant correlation between malaria and diarrhoea mainly in families and within individuals. With regards to factors on knowledge and resources, and care practices the study has shown that there are variations of these between communities and that community health workers as well as committees,

formal education, nearest health facility, distance to nearest hospital, relative wealth, community literacy levels and community density are important determinants.

This study makes a contribution in its application of the multilevel analysis techniques to examine community and household variations in the prevalence of coexisting infectious diseases in Malawi. The results from the Bayesian multilevel analysis give estimates of fixed as well as random factors which are more robust than what can be obtained from individual ordinary studies because they take into account community as well as household factors and in the process avoid underestimation of random effects.

8.2 Models

Chapter 4 presents a careful analysis and selection of the models involved in the analysis of coexistence of malaria and diarrhoea. Each model was chosen after various multilevel models were fitted and compared using deviance information criterion with Bayesian inference based on Markov Chain Monte Carlo simulation techniques in MLwiN 2.10 software and were finally certified after they satisfied model assumptions. Ignoring hierarchical structure due to household and community levels in the data could have, for example, meant an individual-level analysis in the prevalence data. This meant the variation between communities or between households could have been modelled by incorporating separate terms for each community and household. This would have been inefficient because the procedure would have involved estimating many times more coefficients than the multilevel procedure [Rabash et al., 2004]. It would have also been inadequate because it would not have treated communities or households as a random sample hence would not have provided useful quantification of the variation among communities or households. By focusing attention on the levels of hierarchy, this thesis has been able to explain where variations and effects in general are occurring. For example, the results have shown that variation in malaria and diarrhoea prevalence in Chikwawa occurs both at household and community levels although more variation is accounted for at household than at community level. This study has further shown that individual level analysis with no household or community terms cause standard errors of both fixed and random parameters to be underestimated. Thus ignoring clusters in

this study would have possibly led us to certify certain predictors significant when in fact that could have been ascribed to chance i.e. a wrong conclusions could have been made.

8.3 Malaria and diarrhoea prevalence

Chapter 5 gives a thorough examination of the core case study of this thesis and it proffers some answers to questions about the coexistence and the role of community and household factors in prevalence of malaria and diarrhoea. The results show that:

1. In spite of shortfalls of the cross-sectional study, malaria and diarrhoea prevalence are still very high in Chikwawa when compared to national averages;
2. there are shared and/or overlapping risk factors which may be influenced by various factors and conditions. Common risk factors include age of individuals, household size, pregnancy, and community endemicity for both malaria and diarrhoea. Specific significant factors that affect diarrhoea prevalence include formal education, distance to nearest river and drinking water source while a specific factor for malaria is sex of an individual;
3. children under the age of five and old people above 60 years of age were more vulnerable from both malaria and diarrhoea than all other age groups;
4. children under the age of five and people older than 40 years were more likely to suffer from malaria than all other age groups
5. expectant mothers were more likely to suffer from both malaria and diarrhoea than all other individuals in the communities;
6. individuals in high malaria endemic communities were more likely to suffer from both malaria and diarrhoea and similarly individuals in high diarrhoea endemic communities were more likely to suffer from malaria and diarrhoea;
7. there are significant variations in malaria and diarrhoea prevalence both at household and community levels; and
8. there are strong correlations between malaria and diarrhoea within communities, families and within individuals;
9. diarrhoea prevalence is low in the SCHI targeted areas

These observations have important implications towards integrated disease management of illnesses especially in children, pregnant women and the elderly. In

2000, all 189 Member States of the United Nations adopted the Millennium Declaration. The Declaration (Millennium Development Goals) set out a collective vision for the future which includes a world with less poverty, hunger and disease, greater survival, prospects for mothers and their infants, education for all, equal opportunities for women, an improved physical environment and a partnership between developed and developing countries to achieve these objectives. Within the framework of MDGs, WHO and UNICEF proposed an IMCI programme with the aim of focusing on the care of children under the age of five, not only in terms of their overall health status but also on the diseases that may occasionally affect them. IMCI has three objectives that include improving (i) the performance of health workers in the prevention and treatment of childhood diseases; (ii) the organization and operation of health services so they provide quality care; (iii) family and community care practices. Through the same MDGs framework WHO also established other massive programmes such as the Roll Back Malaria (RBM) meant to combat diseases such as malaria especially in children and pregnant women. These and other WHO and local government programmes [Ministry of Health; 2001, WHO, 2004b; NSO, 2005; UNICEF 2006] have been vehicles through which preventive and protective remedies have been provided. These include the distribution of ITNs to pregnant women, administration of IPTs to pregnant women and children, supply of ORS and water disinfectants (WaterGuard) to poor communities, drilling of boreholes and provision of other safe water sources, construction of improved sanitary facilities such as toilets and latrines, and many more.

However, judging from prevalence rates which have almost remained constant in Chikwawa, just like the rest of the country, these programmes seem to be making little progress. A possible explanation is that efforts to fight these diseases have been insufficient or not effective enough and focus may have been misplaced. This study has made the following observations to support this explanation:

1. International as well as local government policy documents and programmes have for sometime advocated for the fight against preventable diseases in children and women. However, the same risk groups keep on featuring proportionally high on vulnerability ladders in study after study and year in year out which may imply there is little progress in trying to address the plight of these vulnerable groups;

2. Most international and local policy documents and programmes keep on emphasizing the plight of children and women, especially pregnant women in the fight against preventable diseases [Ministry of Health; 2001, WHO, 2004; NSO, 2005; UNICEF 2006; Malawi Government, 2008]. This study has shown that old people are equally vulnerable, and even more vulnerable than all other age groups with regards to malaria illness, and yet they are hardly addressed in some of these important policy documents on disease control and prevention. In order to be more effective, strategies against malaria and diarrhoea must be based on in depth assessment and rational management of risk factors. They must be spelt out in comprehensive plans targeting priority high risk areas and vulnerable groups, integrated into relevant existing national, district, and community strategic plans and regularly updated
3. Although success has been reported in the use of ITNs [Lengeler C., 1998; Holtz, 2002; Phillips-Howard, 2003], this study found no impact of bed nets on the scourge of malaria especially in the vulnerable categories. Chapter 6 of this thesis has shown that mosquito net ratios decrease with increasing family size and yet Chapter 5 has shown that malaria infection decreases with household size. Chapter 5 has shown no relationship between malaria prevalence and bed net ownership. A possible explanation in the differences between this thesis and other studies that provide evidence of success in the use of bed nets is that those other studies were carried out in the context of clinical trials. It is very hard to reproduce such clinical trials on a large scale to cover all vulnerable communities in poor countries like Malawi due scarcity of financial and other necessary resources. Objective and practical evaluation coupled with genuine debate is needed on the current malaria prevention strategies. Many nations, including the United States, eradicated malaria-carrying mosquitoes using dichlorodiphenyltrichloroethane (DDT) and other environmental management programmes [Raloff, 2000; IRIN, 2006; Logomasini, 2007]. South Africa nearly did the same, but it stopped using DDT under political pressure. After halting DDT use, malaria cases rose [Attaran and Maharaj, 2000]. However, after South Africa resumed DDT use recently, malaria cases have dropped by about 85%. A study by Curtis and Mnzava [2000] observed that there are other methods such as residual house spraying with DDT that are more effective in killing mosquitoes than use of ITNs. Clearly, a case of DDT use shows that sufficient and effective

methods are available and they are purposely being avoided due to alleged environmental consequences.

4. Correlation between malaria and diarrhoea underscores the importance of strengthening integrated management of diseases as is espoused by the objectives of IMCI. However, implementation of programmes such as the IMCI aimed at integrated approach to fighting infectious diseases is facing problems due to shortage of staff, unskilled community health workers who are sometimes substituted for qualified medical staff, and (iii) shortage of resources [Ministry of Health & Population 2002]. The implementation of IMCI has mostly emphasised on treatment of cases at health facilities as opposed to family and community care practices. Further, implementation of IMCI is supposed to be in phases based on the WHO policy [WHO, 1999]. This may leave gaps in production and education on proper disease prevention and control programmes. A good example is where Bryce and Victoria [2005] observed several problems in the implementation of IMCI in a number of countries due to difficulties in expanding IMCI at national level while maintaining adequate intervention quality. It was observed that guidelines on delivering interventions at family and community levels were slow to materialize as a result essential interventions were slow to be executed [Bryce et al 2005, Forsberg, 2007].
5. Variation in prevalence of both malaria and diarrhoea at household and community levels means more and direct attention is needed within communities and in families. For this to be successful the country needs community workers in every community to directly deal with the communities as well as families in the prevention of diseases. However, shortage of qualified health personnel in most health facilities means these community health workers (HSAs), who are not adequately trained in medicine and are few in numbers, are involved in healthcare delivery at these facilities, thus taking them away from their core preventive responsibilities in the communities [Ministry of Health & Population 2002; Record and Mohiddin, 2006]. Further, poor remuneration packages for these community workers [World Bank, 2004] encourages most of them to concentrate on other activities from which they can supplement on their meagre salaries, again taking most of their time away from healthcare preventive services.

6. Diarrhoea prevalence in the targeted areas by SCHI was relatively low indicating some of the intervention efforts by the SCHI were working and these could have made a difference if they were applied to more communities in Chikwawa

8.4 Knowledge and resource distribution

8.4.1 Knowledge

Chapter 6 gives an analysis of factors that influence knowledge and resource distribution for malaria and diarrhoea. Section 6.2 and Section 6.4 presents results of knowledge on the two diseases by mothers. The results on knowledge of diarrhoea and malaria show that:

1. mothers are familiar with mostly one symptom of diarrhoea, watery stools, and one symptom of malaria, fever;
2. a maximum of only half of the mothers could mention any of the routes through which diarrhoea would be transmitted and that the majority of mothers were aware that malaria is transmitted through mosquito vectors;
3. a maximum of only a quarter of mothers could mention any of the preventative methods against both diarrhoea and malaria except the use of bed nets to avoid malaria which was mentioned by more than two thirds of the women;
4. there are common or shared factors that influence overall mothers knowledge both on diarrhoea and malaria and these are education of the mother, nearest health facility, age of the mother and existence of a health surveillance assistant;
5. there is significant variation both on diarrhoea and malaria knowledge between communities, thus community to which a mother belongs is also a factor in knowledge of the two diseases.

The assumption in this section is that improving matriarchal knowledge on malaria and diarrhoea symptoms, aetiology, and prevention measures can result in better understanding of how to control the two diseases [Bertrand and Walmus, 1983]. Improving malarial and diarrhoeal control in rural communities will require more than effective clinical care, improved medical facilities or well articulated programmes. Mothers' knowledge, perception, attitudes, and behaviour need 'to be developed' to improve malaria and diarrhoea control. Despite existent government health promotion campaign policies aimed at reducing malaria and diarrhoea this study has shown that

most mothers in Chikwawa are not aware of clinical symptoms and how these diseases can be prevented. The study, therefore, proposes that health promotion campaigns should be strengthened for mothers and to provide refresher courses for health-care providers both at health facilities and in the communities emphasizing general awareness in areas regarding aetiology, causes, symptoms and prevention of malaria and diarrhoea apart from education messages on risks and treatments and prompt reporting at health facilities. Although there may be concern that less literate mothers may have problems in assimilating health messages on aetiology, symptoms and prevention measures of diarrhoea and malaria this study has shown that after controlling for formal education, mothers who were in contact with health surveillance assistants were more likely to recall more malaria and diarrhoeal symptoms and prevention measures more than those who were not. This shows that mothers can still understand education messages from HSAs in spite of their literacy levels. What is needed is to remodel techniques in imparting such health promotion messages to equitably reach all families and communities.

8.4.2 Resource distribution

Particular challenges in the fight against diseases are resources and costs that may be involved. Some of the resources emphasized for the control of diarrhoea are safe drinking water and improved sanitation while bed nets are popular for the control of malaria. Section 6.3 and Section 6.4 present results on factors that are related to the distribution of drinking water sources, sanitation and bed-nets in the communities. The results show that:

1. the majority of households have safe water sources while only 40% of the families have their own toilet facility;
2. most families do not have a toilet due to bad (sandy) soils;
3. the factors related to availability of latrines are existence of an HSA, existence of an NGO, family relative wealth, community literacy levels and community density; while factors that are related to safe water drinking sources are community literacy levels and community density. On the other hand factors that influenced ownership of bed nets in households include mothers education, household relative wealth, and household size;

4. there is no significant variation of toilet ownership between communities but there is variation in safe water provision, and bed-net distribution implying that community to which a family belongs is a factor in the distribution of safe water sources and bed-net distribution but is not a factor in latrine and toilet/latrine ownership.
5. That targeted interventions like those being practiced by the SCHI are effective in reaching the intended targets

This study has shown that women use ORS to treat diarrhoea and most households have access to safe drinking water such as boreholes and piped water. However, only a small proportion has toilets or latrines and very few mention other equally important preventive measures such as use of WaterGuard (disinfectants) for the treatment of water after collection. Similarly the study has shown that use of bed nets is the only popular known and used method for the fight against malaria. Other preventive methods such as the use of insecticides and environmental management techniques against mosquito vectors are rarely mentioned in the survey. The thesis has also shown that there is variation in use of ORS and availability of bed nets, safe water sources, and toilets or latrines between communities implying inequity exists in the distribution of these resources among communities.

Although a large proportion of families in Chikwawa are reported to have access to improved water sources, the majority do not have access to improved sanitation. Lack of toilets or latrines may lead to faecal contamination of improved water sources thus retrogressing gains realised in the provision of such improved water sources thereby aggravating the problem of diarrhoea. This thesis has shown that the majority of people in rural areas use boreholes and normally a single borehole is available to an entire village or even two or more villages. Boreholes and protected wells can still be contaminated with faeces thereby delivering microbial unsafe water [WHO, 2009]. Although most households claim to have access to improved water sources they may still be tempted to use other sources of unsafe water such as streams and ponds due to overcrowding at available improved water sources. Indiscriminate littering of faecal matter by human beings due to low coverage of toilets or latrines means these are collected by surface run-off into such streams and ponds during rainy seasons resulting into even bigger problems such as choler epidemics.

Chapter 6 has also argued that small children may come into contact with indiscriminately dropped excreta both with their hands and feet when playing outdoors and this can be passed on to stored water in the house that may have been collected from an improved water source risking contamination by various pathogenic viruses, bacteria and parasites associated with faecal wastes. This happens mostly if safe water is not or is poorly covered or when family members (especially children) playfully or accidentally dip their unwashed hands into the water. Ensuring that there are safe water sources and improved sanitation plus good hygiene practices is of paramount importance in controlling diarrhoeal infection.

