Integrated approach to malaria prevention in rural communities in Uganda: experiences, perceptions and practices

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October, 2015
Declaration

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Dedication

I dedicate this work to my father Prof. Miph Musoke whose public health career for many years inspired me to do this PhD particularly on malaria.
Acknowledgments

First and foremost, I thank the Almighty God for having enabled me study this degree for the past 3 years.

In a special way, I wish to recognise the tremendous encouragement and support from my Director of Studies, Prof. George Karani. I would never have made it to the completion of the programme if it was not for his guidance and belief in my potential to succeed.

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<tbody>
<tr>
<td>AOR</td>
<td>Adjusted Odds Ratio</td>
</tr>
<tr>
<td>APRR</td>
<td>Adjusted Prevalence Rate Ratio</td>
</tr>
<tr>
<td>CDC</td>
<td>United States Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>CHWs</td>
<td>Community Health Workers</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>DDT</td>
<td>Dichloro-diphenyl-trichloroethane</td>
</tr>
<tr>
<td>DEET</td>
<td>N,N-Diethyl-meta-toluamide</td>
</tr>
<tr>
<td>DFID</td>
<td>United Kingdom Department for International Development</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FGD</td>
<td>Focus Group Discussion</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GFATM</td>
<td>Global Fund to fight AIDS, Tuberculosis and Malaria</td>
</tr>
<tr>
<td>HSSP</td>
<td>Health Sector Strategic Plan</td>
</tr>
<tr>
<td>IDI</td>
<td>In-depth interview</td>
</tr>
<tr>
<td>IEC</td>
<td>Information, Education and Communication</td>
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<tr>
<td>IPTp</td>
<td>Intermittent Preventive Treatment of malaria in pregnancy</td>
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<tr>
<td>IRS</td>
<td>Indoor Residual Spraying</td>
</tr>
<tr>
<td>ITN</td>
<td>Insecticide-treated mosquito net</td>
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<td>IVM</td>
<td>Integrated Vector Management</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>LLIN</td>
<td>Long-lasting insecticidal net</td>
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<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
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<td>MOH</td>
<td>Ministry of Health, Uganda</td>
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<tr>
<td>NGO</td>
<td>Non-governmental organisation</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>PCA</td>
<td>Principal Component Analysis</td>
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<tr>
<td>PMI</td>
<td>United States President’s Malaria Initiative</td>
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<tr>
<td>PRR</td>
<td>Prevalence Rate Ratio</td>
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<tr>
<td>RBM</td>
<td>Roll Back Malaria</td>
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<tr>
<td>RCT</td>
<td>Randomised Controlled Trial</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<tr>
<td>SES</td>
<td>Socio economic status</td>
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<tr>
<td>SP</td>
<td>Sulphadoxine-pyrimethamine</td>
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<tr>
<td>UBOS</td>
<td>Uganda Bureau of Statistics</td>
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<tr>
<td>UNCST</td>
<td>Uganda National Council for Science and Technology</td>
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<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<tr>
<td>VHT</td>
<td>Village Health Team</td>
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Abstract

**Background:** Despite immense global malaria prevention efforts, the disease remains a major cause of morbidity and mortality in sub-Saharan Africa. An integrated approach to malaria prevention, which advocates the use of several malaria prevention measures holistically, is being explored to reduce the occurrence of the disease.

**Aim:** The aim of the thesis was to assess experiences, perceptions and practices on the integrated approach to malaria prevention in Wakiso district, Uganda.

**Methods:** Study I was a pilot project that promoted the integrated approach and involved 3 phases. Phase 1 (baseline) was cross-sectional, and determined knowledge and practices on malaria prevention. Phase 2 (intervention) implemented an intervention on the integrated approach. Phase 3 (evaluation) was a cross-sectional impact evaluation of using the integrated approach. Study II was a clustered cross-sectional survey that assessed perceptions, utilisation and barriers of integrated malaria prevention.

**Results:** The majority of participants (64.6%) had low knowledge on malaria prevention methods, with mosquito nets (81.7%) most known. Insecticide-treated nets were the most used method with 45.5% of households owning at least one net (Study I phase 1). The pilot project trained 25 community volunteers, sensitised over 200 community members, and established 40 demonstration households (Study I phase 2). There was improvement in knowledge on removal of mosquito breeding sites (51% versus 7%) in the evaluation in comparison with the baseline respectively. Improvement in practices in the evaluation compared with the baseline included mosquito screening in windows and ventilators ($\chi^2 = 62.3; p < 0.001$). The benefits reported by the demonstration households included reduction in mosquito populations and occurrence of malaria (Study I phase 3). If trained, most participants (68.6%) would use all methods in the integrated approach. Only 33.0% households were using the integrated approach, which was associated with reading newspapers (AOR 0.34; 95% CI 0.22 – 0.53) (Study II).

**Conclusion:** Stakeholders involved in malaria control should intensify efforts of promoting multiple malaria prevention methods.
CHAPTER ONE: INTRODUCTION

1.1 Background and context

In 2013, it was estimated that globally there were 198 million cases of malaria, and 584,000 deaths associated with the disease (WHO, 2014). Africa is the continent with the highest prevalence of malaria, and accounts for over 90% of all malaria deaths with children under five years of age, and pregnant women being most vulnerable (Kimbi et al., 2014). These figures remain high despite global malaria mortality rates falling by 47% between 2000 and 2013, with a decrease of 54% in Africa (WHO, 2014). Estimates of the true burden of malaria have been difficult to obtain, due to many malaria cases and deaths going unreported particularly in developing countries (Lynch & Hewitt, 2012). This implies that the current malaria burden could be much higher than the estimates suggest.

In Uganda, malaria is the leading cause of morbidity and mortality especially among children under five years of age (Malaria Consortium, 2015a; MOH, 2010). The disease has an estimated 8-13 million cases per year, and accounts for approximately 30%-50% of outpatient care in health facilities, 15%-20% of health facility admissions and 9%-14% of inpatient deaths in the country (Malaria Consortium, 2015a). Uganda ranks fourth globally, based on the estimated number of cases among highest malaria burden countries (WHO, 2014). In addition to its impact on health, the burden of malaria on Uganda results in vast social and economic dimensions. The social dimension includes hindrances to usual societal participation due to the disease such as attending community events including political gatherings, health campaigns and family celebrations. The economic costs can be direct including seeking treatment or preventive
measures, or indirect such as low productivity due to absenteeism from school or work, and time lost caring for the sick (Orem *et al.*, 2012).

Globally, malaria prevention has mainly relied on mosquito vector control by using bed nets and indoor residual spraying (IRS). Sleeping under bed nets has been used for several years as a means to prevent malaria due to the physical barrier they provide against mosquitoes. The use of insecticide treated nets (ITNs) was recommended by the World Health Organization (WHO) in the late 1990s because in addition to the barrier effect, the insecticides kill, inhibit or repel mosquitoes (RBM, 1997). ITNs provide good personal protection, and also have a community preventive effect due to the benefits of malaria prevention to individuals beyond those using them (WHO, 2003a). Due to low retreatment rates observed for ITNs below the recommended every six to twelve months (CDC, 2014a), long-lasting insecticidal nets (LLINs) were introduced (Guillet *et al.*, 2001). LLINs are pre-treated during production with an insecticide that is embedded in the fabric therefore do not require any treatment or re-treatment by the user, and can remain effective for up to five years. Several studies have shown that ITNs can reduce the incidence of malaria by up to 50% (Eisele *et al.*, 2011a; Lengeler, 2004; Lim *et al.*, 2011; Schellenberg *et al.*, 2001).

Indoor Residual Spraying (IRS) involves the application of long-acting chemical insecticides on the walls of houses in order to kill mosquitoes that land and rest on them. Despite its widespread use and contribution to the success of malaria eradication and control efforts in the 1950s and 1960s, the use of IRS in recent decades substantially declined (WHO, 2006a). Although IRS is recommended as a primary intervention for malaria control, community acceptance has been
impeded by several challenges. These challenges include insecticide smell, mess left by the sprayers resulting from packets of insecticides used, inconvenience of removing household items from houses before spraying, increased prevalence of other insects, and perceived ineffectiveness and side effects such as skin irritation (Govere et al., 2000; Kaufman et al., 2012; Rodriguez et al., 2006). Household practices that remove the insecticide from sprayed walls such as washing or plastering also affect the effectiveness of IRS (Govere et al., 2000; Mnzava, 1998).

Malaria vector control strategies in Uganda have focused on use of ITNs and IRS, and the use of ITNs in the country has significantly increased in recent years. Households that own at least one ITN are estimated at 90% with an average of 2.5 nets (UBOS, 2015). The Ministry of Health (MOH) has provided free ITNs particularly to children under five years of age and pregnant women since 2006 (Yeka et al., 2012). In addition, the Government of Uganda, with support from the Global Fund to fight AIDS, tuberculosis and malaria (GFATM), United Kingdom Department for International Development (DFID), the United States President’s Malaria Initiative (PMI), and World Vision, supported the distribution of 21 million LLINs across the country in 2013 and 2014 (Malaria Consortium, 2014; WHO, 2013a). These initiatives of increasing access to ITNs are aimed at preventing several malaria deaths particularly among children under five years of age in the country.

There is a large regional variation in coverage of IRS in Uganda due to intensive spraying interventions carried out in only ten districts (out of the 112 districts in the country) (UBOS, 2014) in the malaria endemic mid-northern region spearheaded by the Government and non-governmental organisations (NGOs). Countrywide, only 5% of households had used IRS in 2014.
compared to 44% in the mid-northern region (UBOS, 2015). Country specific studies in Uganda have shown that use of ITNs (Clark et al., 2008) and IRS (Kigozi et al., 2012; Steinhardt, 2013) have reduced the occurrence of malaria in areas where they have been used. However, the national malaria burden has not decreased notably in recent years despite all of these efforts (Kassam et al., 2015; Yeka et al., 2012).

Although global and national malaria vector control efforts have focused on ITNs and IRS, several other practices can be implemented at households to reduce mosquitoes which transmit the disease. These practices include eliminating mosquito breeding sites notably stagnant water; installing screening in windows, ventilators, and open eaves to prevent entry of mosquitoes into houses; clearing overgrown vegetation near houses where mosquitoes harbour; closing windows and doors early in the evenings to limit mosquito entry; spraying houses with insecticides to kill mosquitoes; use of body mosquito repellents; and larviciding. These methods are known to have contributed to a reduction of mosquito populations, their entry into houses, and mosquito bites and hence the occurrence of malaria (CDC, 2008; Ng’ang’a et al., 2008; Tusting et al., 2015; WHO, 1997).

An integrated approach to malaria prevention is therefore being explored to reduce the occurrence of the disease. This innovative approach advocates the use of several malaria prevention measures in a holistic manner within households. These measures include global malaria control methods (WHO, 2011a) and others known to reduce mosquito populations (Lindsay et al., 2002; Markle et al., 2007; Tusting et al., 2015). The specific strategies advocated in the integrated approach are:
1. Sleeping under LLINs; 
2. Installing screening in windows, ventilators and open eaves to prevent mosquito entry into houses; 
3. IRS; 
4. Draining stagnant water to eliminate potential mosquito breeding sites; 
5. Removing vessels that can potentially hold water for mosquito breeding; 
6. Clearing overgrown vegetation around homes where mosquitoes can harbour; 
4. Closing windows and doors at sunset to reduce mosquito entry into houses; 
5. Larviciding in large water pools of stagnant water; 
6. Body mosquito repellents; 
7. Mosquito coils; and 
8. Insecticide sprays. 

This research aimed to assess experiences, perceptions and practices on the integrated approach to malaria prevention among the population in rural communities in Wakiso district, Uganda.

1.2 Rationale

The Ministry of Health has been at the forefront in the fight against malaria in Uganda. The goal of the Malaria Control Programme in the country is to reduce malaria morbidity and mortality, as well as reduce social and economic effects brought about by the disease (MOH, 2010). The principal strategies being used for malaria control are LLINs, IRS, prevention of malaria in pregnancy, and effective diagnosis and treatment (UBOS, 2010). However, malaria remains the
leading cause of morbidity and mortality as well as responsible for a large burden on the
country’s health system (MOH, 2010; UBOS, 2015).

The use of appropriate combinations of non-chemical and chemical methods of malaria vector
control in the context of integrated vector management has been recommended by the World
Health Organization (WHO, 2004). Indeed, a combination of malaria prevention strategies has
been shown to have greater impact than single methods in several studies (Fullman et al., 2013;
Hamel et al., 2011; Kleinschmidt et al., 2009). However, most of these studies have focused on
the use of ITNs and IRS. The integrated approach, which advocates for use of several malaria
prevention methods beyond ITNs and IRS in a holistic manner, is therefore being explored as a
complementary strategy to existing malaria control efforts.

Information on the use of an integrated approach to malaria prevention is scarce as integrated
malaria vector management has not been as yet, adequately explored in Uganda (Mutero et al.,
2012). Although it would be likely that the use of multiple preventive measures would have a
greater impact on a disease than the application of single method, it remains necessary to
investigate community experiences, perceptions and practices on the use of this more complex
preventive strategy. This research was necessary to generate new knowledge and increase the
understanding of this innovative approach for malaria prevention among rural communities in
Uganda. The findings from this research will inform malaria control practice and policy in
Uganda and furthermore, the knowledge obtained will be transferable to other communities
throughout the world, where malaria is endemic and a major public health concern.
1.3 Aim and objectives

1.3.1 Study aim

The study aims to assess experiences, perceptions and practices on the integrated approach to malaria prevention at household level in Wakiso district, Uganda, and to generate information that could inform malaria control practice and policy throughout the country.

1.3.2 Study objectives

1. To determine knowledge and practices on malaria prevention at households (study I, phase 1).

2. To implement an intervention on the integrated approach to malaria prevention in the community (study I, phase 2).

3. To evaluate the impact and experiences of using integrated malaria prevention in the community (study I, phase 3).

4. To assess community perceptions, utilisation and barriers to integrated malaria prevention in the community (study II).

1.4 Structure of the research

In order to implement the objectives of the thesis, the research was conducted in two studies (I and II). Study I, which was a pilot project that promoted the integrated approach to malaria prevention in two rural communities in Wakiso district, Uganda, involved three phases. Each of
the phases of study I, and study II addressed a specific objective of the research as described below.

1.4.1 Study I Phase 1 (Baseline)

The baseline phase of the project aimed at addressing objective one of the research, and ascertained the knowledge and practices of the community on malaria prevention. This was important to establish the status of malaria prevention in the community before implementation of the intervention (study I phase 2) of the pilot project which was objective two of the research. In addition, the findings of the baseline survey were also used in the evaluation of the intervention (study I phase 3) to measure changes in knowledge and practices on malaria prevention in the community.

1.4.2 Study I Phase 2 (Intervention)

The intervention phase of the project aimed at addressing the second objective of the research, and promoted the integrated approach to malaria prevention in the two rural communities. The intervention involved training community volunteers on the integrated approach, community sensitisation on the integrated approach, and establishment of demonstration households using integrated malaria prevention.
1.4.3 Study I Phase 3 (Evaluation)

The evaluation phase of the project aimed at addressing the third objective of the research, and was an impact evaluation of the intervention (study I phase 2) two years after its implementation. The evaluation assessed the benefits, challenges and experiences of using the integrated approach to prevent malaria in the community. The evaluation was carried out among the trained community volunteers, demonstration households, and general community from the intervention phase.

1.4.4 Study II

Study II aimed at addressing the fourth objective of the research, and was a clustered cross-sectional survey carried out in 29 villages from 11 parishes in Wakiso district, Uganda. This study assessed the perceptions, utilisation and barriers to integrated malaria prevention in the community. The study also established malaria environmental risk factors, and structural condition of houses related to entry of mosquitoes. The two villages involved in study I were not involved in study II, and were excluded to prevent the interventions implemented in study I influencing the results of study II.

1.5 Contribution to knowledge

Global and national malaria prevention efforts have focused on use of ITNs and IRS (WHO, 2014). However, several other malaria prevention methods have been shown to contribute towards reducing mosquito populations, prevent their entry in houses, minimise bites and hence reduce the occurrence of malaria (CDC, 2008; Ng’ang’a et al., 2008; Tusting et al., 2015; WHO,
1997). Although these malaria prevention methods have been studied individually, there is minimal literature available when the methods are used in combination. This research therefore provides information on the use of several malaria prevention methods in an integrated approach at households as a complementary strategy towards reduction in occurrence of the disease. The research provides information on community knowledge, experiences, perceptions and practices on using the integrated approach to malaria prevention. The findings of this research are expected to be used in developing future studies on the use of integrated malaria prevention in rural communities in Uganda and beyond.

From the research, three articles have been published in peer reviewed journals (African Health Sciences – appendix 2, Plos One – appendix 3, and Malaria Journal – appendix 4), and one manuscript submitted which is under review (Malaria Journal – appendix 1). The publication in Malaria Journal is among the highly accessed articles which is an outstanding achievement from the research (http://www.malariajournal.com/content/12/1/327). In addition to the publications, five oral presentations from the research have been made in international conferences in Kenya, Tanzania, Nigeria, South Africa, and the United States of America. The dissemination of findings from the research in publications and conference presentations is an indication of scientific rigour through peer review of the manuscripts and conference abstracts. The publications and conference presentations are therefore key outputs from the research which have increased the available literature and knowledge on malaria prevention, and in particular the integrated approach to malaria prevention.
The findings from the research have been disseminated to the communities where the studies were conducted. Therefore, in addition to contributing to knowledge for the scientific community through publications and conference presentations, the local population has also benefitted from learning about the various available malaria prevention measures beyond ITNs and IRS which have largely been promoted in Uganda. In addition, the local leaders and community health workers were appreciative of the research efforts to contribute to malaria prevention, and continued to promote the various methods in the integrated approach in their respective villages. The research has therefore contributed to knowledge at both scientific and community levels.

The research further demonstrates the concept that a pilot project targeting a disease of public health importance can lead to improvement in knowledge and practices. Indeed, the evaluation of the project (study I, phase 3) showed increase in knowledge on malaria prevention methods as well as improvement in non-conventional practices in the integrated approach such as early closing of windows and doors to prevent mosquito entry into houses. Whereas early closing of windows and doors is not done in many areas, this research provides evidence that once communities are trained in such malaria prevention methods, it is likely to lead to improved practices. This information is expected to be vital in potential scaling up of the integrated approach to malaria prevention in other parts of Uganda as well as in other malaria endemic countries.

The establishment of demonstration households using integrated malaria prevention in the intervention (study I, phase 2) showed that such sites can be used by communities to learn about new public health interventions in societies. Indeed, from the intervention phase, the community
learnt about the various malaria prevention methods used by the demonstration households particularly screening in windows and ventilators to prevent mosquito entry. Although screening of windows and ventilators is a measure to prevent mosquito entry into houses, it was hardly known in the study communities before project implementation. Therefore, the research was able to transfer knowledge into practice in rural communities in Uganda. In addition, to their role in increasing community awareness on the integrated approach, these demonstration households continued to benefit from the project interventions including reduction in the occurrence of malaria as established in the evaluation (study I, phase 3). Such evidence is likely to be beneficial to other researchers exploring integrated malaria prevention to contribute towards reducing malaria prevalence in endemic countries.

The research provides evidence that community cohesion is a key component of malaria prevention, and in particular the integrated approach. Indeed, from the pilot project evaluation (study I, phase 3) it was established that whereas households may implement measures to protect them from malaria such as sleeping under ITNs, practices such as removal of mosquito breeding sites, and clearing overgrown vegetation need to be done at community level to reduce the number of mosquito vectors in the area. This is because mosquito breeding many times occurs outside the confines of a household therefore measures implemented at community level benefit several families. This information from the research has the potential for use in future malaria prevention programmes.

The research demonstrates that public health interventions can give emphasis to the most vulnerable and affected groups. Indeed, the intervention (study I, phase 2) gave priority to
children under five years of age, and pregnant women especially while selecting the
demonstration households that benefitted by receiving ITNs and having complete screening
installed in all windows and ventilators of their houses. In addition, these most vulnerable groups
to malaria were emphasised during the community sensitisation and training of community
volunteers during the intervention. This aspect of the research ensured that in addition to
targeting combating malaria (Millennium Development Goal - MDG six), it also contributed to
MDGs four (reducing child mortality) and five (improving maternal health) due to the emphasis
given to children under five years of age, and pregnant women.

Study II provides evidence that although there is high awareness on various malaria prevention
practices, there is low utilisation of integrated malaria prevention in the community. However,
most of the participants were willing to use multiple methods in the prevention of malaria in their
households if trained. This information, which had not previously been established by other
studies in Uganda, could be used by various stakeholders involved in malaria control such as the
Ministry of Health to promote the use of multiple methods in the prevention of the disease. Other
malaria endemic countries, particularly those with similar demographic characteristics to
Uganda, could also utilise these findings to inform future work on integrated malaria prevention.