Since the common reason given for lack of toilet or latrine facilities is bad (sandy) soils that result in the collapse of most toilet/latrine structures, efforts should be put in identifying easy and low-cost techniques in the construction of toilets/latrines that can survive in sandy soils of Chikwawa.

Although this thesis found no relationship between bed net and malaria prevalence, other studies have observed that use of bed nets with combined approach of social marketing and mass free or subsidised distribution of insecticide treated nets reduced child mortality in Malawi [Mathanga et al., 2005], Tanzania [Armstrong-Schellenberg et al.,, 2001] and Kenya [Fegan et al., 2007]. Use of bed nets, therefore, remains an important ant element in the fight against malaria. This study has observed that use of bed nets is skewed in favour of the relatively wealthier and small households in the communities implying current distribution strategies for bed nets in Chikwawa are not addressing the needs of the poorest and do not favour large households. The study has also observed high coverage rates in areas under the SCHI implying targeted interventions are effective in dealing with more vulnerable communities. The study, therefore proposes that increasing access to bed nets by the poor and large families will require distribution techniques that deliberately target the poorest of the poor and addresses net family ratios apart from targeting existing vulnerable groups comprising children and pregnant women.

8.5 Care practices

Chapter 7 analyses factors that affect care behaviour practices towards malaria and diarrhoea. The chapter has shown that:

1. mothers normally administer ORS when a child has diarrhoea although most of them indicated that they visit a health facility when a member of their family is suffering from diarrhoea. However, the majority of women indicated that they visit a health facility when any member of their family has malaria;
2. the problem they face on their way to a health facility is long distance or transport costs;
3. the problems they face at health facilities are long waiting time or absence of health workers and shortage of drugs;
4. the only common factor that affects their care practices for both malaria and diarrhoea is distance to hospital;
5. specific factors that affect care practices for diarrhoea are mother's education, family wealth, mother's age, household diarrhoea endemicity, and household size while specific factors for malaria care practices are existence of an HSA, whether the nearest hospital is CHAM, whether the family has any form of transport;
6. treatment of malaria either at hospital or at home using bought drugs varies across communities and treatment of diarrhoea only varies with regard to visits to the hospital when a member of the family is ill.

The results clearly show that significant number of families promote the use of ORS and rush to the hospital for case management of diarrhoea and malaria respectively. While this is the case, it is important to note that the administration of ORS has been shown to be associated with several problems in families due problems in understanding instructions and measurement of ORS as recommended by WHO [Touchette, 1990; Forsberg, 2007] and that most families will visit hospitals when malaria illness is persistent, at critical stage or when other options such as home case-management with either purchased drugs or traditional methods have failed [Baume et al., 2000; Winstanley et al., 2004; WHO, 2005e]. More research is needed in Chikwawa to assess handling and preparation of ORS and to observe behaviour when

there is malaria illness at household level and its pattern in the communities with the aim of understanding factors involved when there is an illness.

With regard to visits to health facilities it is important to note that:

1. other studies have observed that those who visit health facilities sometimes do so (i) as a last resort after they have tried home treatment, (ii) after persistence in illness, or (iii) after illness is already at a serious stage [Nyamongo, 2002; Thera et al., 2000];
2. treatment-seeking behaviour is related to cultural beliefs about the cause and cure of illness [Thera, 2006];
3. this study has documented people's complaint about shortages or absence of drugs and health personnel at health facilities due to weak health facilities and lack of equipment (and drugs) and qualified staff
4. this study has documented people's complaints about transport and distance problems to the hospitals;

There is no single specific solution to these problems. What is needed is a comprehensive concept addressing several dimensions, ranging from the intensification of health education messages on what constitutes prompt treatment and the concepts of malaria and diarrhoea illnesses, availability of healthcare workers both in the communities and at health facilities, affordability to accessibility of healthcare resources and services, acceptability and quality of care.

8.6 Limitations of the thesis

Finally this thesis is not without its limitations. Due to unavailability of place indicators that continuously consider the space around the individual's place of residence or household's location this thesis has used multilevel modelling which involves the fragmentation of the space into areas when formulating the correlation structure. This means some neighbourhood effects of malaria and diarrhoea prevelance that exist due to neareness between two communities, for example, may not be accounted for and may only affect community variability. Spatial hierarchical models would be the best alternative to multilevels models.

In Section 3.5 of Chapter 3 it was reported that four communities were deliberately over-sampled at the request of the sponsors. It was also reported that sample size was determined based on results of various simulation techniques as reported in literature. The sample was estimated based on a group of at least 30 communities with at least 30 households in them. These scenarios produced large sample estimates of 1,410 households and 6,847 individuals. However, it is known that null hypothesis significant testing (NHST) and p-values depend on sample size such that a result may be significant without necessarily being important or substantively significant [Thompson, 1998; Wright, 2003; Young and Bolton, 2009]. Although this thesis carefully analysed the parameters by observing their statistical significance and DIC values, it is important to focus on substantive significance on policy recommendations than merely making judgements based on statistical significance alone.

This thesis has used the concepts of Bayesian estimation and credible intervals. Based on literature on Bayesian approach[Bernardo and Smith, 1994; Congdon, 2001; Kadane and Wolfson, 1996; Lee, 1997; O'Hagan, 1994; 1998; and Wright and Ayton, 1994] Bayesian methods have the following benefits: (i) they provide more intuitive and meaningful inferences i.e. they provide more direct intuitive and meaningful statements of the probability that the hypothesis is true based on the available data; (ii) they answer more complex questions cleanly and exactly; (iii) they make use of all available information that represent all the available knowledge apart from the data themselves; (iv) posterior distributions are explicitly derived for unknown parameters based on the available evidence which is a crucial component of rational, evidence-based decision-making.

Data was based on retrospective reporting by women in each household. This may have created biases due to incomplete responses, and unrepresentative individual data. Furthermore, only information from households with a matriarchal figure was available which may be a source of bias. During the survey mothers were not given a precise definition of what constitutes an episode of childhood diarrhoea or malaria. Therefore, questions relied on the mother's perception of the two diseases other than clinical or actual definitions. This may have created variations among different

households and villages because perception of an illness episode is not the same across different groups of people as has also been shown by this thesis. To reduce the effect of these methodological limitations, questionnaires from each enumerator were carefully audited after each day's survey and the data was screened to ensure consistency of approach to questioning and responses and to determine if the data conformed to expected patterns.

The survey required mothers to recall information of up to 8 months from January to September 2007 of malaria and diarrhoea prevalence with the aim of capturing data that included the peak of the rain season when malaria and diarrhoeal morbidity are at their highest. There was a risk that some malaria and diarrhoeal episodes would not be reported due to the length of the recall period, particularly when the illness was not extreme. However, since the aim of the thesis was mostly to understand factors that influence malaria and diarrhoeal prevalence at individual, household and community levels of Chikwawa, this risk was overlooked on the basis that the information obtained would outweigh the discrepancies in forgotten malaria and diarrhoeal episodes. Moreover, other studies have concluded that more easily observed symptoms are less likely to suffer from selective reporting [Kazembe et al., 2009]. Recall bias is reported to be related to level of mother's education, with more educated mothers most likely to remember and distinguish symptoms for most illnesses, therefore controlling for mother's education in the analysis may have captured a large part of the self-selective nature of reporting [Filmer, 2005; Kazembe et al., 2009]

This thesis restricted itself to coexistence between malaria and diarrhoea. However, coexistence of diseases goes beyond malaria and diarrhoea alone. For a country like Malawi with a high prevalence of HIV the relationship observed between malaria and diarrhoea may be due to the fact that symptoms of HIV include diarrhoea and symptoms of malaria such as fever. HIV prevalence, therefore, remains a potential risk factor which may explain some variation in malaria and diarrhoeal prevalence. Another potential disease for coexistence with malaria, diarrhoea, and HIV/AIDS is pneumonia. Pneumonia is known to be a common opportunistic infection associated with HIV infection and one of its symptoms is fever which is also a symptom for malaria.

In this thesis, I have analysed community distribution of and factors that influence existence of resources such as access to safe water, sanitation, and bed nets. However, the thesis did not go deeper to explore risk factors associated with behavioural or hygiene practices within communities and households. Earlier studies have shown that behavioural practices related to post-collection of water and child stool disposal have affected the prevalence of diarrhoea [Morse, 2006]. Similarly practices related to bed net use have affected malaria morbidity [Abdulla, 2000]. More analysis outside this thesis is, therefore, required to examine such behaviours to give a more solid picture of the two diseases in Chikwawa.

8.7 Concluding remarks

Malaria and diarrhoeal diseases constitute and continue to be a major public health problem in Malawi and Chikwawa in particular. Although these diseases have been eradicated from nature or almost wiped out in America, Europe, and other Asian countries, they persist in Malawi and other sub-Saharan countries with little or no hope of getting them under control. In addition, the emergency of other diseases such as HIV/AIDS are making the situation even more complicated. Malaria and diarrhoea take an enormous physical toll on rural communities of Chikwawa and cause significant economic losses both in the families, the Lower Shire Valley and the whole country. It is, therefore, a matter of public health and economic interest, to invest in and organise coordinated, more effective and decisive strategies to fight malaria and diarrhoea together with other coexisting diseases.

In order to be more effective and decisive, joint strategies against malaria and diarrhoeal diseases must be based on in-depth assessment and rational management of risk factors. They must be spelt out in comprehensive plans targeting priority high-risk areas, vulnerable communities and families. In particular: (i) all partners such as NGOs, government health officials, and faith organisations involved in malaria and diarrhoea control should coordinate their plans and activities to avoid duplication and to ensure equitable and maximum coverage of their activities to the vulnerable communities; (ii) community committees and community health workers such as HSAs should be used in observing any emerging patterns in diarrhoea and

malaria and report the same to district health officials so that any major signs are dealt with before the situation can escalate; (iii) direct observational and longitudinal studies should be intensified to better understand interactions of different risk factors between coexisting diseases so that there is a better appreciation and understanding of the diseases. In particular, mapping of risk areas in the whole Chikwawa district will allow priorities to be identified and plans to be better focused; (iv) efficient and effective educational campaigns; refresher courses for community committees and health workers and health-care providers; identification of priorities, should be intensified in the communities to ensure maximum awareness by both healthcare providers and receivers; and (v) all plans and activities against malaria and diarrhoea should be integrated into poverty reduction strategic plans as a key element to affordability and to realise the objectives of the MDGs.

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Appendix 3A

SCOTLAND – CHIKWAWA HEALTH INITIATIVE BASELINE QUESTIONNAIRE 2007

IDENTIFYING INFORMATION (ID) SECTION

N^{o}	Questions, Instructions & Filters	Responses	Go To
ID01	Questionnaire ID NUMBER (***LEAVE BLANK)***	/___/___/___/___/___/___/	
ID02	Interviewer ID	/___/___/	
ID03	Date Month Year:	/___/___/ /___/___/ /___/___/	
ID04	District ID Chikwawa=1, Nsanje=2, Mwanza=3, Blantyre=4, Thyolo=5	/___/___/	
ID05	Traditional Authority ID	/___/___/	
ID06	Village ID	/___/___/	
ID07	City/Urban/Peri - urban Area/Rural [City=1, Urban=2, Peri-urban=3, Rural=4]	/___/	
ID08	***Ask to speak to the mother in the household.*** *"Kodi amayi alipo?" Yes = 1, No = 2* Ask to Interview the mother if available	/___/	___
ID09	Respondent's language Mang'anja=1, Sena=2, Nyanja=3, Lomwe=4, Chichewa=5, Ngoni=6, Other (specify)=7	/___/	___
ID10	**HOUSEHOLD NUMBER** (Only applicable to Namila, Sekeni, Mwanayaya and Mwalija)	/___/___/___/___/___/	
ID11	**IDENTIFICATION AREA** (Only applicable to Namila, Sekeni, Mwanayaya and Mwalija)	/___/___/___/___/___/	

Introductory paragraph

I am _____ from _____. The hospital would like to know about health issues in your village. However, in order for us to know what the health situation is now, we would like to collect some data for your village. So feel free to give me as much information as possible. I would like to assure you that your responses will be kept confidential. I have a questionnaire to guide our discussion, if it is alright with you can I ask you some questions?

NB: Proceed with interview only after getting consent from the respondent

HOUSEHOLD INFORMATION (HH) SECTION

USUAL RESIDENTS + VISITORS		RELATIONSHIP TO THE HEAD OF HOUSEHOLD	SEX	RESIDENCE		AGE
Names should start with father, mother, their children, relatives, and others. This must include the deceased that lived in the house the last 2 years		What is the relationship to the head of household[*****]		Does he/she usually live here?	Did he stay here last night?	How old is he/she? (in years)[†††††]
HH001		**HH002**	**HH003**	**HH004**	**HH005**	**HH006**
ID	Name		M F	Yes No	Yes No	IN YEARS
(P1) Person 1		/__/__/	1 2	1 2	1 2	/__/__/
(P2) Person 2		/__/__/	1 2	1 2	1 2	/__/__/
(P3) Person 3		/__/__/	1 2	1 2	1 2	/__/__/
(P4) Person 4		/__/__/	1 2	1 2	1 2	/__/__/
(P5) Person 5		/__/__/	1 2	1 2	1 2	/__/__/
(P6) Person 6		/__/__/	1 2	1 2	1 2	/__/__/
(P7) Person 7		/__/__/	1 2	1 2	1 2	/__/__/
(P8) Person 8		/__/__/	1 2	1 2	1 2	/__/__/
(P9) Person 9		/__/__/	1 2	1 2	1 2	/__/__/
(P10) Person 10		/__/__/	1 2	1 2	1 2	/__/__/
(P11) Person 11		/__/__/	1 2	1 2	1 2	/__/__/

[*****] **For question HH002** - RELATIONSHIP TO HEAD OF HOUSEHOLD: 01=head of household; 02=wife or husband; 03=son or daughter; 04=son or daughter-in-law; 05=grandchild; 06=parent; 07=parent-in-law; 08=brother or sister; 09=brother or sister in-law; 10=adopted/foster/step child; 11=not related; 12=other

[†††††] Put '**00**' for children less than 1 year old (infants)

RESIDENTS		MALARIA	AGE <5 YEARS	BETWEEN 5 & 15 YEARS		ABOVE 15 YEARS	
Same persons as previous page		How many times has he been sick with malaria since January this year	Was it so serious that one of the parents could not do normal work?	Was it so serious that one of the parents could not do normal work?	Was it so serious that he/she could not do normal work?	Was it so serious that another adult could not do normal work?	Was it so serious that he/she could not do normal work
HH001		**HH007**	**HH008**	**HH009**	**HH010**	**HH011**	**HH012**
ID	Name	NUMBER OF TIMES	Yes No	Yes No	Yes No	Yes No	Yes No
Person 1		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 2		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 3		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 4		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 5		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 6		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 7		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 8		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 9		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 10		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 11		/__/__/	1 2	1 2	1 2	1 2	1 2

RESIDENTS		**DIARRHOEA**	**AGE <5 YEARS**	**BETWEEN 5 & 15 YEARS**		**ABOVE 15 YEARS**	
Same persons as previous page		How many times has he been sick with diarrhoea since January this year?	Was it so serious that one of the parents could not do normal work?	Was it so serious that one of the parents could not do normal work?	Was it so serious that he/she could not do normal work?	Was it so serious that another adult could not do normal work?	Was it so serious that he/she could not do normal work
HH001		**HH013**	**HH014**	**HH015**	**HH016**	**HH017**	**HH018**
ID	Name		M F	Yes No	Yes No	Yes No	Yes No
Person 1		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 2		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 3		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 4		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 5		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 6		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 7		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 8		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 9		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 10		/__/__/	1 2	1 2	1 2	1 2	1 2
Person 11		/__/__/	1 2	1 2	1 2	1 2	1 2

RESIDENTS + VISITORS		EDUCATION	STATUS OF PERSON	DEAD PERSON	
		What is the highest level of education attended‡‡‡‡‡	Is he/she still alive?	If dead, at what age did he/she die?	From what disease did he/she die§§§§§
HH001		**HH025**	**HH026**	**HH027**	**HH028**
ID	Name		Yes No	IN YEARS	Yes No
Person 1		/__/__/	1 2	/__/__/	/__/__/
Person 2		/__/__/	1 2	/__/__/	/__/__/
Person 3		/__/__/	1 2	/__/__/	/__/__/
Person 4		/__/__/	1 2	/__/__/	/__/__/
Person 5		/__/__/	1 2	/__/__/	/__/__/
Person 6		/__/__/	1 2	/__/__/	/__/__/
Person 7		/__/__/	1 2	/__/__/	/__/__/
Person 8		/__/__/	1 2	/__/__/	/__/__/
Person 9		/__/__/	1 2	/__/__/	/__/__/
Person 10		/__/__/	1 2	/__/__/	/__/__/
Person 11		/__/__/	1 2	/__/__/	/__/__/

‡‡‡‡‡ For question HH025 - EDUCATION LEVELS: 01=No Education; 02=Primary Education, 03=Secondary Education, 04=Tertiary Education.

§§§§§ For question HH028 - DISEASE CODES: 01=malaria, 02=diarrhoea, 03=TB, 04=HIV/AIDS, 05=respiratory infection, 06=pneumonia, 07=accident, 08=malnutrition, 09=dehydration, 10=bewitched, 11=other(specify)

		PARENTAL SURVIVORSHIP AND RESIDENCE					
		Is the biological mother alive?	If alive, does she live in this household?	Write the number of the person who is the biological mother	Is the biological father alive?	If alive, does he live in this household?	Write the number of the person who is the biological father
HH001		**HH029**	**HH030**	**HH031**	**HH032**	**HH033**	**HH034**
ID	Name	Yes No	Yes No		Yes No	Yes No	Yes No
Person 1		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 2		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 3		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 4		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 5		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 6		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 7		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 8		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 9		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 10		1 2	1 2	/__/__/	1 2	1 2	/__/__/
Person 11		1 2	1 2	/__/__/	1 2	1 2	/__/__/

RESPONDENTS SOCIO ECONOMIC DATA (SOC) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES		GO TO
SOC001	Kodi ndinu a mpingo wanji? *What is your religious denomination*	Anglican Baptist Catholic Church of Christ New Apostolic Pentecostal Presbyterian Salvation Army Seventh Day Adventist Jehovah's Witness/Watch Tower Hindu Muslim None Other (Specify)_____	1 2 3 4 5 6 7 8 9 10 11 12 13 14	
SOC002	Kodi woyang'anira pakhomo pano amapanga kwenikweni chiyani kuti apeze ndalama? *What main job does the head of the household do?*	Farmer Fisherman Sugarcane plantations (Illovo) Vendor Civil Service Private Company Tea Estates In a retail shop Unemployed Businessman Other (specify)_____	1 2 3 4 5 6 7 8 9 10 11	
SOC003	Kodi mai woyang'anira pakhomo pano amapanga kwenikweni chiyani kuti athandize kupeza ndalama? *What main job does the responsible woman in the household do?*	Farmer Fisherman Sugarcane plantations (Illovo) Vendor Civil Service Private Company Tea Estates In a retail shop Unemployed Businessman Other (specify)_____	1 2 3 4 5 6 7 8 9 10 11	
SOC004	Kodi ndi chiyani chimene mumagwiritsa ntchito kawirikawiri pounikira? *What is the main source of lighting in you home?*	Electricity Kerosene/Paraffin Lamp Candle Fuelwood Other (Specify)_____	1 2 3 4 5	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
SOC005	Kodi mauthenga a zaumoyo mumawamvera kuchokelara kuti? *Where do you get health messages?* **(CIRCLE ALL RELEVANT ANSWERS)**		No	Yes	
		a) Health personnel----------	0	1	
		b) HAS----------	0	1	
		c) VHC----------	0	1	
		d) TBA----------	0	1	
		e) Traditional leaders ----------	0	1	
		f) Radio----------	0	1	
		g) Newspapers----------	0	1	
		h) Drama----------	0	1	
		i) Television----------	0	1	
		j) School----------	0	1	
		k) No where----------	0	1	
		l) Other(specify)_____	0	1	
SOC006	Kodi mpingo wanu umatengapo mbali yanji pa za mauthenga a zaumoyo?		No	Yes	
		a) Civic education through sermons in church----------	0	1	
		b) Health (civic) education outside normal church sermons----------	0	1	
		c) other (specify)_____	0	1	
		d) don't know----------	0	1	
SOC007	Kodi ndi matenda ati omwe amene amakuopyani kwambiri mu banja lanu? *Which disease poses a biggest threat (or challenge) to your household?* **(CIRCLE ALL RELEVANT ANSWERS)**		No	Yes	
		a) Malaria (*malungo*)	0	1	
		b) Diarrhoea (*kutsegula m'mimba*)	0	1	
		c) TB (*chifuwa chachikulu*)	0	1	
		d) Bilharzia (*likodzo*)	0	1	
		e) Elephantitis/filariasis (*matchinjiri*)	0	1	
		f) Onchocerciasis	0	1	
		g) HIV/AIDS (*edzi*)	0	1	
		h) Maternal deaths	0	1	
		i) Headache	0	1	
		j) Abdominal pains	0	1	
		k) Cancer	0	1	
		l) Respiratory diseases	0	1	
		m) Others (specify)_____	0	1	
SOC008	Kodi pakhomo pano alipo ali ndi zinthu izi: *Do you or any member of your household own:* (READ OPTIONS) **(CIRCLE ALL RELEVANT ANSWERS)**		No	Yes	
		a) Njinga ya kapalasa *bicycle*	0	1	
		b) Njinga ya moto *motorcycle*	0	1	
		c) Galimoto *car*	0	1	
		d) Wayilesi *radio*	0	1	
		e) Wayilesi ya kanema *television*	0	1	
		f) Fridge	0	1	
		g) Oxcart (*ngolo*)			
SOC009	What is the main heat source you use for cooking? *Ndi moto wanji womwe mumaphikila kawirikawiri?*	Charcoal		1	
		Wood		2	
		Paraffin/kerosene		3	
		Dung		4	
		Gel fuel		5	
		Electricity		6	
		gas		7	
		Other (specify) _____		8	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES		GO TO
SOC010	Kodi mumaphikira kuti? Where do you cook your food	In the Kitchen (*mukichini*) In the house used for sleeping (*nyumba*) Outside, in the open (*panja)*	1 2 3	
SOC011	What do you usually sleep on in your home?	Mphasa Ground Mattress Bed with mattress Bed with sacks Other (specify) _____	1 2 3 4 5 6	
SOC012A	Kodi mumawerenga newspaper siku lililonse, kamodzi pa mulungu, mwakamodzi kamodzi, kapena simuwerenga? *Do you read a newspaper or magazine almost everyday, at least once a week, less than once a week, or not at all?*	Almost every day At least once a week Less than once a week Not at all	1 2 3 4	
SOC013A	Kodi mumamvera wailesi siku lililonse, kamodzi pa mulungu, mwakamodzi kamodzi, kapena simuwerenga? *Do you listen to the radio almost every day, at least once a week, less than once a week or not at all?*	Almost every day At least once a week Less than once a week Not at all	1 2 3 4	
SOC014A	Kodi mumaonera television siku lililonse, kamodzi pa mulungu, mwakamodzi kamodzi, kapena simuwerenga? *Do you watch television almost every day, at least once a week, less than once a week or not at all?*	Almost every day At least once a week Less than once a week Not at all	1 2 3 4	
	NGATI PALI ABAMBO M'YUMBAMO MUWAFUNSENSO MAFUNSOWA ***THESE QUESTIONS MUST ALSO BE ASKED TO THE HUSBAND IF AVAILABLE***		If not available then→	**SOC015**
SOC012B	Kodi mumawerenga newspaper siku lililonse, kamodzi pa mulungu, mwakamodzi kamodzi, kapena simuwerenga? *Do you read a newspaper or magazine almost everyday, at least once a week, less than once a week, or not at all?*	Almost every day At least once a week Less than once a week Not at all	1 2 3 4	
SOC013B	Kodi mumamvera wailesi siku lililonse, kamodzi pa mulungu, mwakamodzi kamodzi, kapena simumvera? *Do you listen to the radio almost every day, at least once a week, less than once a week or not at all?*	Almost every day At least once a week Less than once a week Not at all	1 2 3 4	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
SOC014B	Kodi mumaonera television siku lililonse, kamodzi pa mulungu, mwakamodzi kamodzi, kapena simuwonera? *Do you watch television almost every day, at least once a week, less than once a week or not at all?*	Almost every day 1 At least once a week 2 Less than once a week 3 Not at all 4	
SOC015	What is the surface finish of the floor within the house	Mud 1 Mud and dung 2 Concrete 3 Wood 4 Other (specify) _____ 5	
SOC016	Does this house have any livestock?	Yes 1 No 2	**SOC018**
SOC017	How many of the following types of animals are owned by this household?	a) Number of Goats /__/__/__/ b) Number of Pigs /__/__/__/ c) Number of Cattle /__/__/__/ d) Number of Sheep /__/__/__/ e) Number of chickens *(nkhuku, nkhanga, abakha, nkhukutembo, nkhunda, etc)* /__/__/__/	
SOC18	Is there any NGO or Organization carrying out health initiatives in your area?	Yes 1 No 2	
SOC19	What king of health activities are carried out by this NGO or Organization	General health issues 0 1 Malaria project 0 1 Water, sanitation, hygiene practice 0 1 Health education messages 0 1 Maternal health or family planning issues 0 1 Others (specify) 0 1	

SOC020	FROM OBSERVATION *What is the house built from*:				
	Code	**Walls**	*Roof*	**Windows**	
	1	Poles and grass	Grass	None	
	2	Poles and Mud	Grass	None	
	3	Mud	Grass	None	
	4	Mud Brick	Grass	None	
	5	Mud Brick	Grass	Open windows	
	6	Fired brick	Grass	Open windows	
	7	Fired brick	Grass	Screen or Glass	
	8	Mud brick	Metal/Tiles	Open windows	
	9	Mud brick	Metal/Tiles	Screen or Glass	
	10	Fired brick	Metal/Tiles	Open windows	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
	11	Fired brick	Metal/Tiles	Screen or Glass	
	12	Mud brick	Grass	Screen/glass	
	13	Cement brick	Metal/Tiles	Screen/glass	
	14	Poles and mud	Grass	Open windows	
	15	Mud brick	Metal/Tiles	None	