A total of 31 villages were involved in the research hence demographic and malaria prevention
information from these areas was collected. This data from such a large number of villages could
be explored by other researchers including students with intentions to do further research or
implement other public health interventions. This is a significant contribution of the research
regarding availing data that can be used for future purposes in Uganda and beyond.
1.6 Overview of the thesis

This thesis will comprise six chapters. Chapter one introduces the integrated approach to malaria prevention, provides context, rationale, aim and objectives of the study. Chapter two reviews existing literature on malaria parasites and vectors, malaria burden, malaria prevention globally and in Uganda, the various malaria prevention methods, integrated vector management, the integrated approach to malaria prevention, and health service delivery in Uganda in relation to malaria control. Chapter three describes the methods used in the research including study design, sample size, data collection, data analysis and ethical issues for both studies I (phases 1, 2 and 3) and II. Chapter four presents the results and discussion for study I (phases 1, 2 and 3), while chapter five describes the results and discussion for study II. Chapter six, which is the final chapter of the thesis, provides conclusions, recommendations and areas for future research.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides considerable available literature on malaria globally and in sub-Saharan Africa particularly Uganda. It includes literature on malaria transmission, mosquito life cycle and behaviour, global malaria burden, malaria burden in Uganda, global malaria prevention strategies, malaria prevention in Uganda, and various malaria prevention methods. The malaria prevention methods described are ITNs, IRS, house screening, housing quality, removal of mosquito breeding sites, mosquito skin repellents, mosquito coils, removal of vegetation, space spraying with insecticides, and larviciding. Existing literature on integrated vector management, and the integrated approach to malaria prevention is also provided. In addition, an overview of health service delivery in Uganda in relation to malaria prevention, and the community organisation behaviour change model used in study I are described in this chapter.

2.2 Malaria parasites and vectors

Malaria is caused by protozoa of the genus *Plasmodium* found in the blood of mammals, birds and reptiles. Although there are over 120 species of *Plasmodium*, the ones which infect humans are *P. falciparum, P. vivax, P. malariae, P. ovale* and to a lesser extent *P. knowlesi* (Beanland, 2006). *P. falciparum* is found worldwide and predominates in Africa where it causes more than 1 million deaths every year (CDC, 2012a). *P. vivax*, mainly found in Asia, Latin America and some parts of Africa, is considered the most prevalent human malaria parasite because of its high densities in Asia (Feng et al., 2015). *P. ovale*, which is morphologically similar to *p. vivax*, is
mainly found in West Africa, and is more prevalent than \textit{p. vivax} in Africa (Kang & Young, 2013). \textit{P. malariae} is found worldwide and is the only species known to cause fevers that recur at three-day intervals, the other malarial parasites doing so at two-day intervals (CDC, 2012a). \textit{P. knowlesi} is mainly found in South East Asia and accounts for over 70\% of malaria cases in that region (McCutchan \textit{et al}., 2008).

The life cycle of malaria parasites requires a definitive host (\textit{Anopheles} mosquito) where sexual reproduction occurs, and an intermediate host (mammals such as humans) in which asexual reproduction takes place. Malaria parasites are transmitted by mosquitoes, and in humans exclusively by female \textit{Anopheles}. Although there are more than 60 species of \textit{Anopheles} mosquitoes that transmit malaria globally, it is rare to find more than four species in a particular region (Malaria Consortium, 2007). In sub-Saharan Africa, the species of mosquitoes mainly responsible for transmitting malaria are \textit{A. gambiae} and \textit{A. funestus} (Coetzee \textit{et al}., 2000; Sinka \textit{et al}., 2012). Although some \textit{Anopheles} mosquito species such as \textit{A. stephensi} are zoophilic (feed on animals) (Omrai \textit{et al}., 2010), \textit{A. gambiae} and \textit{A. funestus} are predominantly anthropophilic (feed on humans) making them the most efficient malaria vectors globally (CDC, 2012b).

\textbf{2.3 Mosquito life cycle and behaviour}

Mosquitoes are the most important vector of public health importance due to their abundance, proximity to humans, and need to feed on blood by females (CDC, 2014b). The two main groups of mosquitoes are anophelines and culcines (including \textit{Aedes}) which are differentiated by characteristics in the developmental stages. Whereas \textit{Anopheles} mosquitoes are responsible for
transmitting malaria, *Culex* mosquitoes transmit diseases such as lymphatic filariasis, Japanese encephalitis, and West Nile virus (Webber, 2009). *Aedes* mosquitoes specifically transmit dengue, yellow fever and other viral diseases. Among all diseases transmitted by mosquitoes, malaria is of most significant public health importance in sub-Saharan African including Uganda (WHO, 2013b). Although the burden of other mosquito transmitted diseases such as filariasis and yellow fever is high in some countries in sub-Saharan Africa such as Nigeria and the Democratic Republic of Congo, their prevalence in Uganda is low (Garske *et al.*, 2014; Hotez & Kamath, 2009).

The life cycle of mosquitoes has four distinct stages: eggs, larvae, pupae and adults (Figure 2.1). Female *Anopheles* mosquitoes lay their eggs in pools of water normally at night which finally hatch between two to three days. *A. gambiae*, the most effective malaria vector in sub-Saharan Africa, predominantly lay their eggs in shallow, stagnant, clear pools of water (Coetzee *et al.*, 2000; Malaria Consortium, 2007). Indeed, in many parts of Africa, *A. gambiae* larvae have been seen in hoof prints and roadside pools (Warrel & Giles, 2002). Within 48 hours in tropical conditions, eggs then hatch into larvae and can be seen moving actively in the water. *Anopheles* larvae lie parallel to the water surface, which distinguishes them from those of *Culex* mosquitoes which rest at an angle to the surface of water. The larvae, which feed on algae, bacteria and other microorganisms, develop through four larval instars, and during the fourth instar, moult to become pupae within eight to ten days. Pupae, which are comma shaped, consist of a head, thorax and respiratory trumpets. The pupa stage lasts between one to two days during which they do not feed, and remain on the surface of water from where they breathe. Once disturbed, the
pupae swim to the bottom of the water with jerky movements. During development to the adult, the upper part of the pupae split open and the adult emerges. The adult spends a few hours resting on the water surface before flying. The three main sections of adult mosquitoes are the head, thorax and abdomen. The head has eyes, antennae, proboscis and two sensory palps (Pitts & Zwiebel, 2006). The antennae have sense organs and are useful in sound detection and host identification among females, while the proboscis is used for feeding (CDC, 2012b). The adult stage of mosquitoes is the one most frequently encountered by humans. While resting and

Figure 2.1 Life cycle of mosquitoes

feeding, *Anopheles* mosquitoes incline at an angle on the surface on which they stand, which characteristic differentiates them from *Culex* mosquitoes which lie parallel to the surface (Webber, 2009).

Although mosquito breeding in tropical countries occurs throughout the year, their populations increase in rainy seasons due to multiple breeding sites (Malaria Consortium, 2007). Although the longevity of female adult mosquitoes depends on temperature, humidity and species, they normally live for seven to fourteen days (CDC, 2012b). Humidity greater than 60% (Yamana and Eltahir, 2013) and temperature ranging from 16 °C to 40 °C have been found to favour mosquito breeding (Beck-Johnson *et al.*, 2013). Female *Anopheles* mosquitoes require a blood meal on a regular basis for the development of their eggs, such as from warm blooded animals particularly mammals. It is through this feeding habit that mosquitoes bite and transmit malaria to humans. *Anopheles* mosquitoes are usually attracted to humans through several stimuli including warmth, exhaled carbon dioxide and odours. It is through those stimuli that mosquitoes find humans and bite them hence transmitting malaria. The distance *Anopheles* mosquitoes can fly from their breeding sites varies by species, topography of the area, and meteorological conditions. Although mosquitoes are normally found within two to three kilometres from their breeding sites including *A. gambiae* species (Thomas *et al.*, 2013), it has been shown that wind can carry the vectors to longer distances (Lindsay *et al.*, 1995; Midega *et al.*, 2012). Therefore, community based prevention interventions such as those targeting mosquito breeding and resting sites have the potential to reduce their population hence the occurrence of malaria (White *et al.*, 2011). The timing and place of mosquito feeding is critical while designing interventions to
prevent malaria. Anopheles mosquitoes normally feed between dusk and dawn with a few exceptions feeding during the day (Ndoen et al., 2011). Indeed, studies carried out in sub-Saharan Africa have shown that malaria transmitting mosquitoes mainly feed at night and indoors (Hubo et al., 2013; Killeen et al., 2013; Seyoum et al., 2012). After feeding, female mosquitoes rest so as to enable the eggs develop. Whereas some mosquitoes rest indoors after feeding, others do so outside houses such as on vegetation, pits and fences (Cottrell et al., 2012; Malaria Consortium, 2007; Warrel & Giles, 2002).

2.4 Global malaria burden

Although malaria occurs in all the six regions of the World Health Organization (WHO), the greatest burden is in the African region, with East Africa having over 10 confirmed malaria cases per 1,000 population (Figure 2.2). Malaria causes more death than any other disease in sub-Saharan African, with children under five years of age most affected (López et al., 2014). There are 47 countries that constitute WHO African region, with the most affected by malaria being: Nigeria, Democratic Republic of the Congo, Uganda, Mozambique, Burkina Faso, Ghana, Mali, Guinea, Niger, Malawi, Côte d’Ivoire, Cameroon, Ethiopia, Kenya, United Republic of Tanzania, Benin, Togo and Sierra Leone. The other WHO regions are South-East Asia (11 countries), Eastern Mediterranean (21 countries), Western Pacific (27 countries), European (53 countries) and the Americas (35 countries) (WHO, 2015a). Although WHO African region is estimated to account for 82% of malaria cases, WHO South-East Asia region accounts for 15%, and WHO Eastern Mediterranean region 5% (WHO, 2014).
An estimated 3.2 billion people around the world are at risk of being infected with malaria, majority of these in sub-Saharan Africa (WHO, 2014). Indeed, an estimated 128 million people were infected with malaria in sub-Saharan Africa in 2013 (WHO, 2014). The countries that account for most malaria cases in sub-Saharan African are Nigeria and the Democratic Republic of Congo (Murray et al., 2014) which accounted for 29% and 11% of infections respectively in the region in 2013 (WHO, 2014). Uganda ranks third with over 9 million infections observed in 2013 (WHO, 2014).

Figure 2.2 Global distribution of malaria  
Source: World Malaria Report, 2014
Malaria, a disease that causes severe morbidity and mortality, has for many years greatly affected the population in endemic countries including Uganda. The disease causes long term effects such as neurological disabilities, and impairment of cognitive development among children (Bangirana et al., 2013; Opoka et al., 2009; WHO, 1999). The economic burden due to malaria is high and mainly affects the world’s poorest countries and communities (Novignon & Novignon 2012; WHO, 1999). Indeed, families spend significant amount of time and financial resources to treat malaria (Orem et al., 2012). In addition, households in sub-Saharan Africa spend between 0.2 to 25 US dollars monthly on malaria prevention and treatment (Bocoum et al. 2014; Chima & Mills, 1998). Studies have also shown that up to five days per month are lost from work and school due to being sick of malaria, and caring for patients (Castillo-Riquelme et al., 2008; Chima et al., 2003; Kimbi et al., 2005; Onwujekwe et al., 2009). Reduced travel to malaria endemic countries can also affect economic development by deterring international trade, and limiting tourism (WHO, 1999). Many households especially in rural areas of developing countries cannot afford to access malaria prevention methods such as LLINs. In addition, the economic burden of malaria to countries in Africa is estimated to be above 1% of Gross Domestic Product (GDP) (Bloom & Sachs, 1998; Orem et al., 2012). Malaria therefore greatly impacts on health systems in endemic countries particularly in sub-Saharan Africa.

2.5 Malaria burden in Uganda

Malaria causes more morbidity and mortality than any other disease in Uganda, and is responsible for majority of outpatient visits across the country (MOH, 2010; Malaria Consortium, 2015a). Malaria is endemic in 95% of Uganda (Figure 2.3), with approximately 33
million people at risk of infection (USAID, 2013). The other 5%, mainly in the south and western regions, are unstable and epidemic prone transmission areas. Indeed, the eastern, central and northern regions of Uganda are stable malaria transmission areas (Nuwaha, 2011). The differences in transmission of malaria in Uganda are attributed to the varying climatic patterns which affects breeding of mosquitoes, with the western region having lower temperatures than the rest of the country (Lindblade et al., 2010; USAID, 2014a). Uganda’s climate and rainfall

![Malaria endemicity in Uganda](Source: Nuwaha et al., 2011)
patterns favour vector propagation hence malaria transmission throughout the year with little seasonal variability. Indeed, Uganda’s mean annual temperature of 24°C to 30°C (Nsubuga et al., 2014), and two major rainy seasons of March to May, and September to December (Luganda, 2011) are factors that favour the occurrence of malaria in the country.

*P. falciparum* is responsible for 99% of malaria cases in Uganda, while *P. malariae, P. vivax,* and *P. ovale* are rare (USAID, 2014b). In 2014, Uganda had 10 - 50 confirmed malaria cases per 1,000 population (WHO, 2014). Children and pregnant women are most vulnerable to the disease due to their low immunity, hence these groups are therefore given priority in national malaria control programmes. In the Uganda Malaria Indicator Survey of 2014-2015, 30% of children under five years of age tested positive for malaria (UBOS, 2015). Among pregnant women, malaria leads to negative birth outcomes such as low birth weight, still birth and pre-term labour (Mbonye et al., 2015). In 2014, prevalence of malaria in Uganda was lower in districts that had undergone IRS (7%) compared to other districts (36%) (UBOS, 2015). This is an indication that scaling up IRS is likely to further reduce the occurrence of malaria across the country.

### 2.6 Malaria prevention

#### 2.6.1 Historical and global perspective

Programmes to control malaria in endemic countries globally began in the mid-nineteenth century when the disease was endemic in most parts of the world (WHO, 2008a). In 1955, WHO
launched the Global Programme for Malaria Eradication which majorly used dichloro-diphenyl-trichloroethane (DDT) for IRS in endemic countries (IDAB, 1956). The use of DDT was observed to be effective in killing mosquitoes that rest indoors especially when used on the walls (WHO, 1997). Although programmes using DDT to control malaria were largely successful in reducing mosquitoes, the benefits were not long-lasting as resources limited its use for long periods as well as vectors becoming resistant against the insecticide (Litsios, 1996; WHO 2006a). In 1978, WHO shifted focus from eradication to control which encompassed reducing malaria to levels that were not significant to public health. To expand efforts of malaria prevention beyond use of DDT, environmental management was used as an alternative (Walker & Lynch, 2007). This involved destroying mosquito breeding sites including draining of stagnating water, improving drainage around homes, and filling ditches in the ground (Najera, 2001). Biological control, which involves use of living organisms to kill mosquito larvae where mosquitoes breed, was also introduced (WHO, 1997). By 1982, 24 malaria endemic countries mainly in Europe such as Greece, Italy and Spain were free of malaria (WHO, 1999; WHO, 2008a). Since then, other countries have been certified as malaria free such as Maldives in 1984, United Arab Emirates in 2007, Turkmenistan in 2010, and Armenia in 2011 (Meleigy, 2007; WHO, 2008a; WHO, 2014). Most recently, Kyrgyzstan was declared malaria free by WHO in 2014 (WHO, 2014).

The Global Malaria Programme of WHO coordinates all activities related to malaria control globally (WHO, 2014). It is responsible for directing the course of malaria control among other responsibilities (Figure 2.4). In addition, the Global Malaria Programme carries out formulation and adoption of evidence based guidelines for malaria control. In 1998, WHO launched the Roll
Back Malaria (RBM) campaign which put malaria control as a priority on the international agenda. Indeed, several partners such as Global Fund to fight AIDS, tuberculosis and malaria (GFATM); United Nations Children's Fund (UNICEF); United States Agency for International Development (USAID); and United States President’s Malaria Initiative (PMI) invested heavily in malaria control up to 250 million dollars per year (WHO, 2008a). The majority of the funding in malaria endemic countries has been used for ITNs while other expenditures include malaria treatment, IRS and programme management (WHO, 2011a).

WHO recommends two primary interventions to prevent malaria globally: sleeping under ITNs and IRS (WHO, 2006a). The use of ITNs and IRS has greatly increased globally in recent years (WHO, 2014). Indeed, several governments in malaria endemic countries have intensified efforts to implement these interventions through mass campaigns. Although the use of ITNs has been promoted extensively in recent years, it is estimated that in 2013, 278 million people out of the 840 million at risk of contracting malaria did not have an ITN in their household (WHO, 2014). In addition, only 3.5% of the global population at risk of malaria were protected by IRS in 2013 despite WHO recommending reaching 80% of houses during spraying campaigns (WHO, 2014). The use of ITNs and IRS rely on insecticides which are vulnerable to resistance by mosquito vectors (WHO, 2008a). Therefore, alternative approaches such as the integrated approach to malaria prevention that involves methods that are not insecticide based such as house screening, removal of mosquito breeding sites, and early closing of windows are needed to intensify efforts of preventing the disease globally. ITNs and IRS have been shown to contribute to the reduction in occurrence of malaria in several countries including Uganda, Kenya, Mozambique and Zambia (Eisele et al., 2011a; Kim et al., 2012). However, studies have shown that the cost of
ITNs limits their use especially in rural communities in sub-Saharan Africa (Willey et al., 2012). In addition, misuse of ITNs has been observed in some communities in Zambia, Kenya, Rwanda and Tanzania that have received them for free including use for fishing (Hopkin, 2008; Ingabire et al., 2015; McLean et al., 2014; Minakawa et al., 2008).

Figure 2.4 Roles of the Global Malaria Control Programme

2.6.2 Malaria prevention in Uganda

The Ministry of Health (MOH) is at the forefront of controlling malaria in Uganda. Indeed, control of malaria is among the priorities of MOH as one of the most severe communicable diseases of concern. Use of ITNs and IRS are the most advocated methods to prevent malaria in the country (MOH, 2010). To intensify malaria prevention efforts, MOH has been distributing ITNs since 2006 especially among children under five years of age, and pregnant women identified as vulnerable groups (Yeka et al., 2012). Whereas ITNs have been distributed across the country, IRS has targeted 10 districts in mid northern Uganda (USAID, 2013). The use of ITNs has significantly increased in Uganda in recent years with 90% of households in the country owning at least one ITN with an average of 2.5 five nets per household (UBOS, 2015). However, with a national average household size of 4.7 (UBOS, 2014), the number of nets available are insufficient for the entire population.

The Uganda Malaria Indicator Survey 2014-2015 established that 78% of children under five years of age, and 75% of pregnant women slept under an ITN the night before the research (UBOS, 2015). This shows an increment in use of ITNs as in the 2009 Malaria Indicator Survey, use of ITNs among children under five years of age, and pregnant women the night before the research was 33% and 44% respectively (UBOS, 2010). Indeed, the use of ITNs especially among children under five years of age and pregnant women has increased in recent years (Kassam et al., 2015). Although initial IRS in Uganda was carried out using DDT which has a residual effect of twelve months, a carbamate insecticide with a six month residual effect is currently being used. In 2014, only 5% of houses across the country had been sprayed in the previous six months mainly in the northern region (UBOS, 2015). This shows low national
coverage of IRS in Uganda, a method given priority hitherto. Whereas other malaria prevention strategies such as environmental management and improving housing quality are known, they have received little attention in Uganda (Kassam et al., 2015).

MOH adopted intermittent preventive treatment of malaria in pregnancy (IPTp) with sulphadoxine-pyrimethamine (SP) as recommended by WHO (WHO, 2014). IPTp is a principal malaria prevention strategy among pregnant women in addition to use of ITNs. One of the strategies of Uganda’s Health Sector Strategic Plan (HSSP) III 2010/11 – 2014/15 is to ensure that all pregnant women have access to IPTp (MOH, 2010). MOH policy recommends every pregnant woman to get at least three doses of SP during pregnancy, with a duration of over one month between doses. National coverage of IPTp has steadily increased in recent years due to intensified efforts of MOH on increasing awareness of the strategy as well as ensuring availability of SP at health facilities (Arinaitwe et al., 2013). Indeed, in the 2014-2015 Malaria Indicator Survey, 59% of pregnant women who had a live birth in the two years before the research had received at least one dose of SP compared to 32% in 2009, and 16% in 2006 (UBOS, 2015; UBOS, 2010). However, more effort is needed to ensure all pregnant women receive IPTp as targeted by MOH.

Beyond ITNs and IRS, there has been minimal promotion of other strategies for malaria prevention in Uganda. For example, in Kampala (the capital city) and Jinja (a city 81 kilometres from Kampala), a community based environmental management programme was implemented which commenced in 2002. This programme, which targeted reduction in malaria breeding sites
by improving drainages, filling pools of water, and construction of soak-pits, observed a reduction in prevalence of malaria of between 11% to 36% (Lindsay et al., 2004; Talisuna et al., 2015). Despite the promise shown by this urban programme in Uganda, integrated vector management has not been considered in national malaria control strategies (MOH, 2010; MOH, 2014a; MOH, 2014b).

2.7 Malaria prevention methods

2.7.1 Insecticide Treated Nets

Sleeping under nets is known as an effective method to prevent malaria as they provide a barrier against mosquitoes. The use of bed-nets for preventing insect bites including mosquitoes has been used for several years in different societies (Lindsay & Gibson, 1988; Raghavendra et al., 2011). WHO recommended the use of nets treated with insecticides as a major malaria prevention method in the late 1990s (RBM, 1997). In addition to the physical barrier they provide, ITNs were promoted as they kill and repel mosquitoes and other vectors (WHO, 2003a). Pyrethroid insecticides such as permethrin and deltamethrin that are used in ITNs are effective in killing mosquitoes but have very low risk to humans (CDC, 2014a). These ITNs are supposed to be retreated every six to twelve months so as to maintain the insecticide levels within them. However, after several years of use of ITNs in malaria endemic countries, it was realised that there were challenges in their use leading to low retreatment rates (Binka & Akweongo, 2006). Recently, long lasting insecticidal nets (LLINs) where introduced which maintain the insecticide
levels for at least three years even with repeated washing (CDC, 2014a). Many governments in endemic countries including Uganda have provided these LLINs to the population free of charge particularly to children under five years of age and pregnant women (WHO, 2014). Several brands of LLINs recommended by WHO are available on the market such as Duranet®, Interceptor®, Olyset®, and PermaNet® (WHO, 2012c).

Use of ITNs is the most advocated method of malaria prevention in endemic countries. In addition to governments supporting free distribution of ITNs, several international agencies have invested vast resources for the procurement of ITNs in endemic countries particularly in sub-Saharan Africa. These agencies include Global Fund to fight AIDS, Tuberculosis and Malaria (GFATM), United States Agency for International Development (USAID), United Kingdom Department for International Development (DFID), United Nations Children's Fund (UNICEF), and United States President’s Malaria Initiative (PMI) (Pigott et al., 2012; WHO, 2013a). In 2013, over 142 million nets were distributed to countries in sub-Saharan Africa which has significantly increased their use and subsequently contributing to the reduction in malaria prevalence globally (WHO, 2014). However, the use of ITNs has faced some challenges such as the cost of nets limiting their use in communities that may not have received free nets particularly in poor areas of malaria endemic countries (Augustincic et al., 2015). In addition, due to high poverty levels and ignorance about the importance of sleeping under ITNs in many countries in sub-Saharan Africa such as Uganda, Kenya and Tanzania, they have been used for other purposes such as selling them or use in gardens as temporary fences (Hopkin, 2008; Larson et al., 2014; McLean et al., 2014; Minakawa et al., 2008). Nevertheless, the benefits of use of
ITNs in prevention of malaria in recent years outweigh their misuse particularly for fishing (Eisele et al., 2011b).

### 2.7.2 Indoor Residual Spraying

Indoor residual spraying (IRS) is currently a key strategy for malaria prevention globally (WHO, 2014). The campaign of scaling up IRS as a core malaria prevention method in addition to ITNs began in 2006 (WHO, 2006a). The method involves spraying a long lasting insecticide on the inner surfaces of houses such as walls, eaves and ceilings so as to kill mosquitoes when they rest on them. The insecticide remains active in killing mosquitoes for up to twelve months. When mosquitoes get into contact with the sprayed surface, their lifespan reduces due to the lethal dose they are exposed to (WHO, 2013c). Several insecticides can be used for IRS and the most common categories are organochlorines, pyrethroids, organophosphates and carbamates (WHO, 2006a). Although there are concerns regarding the safety of use of DDT for IRS, it has been rendered safe to use by WHO given that safety precautions such as use by only qualified personnel are observed (WHO, 2011c). Due to the mode of action of IRS, it is effective in areas where mosquitoes feed indoors (endophagic) and rest indoors (endophilic) such as in sub-Saharan Africa (Pluess et al., 2010).

The use of IRS has increased in the past decade due to its recognition as a main malaria prevention strategy together with ITNs (WHO, 2013c). Indeed, governments and international funders have played a key role in promoting IRS in endemic countries (WHO, 2014). Studies have shown that although IRS is being promoted as a core malaria prevention method, its use has
been limited due to negative perceptions including the concern of causing respiratory diseases and cancer (Ediau et al., 2013; Hlongwana, et al., 2013). In addition, the high cost and low residual effect of some insecticides have been identified as challenges affecting IRS in sub-Saharan Africa (Akogbéto et al., 2015; Chanda et al., 2015). Studies carried out in areas that have undergone IRS have found the bad smell of insecticides, and burden of having to remove all household utensils as problems associated with the method (Mazigo et al., 2010; Rodríguez et al., 2006).

2.7.3 Screening in windows, ventilators and open eaves

Female Anopheles mosquitoes that transmit malaria usually enter houses through windows, ventilators, and open eaves (Kirby et al., 2008; Ogoma et al., 2009). Therefore, to prevent entry of mosquitoes into houses, such openings can be screened. In addition, closing doors and unscreened windows early in the evenings also reduces mosquito entry as the A. gambiae species, mainly responsible for transmitting malaria in sub-Saharan Africa, have been found to enter houses in early hours of evenings (Gillies, 1968; Pates & Curtis, 2005; Reddy et al., 2011). This practice of screening houses subsequently reduces the risk of mosquito entry hence the occurrence of malaria where mosquitoes feed indoors (Lindsay et al., 2002; Schofield & White, 1984; Tusting et al., 2015). Although it has been shown for many years that people could be protected from malaria by screening their homes against mosquitoes, this intervention remains ignored in many communities (Lindsay et al., 2002; Musoke et al., 2013). One of the major benefits of house screening is that it reduces human exposure to malaria mosquito vectors indoors, and provides protection for all household members (Bradley et al., 2013). In addition,
house screening not only prevents entry of *Anopheles* mosquitoes into houses but also other mosquito species vectors such as *Culex* and *Aedes* that transmit diseases such as filariasis and Rift Valley fever (Corter et al., 2013; Ogoma et al., 2010). It is known that whereas *Anopheles* mosquitoes that transmit malaria mainly feed on humans while sleeping, they also bite before bedtime hours (Ojuka et al., 2015). Therefore, even with ITNs that may be used during sleeping, people may contract malaria if exposed to mosquitoes when not in bed. These early feeding habits of mosquitoes justify the screening of houses to reduce exposure to the vectors hence reduction in the risk of suffering from malaria.

The amount of resources required to screen windows, ventilators and open eaves is likely to contribute towards the low use of the strategy for malaria prevention (Bradley et al., 2013). Indeed, the resources necessary for house screening include wire mesh, timber and nails which are costly (Massebo & Lindtjørn, 2013). In addition, many households would normally require labour in form of a carpenter to install the screening. Complete house screening in a typical setting in sub-Saharan Africa could cost 10 to 30 US dollars which may not be afforded by many families (Kirby et al., 2009; Ogoma et al., 2009). However, it has also been established that many communities are not aware of house screening as a method to prevent malaria (Abate et al., 2013; Hlongwana et al., 2009; Serengbe et al., 2015).
2.7.4 Housing quality

The quality of houses, particularly in several developing countries where malaria is endemic, is important in preventing the disease. It is known that deficiencies in the structure of houses become entry points for mosquitoes. These housing deficiencies include open eaves, broken window panes, holes in walls, and external doors having spaces in them. Indeed, several studies have shown that poor housing increases the risk of malaria infection (Hiscox, et al., 2013; Wolff et al., 2001; Yé et al., 2006). Recent evidence suggests that improving the quality of housing could contribute to reducing the occurrence of malaria (Tusting et al., 2015). It is therefore important for the structural condition of houses to be considered as an important aspect in the reduction of mosquito entry hence occurrence of the disease in malaria endemic countries.

One of the factors that contributes to the poor structure of houses in sub-Saharan Africa particularly in rural areas is the lack of proper design (Ayele et al., 2012; Kirby et al., 2010). Indeed, housing quality in Uganda is inadequate with 69% of houses having sand, earth or cow dung floors mainly in rural areas (UBOS, 2012a). Inadequate housing in Uganda leads to structural deficiencies such as open eaves, or spaces in walls where mosquitoes can pass to enter hence increasing the risk of malaria transmission (Wanzirah et al., 2015). Although houses that have complete ceilings would limit entry of mosquitoes passing through unscreened eaves, many houses lack them in rural communities in Uganda and other malaria endemic countries (Atieli et al., 2009; Ernst et al., 2009). Indeed, the lack of ceilings on houses that have open eaves aggravates the risk of mosquito entry into houses hence occurrence of malaria (Ogoma et al., 2010). Ensuring that houses with open eaves have ceilings, as well as other structural
deficiencies on houses addressed is therefore important in contributing to the reduction in malaria incidence in endemic countries.

**2.7.5 Removing mosquito breeding sites**

*A. gambiae* mosquitoes breed in shallow pools of water such as those resulting from rain (Malaria Consortium, 2007) and have been seen in small puddles and hoof prints (Carnevale et al., 2015; Mala & Irungu, 2011; Warrel & Giles, 2002). Such pools are numerous in rural areas of many malaria endemic countries particularly in the rainy season. Therefore, removing these breeding places reduces mosquito populations in communities. Draining pools of water, levelling land, construction of drains, and proper waste water management can be carried out to eliminate mosquito breeding sites (Chaki et al., 2014; Markle et al., 2007). Indeed, it has been shown that removal of mosquito breeding areas contributes to the reduction in mosquito populations hence occurrence of malaria (Ault, 1994; Dlamini et al., 2015; Kibret et al., 2014).

Although it is known that removal of mosquito breeding sites reduces the population of mosquito vectors hence risk of malaria transmission, many communities allow such breeding sites to exist near houses (Obala et al., 2015; Soleimani-Ahmadi, et al., 2013; Tabbabi et al., 2015). Simple practices such as filling ditches in the ground, and creating drainage channels can be implemented at household and community levels to reduce mosquito breeding sites. However, such practices are labour intensive and require routine implementation (Chaki et al., 2014; Raghavendra et al., 2011) particularly in the rainy season when pools of water are numerous.
Due to the high burden malaria causes in endemic countries, removing mosquito breeding sites should be encouraged to complement other prevention strategies such as sleeping under ITNs.

2.7.6 Mosquito repellents

Insect repellents have been used in the prevention of malaria (Debboun & Strickman, 2013) including topical repellents applied directly to the skin (Strickman et al., 2009). The use of repellents has a long history (Debboun et al., 2006) and have been used for mosquitoes and tick-borne diseases (EPA, 2010; Pages et al., 2014). Repellents reduce the number of arthropod bites hence the occurrence of associated diseases such as malaria, since the bites are a necessary step in the transmission of vector-borne pathogens. However, many repellents provide protection by preventing contact with mosquitoes compared to insecticides which kill them. Repellents are particularly used where other methods are impractical, and when people have to stay outdoor at night. Mosquito repellents currently in use are either synthetic chemicals (such as N,N-Diethyl-meta-toluamide [DEET]) or plant derivatives (such as Citronella). Travellers to malaria endemic countries are known to use repellents because they can move with and apply them at any time (Croft, 2014). Repellents can also be used during outdoor activities at night such as celebrations and other social events. Indeed, it is common in Uganda to spend many hours in the night outdoors during vigil following the death of a family member or friend. In addition to wearing long sleeved clothing to reduce exposure to mosquito bites at night (Braack et al., 2015), repellents can be used. The duration of action of repellents can range from fifteen minutes to ten hours depending on the type used and its attractiveness to humans (Tuetun et al., 2008).
However, the effectiveness of repellents last longer on clothes and fabrics than on the skin (Banks et al., 2014; WHO, 1997).

Repellents have not been used extensively in many communities particularly in malaria endemic countries such as Uganda because of their cost and fear of possible side effects from their use (CDC, 2007; Leal, 2014). It has been shown that the cost of repellents makes them unaffordable to many poor communities in rural Uganda and neighbouring countries such as Tanzania (McElroy et al., 2009; Sangoro et al., 2014). The use of insecticide based preventive methods such as repellents are also disliked because of the perceptions that they may affect the health of users (Ediau et al., 2013; Nnko et al., 2012). However, use of repellents has been recommended by WHO especially among travellers (WHO, 2015b). Despite the cost and health concerns regarding use of insect repellents, promoting them could increase their use hence contributing to malaria prevention efforts. Although repellents have been shown to prevent mosquito bites, more studies are necessary to measure their protective effect against malaria (Wilson et al., 2014).

2.7.7 Mosquito coils

Mosquito coils have been used in many communities to prevent malaria (Strickman et al., 2009) and are a very popular form of insecticide vapouriser because of being inexpensive compared to other methods, and easy to use (Drabo et al., 2014; WHO, 1997). Coils normally contain pyrethrum powder, combustible material, and sometimes a fragrance to make the smoke acceptable. These coils are lit and smoulder for six to eight hours during which they release the
insecticide which repels mosquitoes. The category of insecticides recommended by WHO for use in coils are pytheroids (Ogoma et al., 2012). Coils are usually lit in the evenings and can burn till morning. However, strong winds could speed up the rate of burning hence affect their effectiveness by reducing their duration of action. There are also concerns regarding the potential health effects of exposure to the smoke emitted from coils (WHO, 2008b). Although more research is recommended on the role of mosquito coils in preventing malaria (Deboun & Strickman, 2013; Lawrance & Croft, 2004), evidence suggests that such repellents increase mortality of mosquitoes, and reduce their ability to bite humans (Ogoma et al., 2012).

Mosquito coils have traditionally been known as a method to prevent malaria, and still being used in many communities such as in Nigeria, Ghana and India (Adebisi et al., 2014; Adu-Acheampong et al., 2014; Babu et al., 2007; Kudom et al., 2013). However, they have received little attention in recent years probably due to the availability and extensive promotion of other methods such as ITNs. Indeed, studies carried out in malaria endemic countries including Swaziland, Ghana and Cameroon have shown that use of mosquito coils is low (Brenyah et al., 2013; Hlongwana et al., 2009; Ndo et al., 2011). It has also been established that the fear of inhaled smoke contributing to respiratory diseases limits the use of mosquito coils in malaria endemic countries (Adu-Acheampong et al., 2014; Chukwuocha et al., 2010; Kohli et al., 2014). The cost of coils has also been found to be a high expenditure among households that use them in sub-Saharan African countries such as in The Gambia and Tanzania (McElroy et al., 2009; Wiseman et al., 2006).
2.7.8 Removal of vegetation

*Anopheles* mosquitoes are known to use vegetation as resting places especially during the day (Forattini *et al*., 1993; Peterson *et al*., 2009; Rubio-Palis and Curtis, 1992). Such vegetation is common around homes particularly in rural communities in malaria endemic countries including Uganda. Mosquitoes travel from such resting places and enter houses from where they transmit malaria (Andrianaivolambo *et al*., 2010; CDC, 2008; Tadei *et al*., 1998). Therefore, presence of overgrown vegetation in communities facilitates the presence of mosquitoes in an area because of availability of resting places (Warell & Gilles, 2002; Ricotta *et al*., 2014; WHO, 1997). Indeed, mosquitoes harbouring close to houses eases their entry because of the reduced distance they have to travel. Therefore, low vegetation cover near homes has been shown to reduce mosquitoes hence the risk of malaria transmission (Amek, *et al*., 2012; Chirebvu *et al*., 2014). Reducing places where mosquitoes harbour can be achieved by slashing overgrown vegetation and trimming hedges nears houses in communities.

Clearing overgrown vegetation has been undertaken in some communities including in Burkina Faso and Nigeria as a means of reducing the proliferation of mosquitoes near homes (Chukwuocha *et al*., 2010; Bocoum *et al*., 2014; Onwujekwe *et al*., 2014). However, the practice of removing such vegetation has been shown to be inadequate in other communities including in Uganda (Chen *et al*., 2014; Musoke *et al*., 2013). Whereas more research is needed to measure the public health benefits of reducing vegetation around homes, it is evident that removing mosquito hiding places reduces their abundance hence limiting the vectors (Mweya *et al*., 2015). Therefore, clearing overgrown vegetation as a complementary method to other malaria prevention strategies is important in the control of the disease.
2.7.9 Space spraying with insecticides

Space spraying of insecticides in houses to kill mosquitoes can be used as a method to prevent malaria. Several insecticides are available for this purpose particularly those containing organophosphates or pyrethroids (WHO, 2003b). Sprays kill mosquitoes rapidly therefore eliminating the vector that transmits malaria. Space spraying has been found to be useful particularly when there is high occurrence of malaria such as during epidemics or high density of mosquitoes (Salve et al., 2014; WHO, 1997). However, the insecticides are not long lasting and are therefore effective for only a short period of time, and require frequent re-application. This implies that if mosquitoes are allowed to enter houses after the duration of protective effect of the insecticide before re-spraying, there would be risk of malaria transmission. After spraying, occupants of the house are advised to stay out for at least thirty minutes so as to limit exposure to the insecticide (WHO, 2003b). In addition to their cost, there is a concern in many communities regarding the potential health effects that could result from inhaling the insecticide when used (WHO, 1997; WHO, 2009).

Although there is considerable knowledge on availability of insecticides for space spraying, their use is low in sub-Saharan Africa (Hlongwana et al., 2009; Kimbi et al; 2014). The brand names of commonly used insecticides in Uganda include Mortein Doom®, Bop®, Kilit®, Baygon® and Ridsect® which are majorly pyrethroids (Nalwanga & Ssempebwa, 2010). However, the high cost of insecticides limits their use in many communities in sub-Saharan Africa particularly in rural areas (Amoran et al., 2013a). The concerns regarding the potential health effects emanating from inhaling insecticides have also been seen for other insecticide-based methods such as IRS and mosquito repellents (Ediau et al., 2013). To reduce on such possible health
outcomes, following recommended instructions for use of insecticides such as spraying at times when there are no people in houses, and ensuring adequate ventilation before reoccupation should be followed (WHO, 2003b).

2.7.10 Larviciding

Use of larvicides to kill mosquito larvae in pools of water where they breed has been used for many years as a vector control method (Walker & Lynch, 2007; Worrall & Fillinger, 2011). Larviciding has been used mainly for breeding sites which cannot be easily filled with soil, or drained such as those resulting from brick making and sand mining which are numerous in sub-Saharan Africa. Larvicides kill larvae when ingested (stomach poisons) or penetrate the body once in contact with the chemical (contact poisons) (Pavela, 2015; WHO, 1997). The main categories of chemical larvicides recommended by WHO are organophosphates, benzoyleureas, juvenile hormone mimics and spinosyns (WHO, 2011b). Biological larvicides such as Bacillus thuringiensis have also been shown to be effective in killing mosquito larvae and are recommended for integrated vector management (Dambach et al., 2014; Fillinger et al., 2009). Indeed, larviciding has been recommended to supplement core interventions such as ITNs and IRS in the control of malaria in sub-Saharan Africa (WHO, 2012b) especially in areas where mosquito breeding sites are well defined (WHO, 1999). Concerns regarding use of larvicides, include harming non-target organisms, toxicity to humans therefore requiring careful handling, and requiring frequent application due to their temporal effect (Marina et al., 2014; WHO, 2012b).
Studies carried out in sub-Saharan Africa including in Tanzania and Kenya have shown that use of larvicides significantly reduces mosquito populations hence the prevalence of malaria (Maheu-Giroux & Castro, 2014; Tusting et al., 2013). Indeed, larviciding has particularly been found effective in urban areas where pools of water are few and can easily be located (Enayati & Hemingway, 2010; Walker & Lynch, 2007). However, in rural areas mosquito breeding sites are more numerous hence higher abundance of vectors which requires more resources and intensity to significantly reduce mosquito breeding sites (Oduola et al., 2013). It is evident that more research on larviciding as a strategy for mosquito larvae source control is needed including in rural areas (Mboera et al., 2014; Worrall & Fillinger, 2011). Nevertheless, evidence available suggests that use of larviciding in addition to other malaria prevention strategies is important in control of the disease in endemic countries particularly in sub-Saharan Africa (Tusting et al., 2013).

2.8 Integrated vector management

Integrated vector management (IVM) is the optimal use of resources for controlling vectors so as to significantly contribute to the prevention of diseases transmitted by vectors such as mosquitoes (WHO, 2011d). One of the key elements of IVM is the integrated approach which advocates the use of a mix of chemical and non-chemical methods for vector control (Beier et al., 2008). Indeed, IVM recommends the use of several methods of proven efficacy in preventing vector borne diseases and reduce reliance on single methods. The other elements of IVM are social mobilization and empowerment of communities, multi-sectoral collaboration, evidence
based decision making, and ensuring adequate human resources (WHO, 2015c). The IVM concept has been in existence for many years (Challet, 1994; Ichimori, et al., 2014; WHO, 1983) and was recommended by WHO to support malaria control as stated in the Global Strategic Framework for Integrated Vector Management (WHO, 2004). Although there have been successful IVM programmes such as in Zambia and Tanzania (Caldas de Castro et al., 2004; Chanda et al., 2008, the potential benefits of the strategy have largely not been realised in Africa including Uganda (Beier et al., 2008; Mutero et al., 2012; Okenu, 1999). Indeed, there is need to further develop and explore new tools and other approaches to malaria prevention as vector resistance to the insecticide based methods such as ITNs and IRS is of great public health concern (WHO, 2008a).

For the success of IVM for malaria control, there is need for all stakeholders concerned to actively take part in planning and implementation of interventions. These stakeholders include government ministries, local authorities, non-government organisations (NGOs), civil society, researchers, health practitioners, and the community. However, the involvement of many actors in IVM has been found to be challenging in many countries in sub-Saharan Africa including in Kenya and Malawi (Chanda et al., 2013; Mutero et al., 2015). Therefore, to increase utilisation of IVM in malaria endemic countries, there is need for more support and participation of various stakeholders at local and international levels. In addition, more research on the benefits of IVM in contributing to global malaria control efforts is necessary (Mutero et al., 2015).
2.9 Integrated approach to malaria prevention

The integrated approach to malaria prevention advocates for use of multiple methods at households and communities to reduce the burden of malaria. The methods include core global malaria prevention strategies such as ITNs and IRS, and others known to contribute to the reduction in occurrence of malaria (WHO, 2013b). The various methods that constitute the integrated approach can be categorised based on their target notably personal protection, mosquito breeding, and entry of mosquitoes into houses as shown below.