HEALTH ACCESS (HAC) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HAC001	Kodi chipatala cha pafupi ndi chiti? *What is your nearest health facility?*	Government hospital Government health centre CHAM hospital Local authority clinic Private clinic Don't know		1 2 3 4 5 98	
HAC002	Kodi nanga mpatali bwanji pa chipatalapo? *How far away is this facility* **(Estimate the distance (from other responses near the respondent) if the answer is don't know)**	< 1 km 1 – 2 km 3 – 5 km 6 – 10 km >10 km Don't know		1 2 3 4 5 98	
HAC003	Kodi nanga mumapitako? *Do you visit this health facility?*	Yes No		1 2	 → **HAC008**
HAC004	Ndi zifukwa ziti zomwe mumapitira kuchipatalako What are the reasons you visit the hospital		No	Yes	
		a) when someone is sick	0	1	
		b) for health education messages	0	1	
		c) outreach clinic	0	1	
		d) maternity	0	1	
		e) Check up	0	1	
		f) To visit patients	0	1	
		g) Other (specify)_____	0	1	
HAC005	Kodi nanga mumapitako mowirikiza bwanji? *How often do you visit the health facility?*	Weekly Fortnightly Monthly When I remember When I do not have work to do When the weather is good When someone in the house is sick Other (specify) _____		1 2 3 4 5 6 7	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HAC006	Kodi ndi zovuta ziti zimene mumakumana nazo kuti mukafike kuchipatalako? *What are the problems you face in reaching the health facility?*		<u>No</u>	<u>Yes</u>	
		a) Distance to travel	0	1	
		b) Transport costs	0	1	
		c) No bridge over the river	0	1	
		d) Too much work at home	0	1	
		e) Have to work in the field	0	1	
		f) Other (specify)_____	0	1	
HAC007	Kodi ndi zovuta ziti zomwe mumakumana nazo pa chipatala? *What are the problems you face while at the health facility*		<u>No</u>	<u>Yes</u>	
		a) Cost of medical services	0	1	
		b) Too long to wait	0	1	
		c) No shelter	0	1	
		d) No female health workers	0	1	
		e) Health workers do not show	0	1	
		f) No drugs	0	1	
		g) Other (specify)_____	0	1	
HAC008	Kodi mumapita ku sikelo yoyendela? *Do you visit an outreach clinic?*	Yes		1	
		No		2	→ **HAC014**
HAC009	Kodi ndi kutali bwanji? *How far away is the outreach clinic?* **(Estimate the distance (from other responses near the respondent) if the answer is don't know)**	In this village		1	
		< 1 km		2	
		1 – 2 km		3	
		3 – 5 km		4	
		6 – 10 km		5	
		>10 km		6	
		Don't know		98	
HAC010	Kodi sikelo yoyendelayi mumapitako kangati? *How often do you attend the outreach clinic?*	Weekly		1	
		Monthly		2	
		When I remember		3	
		When I do not have work to do		4	
		When the weather is good		5	
		Other (specify) _____		6	
HAC011	Kodi sikelo yoyendela imenyo imaku thandizani bwanji? *What are the functions of the outreach clinic you use?*		<u>No</u>	<u>Yes</u>	
		a) Growth monitoring	0	1	
		b) Immunizations	0	1	
		c) Family planning	0	1	
		d) Antenatal care	0	1	
		e) Health education	0	1	
		f) Others (specify)_____	0	1	
HAC012	Kodi nanga ndi mavuto ati amene mumakomana nao musanafike pa sikelopo? *What are the problems you face in reaching the outreach clinic?*		<u>No</u>	<u>Yes</u>	
		a) Distance to travel	0	1	
		b) Transport costs	0	1	
		c) No bridge over the river	0	1	
		d) Too much work at home	0	1	
		e) Have to work in the field	0	1	
		f) Other (specify)_____	0	1	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HAC013	Kodi ndi mavuto ati omwe mumapezana nao mukafika pa sikelo? *What are the problems you face while at the outreach clinic*		No	Yes	
		a) Cost of medical services	0	1	
		b) Too long to wait	0	1	
		c) No shelter	0	1	
		d) No female health workers	0	1	
		e) Health workers do not show	0	1	
		f) No drugs	0	1	
		g) VHC members not helpful	0	1	
		h) Other (specify)_____	0	1	
HAC014	Kodi ndi matenda omwe amabvuta kwambili mudzi wamu uno ndi ati? *What are the major diseases in your village?*		No	Yes	
		a) Malaria	0	1	
		b) Diarrhoea	0	1	
		c) TB	0	1	
		d) Bilharzia	0	1	
		e) Elephantitis/filariasis	0	1	
		f) Onchocerciasis	0	1	
		g) HIV/AIDS	0	1	
		h) dysentery	0	1	
		l) Others (specify)_____	0	1	
		j) Don't know	98		
HAC015	*Kodi ndi mabvuto ati a za umoyo amene mudzi wanu uli nawo?* *What are the health problems your village faces?*	a) maternal deaths	0	1	
		b) lack of clean water	0	1	
		c) lack of pit latrines	0	1	
		d) lack of drugs	0	1	
		e) long distance to health facility	0	1	
		f) shortage of health personnel	0	1	
		g) rude health personnel	0	1	
		h) lack of proper facilities at health facility	0	1	
		i) other (specify)	0	1	
HAC016	*Observe the health passports for all children under the age of five in the household and ensure that immunizations are up to date. Are they up to date?* *If not seen write '**NOT SEEN**)*	Child Name	Person number	No	Yes	
			/____/_____/	1	2	
			/____/_____/	1	2	
			/____/_____/	1	2	
			/____/_____/	1	2	
			/____/_____/	1	2	

DIARRHOEA AWARENESS (DRR) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
DRR001	Kodi alipo m'modzi wa m'nyumba mwanu anatsegulapo m'mimba? *Has a member of your household suffered from diarrhoea?*	Yes 1 No 2	→ **DRR003**
DRR002	Ndi liti lomwe anadwalapo m'mimba mwa kamwaziyu? *When was the last time someone suffered from diarrhoea?*	Last week 1 2 weeks ago 2 1 month ago 3 2 months ago 4 >2 months ago 5 Don't remember 6 Don't know 98	
DRR003	Kodi zizindikilo Zo tsegula m'mimba ndi ziti? MULITPLE ANSWERS POSSIBLE *What are the symptoms of diarrhoea*	No Yes a) Water stools 0 1 b) Increased number of stools 0 1 c) Loose stools 0 1 d) Loose stools and vomiting 0 1 e) Bloody stools 0 1 f) Stomachache 0 1 g) Other (specify) _____ 0 1	
DRR004	Kodi ndi zotsatira zotani zingachitike ndi kutsegula m'mimba? *What are the effects of diarrhoea?*	No Yes a) Body weakness 0 1 b) Loss of salts/fluids from body 0 1 c) Death 0 1 d) Other (specify) _____ 0 1	
DRR005	Kodi kutsegula m'mimba kumapha? *Can diarrhoea cause death?*	Yes 1 No 2	→ **DRR007**
DRR006	Kodi kutsegula m'mimba kumabweretsa ifa bwanji? *How does diarrhoea cause death?*	No Yes a) Dehydration 0 1 b) Diarrhoea 0 1 c) Fever 0 1 d) Witchcraft 0 1 e) Other (specify)_____ 0 1	
DRR007	Kodi mumachiritsa bwanji kutsegula m'mimba? *How do you treat diarrhoea?*	Go to health facility---------- 1 Give Thanzi (ORS) obtained from hospital 2 Give salt sugar solution 3 Give purchased Thanzi (ORS) 4 Give fluids 5 Give fluids and got to hospital/clinic 6 Other (specify) _____ 7 Don't know 98	

DRR008	Pamatenga nthawi yaitali bwanji munthu akayamba kutsegula m'mimba kuti mumpatse chithandizo? *How long after having diarrhoea do you give treatment?*	Same day 1 After 1 day 2 After 2 days 3 After 3 days 4 After 4 days 5 After 5 days 6 After 6 days 7 After 1 week 8 Other (specify) 9	
DRR009	Kodi chenicheni chimene chimayambitsa matenda otsegula m'mimba ndi chiyani? *What is the main cause of diarrhoea?*	No / Yes a) Drinking contaminated (bad quality) water 0 1 b) Eating contaminated food 0 1 c) Flies 0 1 d) Poor hygiene 0 1 e) Dirty environment 0 1 f) Witchcraft 0 1 g) Germs 0 1 h) Other (Specify)_____ 0 1 0 1	
DRR010	Kodi munayamba mwapangapo kanthu kuti banja lanu litetezeke ku matenda otsegula m'mimba? *Have you ever done anything to prevent people in your household from getting diarrhoea?*	Yes 1 No 2 Don't know 98	**DRR012** **DRR012**
DRR011	Munachitapo chiyani? *What did you do to prevent getting diarrhoea?* (MULTIPLE RESPONSES POSSIBLE)	a) Add Chlorine to water 0 1 b) Add a chemical to water 0 1 c) Store water properly in a closed container with lid 0 1 d) Boil drinking water 0 1 e) Clean cooking utensils 0 1 f) Wash hands 0 1 g) Cook leftover food 0 1 h) Eat cooked food hot 0 1 i) Avoid buying cooked food 0 1 j) Cover pit latrines 0 1 k) Clean up stool left by children 0 1 l) Wash hands after visiting the toilet 0 1 m) Singanga 0 1 n) Improve saniatation 0 1 o) Add water guard to water 0 1 p) Other (Specify)_____ 0 1	
DRR012	Munayamba mwamvapo uthenga uliwonse wa kapewedwe ka kutsegula m'mimba? *Have you ever received any information about prevention of diarrhoea?*	Yes 1 No 2	**DRR015**
DRR013	Kodi uthengawo munaumva kuchokera kuti? *Where did you receive this information?* (MULTIPLE RESPONSES POSSIBLE)	a) Family member/friends/village 0 1 b) Health worker/Health clinic 0 1 c) Radio/Television 0 1 d) Newspaper 0 1 e) Other (Specify)_____ 0 1	

DRR014	Munaphunzirapo chiyani za kutsegula m'mimba? (MULTIPLE RESPONSES POSSIBLE) *What was the message about?*	a) How to prevent diarrhoea 0 1 b) How to treat diarrhoea 0 1 c) How to care for children 0 1 d) How to keep your house clean 0 1 e) How to keep water clean 0 1 f) Other (Specify) _____ 0 1	
DRR015	Kodi zimapangitsa kuwosa madzi mthupi ndi chiyani? *What causes dehydration?*	a) Heat 0 1 b) Diarrhoea 0 1 c) Illness 0 1 d) Vomiting 0 1 e) Other (specify) _____ 0 1	
DRR016	Kodi zizindikiro zakusowa madzi mthupi ndi ziti? *What are the symptoms of dehydration?*	a) Sunken eyes 0 1 b) Body weakness 0 1 c) Sunken fontanel 0 1 d) Dry pinched skin 0 1 e) Dry mouth 0 1 f) Other (specify) 0 1	
DRR017	Kodi ndi tsiku liti lomaliza pamene mwana nyumba muno anadwala matenda otsegula m'mimba? *When was the last time a child in the household had diarrhoea?*	One day ago 1 Two days ago 2 One week ago 3 Two weeks ago 4 One month ago 5 3 months ago 6 6 months ago 7 One year ago 8 Never 9	→ **MTH001**
DRR018	Munagonjetsa bwanji kutsegula m'mimba? *How did you treat the diarrhoea?*	Bought Thanzi (ORS) 1 Home made ORS 2 Salt and sugar solution 3 More fluids 4 Less fluids 5 Nothing 6	
DRR019	Kodi mukuyamwitsabe mwana mkaka wambele? *Are you still breastfeeding?*	Yes No	→ **DRR021**
DRR020	Kodi muna sitha mchitidwe woyamwitsa mwana pamene anadwala? *Did you change the frequency breastfeeding when the child had diarrhoea?*	Increased feeding 1 Same amount 2 Decreased feeding 3 Stopped feeding 4 Forgotten 5	
DRR021	Kodi munasitha zakumwa za mwa pamene anatsegula m'mimba? *Did you change fluid intake for the child?*	More fluids 1 Same fluids 2 Less fluids 3 No fluids 4 Other (specify) _____ 5 Forgotten 6	

MATERNAL HEALTH (MTH) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
MTH001	Kodi munamvapo za zizindikiro zoopsya za mimba? *Have you ever received any information about the danger signs and complications in pregnancy?*	Yes	1		
		No	2		→ **MTH003**
MTH002	Kodi uthenga umenewu munauva kuchokera kuti? *From where did you receive this information?*	a) Health facility	0	1	
		b) HSA	0	1	
		c) Family and friends	0	1	
		d) TBA	0	1	
		e) Radio	0	1	
		f) Television	0	1	
		g) VHC	0	1	
		h) Drama in our area	0	1	
		i) Other (specify)	0	1	
MTH003	Kodi ndi zizindikiro ziti zoopsa zomwe mai angakomane nazo pa nthawi yimene ali ndi pakati kapena akuchira? *What were the danger signs in pregnancy?*	a) Bleeding (*kutaya magazi*)	0	1	
		b) Anaemia (*kusowa magazi*)	0	1	
		c) Retained placenta (*kutsalidwe nsengwa*)	0	1	
		d) Malaria (*malungo*)	0	1	
		e) Vaginal discharge	0	1	
		f) Cardiac problems (*matenda a mtima*)	0	1	
		g) Death from pregnancy related problems (*infa chifukwa cha mimba*)	0	1	
		h) General weakness and nausea (*kufookoa*)	0	1	
		i) Prolonged labour	0	1	
		j) Swelling of legs / eclampsia (*kutupa miyendo*)	0	1	
		k) Operation / C-section (*kuchila ndi mpeni*)	0	1	
		l) Abdominal pains (*kupweteka m'mimba*)	0	1	
		m) Body pains (*kupweteka mthupi*)	0	1	
		n) Headache (*mutu*)	0	1	
		o) Other (specify) _____	0	1	
MTH004	Kodi ndi matenda ndinso mavuto otani omwe amabwera ndi mimba? *What are the common illnesses/problems associated with pregnancy?*	a) High blood pressure	0	1	
		b) Anaemia (*kusowa magazi*)	0	1	
		c) Fever (*kudzizila*)	0	1	
		d) Swelling of the body/oedema (*kutupa thupi*)	0	1	
		e) Eclampsia/pre-eclampsia	0	1	
		f) General weakness	0	1	
		g) Nausea and vomiting (*nselu*)	0	1	
		h) Backache	0	1	
		i) Malaria	0	1	
		j) Maternal death	0	1	
		k) Bleeding	0	1	
		l) Prolonged or obstructed labour	0	1	
		m) Operation / caesarian section	0	1	
		n) Other (specify)	0	1	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
MTH005	Kodi matenda ndi mavuto omwe amabwera ndi kubereka ndi ati? *What are the common problems associated with child birth?*	a) Bleeding 0 1 b) High blood pressure (*kuthamanga magazi)* 0 1 c) Anaemia (*kusowa magazi*) 0 1 d) Fever/chills/ (*kudzizila*) 0 1 e) Infection 0 1 f) General weakness 0 1 g) Vomiting / nausea (*nselu)* 0 1 h) Malaria 0 1 i) Swelling of body oedema (*kutupa*) 0 1 j) Eclampsia / pre eclampsia 0 1 k) Prolonged / obstructed labour 0 1 l) Operation / caesarian section 0 1 m) Retained placenta (*kutsalidwa Nsengwa)* 0 1 n) Ruptured uterus (*kung'ambika chibelekelo*) 0 1 o) Maternal death 0 1 p) Other (specify) 0 1	
MTH006	Mungachite chiyani ngati mutatentha thupi mutangobereka? *What would you do if you developed fever after delivery?*	Nothing 1 Go to health facility 2 Go to traditional healer 3 Go to TBA 4 Buy drugs from market 5 Buy drugs from shop/grocery 6 Buy drugs from pharmacy 7 Consult husband 8 Consult relatives 9 Self traditional medicines 10 Other (specify) 11	
MTH007	Mungachite chiyani ngati nsengwa ya mwana yasalira mkati? *What would you do if you had a retained placenta?*	Nothing 1 Go to health facility 2 Go to traditional healer 3 Go to TBA 4 Buy drugs from market 5 Buy drugs from shop/grocery 6 Buy drugs from pharmacy 7 Consult husband 8 Consult relatives 9 Self traditional medicines 10 Other (specify) 11	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
MTH008	Mungachite chiyani ngati mukutaya magazi ambiri mutangobereka? *What would you do if you bled heavily after delivery?*	Nothing 1 Go to health facility 2 Go to traditional healer 3 Go to TBA 4 Buy drugs from market 5 Buy drugs from shop/grocery 6 Buy drugs from pharmacy 7 Consult husband 8 Consult relatives 9 Self traditional medicines 10 Other (specify) 11	
MTH009	Kodi adzimayi amakachilira kuti? *Which maternity unit do women of this area use?*	Government hospital 1 Government health centre 2 CHAM hospital 3 Local authority 4 Private clinic 5 TBA 6 Don't know 98	
MTH010	Komwe amakachilira adzimayiku ndi kutali bwanji? *How far is the nearest maternity unit to your home?*	< 1 km 1 1 – 2 km 2 3 – 5 km 3 6 – 10 km 4 >10 km 5 Don't know 98	
MTH011	Kodi munabelekapo mwana? *Have you delivered a baby?*	Yes 1 No 2	→ **RSP001**
MTH012	Malinga ndi maganizo anu ndi malo otani omwe mungasankhe kukachlirako? *In your opinion what kind of maternity facility would you prefer for delivery of your children?*	a) Where there is a nurse 0 1 b) Where I previously had my delivery 0 1 c) Where I had antenatal services 0 1 d) Where there are doctors 0 1 e) A maternity near my home 0 1 f) Government clinic 0 1 g) TBA 0 1 f) Other (specify)_____ 0 1	
MTH013	Pakubereka, kwanu komaliza anakuthandizani ndani pamene mwana amabadwa? *At your last delivery who assisted you at the actual time the baby was born?*	Nurse 1 Medical assistant 2 TBA 3 Doctor 4 CO (Clinical Officer) 5 No one 6 Relative 7 Cleaner 8 Other (specify) 9	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES		GO TO
MTH014	Mimba yomaliza munachilira kuti? *Where did you deliver your child?*	Home TBA Health centre Hospital On the way to ……. Other (specify)	1 2 3 4 5 6	
MTH015	Nthawi yochira itakwana, munakafika bwanji kumene munachilira? *How did you get to the place you delivered your baby when your labour started?*	Walked Matola Bus Stretcher Bicycle ambulance Bicycle Public transport Own vehicle Didn't travel in labour Other (specify)	1 2 3 4 5 6 7 8 9 10	
MTH016	Mumatenga nthawi yayitali bwanji kukafika ku chipatala? *How long did it take you to get there by this mode of transport?*	<30 minutes 30 minute – 1 hour 1 – 2 hours 2 – 4 hours >4 hours	1 2 3 4 5	
MTH017	Kodi mungakonde mutadzabeleka kuti mwana winayo? *Where would you like to deliver your next baby?*	Home TBA Health centre Hospital On the way to ……. Other (specify)	1 2 3 4 5 6	
MTH018	Kodi pakalipano ndinu oyembekezera? *Are you pregnant at the moment?*	Yes No	1 2	
MTH019	Kodi munalandilapo malangizo okhuzana ndi pakati *Have you received antenatal care?*	Yes No	1 2	 → RSP001
MTH020	Malangizowa munalandilira kuti? *Where did you receive antenatal care?*	Outreach clinic Private clinic Health centre Hospital Other (specify)	1 2 3 4 5	