Personal protection
- Insecticide treated nets
- IRS
- Space spraying with insecticides
- Body mosquito repellents
- Mosquito coils

Reducing mosquito breeding
- Removing mosquito breeding sites
- Clearing overgrown vegetation around homes
- Larviciding in water pools

Limiting entry of mosquitoes into houses
- Closing windows and doors early in the evenings
- Installing screening in ventilators and open eaves
- Installing screening in windows
- Housing quality
Several studies have been carried out to assess the public health benefits of using more than one method in the prevention of malaria (Fullman et al., 2013; Hamel et al., 2011; Kleinschmidt et al., 2009). However, most of these studies have focused on core malaria prevention methods notably ITNs and IRS. A few studies have explored use of multiple methods beyond ITNs and IRS such as larviciding (Zhou et al., 2013), and housing structure (Abate et al., 2013; Temu et al., 2012). However, little is known about the potential of exploring the multitude of methods known to contribute to providing personal protection against mosquitoes, reduce mosquito breeding sites, and limit entry of mosquitoes into houses. This research therefore not only provides information on practices on multiple malaria prevention methods but also perceptions and challenges of their use in the integrated approach.

2.10 Health service delivery in Uganda

In Uganda, delivery of health services is majorly provided by the Government and private health providers. Government services are provided through Ministry of Health (MOH) facilities notably health centres and hospitals. Private health providers include private for profit institutions such as clinics and dispensaries, and private not-for-profit institutions (Nabyonga-Orem et al., 2013). Private not-for-profit institutions are either facility based such as Uganda Protestant Medical Bureau and the Uganda Muslim Medical Bureau, or non-facility based such as Uganda Red Cross and Amref health Africa (Dambisya et al., 2014). Health facilities in Uganda have been shown not only to be used for treating diseases but also provide preventive health education for malaria and other public health issues such as family planning (Mbonye, 2003).
Uganda has various levels of health service delivery in its health system as a result of decentralisation which primarily applies to Government facilities. The levels of health service delivery in Uganda are health centre II, health centre III, health centre IV, district hospitals, regional hospitals, and national referral hospital (MOH, 2010). The national referral hospital offers specialist services, training and research, although these services are limited at regional hospitals. District hospitals offer inpatient, surgical and outpatient services, while health centre IV provides emergency surgical care, outpatient and inpatient services. Health centres III and II mainly offer outpatient care and outreach services (Nabyonga-Orem et al., 2013). Most of the services offered at Government health facilities are offered free of charge such as medical consultation and essential medicines due to abolition of user fees (Nabyonga-Orem et al., 2014). However, some services such as diagnostic tests and certain drugs are paid for at Government health facilities (Setumba et al., 2015). In order to intensify efforts of preventing malaria, Government health facilities at all levels have previously been used to distribute free ITNs to children under five years of age and pregnant women seeking services (Yeka et al., 2012). Community health workers (CHWs), who are known as village health teams (VHTs) in the Ugandan context, do exist and comprise of what at times is called health centre I. These community volunteers support the population by carrying out health promotion, treating children under five years of age suffering from malaria, diarrhoea and pneumonia, and referring patients to health facilities. However, CHWs in Uganda have been found with several challenges affecting their work such as minimal training, low motivation and inadequate supervision (Brunie et al., 2014).
Majority of the users of public health facilities in Uganda are the poor particularly in rural communities who cannot afford private services (Kwesiga et al., 2015). However, many challenges affecting utilisation of these public facilities have been established such as poor infrastructure, long distance to facilities, regular stock out of drugs, inadequate number of health practitioners, lack of skilled health staff, and poor health worker attitudes (Atuyambe et al., 2009; Batwala et al., 2010; Musoke et al., 2014). These challenges not only affect utilisation of services for malaria control but also other diseases affecting the country such as diarrhoea, tuberculosis and human immunodeficiency virus / acquired immune deficiency syndrome (HIV / AIDS) (Mbonye et al., 2014). Due to the several challenges affecting accessing health services in the country, it is imperative for malaria prevention to be strengthened so as to benefit health of the public.

2.11 Community organisation behaviour change model

The community organisation model for behaviour change was used in the design and implementation of study I for health promotion in the two villages. This model empowers communities to improve their health through active involvement in identifying health concerns and designing interventions to address them (Neil & Lee, 1990). The community organisation model has six main characteristics:

- Understanding the context of health issues in the community.
- Collaborative decision making in addressing health problems.
- Emphasis on specific health issues.
- Participation from various stakeholders in the community.
- Capacity building and sustainability.
- Providing feedback to the community.

These characteristics are aimed at ensuring the context of the problem is well understood, the concerned stakeholders are involved in all stages of the project, as well as ensuring interventions are sustainable in the community (Minkler, 2004).

The community organisation model has 5 stages (Figure 2.5). The first stage is community analysis which involves identifying and quantifying the health problems faced by the population. In study I, this was achieved by carrying out a baseline survey to ascertain the knowledge and practices of the community on malaria prevention. The second stage is designing the intervention which in the study involved preparing and planning for activities of the pilot project on the integrated approach to malaria prevention. The design stage involved various stakeholders including the local health department which ensured the interventions were appropriate and relevant to the community. The third stage of the model is implementation which in the study involved community sensitisation, training community volunteers, and establishing demonstration households using the integrated approach. The fourth stage is maintenance / consolidation which in the study was continued use of the various malaria prevention practices in the integrated approach at households and in the community. The fifth stage is dissemination / reassessment which in the study involved conducting an impact evaluation to establish
knowledge and practices of malaria prevention in the community after the intervention. In addition, dissemination workshops were held in the two villages to share achievements of the pilot project as well reemphasising the importance of continued improved practices to prevent the occurrence of malaria.

Figure 2.5. Stages of the community organisation model

Source: [http://www.cwru.edu/med/epidbio/mphp439/Community_Health_Coalition.htm](http://www.cwru.edu/med/epidbio/mphp439/Community_Health_Coalition.htm) [accessed 21 October 2015]
CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter describes the methods used to assess experiences, perceptions and practices on the integrated approach to malaria prevention in Wakiso district, Uganda. It provides details for the three phases of study I, and study II as follows: study I phase 1 (baseline) which assessed knowledge and practices on malaria prevention; study I phase 2 (intervention) that implemented a pilot project on the integrated approach; study I phase 3 (evaluation) which was an impact evaluation of the interventions implemented; and study II which assessed perceptions, practices and barriers to integrated malaria prevention. The major components of study I phase 2 (intervention) of training community volunteers on the integrated approach to malaria prevention; community sensitisation on the integrated approach to malaria prevention; and establishing demonstration sites using integrated malaria prevention are also described. The methodology also provides information on how Millennium Development Goals (MDGs) four (reducing child mortality) and five (improving maternal health) were contributed to in study I phase 2 (intervention) in addition to MDG six (involving combating malaria) which was the main focus of the research. The methodology chapter also provides details for both studies I and II regarding the study areas, study design, sample size, study participants, sampling procedure, data collection and measurements, and data analysis. The ethical considerations for the research are described in this chapter.
3.2 Study I

Study I comprised of three phases, with each phase addressing an objective of the study as follows:

- Study I phase 1 (baseline) which was to determine knowledge and practices on malaria prevention at households – objective one.

- Study I phase 2 (intervention) which was to implement an intervention on the integrated approach to malaria prevention in the community – objective two.

- Study I phase 3 (evaluation) which was to evaluate the impact and experiences of using integrated malaria prevention in the community – objective three.

3.2.1 Study area

The study was conducted in two villages of Mayanzi, Entebbe Municipality (0.0500° N, 32.4600° E) and Lukose, Ssisa sub-county (0.4000° N, 32.4833° E), both in Wakiso district, Uganda. Uganda is one of the countries in East Africa and is bordered by South Sudan in the north, Kenya in the east, Tanzania in the south, Rwanda in the south west, and Democratic Republic of Congo in the west (Figure 3.1). Although Entebbe Municipality and Ssisa sub-county were purposively selected in consultation with health authorities in the district, the two villages involved in the study were randomly selected. The random selection involved listing all villages in the municipality and sub-county to obtain the sampling frames from which the two villages involved in the study were obtained using a table of random numbers. The number of households in Mayanzi and Lukose were 329 and 158 respectively (UBOS, 2012b). After
selection of the villages, the local public health department, which was the entry point into the community, was contacted. Local leaders were then met and notified about the research, and were very supportive particularly in the initial planning stages. The local leaders helped in identifying community mobilisers who were useful in mobilising the community for the various research activities including meetings, trainings and dissemination. The local leaders were also involved in the selection of field assistants who provided support during the data collection process.

Figure 3.1 Map of East Africa and neighbouring countries

Wakiso district is located in the central region of the country with a population of 2,007,700 (UBOS, 2014) and encircles Kampala, the capital city (Figure 3.2). The district, which is among the most populated in the country, has 504,620 households, average household size of 3.9 and an annual growth rate of 6.6 (UBOS, 2014). Wakiso district comprises of fifteen sub-counties, six town councils, and one municipality which has two divisions. The district has four hospitals and 104 lower level health facilities that offer health services against malaria and other illnesses (Wakiso, 2009a). Although Wakiso district has received free ITNs as part of the Government’s malaria campaigns, it is not among those targeted for IRS (UBOS, 2015). Malaria is the leading cause of morbidity and mortality in the district (Wakiso, 2009a) as is the case in most parts of the country.

The study villages were predominantly rural with inhabitants carrying out several activities such as agriculture, animal farming, and small scale business. Specifically, Mayanzi village is located near the shores of Lake Victoria hence some residents are involved in fishing. Brick making is a common economic activity in Lukose village, and a source of livelihood for part of the population. The residents are mainly low income earners which influences access to malaria prevention (and other) services. Although Mayanzi has a Government health centre, Lukose has only private health facilities where services are paid for. Residents of Lukose who cannot afford private services therefore travel over five kilometres to the nearest public facility. Public health facilities have previously been used during malaria prevention campaigns to distribute ITNs to children under five years of age and pregnant women (Yeka et al., 2012). In addition, these health facilities provide information to clients including on malaria prevention and control.
Limited access to public health facilities is therefore likely to influence knowledge and practices regarding malaria prevention in the community.

Figure 3.2 Map of Uganda showing Wakiso district

Source: https://upload.wikimedia.org/wikipedia/commons/8/82/Uganda_Wakiso.png
[accessed 20 May 2015]
3.2.2 Study I Phase 1 (Baseline)

The objective of study I phase 1 (baseline) was to determine knowledge and practices on malaria prevention at households.

3.2.2.1 Study design, data collection methods and context

A baseline cross-sectional survey was conducted in 2012 to assess the knowledge and practices of the community on malaria prevention. The survey utilised both quantitative and qualitative methods of data collection. A structured questionnaire (appendix 5) and observational checklist (appendix 6) were used to collect quantitative data, while key informant interviews (appendix 7 – key informant interview guide) provided qualitative data. The baseline survey (study I phase 1) was conducted so as to establish the situation of the community regarding malaria prevention before the interventions of the pilot project (study I phase 2) were implemented. In addition, the baseline results were to be used during impact evaluation of the interventions implemented in the community (study I phase 3).

3.2.2.2 Sample size and sampling

The sample size of study I phase 1 (baseline) was calculated using a formula for cross-sectional studies (Kish, 1965) as shown below:

\[
 n = \frac{Z^2 \cdot pq}{d^2} \\
\]

(1)

Where: \( n \) = Sample size
Z = 95% level of confidence (which corresponds to 1.96 from statistical tables)
p = Proportion of the population knowledgeable on malaria prevention
q = 1- p
d = Desired level of precision

Using a proportion of 50% as no appropriate data could be found regarding knowledge on malaria prevention in rural communities in Uganda, and a 5% level of precision:

\[ n = \frac{1.96^2 \times 0.5 \times 0.5}{0.05 \times 0.05} = 384 \text{ participants} \]

Non-response was not catered for in the sample size calculation as it was anticipated that all selected households would take part in the survey. The lists of households obtained from the village chairpersons were used to systematically select the households involved in the study. The systematic sampling interval used for each village was based on the number of households therein and required sample size. The reference household for systematic sampling was randomly selected in each village using a table of random numbers.

Qualitative data was obtained from ten key informant interviews. A sample size of ten was used as data from that number of key informants was expected to reach saturation as required in qualitative research (Eslamian et al., 2015). The key informants were three community health workers (CHWs), three village leaders, and four health practitioners in the study area selected purposively based on those who were felt most appropriate to provide information on knowledge and practices on malaria prevention in the community. CHWs in the Ugandan context are known as village health teams (VHTs) and are volunteers who serve their communities in carrying out health promotion and social mobilisation activities. They are also involved in several primary
health care and public health activities including water and sanitation, disease surveillance, and treatment of common illnesses notably diarrhoea, malaria and pneumonia among children under five years of age. The village leaders involved in the study were members of the area local council who provide leadership at village level. The health practitioners who participated in the study were two nurses, and two environmental health practitioners that were working in the area.

3.2.2.3 Data collection and measurements

The questionnaire (appendix 5), which was piloted and translated into the local language (Luganda), gathered information on malaria prevention including participants’ knowledge and household practices. The questionnaire was piloted among 20 households in one of the villages in Ssisa sub-county that had similar demographic characteristics as the two study villages. After piloting the questionnaire, editing was done which ensured the tool was appropriate for collecting data. An observational checklist (appendix 6) was also used to collect data, which assessed the environmental conditions at households that are associated with occurrence of malaria. These environmental conditions were presence of: mosquito breeding sites, vessels that could hold water for mosquito breeding, overgrown vegetation within five metres of houses, and screening in windows, ventilators and open eaves. Regarding overgrown vegetation near houses, a distance of five metres was used because it was considered a good measure of close proximity of mosquitoes to houses. Nevertheless, mosquitoes are known to travel longer distances from breeding sites to households (Rosas-Aguirre et al., 2015). Prior to collection of data, two field assistants were trained by the researcher to provide support during administering the questionnaire and using the checklist. The training of field assistants, which lasted one day,
involved teaching on general research principles including ethical concerns such as seeking consent from participants before their involvement in the study. In addition, the field assistants were trained on the study tools which enabled them support the researcher during data collection. During the process of data collection, the researcher worked with the field assistants daily to ensure the data was complete. The questionnaire and observational checklist were administered once for each household. From the households selected, only one member per household who was the household head participated in the research. In situations where the household head was not available or unwilling to take part, the spouse was selected. In the event that both the household head and spouse could not take part in the research, the other oldest household member such as eldest child found was selected for the research.

The participants provided information on their knowledge on malaria prevention, the methods that were being used by their households to prevent the occurrence of malaria, and their health seeking behaviour when a child under five years of age in their household had malaria. The question regarding knowledge on malaria prevention methods had seven possible responses, plus any other method mentioned by the participants. The seven methods of malaria prevention assessed, selected based on those used in the Uganda Malaria Indicator survey of 2009 (UBOS, 2010), were:

- Untreated mosquito nets;
- ITNs;
- Mosquito coils;
- Spraying houses with insecticides;
- Taking preventive medicine;
- Mosquito repellents; and
- Draining mosquito breeding sites.

Knowledge on malaria prevention was therefore assessed by the number of methods mentioned by the participants, with each method contributing a score of one to form an assessment score. Participants with an assessment score of zero were categorized as having no knowledge; one to three - low knowledge; four and above - high knowledge. From the knowledge assessment scale, the lowest possible score was zero, and highest eight. Although the number of malaria prevention methods listed on the questionnaire were seven, participants had the option to mention any other method they were aware of hence the maximum of eight methods. The knowledge assessment scores were converted into percentages using the number of participants in each category as the numerator and total number of participants involved in the study as the denominator.

Household practices on malaria prevention were assessed by the individual methods being used to prevent the disease, and related environmental risk factors which were obtained from both the questionnaire and observational checklist. The practices and risk factors assessed using the questionnaire were use of mosquito nets (treated and untreated), IRS and time of closing windows on houses. The checklist was used to observe screening in windows and ventilators on houses, presence of stagnant water in compounds, and presence of overgrown vegetation within five metres of houses. Except for IRS that was assessed if it had been conducted in the household within twelve months prior to data collection, all other malaria prevention practices were assessed if they were being used at the time of the research. The environmental risk factors at
households such as presence of stagnant water were also established if present at the time of data collection. Key informants provided qualitative data on community knowledge and practices on malaria prevention which was used to supplement the quantitative findings. The key informant interviews, which were conducted by the researcher in the local language (*Luganda*) at the homes of the key informants, each lasted between 30 and 50 minutes, and were audio recorded.

### 3.2.2.4 Data analysis

Quantitative data was entered in SPSS version 17 (Chicago, Illinois, USA) and transferred to STATA version 12 (College Station, Texas, USA) statistical software for analysis. At univariate analysis, categorical variables (such as educational level, having heard malaria message in the previous 12 months, and presence of screening in windows and ventilators) were summarized using frequencies and percentages while numerical ones (household size and number of mosquito nets owned) are presented using mean and inter-quartile range. The chi-square test was used to identify factors associated with knowledge on malaria prevention methods among the participants. Since use of ITNs is the most advocated method for malaria prevention globally and in Uganda, factors associated with ownership of mosquito nets, and the relationship between number of nets owned with household size were identified. For bivariate and multivariate analysis, log-binomial regression model was used to estimate the crude and adjusted prevalence rate ratios (PRR) at 95% confidence intervals for the factors associated with ownership of mosquito nets. Variables that were significant at $p < 0.1$ at bivariate level and those with biological plausibility were included in multivariable analysis. The variables that made up the final model were sex, age, education level, employment status and monthly income which were
controlled for each during multivariable analysis. Spearman's rank order correlation was run to assess the relationship between number of mosquito nets in households and household size.

Qualitative data from key informant interviews was recorded in the local language (Luganda) and later transcribed before being translated to English. The transcribed data was read several times to ensure all information had been accurately documented. The transcripts where then verified as a true representation of the interviews after making minor revisions. From the verified transcripts, summaries were generated highlighting the emerging issues. Coding of the data was then done for all the transcribed work using Atlas ti version 6.0.15 qualitative data analysis software. The coded data was then used to identify the key emerging themes from the qualitative data which was guided by the summaries initially generated. After the themes were generated, the transcribed data was reread to ensure that all coded data was correctly assigned to respective themes. Appropriate verbatim quotations from the key informants are used in the presentation of the qualitative findings, and written in italics.

3.2.3 Study I Phase 2 (Intervention)

The objective of study I phase 2 (intervention) was to implement an intervention on the integrated approach to malaria prevention in the community.
3.2.3.1 Intervention structure

The intervention phase carried out in 2012 was a pilot project aimed at promoting the use of integrated malaria prevention in the two villages. It involved training community volunteers on integrated malaria prevention; sensitising the community on integrated malaria prevention; and establishing demonstration households implementing integrated malaria prevention. These interventions were designed to increase knowledge and improve practices on malaria prevention in the community.

3.2.3.2 Training of community volunteers on the integrated approach

Community volunteers were trained on the integrated approach to malaria prevention so that they could promote it among the community. The volunteers, who were identified by the chairpersons of the two villages, were met by the researcher who briefed them about the research and what their involvement would be. After getting written informed consent from the volunteers regarding their participation in the research, a training workshop was organised by the researcher. The training of community volunteers involved holding training workshops in the two villages which lasted between five and six hours. The venue used for the trainings were the ones normally used by the respective villages for community meetings. The two training workshops (one in each village), that were facilitated by the researcher, trained the volunteers on the various malaria prevention methods in the integrated approach. The workshops had three sessions:

- **Session one:** Introduction to the research
- **Session two:** Assessment of knowledge of the volunteers on malaria prevention
- **Session three:** Training on the various malaria prevention methods in the integrated approach

All community volunteers involved in health promotion in their respective villages as identified by the chairpersons were involved in the training. A few local leaders and youth involved in health promotion were also trained. A total of 25 volunteers in the two villages (13 in Lukose and 12 in Mayanzi) were trained which included 17 community health workers, four local leaders, and four youth as follows:

**Lukose village:** 9 community health workers, 2 local leaders and 2 youth

**Mayanzi village:** 8 community health workers, 2 local leaders and 2 youth

During the training, the volunteers were informed about their responsibility of promoting the integrated approach to malaria prevention in their respective communities during and after the project period as part of their routine work. This was a key sustainability strategy of the project.

### 3.2.3.3 Community sensitisation on the integrated approach

The community in the project areas was sensitised on the integrated approach to malaria prevention. This involved holding sensitisation sessions in each of the two villages. The chairperson in each of the villages was notified about the sensitisation activities so that they could mobilise their respective residents to attend. In addition to the village chairpersons, community mobilisers existing in the communities were involved in mobilisation in their areas.
Over 200 community members in the two villages were sensitised during the project. Both training of volunteers and community sensitisation, which were facilitated by the researcher, involved use of appropriate information, education and communication (IEC) materials such as posters and fliers (Figures 3.3 and 3.4), in addition to health talks. Reference was made to each poster while teaching the community on the respective malaria prevention method in the integrated approach. The use of health talks and IEC materials was to increase awareness on malaria prevention methods so as to influence practices in the control of the disease. Eight posters were developed for the sensitisation, each containing one malaria prevention method being advocated in the integrated approach. During the community sensitisation, all the eight posters were displayed in such a way that the community could see them (appendix 8 – pilot project pictorial).

Figure 3.3 One of the posters used for training community volunteers, and community sensitisation

Source: Research photo
Figure 3.4 Part of the flier used for training community volunteers, and community sensitisation. The malaria prevention methods in the local language are listed below in English. *Source: Research photo*

The malaria prevention methods promoted in the pilot project were those that could be easily implemented by the community. These malaria prevention methods promoted were:

- ITNs;
- Screening in windows and ventilators;
- Destroying mosquito breeding sites;
- Clearing overgrown vegetation;
- Early closing of doors and windows;
- Space spraying with insecticides;
- Removal of vessels that could harbour water for mosquito breeding; and
- Larviciding.

Each poster used in the training and sensitisation contained an illustrative presentation and name of a malaria prevention method. This illustrative design was meant to capture the attention of the community as well as facilitate the messages being understood by those who could not read. The flier contained all the eight malaria prevention methods being advocated in the integrated approach, and each community member attending the sensitisation received a copy. After the training, several copies of the fliers were also distributed to the community so as to give them out to others who were not able to attend the sessions. Both the fliers and posters were translated into the local language (Luganda) so as to facilitate learning among the population including those who could not read English.

During the community sensitisation sessions, emphasis was given to children under five years of age and pregnant women as the groups most affected by malaria. Putting emphasis on those vulnerable groups was aimed at contributing to Millennium Development Goals (MDGs) four (reducing child mortality) and five (improving maternal health) in addition to MDG six (involving combating malaria) which was the main focus of the project.
3.2.3.4 Establishing demonstration households using the integrated approach

During study I phase 2 (intervention), households were selected and supported to implement the integrated approach to malaria prevention. These were used as demonstration sites in the community to promote the approach. A total of 40 demonstration households (20 in each village) were established. These households were selected by the community leaders following the guidelines provided by the project. The project required that priority be given to households that had children under five years of age and/or a pregnant woman. In addition, the demonstration households needed to be well distributed in the community so that majority of the population could have access to at least one such household.

As part of the integrated approach, complete screening was installed in all windows and ventilators of the demonstration houses to limit mosquito entry (Figures 3.5, 3.6, 3.7 and 3.8). This involved procurement of the necessary materials including rolls of mosquito screens, small pieces of timber, and nails. The installation of mosquito screening was done by experienced local carpenters. The project also provided LLINs for use by members of the demonstration households to protect them against mosquito bites. The number of nets received per household depended on the number of household members, and the available functional nets at the time. Households received between two and six LLINs. Each net cost 7 US dollars while installation of screening in windows and ventilators cost on average 100 US dollars per household. Although the distribution of LLINs lasted one day in each village, the installation of screening in windows and ventilators was done in two weeks. These interventions of provision of LLINs and house screening were carried out after educating the household beneficiaries on the importance of using the methods in the prevention of malaria. It was the responsibility of members of respective
demonstration households to implement the other strategies in the integrated approach such as closing doors early in the evenings to reduce mosquito entry, removal of mosquito breeding sites, and clearing overgrown vegetation near houses. These demonstration households were expected to continue to be used to promote the integrated approach in the community during and after the project period, including for future long-term evaluation activities (study I phase 3).

Figure 3.5 A window and ventilator on one of the demonstration houses with complete mosquito screening  
Source: Research photo
Figure 3.6 One of the demonstration houses with complete mosquito screening in windows and ventilators  
*Source: Research photo*

Figure 3.7 A window on one of the demonstration houses before installation of screening  
*Source: Research photo*
3.2.4 Study I Phase 3 (Evaluation)

The objective of study I phase 3 was to evaluate the impact and experiences of using integrated malaria prevention in the community.

3.2.4.1 Study design, data collection methods, and context

To assess the impact of the study I phase 2 interventions (training community volunteers, community sensitisation, and establishment of demonstration households), an evaluation (study I phase 3) was carried out. The impact evaluation, conducted in 2014 two years after
Implementation of the interventions, was cross-sectional in design and employed quantitative and qualitative data collection methods. The quantitative survey used a questionnaire and observational checklist while the qualitative component employed focus group discussions (FGDs) and in-depth interviews (IDIs). The indicators used in the evaluation were knowledge and practices on malaria prevention in the community. The malaria prevention methods assessed in the evaluation included use of mosquito nets, IRS, time of closing windows on houses, insecticide sprays, and screening in windows and ventilators. In addition, environmental risk factors such as presence of stagnant water in compounds, and overgrown vegetation within five metres of houses were also assessed. The findings of the evaluation were compared with those of the baseline (study I phase 1) to measure changes in knowledge and practices in the community.

### 3.2.4.2 Sample size and sampling

A minimum sample size of 384 as calculated in the baseline (study I phase 1), was used in the evaluation (study I phase 3). The same sampling procedure used in the baseline was employed in the evaluation. Indeed, households involved in the quantitative component of the evaluation were selected using systematic sampling, the sampling interval for each village obtained based on the estimated number of households therein. In addition, the reference household for systematic sampling was randomly selected in each village using a table of random numbers. Households that were selected in the baseline (study I phase 1) were not necessarily selected in the evaluation (study I phase 3). Therefore, the samples of these two phases (1 and 3) were independent of each other. The participants in the evaluation were household heads. However, in the absence of
household heads, the spouse was selected to participate in the research. In situations where both
the household head and spouse were unavailable, the eldest other household member such as
oldest son or daughter was selected as the participant. Only one participant from each selected
household was involved in the evaluation as was the case in the baseline.

Four FGDs (appendix 9 – FGD guide) and 40 IDIs (appendix 10 – IDI guide) made up the
qualitative component of the evaluation. The FGDs were conducted among all the community
volunteers who were trained on integrated malaria prevention in study I phase 2 (intervention).
Two FGDs were conducted in each of the study villages and comprised of between five to eight
members. The 40 IDIs were conducted among all demonstration households implementing
integrated malaria prevention from study I phase 2 (intervention). Participants in the IDIs were
heads of the 40 households. Where household heads were not found during data collection, other
responsible adults notably their spouses were used.

3.2.4.3 Data collection and measurements
The questionnaire and observational checklist used during study I phase 1 (baseline) were
employed for study I phase 3 (evaluation) to measure changes in knowledge and practices on
malaria prevention in the community following the project’s interventions (study I phase 2). The
field assistants, who collected data during study I phase 1 (baseline), were employed in study I
phase 3 (evaluation). Before collecting data in the evaluation, the researcher retrained the field
assistants on ethics in research and the data collection tools to ensure they were competent to
conduct data collection.
Knowledge was assessed by awareness on individual malaria prevention methods, and also multiple interventions using the knowledge assessment scale employed in phase 1 (baseline). As used in the baseline, participants with a knowledge assessment score of zero were categorized as having no knowledge; one to three - low knowledge; four and above - high knowledge. Practices on malaria prevention were assessed by the methods households employed to prevent the disease, as well as the environmental risk factors established using the questionnaire and observational checklist.

The FGDs were used to assess the community volunteers’ knowledge on the integrated approach to malaria prevention, their role in promoting use of multiple malaria prevention methods in the community, and community practices on preventing malaria. The IDIs assessed households’ experiences of using integrated malaria prevention. The IDI guide had questions related to practices on malaria prevention, benefits and challenges of using integrated malaria prevention, preference of malaria prevention methods, and the impact of the demonstration households on the community. The FGD and IDI guides were developed in English then translated to the local language (Luganda). Data from the FGDs and IDIs was collected in Luganda and all proceedings of the discussions and interviews were recorded. The FGDs were held in designated community meeting places as provided by the village leaders. The IDIs were conducted in an ideal location in each household suggested by the participants with no other member allowed within the vicinity of the data collection activity. The average duration of the FGDs and IDIs was 60 and 45 minutes respectively. Both the FGDs and IDIs were audio recorded.
3.2.4.4 Data analysis

Quantitative data was entered in SPSS version 17 (Chicago, Illinois, USA) and analysed in STATA version 12 (College Station, Texas, USA) statistical software. The quantitative results from the evaluation (study I phase 3) are compared with those of the baseline (study I phase 1) regarding knowledge and practices in the community. Percentages from the evaluation were compared with those from the baseline to assess changes in knowledge and practices on malaria prevention in the community following implementation of the interventions. In addition, the chi-square test was employed to measure statistical association between practices and risk factors for malaria prevention from the evaluation and baseline.

For the qualitative component, all FGDs and IDIs which were audio recorded were later transcribed verbatim in the local language. The transcriptions were then read to ensure they were a true representation of the data collected. Minor editing to the transcripts was done at this stage. Once the transcripts had been validated, they were translated to English and verified. Codes were then developed from the study objectives and transcribed data for use in analysis. Using Atlas ti version 6.0.15 qualitative data analysis software, the transcripts were coded. The coded transcripts were reviewed to adequately categorise the data. Using thematic analysis, the categorised data was used to generate themes which are employed to present the major qualitative findings from the evaluation. The most appropriate quotations from the qualitative data based on the themes developed from the analysis are presented in the results section using italics.
3.3 Study II

The objective of study II was to assess community perceptions, utilisation and barriers of integrated malaria prevention in the community.

3.3.1 Study area

The study was carried out in 2013 in Ssisa sub-county, one of the fifteen sub-counties in Wakiso district, Uganda. Ssisa sub-county was randomly selected for study II though it had provided one village for study I in addition to the other village from Entebbe municipality (Figure 3.9). Nevertheless, the village in Ssisa sub-county involved in study I was not considered in the sampling frame for possible inclusion in study II. Therefore, the interventions implemented in study I were not expected to have any influence on the findings from study II. Ssisa sub-county is predominantly a rural area made up of eleven parishes which were all involved in study II. These parishes were Bulwanyi, Bweya, Kitende, Nakawuka, Namulanda, Nankonge, Ngongolo, Nkungulutale, Nsaggu, Ssisa and Wamala. Agriculture is the main economic activity carried out in the sub-county, the others being trade, manufacturing and provision of services (Wakiso, 2009b). Specifically, the population is engaged in crop farming, animal husbandry, small scale businesses, stone quarrying, brick making and sand mining. Ssisa sub-county has a population of 93,238 (UBOS, 2014), and malaria is the leading cause of morbidity and mortality in the area (URN, 2008; Wakiso, 2009a). The sub-county has 23,992 households and an average household size of 3.8 (UBOS, 2014). Although there is no government hospital in Ssisa sub-county, there are lower level Government health facilities and several private ones that offer health services to the community.
3.3.2 Study design

The study was a clustered cross-sectional survey at household level involving both quantitative and qualitative data collection methods. The clusters were villages while the study units were households. Clustering was employed as heterogeneity between clusters was assumed especially in terms of exposure to malaria. However, exposure within clusters was expected to be similar.
### 3.3.3 Study participants

The study participants were household heads or other responsible adults (such as spouses) at the selected households. These participants were expected to be knowledgeable on the malaria prevention strategies used by their households compared to other household members due to their authority and responsibility. The participants were also expected to have lived in the households for longer periods of time when compared to other household members. If there were two or more other responsible adults in a household, random selection was done to obtain the one who participated in the study.

### 3.3.4 Sample size and sampling method

Using the sample size calculation formula for cross-sectional studies (page 56), a proportion of 50% as no data could be found on the use of the integrated approach in Uganda, and a 5% level of precision:

\[
n = \frac{1.96^2 \times 0.5 \times 0.5}{0.05 \times 0.05} = 384 \text{ participants}
\]

The study proposed to get the 384 households from clusters which in this case were enumeration areas (villages). This meant the sample size had to cater for the clustering effect because cluster sampling results in greater statistical variance than simple random sampling. Therefore, the sample size calculation had to be enhanced by a factor known as design effect.

\[
S_c = n \times D \quad \text{Where the} \quad D = 1 + (b - 1)roh \quad \text{(Rossi et al., 1985)} \quad \text{……………………………………. (2)}
\]

\[
S_c = \text{Sample size after adjusting for the cluster effect.}
\]
\( n \) = Sample size assuming no clustering effect. In this case it was 384.

\( roh \) = rate of homogeneity within a cluster

\( D \) = Design effect

\( b \) = Cluster size

As the cluster size \( b \) of 20 was chosen, and a rate of homogeneity \( roh \) of 0.025 (Knox & Chindros, 2004) taken (they commonly range from 0.01-0.1), then the design effect \( D \) became nearly 1.5. This implied that a final sample size \( S_c = 566 \) from 28 enumeration areas (getting 20 per enumeration area). Assuming a ten percent non-response rate, a sample size of 629 was obtained. Due to non-response, the cluster size was increased from 20 to 23 so as to maintain the number of clusters at 28. A cluster size of 23 provided a final minimum sample size of 644 households for the study.

The number of villages from each parish involved in the study was determined as proportionate to the number of households per parish [data obtained from Uganda Bureau of Statistics (UBOS)] which ranged from one to seven. For parishes which provided more than one village, random sampling was used to identify those involved in the study. Using the village chairperson’s home as the starting point, data collectors systematically selected households to be involved in the study. The household sampling interval, which ranged from three to thirteen, was determined by the number of households in each village as obtained from UBOS.
3.3.5 Data collection

Quantitative data was collected using a questionnaire (appendix 11) and observational checklist (appendix 12) while FGDs (appendix 13 – FGD guide) provided qualitative data. The questionnaire assessed the participants’ knowledge, perceptions, practices, and anticipated challenges on integrated malaria prevention. The questionnaire also obtained information on the mosquito nets owned by households including type, source and use the previous night. Data was collected for each net to a maximum of three nets per household. The observational checklist was used to assess environmental risk factors associated with the occurrence of malaria present at households, and the structural condition of houses related to mosquito entry. The questionnaire and checklist were administered once for each household involved in the study. Six FGDs (three male, three female) were conducted to assess the perceptions on the various malaria prevention methods, and use of the integrated approach to prevent the disease. Participants of the FGDs were selected from the general population in three randomly selected villages, and each FGD comprised of between eight to twelve participants. Each selected village provided participants for one male and one female FGD.

3.3.6 Data analysis

3.3.6.1 Quantitative data

Quantitative data was entered in SPSS version 10.0 (Chicago, Illinois, USA) and analysed in STATA version 10.0 (College Station, Texas, USA). Perceptions on the integrated approach were assessed both quantitatively and qualitatively. Quantitatively, participants were asked about
their awareness of the various malaria prevention methods in the integrated approach. Awareness was defined as knowledge on the possible use of a method for preventing malaria, and assessed by prompting using the several practices in the integrated approach. These methods assessed were:

- Sleeping under untreated mosquito net;
- Sleeping under ITN;
- Installing screening in windows;
- Installing screening in ventilators and open eaves;
- Removing mosquito breeding sites;
- Spraying house with insecticides;
- Clearing overgrown vegetation around homes;
- Closing windows and doors early in the evenings;
- Larviciding in water pools;
- Indoor residual spraying;
- Using body mosquito repellents; and
- Using mosquito coils.

Furthermore, the participants were asked whether they would use all the methods in the integrated approach in a combined manner if trained. For participants who would not use all the methods, reasons for their preferences were assessed. In addition to establishing the individual
methods used to prevent malaria, utilisation of integrated malaria prevention assessed was defined as using at least two methods by a household.

Using the observational checklist, assessment of structural condition of houses was done for the following parameters:

- Windows having complete shutters;
- Windows having mosquito screening hence no space for possible mosquito entry;
- Ventilators and open eaves having mosquito screening;
- Houses with open eaves having ceilings;
- External doors having complete shutters and no space for possible mosquito entry; and
- Presence of any other opening on house.

To assess the association between socio-demographic variables, malaria prevention associated factors, and integrated malaria prevention, frequencies and associated proportions were obtained for each variable category. The 95% confidence interval (CI) of the proportions were obtained using the analytically derived variance estimator associated with the sample proportion - \( \text{SE}(p) = \sqrt{\frac{p(1-p)}{n}} \). The association between each variable and the main outcome (integrated malaria prevention) was analysed using logistic regression. Principal component analysis (PCA) was undertaken to select variables to include in the socio-economic status (SES) index. Initially, there were seven variables considered:

- Source of water;
• Toilet facilities;
• Fuel for cooking;
• Materials of the floor;
• Vehicle ownership;
• A wealth index composed of ownership of TV, refrigerator, telephone and radio; and
• Having electricity.

Vehicle ownership was computed using a score which composed of possession of a bicycle, motorcycle and car. The categories of each of the variables were arranged from worst to best, with the best scoring the highest points. The PCA yielded five variables (water source, toilet facilities, cooking fuel, floor material, and wealth index) as the best predictor for SES and these were used to compute the SES index used in the analysis. After ordering the SES index, households were divided into terciles with those scoring lowest considered as the poorest while those with the highest score were considered the richest. The remaining two variables (having electricity and vehicle ownership) were analysed individually in the crude analysis. A multivariable model was fitted using multiple logistic regression with robust standard errors to account for clustering within villages. All variables with p-values ≤ 0.1 and the known prior confounders (age and sex) were added into the model by backward stepwise regression. The significance of each additional variable was tested using log likelihood and if not significant, was excluded from the model. The variables initially included in the multivariable model were: age, sex, education level, occupation, family size, whether a household had a child under five years of
age, whether there was a pregnant woman in the household, reading newspapers, listening to radio, and vehicle ownership. Variables which remained significant at the end of model fitting made up the final regression model.

3.3.6.2 Qualitative data

Qualitatively, the FGDs established what the participants thought about the integrated approach, and explored why some of the methods were likely not to be used. All FGDs were audio recorded and later transcribed verbatim in the local language (Luganda). They were then translated into English and reviewed several times. By using a qualitative thematic analysis, data were coded into initially predetermined themes and other emerging ones. This was done using QSR International’s NVivo version 10 qualitative data analysis software. NVivo software was used in this study (and not study I) as it was identified at the time to be more user friendly while being able to be used to suitably code and analyse qualitative data. The data with developed themes was then examined to ensure all data had been correctly coded and assigned to appropriate themes. The most appropriate direct quotations from the FGDs based on the emerging themes are presented in italics in the results to highlight key findings.

3.4 Ethical considerations

Ethical approval for the research (study I - phases 1, 2 and 3; and study II) was obtained from the Makerere University School of Public Health Higher Degrees, Research and Ethics Committee. The research was also registered at the Uganda National Council for Science and Technology.
(UNCST). The local leaders of all the villages involved were duly informed about research and permission obtained from them. Written informed consent was obtained from all participants before taking part in the research. Participation in all components of the studies was voluntary, and consent was obtained only after clearly explaining the purpose of the research including the anticipated risks and potential benefits.
CHAPTER FOUR: STUDY I RESULTS AND DISCUSSION

4.1 Introduction

This chapter provides the results from study I, and discussion. This includes findings from study I phase 1 (baseline), study I phase 2 (intervention), and study I phase 3 (evaluation). Study I phase 1 (baseline) established knowledge and practices on malaria prevention before implementation of the pilot project interventions (study I phase 2). Study I phase 3 (evaluation) evaluated the impact and community experiences in using the integrated approach to malaria prevention. This evaluation includes comparison of knowledge and practices on malaria prevention before and after implementation of the intervention; experiences of community volunteers in promoting the integrated approach; malaria prevention practices of demonstration households; and benefits and challenges of using integrated malaria prevention by the demonstration households. In the discussion, the results are put into context with reference to exiting literature on malaria prevention in Uganda and globally. Limitations of study I phase 1 (baseline), study I phase 2 (intervention), study I phase 3 (evaluation), as well as key lessons learnt and challenges of study I phase 2 (intervention) are also provided in this chapter.

4.2 Study I Phase 1 (Baseline) Results

A total of 376 households (Lukose - 168 and Mayanzi - 208) were involved in the quantitative component of the baseline survey. All sampled households accepted and took part in the research. In addition, ten key informant interviews were conducted that provided qualitative data. The ten key informants were three community health workers (CHWs), three village leaders, and
four health practitioners. The actual titles of the different health practitioners, and village leaders are not provided while presenting quotations from the qualitative data to maintain confidentiality.

4.2.1 Socio-demographic characteristics of participants of study I phase 1 (baseline)

The majority of participants had gone to school, with 45.2% (170/376) having attained primary school education as their highest level of education, and 39.1% (147/376) with secondary school education. Nearly half of the participants (49.2%; 185/376) had an average household monthly income between 20 – 60 US dollars ($), with only 5.9% (22/376) earning more than 100 $. Over half of the participants (50.5%; 190/376) had household size between four and six members, while most were female (67.6%; 254/376). The largest number of participants (33.8%; 127/376) was in the age category of 25 – 34 years (Table 4.1).

4.2.2 Knowledge on malaria transmission and prevention

The majority of participants (89.6%; 337/376) were aware of malaria being transmitted through mosquito bites. However, other transmission routes of the disease given were cold / changing weather (11.7%; 44/376), drinking unboiled water (10.1%; 39/376), and eating maize (6.9%; 26/376). Over half of the participants (56.1%; 211/376) had heard or seen messages about malaria in the previous twelve months. The main source of malaria information was radio (70.6%; 149/211) while others were health facilities (9.5%; 20/211), community leaders (5.2%; 11/211), and television (4.3%; 9/211).
Table 4.1 Socio-demographic characteristics of participants of the baseline

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (n = 376)</th>
<th>Percentage (%)</th>
</tr>
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<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
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<tr>
<td>18-24</td>
<td>80</td>
<td>21.3</td>
</tr>
<tr>
<td>25-34</td>
<td>127</td>
<td>33.8</td>
</tr>
<tr>
<td>35-44</td>
<td>76</td>
<td>20.2</td>
</tr>
<tr>
<td>&gt; 44</td>
<td>93</td>
<td>24.7</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>122</td>
<td>32.4</td>
</tr>
<tr>
<td>Female</td>
<td>254</td>
<td>67.6</td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catholic</td>
<td>148</td>
<td>39.4</td>
</tr>
<tr>
<td>Anglican</td>
<td>116</td>
<td>30.9</td>
</tr>
<tr>
<td>Muslim</td>
<td>64</td>
<td>17.0</td>
</tr>
<tr>
<td>Pentecostal</td>
<td>39</td>
<td>10.4</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Occupation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>121</td>
<td>32.2</td>
</tr>
<tr>
<td>Business</td>
<td>93</td>
<td>24.7</td>
</tr>
<tr>
<td>Housewife</td>
<td>88</td>
<td>23.4</td>
</tr>
<tr>
<td>Others</td>
<td>74</td>
<td>19.7</td>
</tr>
<tr>
<td><strong>Highest level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>51</td>
<td>13.6</td>
</tr>
<tr>
<td>Primary</td>
<td>170</td>
<td>45.2</td>
</tr>
<tr>
<td>Secondary</td>
<td>147</td>
<td>39.1</td>
</tr>
<tr>
<td>Tertiary / university</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Average household monthly income (US dollars)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>123</td>
<td>32.7</td>
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<tr>
<td>20 - 60</td>
<td>185</td>
<td>49.2</td>
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<tr>
<td>60 - 100</td>
<td>46</td>
<td>12.2</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>22</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>Household size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 3</td>
<td>117</td>
<td>31.1</td>
</tr>
<tr>
<td>4 - 6</td>
<td>190</td>
<td>50.5</td>
</tr>
<tr>
<td>≥7</td>
<td>69</td>
<td>18.4</td>
</tr>
</tbody>
</table>
The majority of participants (67.6%; 257/376) were aware of ways to avoid getting malaria. The most prominent methods mentioned were: sleeping under mosquito nets including untreated (81.7%; 210/257) and insecticide treated ones (29.6%; 76/257), using mosquito coils (54.1%; 139/257), and spraying houses with insecticides (25.3%; 65/257) (Figure 4.1).