RESPIRATORY INFECTIONS (RSP) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
RSP001	Kodi alipo yemwe anadwala matenda okhuzana ndi kupuma? *Has anyone in the household ever suffered from a respiratory infection?*	Yes 1 No 2	→ **MLR001**
RSP002	Ndi ndani anadwala matenda okhuzana ndi kupuma? *Who suffered from the infection?* *MULTIPLE ANSWERS POSSIBLE* **Specify according to HH001**	a) Person 1 0 1 b) Person 2 0 1 c) Person 3 0 1 d) Person 4 0 1 e) Person 5 0 1 f) Person 6 0 1 g) Person 7 0 1 h) Person 8 0 1 i) Person 9 0 1 j) Person 10 0 1 k) Other (specify) 0 1	
RSP003	Matenda ake ndi chani? Which infections have they suffered from? **Specify according to HH001** Pn=Pneumonia (***chibayo***), TB=Tuberclousis (***chifuwa chachikulu***), As=Asthma (***Mphumu***), Br=Bronchitis (***kubanika***), W=Whooping cough/pertusis (***chifuwa chokoka mtima***), O=Others respiratory disease (please specify) **If TB go to RSP006**	a) Person 1: Pn 1, TB 2, As 3, Br 4, W 5, O 6 b) Person 2: Pn 1, TB 2, As 3, Br 4, W 5, O 6 c) Person 3: Pn 1, TB 2, As 3, Br 4, W 5, O 6 d) Person 4: Pn 1, TB 2, As 3, Br 4, W 5, O 6 e) Person 5: Pn 1, TB 2, As 3, Br 4, W 5, O 6 f) Person 6: Pn 1, TB 2, As 3, Br 4, W 5, O 6 g) Person 7: Pn 1, TB 2, As 3, Br 4, W 5, O 6 h) Person 8: Pn 1, TB 2, As 3, Br 4, W 5, O 6 i) Person 9: Pn 1, TB 2, As 3, Br 4, W 5, O 6 j) Person 10: Pn 1, TB 2, As 3, Br 4, W 5, O 6 k) Other (specify): Pn 1, TB 2, As 3, Br 4, W 5, O 6	
RSP004	Kodi analandirapo chithandizo? *Did the person receive treatment for the respiratory infection?* **Specify according to HH001**	a) Person 1: No 0, Yes 1 b) Person 2: No 0, Yes 1 c) Person 3: No 0, Yes 1 d) Person 4: No 0, Yes 1 e) Person 5: No 0, Yes 1 f) Person 6: No 0, Yes 1 g) Person 7: No 0, Yes 1 h) Person 8: No 0, Yes 1 i) Person 9: No 0, Yes 1 j) Person 10: No 0, Yes 1 k) Other (specify): No 0, Yes 1	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES						GO TO
RSP005	Chithandizocho chinachokera kuti? *Where did you receive the treatment from?* **Specify according to HH001** *HF=Health facility, PH=Pharmacy after doctor hospital prescription, PM=Pharmacy without hospital prescription, H=home treatment without hospital prescription, T=Traditional healer, O=Other methods (specify)*		HF	PH	PM	H	T O	
		Person 1	1	2	3	4	5 6	
		Person 2	1	2	3	4	5 6	
		Person 3	1	2	3	4	5 6	
		Person 4	1	2	3	4	5 6	
		Person 5	1	2	3	4	5 6	
		Person 6	1	2	3	4	5 6	
		Person 7	1	2	3	4	5 6	
		Person 8	1	2	3	4	5 6	
		Person 9	1	2	3	4	5 6	
		Person 10	1	2	3	4	5 6	
		Other (specify)	1	2	3	4	5 6	
RSP006	Kodi anamaliza mankwala a chifuwa chachikulu (TB) mwandondomeko? Was the treatment for TB completed? **Specify according to HH001**					No	Yes	
		a) Person 1				1	2	
		b) Person 2				1	2	
		c) Person 3				1	2	
		d) Person 4				1	2	
		e) Person 5				1	2	
		f) Person 6				1	2	
		g) Person 7				1	2	
		h) Person 8				1	2	
		i) Person 9				1	2	
		j) Person 10				1	2	
		k) Other (specify)				1	2	
RSP007	Kodi amaonetsetsa kuti mankwala akumwedwa motsatira ndondomeko ndani? Who is/was supervising you treatment regime? **Specify according to HH001** Family= family members, HO=Health officers, Others= VHC, HSA, etc.		Family	HO	Other			
		a) Person 1	1	2	3			
		b) Person 2	1	2	3			
		c) Person 3	1	2	3			
		d) Person 4	1	2	3			
		e) Person 5	1	2	3			
		f) Person 6	1	2	3			
		g) Person 7	1	2	3			
		h) Person 8	1	2	3			
		i) Person 9	1	2	3			
		j) Person 10	1	2	3			
		k) Other (specify)	1	2	3			
RSP008	Kodi amasuta fodya ndi ndani? *Who smokes?* **Specify according to HH001**					No	Yes	
		a) Person 1				0	1	
		b) Person 2				0	1	
		c) Person 3				0	1	
		d) Person 4				0	1	
		e) Person 5				0	1	
		f) Person 6				0	1	
		g) Person 7				0	1	
		h) Person 8				0	1	
		i) Person 9				0	1	
		j) Person 10				0	1	
		k) Other (specify)				0	1	

MALARIA (MLR) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
MLR001	Kodi ndi nthawi iti yomaliza yomwe m'modzi wa mbanjamu anadwala malungo? *When was the last time someone in the house suffered from malaria?*	Last week 1 2 weeks ago 2 1 month ago 3 2 months ago 4 >2 months ago 5 Don't know 98	
MLR002	Kodi mumadziwa bwanji kuti ndi malungo? *How do you diagnose malaria?*	a) Fever 0 1 b) Diarrhoea 0 1 c) Rigors 0 1 d) Vomiting 0 1 e) Eyes rolling 0 1 f) Blood test at clinic 0 1 g) Blood test at hospital 0 1 h) Others (specify) 0 1	
MLR003	Kodi mumatani pamene munthu wamkulu akudwala malungo? *What do you do when someone is suffering from malaria (adult)*	Nothing---------- 1 Take patient to a Health facility---------- 2 Give patient drugs previously obtained from health facility---------- 3 Give patient drugs bought from grocery/shop/market---------- 4 Give patient drugs bought from pharmacy---------- 5 Give patient drugs then, thereafter, take patient to hospital---------- 6 Use traditional methods to treat patient-- 7 Other (specify)_____ 8	
MLR004	Kodi mumatani pamene mwana akudwala malungo? *What do you do when someone is suffering from malaria (child)*	Nothing---------- 1 Take patient to a Health facility---------- 2 Give patient drugs previously obtained from health facility---------- 3 Give patient drugs bought from grocery/shop/market---------- 4 Give patient drugs bought from pharmacy---------- 5 Give patient drugs then, thereafter, take him to hospital---------- 6 Use traditional methods to treat patient-- 7 Other (specify)_____---------- 8	
MLR005	Kodi ndi njira ziti zimene mumatsata zochepetsera matenda a malungo mu banja lanu? *What measures have you taken to reduce the chance of members of your household contracting malaria?*	a) Clearing weeds/bushes---------- 0 1 b) Draining standing water ---------- 0 1 c) Sleeping under a mosquito net----- 0 1 d) Insecticide treatment indoors------ 0 1 e) Insecticide treatment outdoors----- 0 1 d) Other (specify)_____ 0 1	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
MLR006	Kodi ndi njira ziti zimene mudzi wanu umatsata mogwirizana zochepetsera matenda a malungo? *What collective measures does your village take in order to reduce the chance of members of this village from contracting malaria?*	a) Clearing weeds/bushes---------- b) Draining standing water ---------- c) Sleeping under a mosquito nets---- d) Insecticide treatment indoors------ e) Insecticide treatment outdoors----- f) taking malaria drugs (sp etc.)----- g) Other (specify)_____	0 0 0 0 0 0 0	1 1 1 1 1 1 1	
MLR007	Kodi mauthenga ozitetezera ku malungo mumawamvera kuchokera kwa yani? *Where do you get messages on malaria prevention?*	a) Health personnel---------- b) HSA---------- c) VHC---------- d) TBA---------- e) Traditional leaders ---------- f) Radio---------- g) Newspapers---------- h) Drama---------- i) Television---------- j) School---------- k) No where---------- l) Other(specify)_____	0 0 0 0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1 1 1 1	
MLR008	Mauthengawo amalungowo amati chani? *What are (the malaria prevention) messages about?*		No	Yes	
		a) Clearing weeds/bushes---------- b) Treating and Draining standing water in household environment-- c) management of aquatic systems due to natural water bodies---------- d) management of man-made (infrastructural) water bodies------- e) Sleeping under mosquito nets--- f) Insecticide treatment indoors----- g) Insecticide treatment outdoors--- h) good agricultural practices------- i) Other (specify)_____	0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1	
MLR009	Kodi msinje wapafupi ndi mudzi uno uli patali bwanji? *How far is the nearest river to this village?*	< 1 km 1 – 2 km 3 – 5 km 6 – 10 km >10 km Don't know		1 2 3 4 5 6	
MLR010	Kodi madzi munsinjewu amathamanga bwanji? *How does water flow in this river?*	a) Still water (Sayenda) b) Flows slowly (Pang'ono) c) Flows fast (Kwambiri) d) Dry river e) Don't know		1 2 3 4 98	
MLR011	**OBSERVATION** **IF THE RIVER IS NEAR OBSERVE THE SPEED OF FLOW OF WATER AND TICK ON AN APPROPRIATE NUMBER**	a) Very slow b) Slow c) Fast d) Very fast e) Dry river f) no observation made		1 2 3 4 98	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
MLR012	Kodi maenje akuluakulu omwe amasunga madzi ambiri nthawi yamvula muli nawo patali bwanji? *How far are the nearest trenches or ditches that keep water during the rainy season?*	< 1 km 1 1 – 2 km 2 3 – 5 km 3 6 – 10 km 4 >10 km 5 Don't know 6	
MLR013	Maenje amenewa anabwera bwanji? *How did the trenches or ditches originate?*	a) Due to brick making---------- 1 b) Due to construction---------- 2 c) Due to estates---------- 3 d) Due agricultural practices---------- 4 e) River diversion---------- 5 f) Natural depression---------- 6 g) Napolo---------- 7 g) Other (specify)_____ 8 h) Don't know---------- 98	
MLR014	Kodi madambo okhala ndi madzi kapena titi zithaphwira mudzi uno muli nazo patali bwanji? *How far is the nearest stagnant water mass body?*	a) < 1 km 1 b) 1 – 2 km 2 c) 3 – 5 km 3 d) 6 – 10 km 4 e) >10 km 5 f) Don't know 98	
MLR015	Madambowa kapena zithaphwirazi zinabwera bwanji? How did the water body originate?	a) Due to brick making---------- 1 b) Due to construction---------- 2 c) Due to estates---------- 3 d) Due agricultural practices---------- 4 e) River diversion---------- 5 f) Natural depression---------- 6 g) Napolo---------- 7 g) Other (specify)_____ 8 h) Don't know---------- 98	
MLR016	**OBSERVATION** **IF THE WATER BODY IS NEAR OBSERVE THE FOLLOWING AND CIRCLE IF APPLICABLE**	a) Mosquitoes bleed there------ 0 1 b) The water is clear---------- 0 1 c) The water is not clear-------- 0 1 d) The place is used by people 0 1 e) The place is used by animals 0 1 f) The place is used for agricultural purposes---------- 0 1 g) No observation made--------- 0 1	
MLR017	Kodi ma estate kapena malimidwe othilira muli nawo patali bwanji *How far are irrigated estates or plantations from your household?*	a) < 1 km 1 b) 1 – 2 km 1 c) 3 – 5 km 1 d) 6 – 10 km 1 e) >10 km 1 f) Don't know 98	
MLR018	Ndi ma estate kapena malimidwe achani? What type of estates or plantations are they?	a) Sugarcane 1 b) Tea/coffee 2 c) Bananas 3 d) Rice 4 e) Cotton 5 f) oranges/mandalines, etc 6 g) other (specify) _____ 7	