![Malaria prevention methods](image)

**Figure 4.1 Knowledge on individual malaria prevention methods**

From the knowledge assessment score, the majority of participants (64.6%; 243/376) had low knowledge on malaria prevention methods, with the rest having no knowledge (32.5%; 122/376) or high knowledge (2.9%; 11/376). The factors found to be associated with knowledge on
malaria prevention methods hence statistically significant were age ($\chi^2 = 32.1; p < 0.01$), employment status ($\chi^2 = 18.1; p < 0.01$), education ($\chi^2 = 20.3; p = 0.01$), income ($\chi^2 = 14.5; p = 0.01$), and having heard malaria message in the previous twelve months ($\chi^2 = 92.3; p < 0.01$) (Table 4.2).

The key informants revealed that although the community was aware of malaria prevention methods such as sleeping under mosquito nets, many families could not afford to implement these measures in their households:

“Basing on the income of people in this village, very few can afford to prevent malaria because they do not have money to buy mosquito nets or screens for their windows and ventilators even when they know such practices would help their families”. Village leader 2, Lukose

4.2.3 Practices on malaria prevention

Households that had at least one mosquito net (treated or untreated) for use in the prevention of malaria were 45.5% (171/376), with the mean number of nets being 2.11 (inter quartile range, IQR 1-3) compared to the mean household size of 4.69 (IQR 3-6). The proportion of children under five years of age who slept under a mosquito net the night before the survey was 43.3% (126/291) compared with 28.4% (390/1,372) among other household members. There was a positive correlation between household size and number of mosquito nets owned (Spearman’s correlation coefficient = 0.405, p <0.01). Participants aged 35–44 years were less likely to report having a mosquito net in their household compared to those aged 18–24 years (Adjusted
### Table 4.2 Factors associated with knowledge on malaria prevention methods

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>No knowledge (score 0)</th>
<th>Low knowledge (score 1-3)</th>
<th>High knowledge (score ≥ 4)</th>
<th>Chi square (χ²)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>18-24</td>
<td>16(20.0)</td>
<td>62(77.5)</td>
<td>2(2.5)</td>
<td>32.1</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td></td>
<td>25-34</td>
<td>26(20.5)</td>
<td>96(75.6)</td>
<td>5(3.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>35(46.1)</td>
<td>40(52.6)</td>
<td>1(1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45+</td>
<td>45(48.4)</td>
<td>45(48.4)</td>
<td>3(3.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>45(36.9)</td>
<td>74(60.7)</td>
<td>3(2.46)</td>
<td>1.7</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>77(30.3)</td>
<td>169(66.5)</td>
<td>8(64.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment status</td>
<td>Unemployed</td>
<td>10(13.5)</td>
<td>59(79.7)</td>
<td>5(6.8)</td>
<td>18.1</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td></td>
<td>Employed</td>
<td>112(37.1)</td>
<td>184(60.9)</td>
<td>6(2.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest level of education</td>
<td>None</td>
<td>22(43.1)</td>
<td>28(54.9)</td>
<td>1(1.9)</td>
<td>20.3</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>47(27.7)</td>
<td>120(70.6)</td>
<td>3(1.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary (ordinary level)</td>
<td>40(34.5)</td>
<td>72(62.1)</td>
<td>4(3.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary (advanced level)</td>
<td>10(32.3)</td>
<td>20(64.5)</td>
<td>1(3.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tertiary / university</td>
<td>3(37.5)</td>
<td>3(37.5)</td>
<td>2(25.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average household monthly income (US dollars)</td>
<td>&lt; 20</td>
<td>54(43.9)</td>
<td>65(52.9)</td>
<td>4(3.3)</td>
<td>14.5</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>20 – 60</td>
<td>55(29.7)</td>
<td>126(68.1)</td>
<td>4(2.16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 60</td>
<td>13(19.1)</td>
<td>52(76.5)</td>
<td>3(4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>1 - 3</td>
<td>32(27.4)</td>
<td>80(68.4)</td>
<td>5(4.3)</td>
<td>5.3</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>4 - 6</td>
<td>70(36.8)</td>
<td>117(61.6)</td>
<td>3(1.58)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥7</td>
<td>20(29.0)</td>
<td>46(66.7)</td>
<td>3(4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heard malaria message in previous 12 months</td>
<td>Yes</td>
<td>26(12.3)</td>
<td>174(82.5)</td>
<td>11(5.2)</td>
<td>92.3</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>96(58.2)</td>
<td>69(41.8)</td>
<td>0(0.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Statistically significant at p < 0.05
Prevalence Rate Ratio – APRR 0.7, Confidence Interval – CI 0.51 – 0.92). Similarly, participants aged 45 years or older were less likely to report having a mosquito net in their household compared to those aged 18–24 years (APRR 0.4, CI 0.27–0.66). Participants who were employed were more likely to report having a mosquito net in their households compared to those who were unemployed (APRR 1.2, CI 1.01–1.53). Participants whose households had an average monthly income between 20 – 60 US dollars ($) were more likely to report having a mosquito net in their households compared to those earning less than 20 $ (APRR 1.5, CI 1.05–2.03). Similarly, participants whose households had an average monthly income above 60 $ were more likely to report having a mosquito net in their households compared to those earning less than 20 $ (APRR 2.1, CI 1.47–2.91) (Table 4.3).

Key informant interviews revealed that the community had previously received support from the Government in form of ITNs. However, these ITNs provided were not regarded as sufficient as noted below:

“We received mosquito nets from Government. However, they were given to only households with children under five years and pregnant women but still, not all households that had children or pregnant women received these nets”. Health practitioner 3, Mayanzi

Although it was generally appreciated by the key informants that use of ITNs played a big role in the prevention of malaria, some of the challenges faced by the community in using them were poverty and large family size:
“Most families in this village have many members therefore based on this fact, they cannot buy insecticide treated nets for each person in the family.” Village leader 3, Mayanzi

### Table 4.3 Factors associated with ownership of mosquito nets in households

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Ownership net n = 376</th>
<th>Crude PRR(^\wedge) (95% CI(^\wedge))</th>
<th>Adjusted PRR (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No n=205</td>
<td>Yes n=171</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>78</td>
<td>44</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>127</td>
<td>127</td>
<td>1.4(1.06-1.81)*</td>
<td>1.3(0.99-1.62)</td>
</tr>
<tr>
<td>Age</td>
<td>18-24</td>
<td>34</td>
<td>46</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>25-34</td>
<td>52</td>
<td>75</td>
<td>1.0(0.81-1.30)</td>
<td>1.0(0.79 - 1.22)</td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>48</td>
<td>28</td>
<td>0.6(0.45-0.91)*</td>
<td>0.7(0.51 - 0.92)*</td>
</tr>
<tr>
<td></td>
<td>≥ 45+</td>
<td>71</td>
<td>22</td>
<td>0.4(0.27-0.62)*</td>
<td>0.4(0.27 - 0.66)*</td>
</tr>
<tr>
<td>Highest level of educational</td>
<td>None</td>
<td>32</td>
<td>19</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>94</td>
<td>76</td>
<td>1.2(0.81-1.78)</td>
<td>0.9(0.67 - 1.26)</td>
</tr>
<tr>
<td></td>
<td>Ordinary level</td>
<td>56</td>
<td>60</td>
<td>1.4(0.93-2.07)</td>
<td>1.0(0.71 -1.31)</td>
</tr>
<tr>
<td></td>
<td>Advanced level and tertiary</td>
<td>23</td>
<td>16</td>
<td>1.1(0.66-1.85)</td>
<td>0.8(0.52 - 1.22)</td>
</tr>
<tr>
<td>Employment status</td>
<td>Unemployed</td>
<td>127</td>
<td>82</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>Employed</td>
<td>78</td>
<td>89</td>
<td>1.4(1.09-1.69)*</td>
<td>1.2(1.01 – 1.53)*</td>
</tr>
<tr>
<td>Average monthly household income (US dollars)</td>
<td>&lt; 20</td>
<td>87</td>
<td>36</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>20 - 60</td>
<td>93</td>
<td>92</td>
<td>1.7(1.25-2.32)*</td>
<td>1.5(1.05-2.03)*</td>
</tr>
<tr>
<td></td>
<td>&gt; 60</td>
<td>25</td>
<td>43</td>
<td>2.2(1.55-3.00)*</td>
<td>2.1(1.47 - 2.91)*</td>
</tr>
</tbody>
</table>

\(^\wedge\) PRR - Prevalence rate ratio

\(^\wedge\wedge\) CI – Confidence Interval

* Statistically significant at 95% confidence interval
“Due to poverty, many households cannot afford to buy mosquito nets and mainly use those that were provided by the Government. Some families cannot even afford to buy drugs when members have malaria, in addition to not being able to buy screening for their windows and ventilators to prevent mosquitoes entering their houses.” Health practitioner 1, Lukose

Only 0.5% (2/376) of the participants’ houses had undergone IRS in the previous twelve months, and this had been done by household members. Only 2.1% (8/376) of the houses had complete screening in windows and ventilators to prevent mosquito entry. Stagnating water was found around 17.6% (66/376) of the houses, while vessels that could potentially hold water for mosquito breeding were found in 37.2% (140/376) households. In 42.8% (161/376) of households, overgrown vegetation was found within five metres of the house. Nearly half (47.3%; 178/376) of the households stated that they closed windows on their houses after 6.00pm (Table 4.4). In addition to the stagnant water in compounds, it was established from the key informants that numerous persistent pools of water that could be used by mosquitoes for breeding existed in the community:

“There are very many mosquito breeding places in this area especially those resulting from excavation of clay for brick making. These breeding sites greatly contribute to the many cases of malaria in our community.” Community health worker 2, Lukose
Table 4.4 Malaria prevention practices and risk factors at households

<table>
<thead>
<tr>
<th>Variable</th>
<th>n = 376</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of at least one mosquito net</td>
<td>171</td>
<td>45.5</td>
</tr>
<tr>
<td>Used indoor residual spraying in previous 12 months</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Presence of mosquito screening in windows and</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>ventilators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of stagnant water in compound</td>
<td>66</td>
<td>17.6</td>
</tr>
<tr>
<td>Presence of vessels around house that can potentially hold water for mosquito breeding</td>
<td>140</td>
<td>37.2</td>
</tr>
<tr>
<td>Closed windows on houses after 6.00 pm</td>
<td>178</td>
<td>47.3</td>
</tr>
<tr>
<td>Presence of overgrown vegetation within 5 metres of house</td>
<td>161</td>
<td>42.8</td>
</tr>
</tbody>
</table>

4.2.4 Health seeking practices for malaria

Among the participants, 30.6% (115/376) had children under five years of age in their households who had had a fever two weeks prior to data collection. Among these sick children, 85.2% (98/115) sought treatment from various sources, the main ones being Government health facilities (59.1%; 58/98), community health workers (CHWs) (33.7%; 33/98), and private facilities (21.4%; 21/98). Treatment of the sick children was first sought mainly from Government facilities (53.1%; 52/98). Only 29.6% (29/98) of the households sought treatment for the sick children on the very day the fever began. The rest sought treatment one to three days (61.2%; 60/98) or more than three days (9.2%; 9/98) after onset of the fever. Among those who did not seek treatment, the main reasons given were the child not being very ill (23.5%; 4/17), having no money (23.5%; 4/17), and waiting for the child’s parent (11.8%; 2/17). Most participants (62.2%; 61/98) had travelled between one to four kilometres to seek treatment when children in their household were sick. The rest travelled less than one kilometer (23.5%; 23/98)
or more than five kilometres (9.2%; 9/98). The long distances that the community had to travel to seek healthcare was a significant challenge also noted by the key informants:

“One of the main challenges we face in seeking health services is the distance we have to cover to get to health facilities. Due to having few Government health facilities, people have to travel very long distances to get treatment. Families therefore spend a lot of money on transportation alone.” Village leader 1, Lukose

The majority of participants 62.5% (235/376) were aware of the existence of CHWs in form of village health teams (VHTs) in their respective areas who distributed malaria medicines among other health promotion activities such as household visiting, and health education. However, among these participants, 62.7% (148/235) did not know whether the VHTs had malaria medicine available at the time while only 9.7% (23/235) confirmed existence of the medicine. The number of VHTs distributing malaria medicine in the community was found to be insufficient as established from the key informants:

“We have only four Government trained VHTs for the whole village. However, it is only two of these volunteers who were given malaria drugs for use by children when sick. Due to the many malaria cases among children, this medicine is usually used up in a short time leaving no medicine with these community health workers for long periods.” Village leader 2, Mayanzi
### 4.3 Study I Phase 1 (Baseline) Discussion

The baseline established that knowledge on malaria prevention methods was low, as 64.6% of the participants were aware of between one and three malaria prevention methods, and only 2.9% aware of four or more methods. However, participants were specifically highly aware of sleeping under mosquito nets (81.7% - untreated and 29.6% - treated) to prevent malaria. High knowledge on mosquito nets can be attributed to the Ministry of Health’s extensive campaign on increasing awareness and use of ITNs in recent years, including free distribution to vulnerable groups of children and pregnant women as established by the baseline. However, beyond the ITNs provided by the Government, many families could not afford to buy such nets which directly relates to the low income levels in rural areas in Uganda as established by the baseline and other studies (Mbonye et al., 2006; Welch & Fuster, 2012). Poverty not only affected use of malaria prevention methods in the baseline but also health seeking behaviours as has been documented in other studies (Das et al., 2013; Tumwesigire & Watson, 2002). Since poverty remains high in rural areas of Uganda, the Government’s strategy of free distribution of ITNs is likely to greatly benefit such communities. However, some studies conducted in other parts of Africa have shown misuse of received nets including being used for fishing (Hopkin, 2008; McLean et al., 2014; Minakawa et al., 2008). Therefore, an all-encompassing approach including health education on the importance of using the nets, and targeting other malaria prevention methods is recommended.

Knowledge on malaria prevention methods was associated with age ($\chi^2 = 32.1; p < 0.01$), employment status ($\chi^2 = 18.1; p < 0.01$), education ($\chi^2 = 20.3; p = 0.01$), income ($\chi^2 = 14.5; p = 0.01$),
0.01), and having heard malaria message in the previous twelve months ($\chi^2 = 92.3; p < 0.01$). People who are educated are expected to have had more exposure to malaria prevention methods compared to those who are not (Akinleye & Ajayi, 2011). Since education is a contributing factor to employment hence income (Gregorio & Lee, 2002; Kakai et al., 2009), the association of employment and income to knowledge on malaria is justified. The strong association between knowledge on malaria prevention and having heard malaria message is an indication that increased publicity could contribute towards improving malaria prevention practices in Uganda and beyond (Rhee et al., 2005; Saha et al., 2015).

With less than half of the households (45.5%) owning at least one mosquito net, this most advocated method of malaria prevention by WHO and MOH was being underutilised. However, it is possible that some participants may have under reported the number of nets in their households in anticipation of being given ITNs if they had a few or none. It was evident in the baseline that households gave priority to children under five years of age regarding sleeping under mosquito nets, a category most affected by malaria (WHO, 2014). Indeed, 43.3% of children under five years of age slept under a mosquito net the night before the survey compared to 28.4% among other household members. The estimated number of households owning at least one ITN nationally is 90%, with an average of 2.5 nets (UBOS, 2015), much higher than in the baseline. The main reason for the difference in current ownership of nets nationally compared to this baseline conducted in 2012 is likely to be the recent distribution of over 21 million ITNs throughout the country in 2013 and 2014 (Malaria Consortium, 2014; WHO, 2013a). The positive correlation between household size and number of nets owned established in the baseline (Spearman’s correlation coefficient = 0.405, p <0.001) could be attributed to households
with more children having received more nets from the Government. However, with the mean number of nets being two compared to the mean household size of five, the available nets among households were clearly insufficient for the members. Ownership of nets in the baseline increased with household income as established in other studies (Biswa et al., 2010; Kaliyaperumal et al., 2010). This finding of association between net ownership and income is logical as nets are costly and may not be affordable by families with low income. Indeed, participants who were employed and had an income were more likely to own a net in their household as established by the baseline. The negative association between ownership of nets and participants who were above 34 years could be due to such households having fewer children under five years of age hence receiving less free nets from the Government. Indeed, nets in previous campaigns were provided to households with children under five years of age and/or pregnant women (Yeka et al., 2012). The latest universal coverage campaign by MOH where one net was to be given to every two people in a household is likely to benefit all age groups. In this campaign, an estimated 21 million LLINs were to be distributed countrywide (Malaria Consortium, 2015b; MOH, 2014c).

Besides mosquito nets, there was low knowledge and utilisation of other malaria prevention methods including IRS which is a key national and global strategy (MOH, 2010; WHO, 2006). Wakiso district, located in central Uganda where this study was conducted, is not among the areas where IRS has been implemented by the Government which targeted mainly the northern region of the country (USAID, 2014b; Yeka et al., 2012). In addition, the use of IRS has been found to have several challenges elsewhere including insecticide smell, mess left by the sprayers, inconvenience of removing household items from houses before spraying, increased prevalence
of other insects, perceived ineffectiveness and side effects (Govere et al., 2000; Kaufman et al., 2012; Rodriguez et al., 2006). Installing screening in windows and ventilators of houses was also underutilised in the baseline as has been found in a related study (Musoke et al., 2013). Although screening of windows, ventilators and open eaves has historically been used to prevent entry of mosquitoes in houses, the method has been ignored in many communities (Lindsay et al., 2002; Ogoma et al., 2009). In addition to promotion of use of ITNs and IRS, advocating the use of other malaria prevention methods is important in reducing the burden of the disease in endemic countries. Indeed, malaria prevention practices in the integrated approach such as house screening have been shown to have benefits such as reduced presence of mosquitoes in houses (Bradley et al., 2013; Massebo & Lindtjørn, 2013). More studies are therefore necessary to assess the benefits of use of multiple malaria prevention methods at households in endemic communities.

The baseline re-emphasises the high utilisation of government health facilities and community health workers in rural communities for the treatment of fever which is a major symptom of malaria among children under five years of age (UBOS, 2015). However, the challenges of accessing these services noted in this research included long distance to facilities, insufficient number of VHTs, and stock-out of drugs among them. Similar challenges affecting utilisation of health services have been found in other studies carried out in Uganda and beyond (Kiguli et al., 2009; Smith et al., 2011). These health system challenges greatly affect health outcomes particularly in rural communities which are most at need of health services (Kassam et al., 2015; Kiwanuka et al., 2008). Therefore to improve the health of rural populations, concerned authorities such as MOH need to address these challenges. These challenges in accessing health
services when sick with malaria established in the baseline justify the importance of a strong public health system to reduce the occurrence of the disease.

The findings of the baseline survey were important in determining the situation in the community including knowledge and practices on malaria prevention before designing project interventions for study I phase 2. Indeed, the baseline findings showed that the community was poor, strategies targeting prevention of malaria were few, and several challenges in treatment of malaria existed. Such surveys done before implementation of projects are key in establishing the actual situation in the community before designing interventions (Georgiou et al., 2003; Zhu et al., 2014). The survey established a low use of core WHO malaria prevention methods of ITNs and IRS. This, therefore, necessitated the implementation of the project in these areas, which advocated for use of multiple methods at households in a holistic manner. Baseline surveys also provide data that can be used during monitoring and evaluation of interventions (Habicht et al., 1999; Langston et al., 2014) as was the case in study I phase 2 (intervention) and 3 (evaluation).

4.3.1 Study I Phase 1 (Baseline) Limitations

A major limitation of the baseline survey was some of the malaria prevention practices such as use of mosquito nets and IRS were reported, and not physically seen. Nevertheless, for the malaria prevention methods that could be physically seen including mosquito screening in windows and ventilators, these were observed with guidance of an observational checklist which is indeed a strength of the research. Another limitation is that the research was conducted in only two villages, where the pilot project intervention (study I phase 2) was to be implemented, hence
this could be regarded as a relatively small sample. Therefore, it is difficult to generalise the results to a wider geographical area. In addition, the sample size used of 376 was slightly less than the calculated one of 384 due to incompleteness of some data collected. However, this difference was small and unlikely to have a substantial effect on the results obtained. Nevertheless, the qualitative data suitably supplemented the quantitative one, and the findings can be used to inform future studies in Uganda and other malaria endemic countries.

4.4 Study I Phase 2 (Intervention) Results and Discussion

The pilot project that promoted the integrated approach to malaria prevention in two rural communities trained 25 volunteers, established 40 demonstration households using the approach, and sensitised over 200 members of the community on integrated malaria prevention. The training of volunteers and community sensitisation utilised posters and fliers translated to the local language to facilitate learning. The 40 demonstration households were provided with LLINs as well as complete screening in the windows and ventilators of their houses so as to prevent mosquito entry. The other methods in the integrated approach such as eliminating mosquito breeding sites, early closing of doors, and removal of overgrown vegetation was done by respective demonstration household members. The carrying out of these practices by household members was to ensure their participation in implementation of the integrated approach. In addition, carrying out all activities for households was impractical and would not have been sustainable.
During the intervention phase, the demonstration households were important in promoting the integrated approach among the community. The activities were not only beneficial to the members of the demonstration households but also the entire community who appreciated the integrated approach, which they had been taught during the intervention sensitisation. Indeed, several community members on seeing the demonstration households expressed interest in having the interventions also implemented in their houses. In addition, villages neighbouring those involved in the intervention requested to extend the activities to their areas. However, increasing the number of beneficiaries of the interventions was not possible mainly due to limited financial resources.

Community volunteers such as CHWs are known to greatly increase access to health services especially among rural and hard-to-reach communities (Haver et al., 2015; Zuvekas et al., 1999). As people involved in health service delivery, CHWs can be utilised to carry out health promotion (Love et al., 1997; Perry et al., 2014). The incorporation of promoting the integrated approach in the work of the volunteers was well received as they were already involved in malaria control work. However, adding more responsibilities to volunteers needs to be carefully considered so as not to lead them to exhaustion as has been observed among social workers (Lloyd et al., 2002; Perry et al., 2014).

The use of the local language in activities of the intervention including sensitisation is very important in rural communities in Uganda because many of the inhabitants do not understand English, the country’s official language. Although malaria affects all categories of people, it is
also important to recognise the high-risk groups of children under five years of age and pregnant women which was undertaken during the intervention as recommended by WHO (WHO, 2013d). This ensures that with limited resources, priority is given to those at most risk and hence need such as children under five years of age using the available ITNs in households.

Use of demonstrations, as was the case in the intervention (study I phase 2) where 40 demonstration households were established, has been shown to promote community-based health programmes including sustainability of interventions (Kemner et al., 2015; Shediac-Rizkallah & Bone, 1998). The demonstration households in the intervention were well distributed in the area so as to ensure a wide geographical coverage. This enabled increased access of community members to these households. The interventions implemented among these demonstration households of provision of LLINs, and screening of houses against mosquitoes were beneficial given the financial constraints in rural communities. Nevertheless, it was important that the households had responsibilities to accomplish on their own, such as early closing of doors, and removal of mosquito breeding sites. Indeed, the implementation of such simple measures at the households by the researcher was impractical and would have reduced community participation. In addition, carrying out all activities for the demonstration households in the intervention phase would not have been sustainable.

Initial evaluation was carried out at the end of the intervention through interviews with community members including demonstration households. Members of the demonstration households reported fewer mosquitoes in their houses following the interventions. It was also
established that after sensitisation, the community was more knowledgeable about the various malaria prevention methods that were advocated in the integrated approach. Some of the interventions that were not being used before implementation, were being practiced in the area. These included early closing of doors and windows, and removal of mosquito breeding sites. However, other methods, such as larviciding, were not being used because of the high costs of commercial larvicides involved. Although some methods in the integrated approach were not implemented, the ones that were being used in the community on their own play a significant role in malaria prevention. A combination of multiple malaria prevention strategies has been shown to have greater impact than single methods in some studies (Fullman et al., 2013; Hamel et al., 2011). This therefore further emphasises the need to promote use of several malaria prevention methods for greater public health impact in communities.

4.4.1 Study I Phase 2 (Intervention) Challenges and limitations

There were only four official village health team (VHT) members in each village that constituted the trained community volunteers yet they had to work in relatively large geographical areas. The other trained volunteers, such as local leaders, are not always involved in health promotion work as much as VHTs. This could have reduced the impact such human resource could have had to improve health in their communities. In addition, the VHTs were found with existing challenges such as minimal training, and low motivation.

The intervention was implemented in only two villages therefore a greater impact could have been realised if resources permitted the involvement of more areas. Indeed, neighbouring
communities to the study area showed interest in project activities. In addition, only 40 demonstration households were established, yet more households wanted to benefit from the interventions that were implemented in the community.

### 4.4.2 Study I Phase 2 (Intervention) Key lessons learnt

From study I phase 2 (intervention), it was established that a strong team of community mobilisers is imperative for the success of community programmes. These mobilisers were crucial in mobilising the community during various project activities, such as meetings and community sensitisation sessions. It is therefore important that such mobilisers are used in future interventions targeting public health improvement in communities in Uganda and beyond.

Obtaining the goodwill of local leaders and officials from the health department before project implementation was of paramount importance to the success of the intervention. These personnel were not only actively participating in project activities but also mobilising the community members for various interventions. Such information regarding involvement of local stakeholders could be utilised by other researchers designing similar interventions in future.

### 4.5 Study I Phase 3 (Evaluation) Results

A total of 540 households (Lukose - 236, Mayanzi - 304) were involved in the quantitative component of study I phase 3 (evaluation). All households that were selected during sampling
accepted and took part in the research. For the qualitative component, the four focus group discussions (FGDs) conducted among community volunteers comprised of 24 members (15 female, 9 male) while 40 participants from the demonstration households were involved in the in-depth interviews (IDIs). Of the 40 participants, 28 were female of whom majority were spouses to household heads. Most of the participants were staying with their spouses (married or cohabiting), and involved in agriculture while others operated small business at or near their homes. Although all participants of the IDIs had attended school, they had either stopped in primary or secondary levels with none having reached tertiary institutions or university.

4.5.1 Socio-demographic characteristics of participants of study I phase 3 (evaluation)

The majority of participants (59.8%; 323/540) were female, and Christians (Catholics – 40.6%; 219/540 and Anglicans – 26.5%; 143/540). Most participants had their highest level of education as secondary (39.1%; 211/540) or primary (36.1%; 195/540). The average household monthly income of the participants was majorly between 20 and 60 US dollars ($) (48.7%; 263/540) and less than 20$ (37.2%; 201/540). Most of the participants (44.6%; 241/540) were involved in farming as their occupation (Table 4.5).

4.5.2 Knowledge on malaria transmission and prevention

Although majority of participants in the baseline group (89.9%; 337/376) were aware that malaria is transmitted through mosquito bites, awareness was higher in the evaluation group
Table 4.5 Socio-demographic characteristics of participants of the evaluation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (n = 540)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-24</td>
<td>84</td>
<td>15.6</td>
</tr>
<tr>
<td>25-34</td>
<td>192</td>
<td>35.4</td>
</tr>
<tr>
<td>35-44</td>
<td>143</td>
<td>26.5</td>
</tr>
<tr>
<td>&gt; 44</td>
<td>122</td>
<td>22.6</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>217</td>
<td>40.2</td>
</tr>
<tr>
<td>Female</td>
<td>323</td>
<td>59.8</td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catholic</td>
<td>219</td>
<td>40.6</td>
</tr>
<tr>
<td>Anglican</td>
<td>143</td>
<td>26.5</td>
</tr>
<tr>
<td>Muslim</td>
<td>105</td>
<td>19.4</td>
</tr>
<tr>
<td>Pentecostal</td>
<td>69</td>
<td>12.8</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Occupation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>241</td>
<td>44.6</td>
</tr>
<tr>
<td>Business</td>
<td>124</td>
<td>23.0</td>
</tr>
<tr>
<td>Housewife</td>
<td>129</td>
<td>23.9</td>
</tr>
<tr>
<td>Others</td>
<td>46</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Highest level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>117</td>
<td>21.7</td>
</tr>
<tr>
<td>Primary</td>
<td>195</td>
<td>36.1</td>
</tr>
<tr>
<td>Secondary</td>
<td>211</td>
<td>39.1</td>
</tr>
<tr>
<td>Tertiary / university</td>
<td>17</td>
<td>3.1</td>
</tr>
<tr>
<td><strong>Average household monthly income (US dollars)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>201</td>
<td>37.2</td>
</tr>
<tr>
<td>20 - 60</td>
<td>263</td>
<td>48.7</td>
</tr>
<tr>
<td>60 - 100</td>
<td>63</td>
<td>11.7</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>13</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Household size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 3</td>
<td>183</td>
<td>33.9</td>
</tr>
<tr>
<td>4 - 6</td>
<td>307</td>
<td>56.9</td>
</tr>
<tr>
<td>≥7</td>
<td>50</td>
<td>9.3</td>
</tr>
</tbody>
</table>
(97.2%, 525/540). In addition, more participants in the evaluation (91.7%; 495/540) were aware that there are ways to avoid getting malaria compared to the baseline (68.4%; 257/376).

Knowledge on sleeping under untreated mosquito nets to prevent malaria was lower in the evaluation (67%; 362/540) compared to baseline (82%; 308/376). However, there was a slight increase in knowledge of ITNs in the evaluation (32%; 173/540) in comparison with the baseline (30%; 113/376). Knowledge on use of mosquito skin repellents (23%; 124/540 versus 14%; 53/376), and removal of mosquito breeding sites (51%; 275/540 versus 7%; 26/376) was higher in the evaluation in comparison with the baseline respectively (Figure 4.2). However, from the knowledge assessment scale which assessed knowledge on multiple malaria prevention methods, no statistically significant difference in knowledge was observed in the evaluation group compared with the baseline ($\chi^2 = 1.87; p = 0.392$).

From the FGDs, community volunteers were highly knowledgeable about the various malaria prevention methods advocated in the integrated approach. These included sleeping under ITNs, screening of houses, destroying mosquito breeding sites, and removing overgrown vegetation near homes. However, they noted that although they continued to promote these malaria prevention methods in their communities, some section of the population were not keen to learn about them while others were lazy regarding implementing them. It was also established that to significantly increase community knowledge on malaria prevention, continuous sensitisation was needed particularly facilitated by personnel who were not members of the villages. This is
because the volunteers were at times despised by some members of the community due to being accustomed to them, and also their low education status.

Figure 4.2 Comparison of knowledge on individual malaria prevention methods between the baseline and evaluation

“Regarding how to avoid getting malaria, there is slashing overgrown grass from our surroundings. We also need to close doors and windows early in the evening from around 6:00pm throughout the night, sleep under insecticide treated mosquito nets, and drain all
stagnant water near our homes. There is also indoor residual spraying, and larviciding to kill mosquito larvae. Removal of bottles and other containers from our compounds is also important.” Community volunteers FGD 2, Lukose

“One problem we have in our community is people are ignorant about some of these malaria prevention methods and do not want to learn. Another issue is that many times when community members leave their homes to go and work in trading centres, they only care about where they work and forget to protect their homes against mosquitoes. They therefore spend the day in the trading centres where there are no pools of stagnant water and go back to sleep in the village where there are numerous breeding sites. So our communities still need a lot of sensitisation.” Community volunteers FGD 1, Lukose

“Some of the community members know about these malaria prevention methods though there are still those who are lazy to implement them while others do not consider them important. For example, there are people you will find in rental houses with bushes surrounding their premises and they claim that they are waiting for the landlord to do the slashing of overgrown grass without considering doing it themselves.” Community volunteers FGD 1, Mayanzi

4.5.3 Community practices on malaria prevention

The positive changes in practices on malaria prevention between the evaluation and baseline that were statistically significant were use of IRS in the previous twelve months ($\chi^2 = 7.9; p = 0.019$),
presence of mosquito screening in windows and ventilators ($\chi^2 = 62.3; p < 0.001$), and closing windows before 6.00pm ($\chi^2 = 60.2; p = 0.001$). However, there was a statistically significant negative change between the evaluation and baseline regarding presence of stagnant water in compounds ($\chi^2 = 12; p = 0.001$) (Table 4.6).

From the FGDs, community volunteers were found to be promoting use of several malaria prevention methods in the community during their routine work including management of childhood illnesses. Some of the methods in the integrated approach had been embraced by the community such as removing mosquito breeding sites, and early closing of doors and windows. However, several challenges were identified for the non-use of other methods. Indeed, although methods such as screening of houses to prevent mosquito entry were appreciated by many households, they lacked resources required to have such screens installed. The screens installed in the windows and ventilators of the demonstration houses during the intervention phase continued to be seen by community members in addition to the volunteers’ sensitisation. Sleeping under mosquito nets was also found to partly lead to complacency regarding use of other malaria prevention methods. In addition, a few households did not close windows till late in the night due to the excess heat in their houses.

“Community members now mind about water ponds in the area. There is a place I passed recently and found a lady and her daughter trying to drain stagnant water from the road and she told me it would breed mosquitoes if left unattended to. Such practices are done by people who have been taught about malaria prevention. Some people would ask
Table 4.6 Comparison of malaria prevention practices at households between the baseline and evaluation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Baseline n = 376 (%)</th>
<th>Evaluation n = 540 (%)</th>
<th>Chi square ($\chi^2$)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of at least one mosquito net in household</td>
<td>Yes</td>
<td>171 (45.5)</td>
<td>247 (45.7)</td>
<td>0.0061</td>
<td>0.938</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>205 (54.5)</td>
<td>293 (54.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used indoor residual spraying in previous 12 months</td>
<td>Yes</td>
<td>2 (0.5)</td>
<td>17 (3.2)</td>
<td>7.9</td>
<td>0.019*</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>374 (99.5)</td>
<td>523 (96.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of mosquito screening in windows and ventilators</td>
<td>Yes</td>
<td>8 (2.1)</td>
<td>106 (19.6)</td>
<td>62.3</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>368 (97.9)</td>
<td>434 (80.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of stagnant water in compound</td>
<td>Yes</td>
<td>66 (17.6)</td>
<td>148 (27.4)</td>
<td>12.0</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>310 (82.5)</td>
<td>392 (72.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of vessels around house that can potentially hold water for mosquito breeding</td>
<td>Yes</td>
<td>140 (37.2)</td>
<td>195 (36.1)</td>
<td>0.1</td>
<td>0.729</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>236 (62.8)</td>
<td>345 (63.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed windows on houses before 6.00pm</td>
<td>Yes</td>
<td>146 (45.1)</td>
<td>364 (71.9)</td>
<td>60.2</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>178 (54.9)</td>
<td>142 (28.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of overgrown vegetation within 5 metres of house</td>
<td>Yes</td>
<td>161 (42.8)</td>
<td>250 (46.3)</td>
<td>1.1</td>
<td>0.298</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>215 (57.2)</td>
<td>290 (53.7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Statistically significant at p < 0.05
why others have to spend time doing such a thing and what they would benefit from it not knowing that since they are close to these pools of water, the mosquitoes could breed and transmit malaria.” Community volunteers FGD 1, Lukose

“There are some households that close their windows very late in the night at around 10.00 pm saying that their houses are very hot and either lack ceilings or the ceilings are within a short distance from the ground. Therefore, they need to open the doors and windows for a long time at night to get rid of the accumulated heat. Others claim that they don’t mind about mosquitoes entering their houses as they sleep under mosquito nets not knowing that the mosquitoes could still bite them during the time they are not in bed.” Community volunteers FGD 2, Mayanzi

Although it was established from the FGDs that sleeping under mosquito nets was predominantly used to prevent malaria, the community was mainly using those provided for free by the Government with only a few households buying nets. Even households that could afford to buy nets often waited to receive those from Government. However, the nets provided by the Government had become old and needed replacement. There was also low use of other methods in the community such as IRS, mosquito coils, insecticide sprays and larviciding due to concerns about the potential effects on health, and costs involved.

“Among the many malaria prevention methods available, most community members use mosquito nets though the challenge with the nets is that they become old and get torn after some time yet the Government takes a long time to distribute new ones. Another
issue is that most people really yearn for the nets but do not have the money to buy them. I am one of the few people who bought myself a net but they are expensive and it is therefore a big sacrifice. Some women even pretend to be pregnant and go to the health centre to receive a free mosquito net.” Community volunteers FGD 2, Lukose

“The use of indoor residual spraying is not liked by most community members as they say the insecticides used could be harmful to health. They sometimes ask us why a chemical that remains on the walls and continues killing mosquitoes for a long time should be trusted. Our communities still need lot of sensitisation to change these negative attitudes towards some malaria prevention methods.” Community volunteers FGD 2, Lukose

“The use of insecticide sprays is low in this village because they are sold in small cans which are expensive and very many community members have not embraced this method. We usually teach the community to spray the insecticide and leave the house for a minimum of 30 minutes before they can go back inside. Some of them say the insecticides negatively affects them when used and could have adverse health effects including causing cancer.” Community volunteers FGD 1, Mayanzi

4.5.4 Malaria prevention practices of demonstration households

The demonstration households continued to use many of the malaria prevention methods in the integrated approach that they were trained during the intervention. These included sleeping under
LLINs, screening in windows and ventilators, removing mosquito breeding sites, closing of doors early in the evenings, and clearing overgrown vegetation near their homes.

“We utilise those methods that we were taught during the training on malaria prevention for example closing doors and windows at 6.00pm, draining of stagnant pools of water, slashing overgrown grass from the compound, and removal of empty bottles from near the house. We also use the mosquito nets that we were provided.” Demonstration household 6, Mayanzi

“It is important that the home is maintained clean by slashing overgrown grass from the compound which could harbour mosquitoes. Bottles in the compound should also be removed and this ensures that mosquitoes do not breed close to our home and now that we have children around, we need to keep the mosquitoes away. Personally, I take the initiative to do some of these practices because they are very beneficial. Like today, I didn’t even know that you were coming but when you check my surroundings, the bushes are slashed and there are no bottles in my compound.” Demonstration household 14, Lukose

Regarding preference of the two malaria prevention methods that the intervention phase provided to the households (LLINs and screening in windows and ventilators), mixed responses were observed. Some of the participants were in favour of LLINs because of their known efficacy in malaria prevention. However, it was noted that there were situations where LLINs could not be used such as when they are insufficient for entire households, or disliked for various reasons
such as discomfort due to increased heat. In such scenarios, screening in windows and ventilators was seen to be more beneficial especially to all household members if external doors on houses were closed at an appropriate time.

“I think sleeping under a mosquito net works better because there are some days when I may delay to close the doors and mosquitoes enter the house. However, if I sleep under my net on such a day, there is no risk of mosquitoes biting me while asleep.”
Demonstration household 19, Lukose

“In my view, screening in windows and ventilators would be better than mosquito nets. You may have enough mosquito nets for your household members but not for your visitors and their children. In such cases, the screens in windows and ventilators would still keep the mosquitoes away from entering the house and protect all people including those without mosquito nets.” Demonstration household 2, Mayanzi

4.5.5 Benefits of using integrated malaria prevention by demonstration households

The participants of the IDIs reported several benefits for their households ever since they started using integrated malaria prevention. One of the major benefits observed was the reduction in mosquito populations in their houses ever since the various interventions notably screening in windows and ventilators were implemented.

“We have benefited a lot from the interventions the project implemented for us. The various barriers we use in the home have been effective in preventing us from
encountering mosquitoes. The screens in the windows and ventilators ensure mosquitoes are kept away and if by any chance they enter the house, they cannot pass through the nets we use at night hence we do not get bitten by mosquitoes.” Demonstration household 8, Mayanzi

“We have really experienced changes in the mosquito population in our home. Previously, whenever I entered the house, mosquitoes could be hovering around the children but nowadays, I no longer see any. I can only attribute this change to the nets that were installed in the windows and ventilators. We also endeavour to close the doors and windows early in the evening.” Demonstration household 20, Mayanzi

The participants of the IDIs reported that occupants of their households particularly children suffered less from malaria ever since they started using the integrated approach. This led to less expenditure on malaria treatment, reduced visits to health facilities, and fewer days of children missing school. These outcomes were attributed to the interventions they were using which were seen to have generally led to improved family wellbeing.

“There is a significant difference in the occurrence of malaria in our household. Before I started using those methods, I could have a child suffering from malaria almost every month which made me spend a lot of money buying drugs and taking these children to health centres. However, when I started using mosquito nets and screening in windows among other practices, malaria is now very rare in my household. In fact, only one child has suffered from malaria in the last five months.” Demonstration household 1, Lukose
“There is certainly a difference now. Previously, my children would get recurrent episodes of malaria every month but nowadays, they take a very long time without falling sick. They can go to school consistently for a whole term and no longer have to miss classes due to malaria which is different from the situation before the project. Actually, ever since we were given nets and implemented the other interventions, I have personally spent over a year without going to the health facility.” Demonstration household 10, Mayanzi

4.5.6 Community use of demonstration households

The research established that several community members learnt about various malaria prevention methods from the demonstration households especially screening in windows and ventilators. Some individuals showed interest in having their households also benefit from the interventions implemented in demonstration households. However, it was established that although many households had appreciated the various interventions, the majority could not afford to implement some of the methods such as screening in ventilators as they lacked the required financial resources.

“Many community members who saw how we had benefitted from the interventions kept asking how we got the screening in the windows, and whether they could also get a similar opportunity. We told them that we were selected by the local leaders to be part of a project and advised them to buy the screens and have them installed on their houses. However, many of them often told us that they did not have the money to do so.” Demonstration household 2, Lukose
"As my house is near the main road, many people usually ask where I got the knowledge of putting screening in windows and ventilators from. I then tell them about the project interventions and how such methods can be used to control mosquitoes in their households as well. I normally advise them to also install the nets if they can but very few people in this village have the means. When one of my sisters came to visit me, she was so impressed with how the screens had been fitted. She told me that she would do the same when she goes back to her home." Demonstration household 11, Mayanzi

In addition to the screening in windows and ventilators preventing mosquitoes from entering houses among demonstration households, it was established that the houses looked better than they did before. This was noted by both members of the demonstrations households and the general community.