MLR019	Kodi m'banja lanu muli ndi ma mosquito net omwe mumagwiritsa ntchito pogona? Does your household have any mosquito nets that can be used while sleeping?	Yes 1 No 2	→ **MLR031**
MLR020	Alipo ma mosquito net angati? *How many mosquito nets does your household have?*	Alipo /___/	
MLR021	ASK THE RESPONDENT TO SHOW YOU THE NET(S) IN THE HOUSEHOLD. IF MORE THAN 7 NETS USE ADDITIONAL SHEETS	OBSERVED 1 NOT OBSERVED 2	→

MLR022	**OBSERVE (OR ASK) THE COLOUR OF THE MOSQUITO NET** Kodi mosquito net ili ndi maboo akulu oti pangalowe chala chanu chachikulu? *Does the net have the holes in it (the size of the tip of your thumb or larger)?*		No	Yes
		a) NET #1	1	2
		b) NET #2	1	2
		c) NET #3	1	2
		d) NET #4	1	2
		e) NET#5	1	2
		f) NET#6	1	2
		g) NET#7	1	2

MLR023	**OBSERVE (OR ASK) THE SHAPE OF THE MOSQUITO NET** Kodi mosquito net ndi yozungulira kapena yamakona? *What is the shape of the net?*		conical	rectangle
		a) NET #1	1	2
		b) NET #2	1	2
		c) NET #3	1	2
		d) NET #4	1	2
		e) NET#5	1	2
		f) NET#6	1	2
		g) NET#7	1	2

MLR024	**OBSERVE (OR ASK) THE COLOUR OF THE MOSQUITO NET** **Kudi mosquito net ili ndi makaka otani?** *What is the colour of the mosquito net?*		Blue	Green	White	Other
		a) NET #1	1	2	3	4
		b) NET #2	1	2	3	4
		c) NET #3	1	2	3	4
		d) NET #4	1	2	3	4
		e) NET#5	1	2	3	4
		f) NET#6	1	2	3	4
		g) NET#7	1	2	3	4

MLR025	Kodi mosquito net amenewa munawapeza kuti? *Where did you get this mosquito net?* **HF=HEALTH FACILITY** **CD=COMMUNITY DISTRIBUTED** **SGM= SHOP/GROCERY/MARKET** **OT=OTHER**		HF	CD	SGM	OT
		a) NET #1	1	2	3	4
		b) NET #2	1	2	3	4
		c) NET #3	1	2	3	4
		d) NET #4	1	2	3	4
		e) NET#5	1	2	3	4
		f) NET#6	1	2	3	4
		g) NET#7	1	2	3	4

MLR026	Kodi mosquito net imeneyi inabwera ndi mankhwala? *When you got the net, did it come with an insecticide treatment kit?*		Yes	No	Not sure	
		a) NET #1	1	2	3	
		b) NET#2	1	2	3	
		c) NET#3	1	2	3	
		d) NET#4	1	2	3	
		e) NET#5	1	2	3	
		f) NET#6	1	2	3	
		g) NET#7	1	2	3	
MLR027	Kodi chigulire ma mosquito net munayamba mwawanyikapo mu mankhwala (chitetezo net)? *Since you got the mosquito net have you ever soaked or dipped it in an insecticide to kill or repel mosquitoes?*			No	Yes	**IF NO GO TO MLR029**
		a) NET#1		1	2	
		b) NET#2		1	2	
		c) NET#3		1	2	
		d) NET#4		1	2	
		e) NET#5		1	2	
		f) NET#6		1	2	
		g) NET#7		1	2	
MLR028	Ngati munanyikapo, ndi kale bwanji chinyikile mosquito net yanu mumankhwala? *If yes, how long ago was the net last soaked or dipped?* **If less than I month record '00'**		Months	>3years	Not sure	
		a) NET#1	/__/__/	2	3	
		b) NET#2	/__/__/	2	3	
		c) NET#3	/__/__/	2	3	
		d) NET#4	/__/__/	2	3	
		e) NET#5	/__/__/	2	3	
		f) NET#6	/__/__/	2	3	
		g) NET#7	/__/__/	2	3	
MLR029	Alipo anagona mu mosquito net imeneyi usiku wapitawu? *Did anyone sleep under this mosquito net last night?*			No	Yes	**IF NO GO TO MLR031**
		a) NET#1		1	2	
		b) NET#2		1	2	
		c) NET#3		1	2	
		d) NET#4		1	2	
		e) NET#5		1	2	
		f) NET#6		1	2	
		g) NET#7		1	2	
MLR030	Ndi ndani anagona mu masquito net imeneyi? *Who slept under the mosquito net?* **INSERT THE NUMBER OF THE PERSON ACCORDING TO THE IDENTIFICATION QUESTIONNAIRE**		Person	Person	Person	Person	Person
		a) NET#1	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
		b) NET#2	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
		c) NET#3	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
		d) NET#4	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
		e) NET#5	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
		f) NET#6	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
		g) NET#7	/__/__/	/__/__/	/__/__/	/__/__/	/__/__/
MLR031	Kodi ndi makanga (colour) ati amene mumafuna kukhala ndi mosquito net yanu? *What colour of mosquito net do you prefer?*					
		Blue			1	
		Green			2	
		White			3	
		Other			4	
		No preference/don't know			5	
MLR032	Kodi mumafuna mosquito net ya makona kapena yo zungulira? *What shape of mosquito net do you prefer?*					
		Conical			1	
		Rectangular			2	
		Do preference/don't know			3	

	Kodi chenicheni chimayambitsa malungo ndi chani? *What causes malaria?*	Mosquitoes 1 Bad hygiene practices 2 Witchcraft 3 Weather 4 Other (specify)_____ 5 Don't know 98	

HIV/AIDS (HIV) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HIV001	Kodi mungadziwe chomwe chimayambitsa edzi? *Can you explain what causes HIV/AIDS?*	Yes		1	
		No		2	→QHIV003
HIV002	Kodi mungalongosole chomwe chi mayanbitsa matendawa? *Can you describe what causes HIV/AIDS?*		No	Yes	
		a) Multiple sex partners	0	1	
		b) Sharing razor blades	0	1	
		c) Unprotected sex	0	1	
		d) Blood transfusion	0	1	
		e) Kissing	0	1	
		f) mosquitoes	0	1	
		g) Other (specify)	0	1	
HIV003	Kodi mungaiteteze bwanji HIV/AIDS? *How can you prevent HIV/AIDS*	a) Abstain from sex	0	1	
		b) Have one sexual partner	0	1	
		c) Avoid sharing razor blades	0	1	
		d) Use condoms	0	1	
		e) Avoid sharing toothbrush	0	1	
		f) Other (specify)_____	0	1	
HIV004	Kodi muna phunzitsidwapo zokhudzana ndi HIV/AIDS? *Have you received education on HIV/AIDS*	Yes		1	
		No		2	→HIV007
HIV005	Kodi ndi kuti, ndipo kuchokera kwa yani munaphunzitsidwa za nthendayi? *Where did you obtain this education from*		No	Yes	
		a) Health facility	0	1	
		b) HSA	0	1	
		c) Family and friends	0	1	
		d) TBA	0	1	
		e) Radio	0	1	
		f) Television	0	1	
		g) VHC	0	1	
		h) Other (specify)_____	0	1	
HIV006	Kodi maphunziro amenewa amakupatsani unthenga wa mtu ndu wanji? *What did the educational messages tell you?*		No	Yes	
		a) To abstain from sex	0	1	
		b) To have one sexual partner	0	1	
		c) To use condoms	0	1	
		d) Other (specify)	0	1	
HIV007	Kodi mumakudziwa konwe mungapimitse (kuyezesa) edzi? *Do you know where you can have an HIV test?*	Yes		1	
		No		2	→HIV009

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
HIV008	Kodi mungakayezetse kuti? *Where can you have it?*	<u>No</u> <u>Yes**</u> a) Health clinic 0 1 b) Hospital 0 1 c) Mobile VCT clinic 0 1 d) BML 0 1 e) MACRO 0 1 f) Other (specify) 0 1	
HIV009	Kodi pali mankhwala a edzi? *Is there a treatment for HIV/AIDS*	Yes 1 No 2	→QHIV011
HIV010	Kodi mungalandile kuti mankhwala a HIV/AIDS? *Where can you receive this treatment*	Government Hospital 1 CHAM hospital 2 Health clinic 3 Mobile VCT Clinic 4 BML 5 MACRO 6 Traditional healer 7 Private Doctor 8 Other (specify) 9	
HIV011	Kodi ndinu okonzeka kuedzesa kuti mudziwe ngati muli ndi kachilombo kobweretsa matenda a HIV/AIDS? *Are you willing to test for HIV/AIDS to know your status if given a chance?*	No 1 Yes 2	
HIV012	Kodi HIV ingafalikire kuchoka kwa mai wapakati kupita kwa mwana? *Can HIV be transmitted from mother to child when the mother is pregnant?*	No 1 Yes 2	
HIV013	Kodi HIV ingafalikire kuchoka kwa mai kupita kwa mwana munjira izi? *Can HIV be transmitted from a mother to a child*	<u>No</u> <u>Yes</u> <u>Don't know</u> a) During pregnancy? 1 2 98 b) During delivery? 1 2 98 c) By breastfeeding? 1 2 98	
HIV014	Kodi pali mankwala apadera omwe a dokotala kapena a nurse angapereke kwa mayi wodwala EDZI kuti ateteze kupatsila mwana wawo matenda a edzi? *Are there any special medication that a doctor or a nurse can give to a woman infected with the HIV virus to reduce the risk of transmission to the baby?*	No 1 Yes 2 Don't know/not sure 98	
HIV015	Kodi pali mankwala apadera omwe anthu odwala EDZI angapeze kuchokera kwa dokotala? *Is there any special medication that people infected with HIV can get from a doctor?*	No 1 Yes 2 Don't know/not sure 98	
HIV016	Kodi pangakhale njira yochepetsera mpata wofalitsila matenda a AIDS kuchoka kwa mai kupita kwa mwana? *Is there any way you can reduce the chance of transmitting HIV from mother to child when pregnant?*	Yes 1 No 2	→QHIV018

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
HIV017	Kodi zingachitike bwanji? *How?*	PMTCT (*prevention of mother to child transmission*) 1 Traditional Healer 2 Prayer 3 Other (specify) 4	
HIV018	Munayamba mwakambiranapo ndi abambo akunyumba njira zozitetezera ku EDZI? *Have you ever talked about ways to prevent getting the virus that causes HIV/AIDS with your husband?*	No 1 Yes 2	
HIV019	Kodi ndikoyenerela kukamba za EDZI kudzera muzinthu izi? *In your opinion is it acceptable for HIV/AIDS to be discussed at the following?* **DK = Don't know**	<u>No</u> <u>Yes</u> <u>DK**</u> a) Radio 1 2 98 b) TV 1 2 98 c) Newspapers 1 2 98 d) Political rallies 1 2 98 e) Community groups 1 2 98 f) Church 1 2 98 g) Through drama 1 2 98 h) Through songs 1 2 98	
HIV020	Kodi mungagule masamba a ndiwo kuchokera kwa munthu wodwala edzi? *Would you buy vegetables from a vendor who has HIV/AIDS?*	No 1 yes 2 Don't know/not sure 98	
HIV021	Kodi m'bale wanu atakhala ndi edzi, mungawaudze anthu za matendawa? *If a member of your family got infected with HIV/AIDS, would you fear disclosing their status?*	No 1 Yes 2 Don't know/not sure 98	
HIV022	Kodi mphunzitsi atapezeka ndi matenda a edzi, kodi adziloledwa kupitiliza kuphunzitsa? *If a teacher got infected with HIV/AIDS, should he/she be allowed to continue teaching in the school?*	No 1 Yes 2 Don't know/not sure 98	
HIV023	Kodi anthu odwala matenda a edzi adziloledwa kugwira ntchito limodzi ndi anzawo oti alibe edzi? *Should persons with HIV/AIDS who work with other people be allowed to continue their work or not?*	No 1 Yes 2 Don't know/not sure 98	
HIV024	Kodi anthu amene akudwala edzi ndi achiwelewere kapena oipa? *Are people with HIV/AIDS immoral?*	No 1 Yes 2 Don't know/not sure 98	
HIV025	Kodi ana aziphunzitsidwa kagwiritsidwe ntchito ka makondomu kusukulu? *Should children be taught how to use a condom in schools?*	No 1 Yes 2 Don't know/not sure 98	
HIV026	Mukuganiza kuti kugwiritsa ntchito kondomu kungateteze kutenga matenda kudzera muchiwerewere? *Do you think that condoms are safe to use?*	No 1 Yes 2 Don't know/not sure 98	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HIV027	Chifukwa chani mukuganiza kuti makondomu sangateteze kutenga matenda? Why do you think condoms are not safe to use?	a) They easily burst b) Others who have used condoms before have contracted diseases c) Careless use may lead to contracting of disease d) They are not reliable e) May not be sustained by those that use them f) others (specify)	0 0 0 0 0 0	1 1 1 1 1 0	
HIV028	Kodi ndikoyenera kuti anthu adziyezetsa matenda a edzi akafuna kulowa m'banja? *Do you think men or women who intend to marry should be tested for the AIDS virus before marriage?*	No Yes Don't know/not sure	1 2 98		

SANITATION (SAN) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES		GO TO
SAN001	Kodi mumagwiritsa ntchito chimbudzi cha mtundu wanji pakhomo pano? *What kind of toilet facilities does your house have?*	Own flush toilet Shared flush toilet Own Traditional pit latrine Shared traditional pit latrine Own Ventilated improved pit latrine Shared Ventilated improved pit latrine Ecosar No facility/bush/field/water Other (Specify)_____	1 2 3 4 5 6 7 8 9	→**SAN003** →**SAN003** →**SAN003** →**SAN003** →**SAN003** →**SAN003** →**SAN003** →**SAN003**
SAN002	Kodi ndi chifukwa ninji mulibe chimbudzi? *Why do you not have a pit latrine?*	Do not like to use them Bad soil/collapses easily No money for materials No one to construct toilet No place to construct toilet Rented premises Other _____	1 2 3 4 5 6 7	→**SAN009** →**SAN009** →**SAN009** →**SAN009** →**SAN009** →**SAN009** →**SAN009**
SAN003	Kodi zopondera za chimbudzi chanu zina mangidwa ndi chiyani? *What is the surface of the latrine made from?*	Wood Mud/Soil only Mud/Soil containing animals manure Concrete Concrete sanitation platform Other (specify)	1 2 3 4 5 6	
SAN004	Kodi khoma la chimbuzi chanu linamangidwa ndi chani? *What is the superstructure of the latrine constructed from?*	Reeds Bamboo Grass Mud bricks Burnt bricks Other (specify)	1 2 3 4 5 6	
SAN005	Kodi chimbuzi chanu chili ndi denga? *Does the latrine have a roof*	Yes No	1 2	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
SAN006	Kodi ndi anthu angati m'banji lanu amene amagwiritsa ntchito chimbudzi? Does everyone in the household use the pit latrine	Yes 1 No 2	→**SAN009**
SAN007	Kodi ndi athu ati amene sagwiritsa ntchito? *Who does not use the pit latrine*	a) Children <5 0 1 b) Children 5 – 15 0 1 c) Pregnant women 0 1 d) Adults: specify 0 1	
SAN008	Kodi ndi chifukwa ninji sakonda kugwiritsa ntchito? *Why do they not like to use the pit latrine*	Bad smell 1 Dark 2 Use by elders 3 Fear of falling in/hole too big 4 Others (specify) 5	
SAN009	Kodi chimbudzi cha ana aang'ono chimakataidwa kuti? *Where are stools from small children disposed of?*	Latrine 1 Bush 2 Ground around the house 3 Refuse pit 4 Dig a hole and cover 5 Other _____ 6	
SAN010	Kodi posachedwapa mwamangapo chimbuzi posachedwapa? *Have you recently constructed a latrine in your household?*	Yes 1 No 2	
SAN011	Chifukwa chani mwangomanga kumene chimbuzi *What is the main reason you have recently constructed a latrine?*	New technology 1 To replace old one 2 Had no toilet facility 3 Have learned the importance of a latrine 4 To avoid sickness (diseases) in the family 5 Other (specify) 6	

DRINKING WATER SOURCES (DWS) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
DWS001	Kodi madzi anu akumwa kwenikweni mumawatunga kuti? *What is the main source of drinking water for members of your household?*	Piped water into compound with outdoor tap 1 Public tap 2 Private tap 3 Protected well 4 Unprotected shallow well 5 Borehole 6 Spring 7 River/stream 8 Pond/lake 9 Water truck 10 Rainwater tank 11 Other (Specify)_____ 12	
DWS002	Kodi mumatunga kangati madzi akumwa kuchokera ku …….(refer to question 301) *How often do you obtain drinking water from this source?*	Twice a day 1 Once a day 2 Six times a week 3 Five times a week 4 Four times a week 5 Three times a week 6 Twice a week 7 Once a week 8 Other (specify) _____ 9	
DWS003	Kodi mumalipira madziwo? *Do you have to pay for the water?*	Yes 1 No 2	→ **DWS005**
DWS004	Kodi mumalipira zingati? *How much do you pay?*	_____per container _____per (Specify)_____	
DWS005	Kodi madzi okumwawo ndi wotetezedwa? *Is the drinking water at the source treated (protected) at any time?*	Yes 1 No 2 Don't know 98	→ **DWS009** → **DWS009**
DWS006	Kodi amawateteza madzi akumwawo ndi ndani? *Who treats (protects) the drinking water source?*	Health surveillance assistant 1 Water officer 2 Village health committee 3 Water board 4 Water Point Committee 5 Other (specify) _____ 6 Don't know 98	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
DWS007	Kodi madzi akumwawo amatetezedwa bwanji? *What is the drinking water source treated (protected) with?*	Water-guard 1 Chlorine 2 Chemical 3 Filter 4 Traditional medicine 5 Concrete surround 6 Other (specify) _____ 7 Don't know 98	
DWS008	Kodi madzi akumwawo amatetezedwa kawirikawiri bwanji? *How often is the drinking water source treated (protected)?*	Once a day 1 Once a week 2 Once a month 3 During cholera season 4 During rainy season 5 Other (specify) _____ 6 Don't know 98	
DWS009	Kodi alipo malo ena amene kumapezeka madzi akumwa kupatula amene mwatchulawo. *Are there any other drinking water sources available?*	Yes 1 No 2	→ **SDW001**
DWS010	Ndi ati? *What are the other drinking water sources available?* **MULTIPLE RESPONSES POSSIBLE**	a) Piped water into home 0 1 b) Piped water into compound 0 1 with outdoor tap 0 1 c) Public tap 0 1 d) Private tap 0 1 e) Protected well 0 1 f) Unprotected shallow well 0 1 g) Public bore hole 0 1 h) Spring 0 1 j) River/stream 0 1 k) Pond/lake 0 1 l) Water truck 0 1 m) Rainwater tank 0 1 n) Other (Specify)_____ 0 1	
DWS011	Kodi mumathanso kumwa? *Do you use this other source for drinking water?*	Sometimes 1 Never 2	→ **SDW001**

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
DWS012	Chifukwa chiyani simumamwa? *Why do you not use this source for drinking water?* MULTIPLE RESPONSES AVAILABLE	a) Too far away 0 1 b) Too expensive 0 1 c) Water runs out 0 1 d) Too busy 0 1 e) Bad Smell 0 1 f) Bad Taste 0 1 g) Bad Appearance 0 1 h) People get sick 0 1 i) Children get sick 0 1 j) Other (Specify)_____ 0 1 0 1	

STORAGE AND USE OF DRINKING WATER (SDW) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
SDW001	Kodi mumasunga madzi okumwa mu ziwiya mnyumba mwanu? *Do you store drinking water in containers in your home?*	Yes 1 No 2	→ **DWSF001**
SDW002	Chiwiya chenicheni chimene mumasungira madzi okumwa ndi chiti? *What is the main type of container you use to store drinking water in your household?*	Metal bucket 1 Plastic bucket 2 Jerrycan 3 Barrel/drum 4 Clay pot 5 Basin 6 Cooking pots/sauce pan 7 Other (specify) _____ 8	
SDW003	Kodi ndi chifukwa chenicheni chiti chomwe mumagwiritsa ntchito chiwiya chimenechi posungira madzi akumwa? *What is the most important reason you use this type of container to store drinking water?*	Prevent contamination 1 Cheap 2 Easily available 3 Easy to pour water 4 Strong 5 Water stays cold 6 Easy to cover 7 Good size 8 Other (Specify)_____ 9	
SDW004	Mukatunga madzi akumwawo kodi mumathira mu chiwiya chosungiracho nthawi yomweyo? *After you have collected drinking water, is it poured into the storage container straight away?*	Yes 1 No 2	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
SDW005	Mumatani? *What do you do when you renew the water in the storage container?*	Top up existing water in the container 1 Refill when empty without cleaning 2 Clean container and refill 3 Other (specify) _____ 4	
SDW006	Kodi madzi akumwawo mumachita kupungulira mu kapu kapena mumagwiritsa kapuyo potungira? *Is drinking water poured into a glass or a cup from these containers or, does a person have to use a glass or a cup to scoop it out?*	Water is poured out 1 Water is scooped out 2 Other (Specify)_____ 3	→ **SDW008**
SDW007	Kodi mukugwiritsa ntchito chiyani potunga madzi kuchokera mchiwiya chanu lero? *What is used to scoop drinking water out of the water container you are using today?*	Cup 1 Jug 2 Bowl 3 Bucket 4 Chikho 5 Other (Specify)_____ 6	
SDW008	Mungandionetseko komwe mumasungira madzi? *Could you show me where you store your water in the house?*	Yes 1 No 2	
SDW009	**OBSERVATION** Are the containers in which **drinking water** is stored……..	Not covered 1 Partially covered 2 Completely covered 3 Not observed 4	
SDW010	**OBSERVATION** *Ask the person to demonstrate how they scoop water from the container and prepare to drink?* Is the utensil used for scooping water the same used for drinking?	Yes 1 No 2 Not observed 3	

SDW011	Kodi madzi a muchiwiyachi mumagwiritsiranso ntchito zina kupatula kumwa? *Do you use the water in this container for uses other than drinking?*	Yes 1 No 2	→ **DWSF001**
SDW012	Mumagwiritsira ntchito zake ziti? *For what do you use this water?* (CIRCLE ALL ANSWERS THAT APPLY) **Prompt 'pali zinanso…?' but do not give answers. '***Anything else…?'*	a) Cooking 0 1 b) Washing vegetables 0 1 c) Cleaning plates and utensils 0 1 d) Washing clothes 0 1 e) Bathing 0 1 f) Other (Specify)_____ 0 1	

DRINKING WATER SAFETY (DWSF) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
DWSF001	Kodi chitetezo cha madzi anu akumwa munganene kuti nchotani? *Is the safety of the drinking water in your house .....* (READ OUT RESPONSES)	Choyipa *poor* 1 Chabwino *good* 2 Cha bwino bwino *resonable* 3	
DWSF002	Kodi mukudziwa bwanji kuti chitetezo cha madzi akumwa ndi chotere……? *How do you know that the safety of the drinking water in your house is .....?* (USE RESPONSE FROM Q501) (MULTIPLE RESONSES POSSIBLE) PROMPT: 'Pali zinaso**…..?'** '*Anything else..?@*	a) Smell 0 1 b) Taste 0 1 c) Appearance 0 1 d) People get sick 0 1 e) Children get sick 0 1 f) No one gets sick 0 1 g) It is protected 0 1 h) Containers are cleaned and covered 0 1 i) Other (Specify)_____ 0 1	
DWSF003	Kodi ndi matenda anji amene amgadze chifukwa chokumwa madzi osatetezedwa? *Which diseases can result from drinking unsafe water?* (MULTIPLE RESPONSES POSSIBLE)	a) Diarrhoea 0 1 b) Cholera 0 1 c) Dysentry 0 1 d) Bilharzia 0 1 e) Fever 0 1 f) Other diseases (Specify)_____ 0 1	
DWSF004	Kodi mungandiuze ngati madzi otungidwa m'malo awa ndi osatetezedwa, otetezedwa pang'ono, kapena ndi otetezedwa bwino: *Please tell me if you think the safety of the following water sources is 'good', 'medium' or 'bad'.* **READ ALL RESPONSES AND USE PROMPT CARDS**	a) Mpope wa mnyumba *piped water into the house* 0 1 2 N b) Mpope wa panja *water piped into compound* 0 1 2 N c) Mpope wa aliyense public tap 0 1 2 N d) Chitsime chowaka, chovindikiridwa 0 1 2 N e) Chitsime chosawaka *protected well* 0 1 2 N f) Mjigo *borehole* 0 1 2 N g) Kasupe *spring* 0 1 2 N h) Nsinje *river* 0 1 2 N i) Dziwe *pond* 0 1 2 N j) Nyanja *lake* 0 1 2 N k) Chigalimoto cha madzi *tanker truck* 0 1 2 N l) Thanki ya madzi a mvula *rainwater tank* 0 1 2 N	Unprotected shallow well
DWSF005	Kodi madzi ooneka bwino angakudwalitseni? *Can water that looks clear make you sick?*	Yes 1 No 2 Don't know 98	
DWSF006	Kodi madzi amene mukumwa pa nyumba pano ndi ofunika kutetezedwanso? *Does the protection of the drinking water in your house need to be improved?*	Yes 1 No 2	

DWSF007	Kodi inu kapena wina wa mnyumba mwanu mumachitapo kanthu pofuna kupititsa patsogolo katetezedwe ka madzi anu akumwa? *Do you, or any household member, regularly do anything to protect the safety of the drinking water in your house?*	Yes		1	→ **DWSF009**
		No		2	
DWSF008	Ndi chifukwa chiyani sumuchitapo kanthu? *What is the main reason you, or another member of your household, do not do anything to protect the safety of water in your house?*	Water is safe already		1	→ **DWSF012**
		Too expensive		2	→ **DWSF012**
		Too time consuming		3	→ **DWSF012**
		Method not available		4	→ **DWSF012**
		Too difficult to carry out		5	→ **DWSF012**
		Not possible		6	→ **DWSF012**
		Other (specify) _____		7	→ **DWSF012**
		Don't know		98	
DWSF009	Kodi inu kapena wina wa mnyumba mwanumu mumachitapo chiyani kuti muteteze madzi? *What do you, or another household member, do to protect the safety of your drinking water?*	a) add water-guard	0	1	
		b) Boiling	0	1	
		c) Sieving/Filtering	0	1	
		d) Add chlorine	0	1	
		e) Add chemical	0	1	
		f) Add iodine	0	1	
		g) Add purifying solution	0	1	
		h) Add purifying soda	0	1	
		i) Clean and cover containers	0	1	
		j) Use 2 cup system for drinking	0	1	
		k) Other (Specify)_____	0	1	
DWSF011	Kodi ndi kawiri kawiri bwanji kamene mumateteza madzi anu mu njira imeneyi? *How often do you treat your water in this way?*	Every day		1	
		Every time new water is collected		2	
		Every time they drink water			
		Once a week		3	
		When there is cholera		4	
		Other (specify) _____		5	
				6	
DWSF012	Kodi munayamba mwathirapo water-guard mu madzi anu akumwa? *Have you ever received water-guard*	Yes		1	
		No		2	→ **HYP001**
DWSF013	Kodi kuthira water-guard mu madzi anu akumwa kunathandiza bwanji umoyo wa pa banja panu? *How did adding water-guard to you drinking water affect the health of the household?*	Reduced diarrhoea		1	
		Reduced sickness		2	
		Reduce cholera		3	
		Made water safe to drink		4	
		No change in health		5	
		Other (specify) _____		6	

HYGIENE PRACTICES (HYP) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
'Tsopano ndikufunsani za kusamba m'manja' *Now I would like to ask you some questions about hand washing*			
HYP001	Kodi mumasamba m'manja nthawi ziti? *When do you wash your hands?* **(CIRCLE ALL THAT APPLY)** **Prompt: 'Pali zina…??' until no more answers are given**	a) Before food preparation 0 1 b) Before eating 0 1 c) After eating 0 1 d) Before feeding children 0 1 e) After visiting the toilet 0 1 f) After attending to a child who has defecated 0 1 g) In the morning/after waking 0 1 h) After working in the garden 0 1 i) When they look dirty 0 1 j) Other (specify) _____ 0 1	
HYP002	Kodi nthawi zambiri mumasambira ndi chiyani m'manja? *What do you wash your hands with most of the time?*	Soap and water 1 Water only 2 Ash/sand and water 3 Other (specify) _____ 4	→ **HYP004** → **HYP004** → **HYP004**
HYP003	Kodi mungathe kundionetsa sopo imene mumasambira m'manjayo? *Could you please show me the soap that you use?*	Soap available 1 Soap not available 2	
HYP004	Mwa njira zomwe mumazidziwa zosambira m'manja, ndi njira yiti yeniyeni imene mumatsata mnyumba mwanu? *What is the main method you use to wash your hands in the house?*	Wash hands under water poured from a jug/cup---------- 1 Wash hands in a basin of water---------- 2 Wash hands in basin of water used by other members of the family.---------- 3 Wash hands under a running tap in the house/compound.---------- 4 Other (specify) _____ 5	
HYP005	Kodi mumakhula/mumatikita posamba m'manjamo? *Do you rub your hands together when washing?*	Yes 1 No 2	
HYP006	Kodi chifukwa chenicheni chomwe mumasambira m'manja ndi chiyani? *What is the main reason you wash your hands?*	To remove dirt 1 To remove germs 2 To prevent diarrhoea 3 To prevent sickness 4 Other (specify) _____ 5	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
HYP007	Kodi mnyumba mwanu muli ndi malo kapena chiwiya chapadera chosambira m'manja? *Does you household have a special place/utensil for handwashing?*	Yes 1 No 2	→ **HSA001**
HYP008	ASK TO SEE THE PLACE MOST OFTEN USED FOR HAND WASHING AND OBSERVE IF EACH OF THE FOLLOWING ITEMS ARE PRESENT	a) Water/Tap 0 1 b) Soap/Ash/Other cleansing agents 0 1 c) Basin or other receptacle 0 1	
HYP009	Kodi munalandi apo malangizo osamalira zakudya? Have you received advice on food hygiene at home	Yes 1 No 2	→ **HSA001**
HYP010	Kodi malangizo anali otani? *What was this advice?*	a) Do not keep leftovers 0 1 b) Use clean utensils 0 1 c) Cover food to protect it 0 1 d) Wash hands before handling food 0 1 e) Wash hands before eating 0 1 f) Other (specify) 0 1	
HYP011	Kosi ndi ndani amene anapeleka malangizowa? Who gave you this advice?	a) Family member/friends 0 1 b) Village health committee 0 1 c) Health worker/Health clinic 0 1 d) Radio/Television 0 1 e) Newspaper 0 1 f) Other (Specify) 0 1	
HYP012	ASK TO SEE THE FOLLOWING AND RECORD IF PRESENT	a) Dish rack (*thandala la mbale*) 0 1 b) Kitchen shelter 0 1 c) Charcoal burner 0 1	

HSA/VHC (HSA) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HSA001	Kodi mudzi wanu uli ndi komiti ya za umoyo? *Does your village have a health committee*	Yes		1	
		No		2	**HSA005**
		Don't know		98	
HSA002	Kodi mungadzi we maina a membala a komiti? *Do you know the members of your village health committee*	Yes		1	
		No		2	
HSA003	Kodi komiti ya za umoyo yanu imachita ntchito zotani? What functions do your health committee perform	a) Maintain water source	0	1	
		b) Advise of outreach clinic times	0	1	
		c) Check on pregnant women	0	1	
		d) Check on new mothers	0	1	
		e) Sell mosquito nets	0	1	
		f) Carry out health education	0	1	
		g) Train on pit latrine construction	0	1	
		h) Advise on family planning	0	1	
		i) Advise on HIV/AIDS	0	1	
		j) Help sick access health care	0	1	
		k) Liaise with HSA	0	1	
		l) Attend training	0	1	
		m) Nothing	0	1	
		n) Don't know	0	1	
		o) Other (specify)	0	1	
HSA004	Kodi komiti ya za umoyo kuthandizani kusintha? Do you think your village health committee is effective?	Yes		1	
		No		2	
HSA005	Kodi ndi mbali yanji yomwe mukufuna kona a komiti ya zaumoyo yanu idzichita? What roles would you like to see you village health committee take	a) Maintain water source	0	1	
		b) Advise of outreach clinic times	0	1	
		c) Check on pregnant women	0	1	
		d) Check on new mothers	0	1	
		e) Sell mosquito nets	0	1	
		f) Carry out health education	0	1	
		g) Train on pit latrine construction	0	1	
		h) Advise on family planning	0	1	
		i) Advise on HIV/AIDS	0	1	
		j) Help sick access health care	0	1	
		k) Liaise with HSA	0	1	
		l) Attend training	0	1	
		m) Nothing	0	1	
		n) Don't know	0	1	
		o) Other (specify)	0	1	
HSA006	Kodi mudzi wanu uli ndi komiti ya za madzi? *Does your village have a water point committee*	Yes		1	
		No		2	**HSA011**
		Don't know		98	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HSA007	Kodi mungadzi we maina a membala a komiti? *Do you know the members of your water point committee*	Yes No		1 2	
HSA008	Kodi komiti ya za madzi yanu imachita ntchito zotani? What functions do your water point committee perform	a) Maintain water source b) Collect money for water point maintenance c) Liaise with water supervisor d) Advise community on water safety e) Liaise with HSA f) Attend training g) Nothing h) Don't know i) Other (specify)	0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1	
HSA009	Kodi komiti ya za madzi kuthandizani kusintha? Do you think your water point committee is effective?	Yes No		1 2	
HSA010	Kodi ndi mbali yanji yomwe mukufuna kona a komiti ya za madzi yanu idzichita? What roles would you like to see your water point committee take	a) Maintain water source b) Collect money for water point maintenance c) Liaise with water supervisor d) Advise community on water safety e) Liaise with HSA f) Attend training g) Nothing h) Don't know i) Other (specify)	0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1	
HSA011	Kodi mukumudziwa wa za umoyo wa m'mudzi wamu? Do you know the HSA responsible for your village	Yes No		1 2	 **HSA015**
HSA012	Kodi mlangizi wa za umoyo ndi wa mkazi kapena wa mawamuna? What sex is your HSA?	Male Female		1 2	
HSA013	Kodi mlangizi was za umoyo a mayenderadi mudzi wanuwu? Does the HSA visit your village?	Yes No		1 2	 **HSA015**
HSA014	Kodi kukuyenderani kwao kumakhala kodzagwira ntchito iti? What is the purpose of their visits	a) Outreach clinic b) Growth monitoring c) Immunisations d) Check village hygiene e) Check water supply f) Check pit latrine coverage g) Train VHC h) Provide chlorine for water treatment i) Ante natal training j) Other (specify)	0 0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1 1	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
HSA015	Kodi mungakonde kuona alangizi a zaumoyo anuwa akumachita chiyani panopa sakumachita? What roles would you like to see your HSA take which they do not presently do?	a) Outreach clinic b) Growth monitoring c) Immunisations d) Check village hygiene e) Check water supply f) Check pit latrine coverage g) Train VHC h) Provide chlorine for water treatment i) Ante natal training j) Other (specify)	0 0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1 1	

NUTRITION (NTR) SECTION

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
NTR001	Kodi mu banja lanu kawirikawiri mumadya kangati pasiku? *How many times do you usually eat in a day in your household?*	Once a day 2 times a day 3 times a day 4 times a day >4 times a day		1 2 3 4 5	
NTR002	*Kodi dzulo mwadya zokudya za nthawi iti?* *What meals did you have yesterday?*	a) Early morning meal (breakfast) b) Day meal (Lunch) c) Night meal (dinner) d) Any other (specify)	0 0 0 0	1 1 1 1	
NTR003	Kodi masiku ano aliyense pakhomo panu amadya mpakana kukhuta (kukwanira)? Does your household eat until satisfied right now?	No Yes		1 2	
NTR004	Kodi chaka chino munayamba mwachepetsapo kadyedwe pakhomo pano chifukwa chakusowa chakudya? Have you at any time reduced the amount of food you eat because there wasn't enough food?	No yes		1 2	→ **NTR006**
NTR005	Kodi ndi zokudya za nthawi iti zimene munachepetsa? Which meals did you suppress?	Breakfast Lunch Dinner Breakfast and lunch Lunch and dinner Breakfast and dinner All meals		1 2 3 4 5 6 7	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES					GO TO
NTR006	Kodi zinthu izi mumadya kangati pa mwezi uli wonse? How many times in a month can you afford the following foods for your household members?	**Frequency/month**	<4	5-10	11-20	>20	
		a) rice (Mpunga)	1	2	3	4	
		b) Cassava (Chinangwa)	1	2	3	4	
		c) Bananas (Nthochi)	1	2	3	4	
		d) meat/poutry (Nyama/nkhuku)	1	2	3	4	
		e) Fresh Fish (Nsomba za fleshi)	1	2	3	4	
		f) Dried Fish (Nsomba zouma)	1	2	3	4	
		g) Milk (Mkaka)	1	2	3	4	
		h) Fruits (Zipatso)	1	2	3	4	
		i) Nuts (ntedza)	1	2	3	4	
		j) Beans (Nyemba)	1	2	3	4	
		k) Vegetables (masamba)	1	2	3	4	
NTR007	Kodi muli ndi nkhawa kuti mukhala mulibe chokudya…..? Do you worry that you will lack food for…?	This week? Next week? Next month? Next two months? In three months? In four months? 5 or more months?				1 2 3 4 5 6 7	
NTR008	Kodi zimenezi mukumasowa nozo mtendere kwambiri? *Does this concern you a lot?*	Yes No				1 2	
NTR009	Chikololere mwayambapo mwagula chimanga kapena ufa zoti mupangire zokudya myimba mwanu? *Since last harvest, have you bought maize or maize flour to feed your family?*	Yes no				1 2	**NTR012**
NTR010	Munayamba liti kugula chakudyachi? *When did you start buying maize or maize flour?*	This month Last month Two months ago Three months ago 4 months ago More than 4 months ago?				1 2 3 4 5 6	
NTR011	Kodi mukafuna kugula chimanga/ufa mumagula wochuluka bwanji? *When you purchase maize/flour, how much do you normally purchase?*	50kg bags or more Between 25kg and 49 kg Between 10kg and 24kg Between 5kg and 9kg Less than 5kgs				1 2 3 4 5	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES			GO TO
NTR012	Kawiri-kawiri Mumazipeza kuti ndalama zogulira chimanga/ufa? *Where do you usually get money to buy maize/flour?*	a) Sale of cow (*kugulitsa ng'ombe*) b) Sale of small ruminants such as goats etc. (*kugulitsa mbuzi, nkhosa, nkhumba, akalulu, ndi mbila*) c) Sale of poultry (*kugulitsa nkhuku, abakha, nkhanga, nkhukutembo, nkhunda*) d) Sale of wild animals and birds (*Kugulitsa mbewa, mbalame, ndi zina zosaka*) e) Income generating activity (*business*) f) Gift from relatives(*ndalama zochokela kwa ana kapena achibale*) g) Other (specify)_____	0 0 0 0 0 0 0	1 1 1 1 1 1 1	
NTR013	Chikololere, munayamba mwadyapo chokudya chimene simumachifuna chifukwa chopelewera kapena chosowa zakudya? *Did your household ever eat food it didn't want to eat because there wasn't enough or no food at all at home?*	yes No		1 2	**NTR016**
NTR014	Kangati komwe munadya chakudya chomwe simumachifuna chikololere? *Since harvest, how many times did you eat food you did not want?*	1-5 6-10 11-20 > 20		1 2 3 4	
NTR015	Zokudya zake ziti zomwe munadya? Which food did you eat?	a) Maize husks (Madeya) b) Wild Leaves (Masamba) c) Roots (Mizu) d) Wild beans (Kalongonda) e) Mangoes f) Dried kasava (Chinangwa chophika chouma) g) Dried Pigeon peas (Nandolo) h) Boiled dried maize (Chimanga chouma chophika i) Cooked green bananas (Nthochi zophika) j) Hard polidge from sorghum (Nsima yamapira) k) Wild roots (Nyika etc.) k) Other (specify)_____	0 0 0 0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1 1 1 1	
NTR016	Munayamba mwagonapo ndi njala chikololere? *Have you ever gone to sleep at night without food since you harvested?*	Yes No		1 2	**NTR018**
NTR017	Zimenezi zinachitikapo kangati? *How many times did this happen?*	1-5 times 6-10 times 11-20 times > 20 times		1 2 3 4	
NTR018	Munayamba mwagonapo ndi njala tsiku lonse latunthu chikololere? *Have you ever gone the whole day without food since you harvested?*	Yes No		1 2	

No.	QUESTIONS, INSTRUCTIONS & FILTERS	RESPONSES	GO TO
NTR019	Zimenezi zinachitikapo kangati? *How many times did this happen?*	1-5 times 1 6-10 times 2 11-20 times 3 > 20 times 4	
NTR020	Kodi bamboo a myumbamu amamwa mowa? Does the head of household drink beer?	Yes 1 No 2	
NTR021	Amamwa mowilikiza bwanji? How often does he drink?	Every day 1 3 times per week 2 Twice per week 3 Once a week 4 Twice a month 5 Once a month 6 Whenever he has money 7 Can't tell 8	
NTR022	Nanga inu mumamwa mowa? Do you drink beer yourself?	Yes 1 No 2	
NTR023	Mumamwa mowilikiza bwanji? How often does he drink?	Every day 1 3 times per week 2 Twice per week 3 Once a week 4 Twice a month 5 Once a month 6 Whenever he has money 7 Can't tell 8	

THIS IS THE END OF QUESTIONAIRE.
THANK THE PERSON FOR HIS/HER COOPERATION AND PARTICIPATION

Appendix 5A

MULTILEVEL RESIDUALS

Based on Rasbash et al., [2004], suppose y_{ij} is the observed value for the ith individual in the jth household and that $\hat{y}_{ij}$ is the predicted value from the regression, then raw residual for this individual is $r_{ij} = y_{ij} - \hat{y}_{ij}$. The raw residual for the jth household is the mean of the r_{ij} for the individuals in the household. Let this residual be r_{+j}. Then the estimated household level residual is given by

$$\hat{u}_{0j} = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2 / n_j} r_{+j}$$

where n_j is the number of individuals in household j ; σ_{u0}^2 is household variation; σ_e^2 is individual variation; and $\frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2 / n_j}$ is known as the shrinkage factor.