"Very many people have admired our house and they usually ask how we got screening in our windows and ventilators. I usually tell them that some people promoting malaria prevention brought us trainings where we learnt about several methods and then 20 households in the village were selected in which they installed them so that other community members could learn and replicate it in their households. Recently when we had a party here, many community members said our house now looked better and they really appreciated it." Demonstration household 19, Mayanzi
4.5.7 Challenges of using integrated malaria prevention by demonstration households

From experiences of the demonstration households, it was evident that many of the methods in the integrated approach required to be implemented continuously which was time consuming. This included early closing of doors and windows, clearing unnecessary vegetation, and removing potential mosquito breeding places. In addition, some of the interventions were only effective if households observed certain practices. As an example, screening in windows and ventilators would only significantly limit mosquito entry if doors were kept closed in the evenings and throughout the night.

“If one takes it for granted that they have screening in windows and ventilators and do not bother to close the doors before evening, mosquitoes will enter the house and may bite them even before going to bed where they could have a mosquito net. This practice of closing doors early has to be done every day irrespective of who is at home.”

Demonstration household 9, Lukose

It was established that since the integrated approach involved using several malaria prevention methods, complacency had led to households not utilising some of the methods because of using others. For example, a few households were not sleeping under LLINs because of having screening in windows and ventilators on their houses.

“Ever since my windows and ventilators were screened, mosquitoes no longer enter my house. For that reason, I see no need to sleep under a mosquito net anymore. In fact, I have now used the net that was given to me by the project to act as a pillow.”

Demonstration household 13, Mayanzi
“We don’t use mosquito nets since they bring discomfort in form of heat in the night. Without a net, I sleep comfortably with my grandchildren. We only ensure that we close the doors early as we were advised. I think the screens installed in the ventilators and windows have been the most beneficial intervention since even my older children, who do not sleep under mosquito nets for the same reasons as me, don’t get malaria.”
Demonstration household 4, Lukose

In addition, it was found out that some of the methods in the integrated approach were also the responsibility of other households as well as the general community such as clearing vegetation and removing mosquito breeding sites. It therefore required that other households were aware of and implemented the various methods so as to have a greater impact in the community.

“I personally endeavour to slash grass in my compound. However, many times I may want the entire neighbourhood free from bushes but in case my neighbour is not interested, I can’t slash the unnecessary vegetation in their compound. This is a problem we sometimes face in our area and thus affects malaria preventing efforts at community level.” Demonstration household 20, Mayanzi

4.5.8 Opinions of demonstration households regarding promoting use of integrated malaria prevention in community

The demonstration households generally supported use of the integrated approach in other homes in future due to the benefits they experienced for over two years between the intervention and
evaluation phases. However, it was stressed that more sensitisation was needed to make the community more aware of the various available malaria prevention methods so as to positively influence their practices.

“I fully support the integrated approach because these methods are very effective in keeping mosquitoes away and preventing them from entering the house. Even when you open the door and a few of them sneak in, they will not be able to bite you since you will sleep under your mosquito net further showing the importance of many barriers. I would support other households to also receive and use the interventions as my family has benefitted a lot from them.” Demonstration household 8, Lukose

“It is generally easy to implement the several malaria prevention methods. It doesn’t help having a bushy compound where mosquitoes will hide and continue entering your house. I also don’t see anything hard in slashing overgrown grass or removing bottles from the compound to prevent mosquito breeding. More households should be taught and supported to use these methods to prevent malaria.” Demonstration household 11, Lukose

4.6 Study I Phase 3 (Evaluation) Discussion

From the findings of the quantitative component of study I phase 3 (evaluation), there was increase in knowledge on individual malaria prevention methods in the integrated approach such as use of mosquito skin repellents, and removal of mosquito breeding sites in comparison with study I phase 1 (baseline). The community sensitisation carried out during study I phase 2
(intervention) is likely to have contributed to increase in knowledge in the community. Indeed, studies have shown that interventions aimed at creating awareness on public health contribute to increase in knowledge among populations (Foley et al., 2015; Mugisa & Muzoora, 2012; Wu et al., 2015). However, from the knowledge assessment scale, changes in knowledge on multiple malaria prevention methods in the integrated approach in the evaluation in comparison with the baseline was not statistically significant. This could be an indication that the interventions in study I phase 2 were able lead to increase in knowledge on individual methods but with little influence on multiple methods. Future programmes aimed at promoting the integrated approach to malaria prevention need to intensify efforts of sensitisation so as to significantly influence changes in knowledge on multiple methods for greater public health impact.

The community volunteers trained during the intervention phase were found to be highly knowledgeable on the various malaria prevention methods in the integrated approach. These volunteers continued to promote the use of multiple malaria prevention methods in their villages, and are key in improving knowledge and practices on malaria control as has been established elsewhere (Tobin-West & Briggs, 2015). However, several hindrances such as laziness and complacency were identified as limiting the embracing of many of the methods as has been found in other studies in sub-Saharan Africa (Berthe et al., 2014; Chukwuocha et al., 2010). Due to the high burden malaria causes to the population in Uganda (Malaria Consortium, 2015a), it is important that measures to reduce the occurrence of the disease are taken seriously. It has been shown in some malaria endemic communities that at times people do nothing to prevent the disease even when knowledgeable on methods that can be used (Hlongwana et al., 2009; Legesse et al., 2007). It is therefore critical that such attitudes are changed by stakeholders concerned
with malaria control in endemic countries so as to reduce morbidity and mortality associated with the disease.

It was established that there was a statistically significant positive change in malaria prevention practices in the evaluation compared with the baseline regarding use of IRS ($\chi^2 = 7.9$, $p = 0.019$), mosquito screening in windows and ventilators ($\chi^2 = 62.3$, $p < 0.001$), and closing windows on houses before 6:00 pm ($\chi^2 = 60.2$, $p < 0.001$). The interventions implemented in study I phase 2 should have contributed to the improvement in practices on malaria prevention in the community. Among the improved practices were house screening, and early closing of windows which are not among core current global and national malaria prevention efforts (WHO, 2014). This implies that practices on malaria prevention beyond ITNs and IRS could improve if promoted extensively in communities. Indeed, although practices on malaria prevention beyond ITNs and IRS in many malaria endemic communities is low (Bocoum et al., 2014; Hlongwana et al., 2009; Legesse et al., 2009), this has been improved in community based programmes targeting several malaria prevention methods (Salam et al., 2014) as was the case in this research. Therefore, the utilisation of various malaria prevention methods could increase if campaigns targeting them are implemented as part of malaria control programmes. The statistically significant negative change regarding presence of stagnant water in compounds is likely due to the fact that data was collected at different times of the year for the baseline and evaluation. Indeed, it is known that mosquito breeding sites are more numerous in the rainy season in comparison with when it is dry (Malaria Consortium, 2007). Nevertheless, it is important to remove all present pools of stagnant water in communities irrespective of the season so as to reduce mosquito breeding sites.
The main challenges identified during the evaluation from the FGDs among community volunteers regarding utilisation of multiple malaria prevention methods were cost and negative attitude towards some of them. These challenges in malaria prevention practices were also identified in the baseline (study I phase 1). This implies that even with interventions to promote integrated malaria prevention such as sensitisation (as was the case in the intervention phase), issues such as poverty in rural communities, which affect expenditure on malaria prevention, have an impact on practices. Indeed, poverty has been found to be a hindrance in use of various malaria prevention methods including ITNs and IRS (Dickinson et al., 2012; Welch & Fuster, 2012; West et al., 2013). Side effects such as skin irritation and smell resulting from use of insecticide-based methods as established in the evaluation (study I phase 3) has also been found elsewhere (Anand et al., 2014). More sensitisation is therefore required so as to reduce the negative perceptions about methods that use insecticides as well as increase knowledge on their correct use to minimise side effects.

Preventing the occurrence of malaria in endemic communities is crucial to reduce the burden of the disease among affected countries particularly in sub-Saharan Africa. The evaluation among the demonstration households established that malaria prevention practices in the integrated approach that they had been trained during the intervention were still being used. This is a promising finding which provides optimism that continued campaigns aimed at increasing awareness on several malaria prevention methods are likely to result in improved preventive behaviour. Indeed, it has been shown that empowering communities with knowledge on malaria prevention through health education can lead to improved practices (Amoran, 2013b). However, as the current global and national malaria prevention efforts have focused on ITNs and IRS, little
attention has been given to promoting other malaria prevention practices despite evidence of these methods individually contributing to reducing the burden of malaria (CDC, 2008; Lindsay et al., 2002; Markle et al., 2007; Massebo & Lindtjørn, 2013). The positive experiences of the demonstration households reveal that use of several malaria prevention methods could be increased if multiple methods (beyond ITNs and IRS) are continuously promoted in endemic communities.

The main benefits demonstration households realised from using the integrated approach were reduction in mosquitoes in their houses and malaria occurrence. This finding shows that use of several malaria prevention methods is likely to have more impact than single methods as has been demonstrated in other studies (Fullman et al., 2013; Hamel et al., 2011; Kleinschmidt, 2009). However, the studies that have measured the actual reduction in the prevalence of malaria due to use of multiple methods have mainly focused on use ITNs and IRS. Given the promise shown among the demonstration households in this research, there is need to carry out more rigorous investigations such as randomised controlled trials (RCTs) to quantify the actual benefits of the integrated approach among households particularly in terms of malaria prevalence.

The community was able to learn about the methods in the integrated approach being used by the demonstrations households particularly screening in windows and ventilators to prevent mosquito entry. However, the study established that majority of the population could not afford to have such screening installed on their houses. It is well known that poverty in developing
countries such as Uganda affects malaria prevention practices including use of ITNs (Berthélemy et al., 2013). Indeed, majority of ITNs owned nationwide have been provided for free by the Government through the Ministry of Health (Yeka et al., 2012). This lack of resources is therefore expected to negatively affect use of methods in the integrated approach that require funds such as screening in windows and ventilators. However, some of the practices such as early closing of doors and windows, which do not require financial resources, should be implemented by households irrespective of use of other malaria prevention methods.

The demonstration households reported that implementing the several practices in the integrated approach was time consuming hence could limit use of all the methods. Indeed, use of multiple methods particularly environmental management can be work-intensive (Raghavendra et al., 2011). This concern of the time involved is important to consider while promoting the integrated approach on a large scale. Although it may not be realistic for all households to implement all the methods in the integrated approach, use of as many methods as may be possible is likely to be more beneficial that using a single method. Therefore, whereas promoting the integrated approach in communities may not necessarily lead to use of all the methods, it would encourage utilisation of as many practices that each household can manage. This includes simple measures such as clearing overgrown vegetation near houses, and removal of mosquito breeding sites, as well as use of ITNs, and screening in windows and ventilators. Early closing of doors and windows in the evenings is also practical. These practices are likely to contribute to reduction in the burden of malaria in communities as observed in the evaluation (study I phase 3).
A major concern from the evaluation on the experiences of using the integrated approach by the demonstration households was complacency resulting in non-use of certain methods in favour of others. This was mainly seen for discarding ITNs due to having screening in windows and ventilators. During the training conducted among the demonstration households on the integrated approach in the intervention (study I phase 2), it was stressed that the various practices were complementing each other and not replacing any method. It is also important to note that different malaria prevention methods have varying levels of efficacy regarding malaria prevention. This therefore necessitates that studies to measure the efficacy of other methods beyond ITNs and IRS for malaria prevention are conducted. This is important as use of ITNs and IRS are sometimes compromised due to financial, social and cultural factors (Alaii et al., 2003; Kaufman et al., 2012). Such research would enable the ranking of the most and least effective methods in preventing malaria among the many practices in the integrated approach. The finding on complacency necessitates more community sensitisation in future work to promote the integrated approach to malaria prevention, which even in its infancy is generating considerable interest and support in communities.

It was evident from the evaluation (study I phase 3) that some interventions in the integrated approach such as clearing overgrown vegetation and removal of mosquito breeding sites are not only household but community responsibility. Indeed, demonstration households whose neighbours did not implement these measures felt that it negatively affected their malaria prevention. Anopheles mosquitoes that transmit malaria are known to travel long distances up to two kilometres from breeding sites (Rosas-Aguirre et al., 2015; Warrel & Giles, 2002). It is therefore necessary to reduce such breeding places in entire villages and not merely households.
Future promotion of the integrated approach therefore should ensure that interventions targeting mosquito breeding places are not only implemented at household level but also within entire communities so as to have better impact in the areas. Larviciding, which has been recommended for malaria prevention by WHO in communities where breeding sites are few, fixed and findable (WHO, 2012), could be used for this purpose.

From the experiences of demonstration households in using the integrated approach, they generally supported scaling up of the strategy among other homes and communities. This was due to the benefits that they observed while implementing the approach. Such pilot projects are important in generating evidence while exploring new public health interventions (Donohoe & McGurk, 2014; Islam et al., 2014; Kampango et al., 2013). Due to the known benefits of the various methods in preventing malaria as well as the advantages of integrated malaria prevention approaches (Chanda et al., 2013; Okenu, 1999; Zhou et al., 2013), promoting use of multiple practices at households and in communities is necessary.

4.6.1 Study I Phase 3 (Evaluation) Limitations

Changes in knowledge and practices on malaria prevention in the study community could have been contributed to by other sources beyond the interventions of the project. Therefore, the improvement in knowledge and practices on malaria prevention in this research cannot be solely attributed to the interventions implemented during study I phase 2. Nevertheless, as the
demonstration households using the integrated approach to malaria prevention that were established during the intervention phase reported benefits such as reduction in number of mosquitoes in their houses and less occurrence of malaria, the interventions should have had a considerable positive impact in the community. In addition, from the FGDs conducted among the community volunteers trained on the integrated approach, it was evident that the community knowledge and practices were enhanced by the interventions implemented during study I phase 2.

Another limitation of the evaluation is that since the demonstration households had received support during the intervention, this could have influenced the responses they provided. However, given that the use of multiple interventions to prevent malaria in endemic communities especially in Uganda is low, the design of this study which involved provision of LLINs and house screening was justified for this research. Future studies among households using integrated malaria prevention without having received external support are required. However, such studies may only be feasible once there is increased use of multiple methods for malaria prevention in communities. Future research assessing the integrated approach to malaria prevention may also use a control population for purposes of impact evaluation of interventions which was not the case in this study.
CHAPTER FIVE: STUDY II RESULTS AND DISCUSSION

5.1 Introduction

This chapter provides the quantitative and qualitative results from study II. Study II assessed perceptions, utilisation and barriers of integrated malaria prevention in the community, environmental risk factors that contribute to malaria occurrence, and structural conditions of houses related to mosquito entry. In the discussion, the results of study II are put into context with reference to exiting literature on malaria prevention in Uganda and globally. The limitations, as well as the public health implications of study II results are also provided in this chapter.

5.2 Study II Results

A total of 727 households were selected from 29 villages in Ssisa sub-county, Wakiso district with a minimum of 23 households obtained from each village. All households sampled accepted and took part in the research. A total of 58 individuals, 27 men and 31 women, participated in the six FGDs (three male, three female) carried out among the general population.

5.2.1 Socio-demographic characteristics of participants of study II

The mean age of participants was 32 years, over two thirds (67.8%; 493/727) were female while a third were involved in business (34.2%; 249/727) and farming (32.3%; 235/727). Nearly half of the participants (45.3%; 329/727) had primary as their highest academic level attended, and
only 3.2% (23/727) had reached tertiary level / university. Over half of the participants (53.7%; 390/727) earned less than 40 US dollars per month in their households. Nearly half of the participants (47.7%; 347/727) had household size between three and five members, while 32.7% (238/727) had at least two children under five years of age in their household (Table 5.1).

5.2.2 Awareness, perceptions and barriers of integrated malaria prevention

Participants were highly aware of the various malaria prevention methods, which was assessed by prompting using the several practices in the integrated approach. These included use of ITNs (97.5%; 709/727), removing mosquito breeding sites (89.1%; 648/727), clearing overgrown vegetation near houses (97.9%; 712/727), and closing windows and doors early in the evenings (96.4%; 701/727). The least known methods were use of body mosquito repellents (48.0%; 349/727), IRS (59.3%; 431/727) and larviciding (59.4%; 432/727) (Table 5.2).

When participants were asked if their households would use all the suggested malaria prevention methods (in Table 5.2) in a combined manner to prevent malaria if trained, over two thirds (68.6%; 499/727) said they would. Among those who said their households would not use all the methods, the main reasons given included their being too many hence would use only some of them (70.2%, 160/228), and very costly (32.0%, 73/228). The main methods in the integrated approach that would not be used were body mosquito repellents (81.1%, 185/228), larviciding (63.2%, 144/228), IRS (62.3%, 142/228) and mosquito coils (53.1%, 121/228) (Table 5.3).
Table 5.1 Socio-demographic characteristics of participants of study II

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (n = 727)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
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</tr>
<tr>
<td>Male</td>
<td>234</td>
<td>32.2</td>
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<tr>
<td>Female</td>
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<tr>
<td><strong>Age (years)</strong></td>
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</tr>
<tr>
<td>18-29</td>
<td>289</td>
<td>39.8</td>
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<tr>
<td>≥ 30</td>
<td>438</td>
<td>60.3</td>
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<td><strong>Religion</strong></td>
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<tr>
<td>Catholic</td>
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<tr>
<td>Anglican</td>
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<td>30.3</td>
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<tr>
<td>Pentecostal</td>
<td>95</td>
<td>13.1</td>
</tr>
<tr>
<td>Muslim</td>
<td>94</td>
<td>13.0</td>
</tr>
<tr>
<td>Seventh Day Adventists</td>
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<td>2.6</td>
</tr>
<tr>
<td>Others</td>
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<td>1.0</td>
</tr>
<tr>
<td><strong>Occupation</strong></td>
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<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>235</td>
<td>32.3</td>
</tr>
<tr>
<td>Business</td>
<td>249</td>
<td>34.2</td>
</tr>
<tr>
<td>Housewife</td>
<td>82</td>
<td>11.3</td>
</tr>
<tr>
<td>Unemployed</td>
<td>108</td>
<td>14.9</td>
</tr>
<tr>
<td>Others</td>
<td>53</td>
<td>7.3</td>
</tr>
<tr>
<td><strong>Highest level of education</strong></td>
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<td></td>
</tr>
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<td>78</td>
<td>10.7</td>
</tr>
<tr>
<td>Primary</td>
<td>329</td>
<td>45.3</td>
</tr>
<tr>
<td>Secondary (ordinary) level</td>
<td>259</td>
<td>35.6</td>
</tr>
<tr>
<td>Secondary (advanced) level</td>
<td>38</td>
<td>5.2</td>
</tr>
<tr>
<td>Tertiary / university</td>
<td>23</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Average household monthly income (US dollars)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 40</td>
<td>390</td>
<td>53.7</td>
</tr>
<tr>
<td>≥ 40</td>
<td>337</td>
<td>46.4</td>
</tr>
<tr>
<td><strong>Position in household in relation to household head</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head</td>
<td>416</td>
<td>57.2</td>
</tr>
<tr>
<td>Spouse</td>
<td>227</td>
<td>31.2</td>
</tr>
<tr>
<td>Parent</td>
<td>35</td>
<td>4.8</td>
</tr>
<tr>
<td>Sibling</td>
<td>20</td>
<td>2.8</td>
</tr>
<tr>
<td>Other relative / not related</td>
<td>29</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Household size (median 5, upper range 15)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 2</td>
<td>112</td>
<td>15.4</td>
</tr>
<tr>
<td>3 - 5</td>
<td>347</td>
<td>47.7</td>
</tr>
<tr>
<td>≥ 6</td>
<td>268</td>
<td>36.9</td>
</tr>
<tr>
<td><strong>Number of children under 5 years in household</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>254</td>
<td>34.9</td>
</tr>
<tr>
<td>1</td>
<td>235</td>
<td>32.3</td>
</tr>
<tr>
<td>≥ 2</td>
<td>238</td>
<td>32.7</td>
</tr>
</tbody>
</table>
### Table 5.2 Awareness of malaria prevention methods in the integrated approach

<table>
<thead>
<tr>
<th>Methods categorised by target</th>
<th>Frequency (n = 727)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeping under untreated mosquito net</td>
<td>721</td>
<td>99.2</td>
</tr>
<tr>
<td>Sleeping under ITN</td>
<td>709</td>
<td>97.5</td>
</tr>
<tr>
<td>Spraying house with insecticides</td>
<td>680</td>
<td>93.5</td>
</tr>
<tr>
<td>Using mosquito coils</td>
<td>633</td>
<td>87.1</td>
</tr>
<tr>
<td>Indoor residual spraying</td>
<td>431</td>
<td>59.3</td>
</tr>
<tr>
<td>Using body mosquito repellents</td>
<td>349</td>
<td>48.0</td>
</tr>
<tr>
<td><strong>Mosquito breeding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearing overgrown vegetation around homes</td>
<td>712</td>
<td>97.9</td>
</tr>
<tr>
<td>Removing mosquito breeding sites</td>
<td>648</td>
<td>89.1</td>
</tr>
<tr>
<td>Larviciding in water pools</td>
<td>432</td>
<td>59.4</td>
</tr>
<tr>
<td><strong>Entry of mosquitoes into houses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing windows and doors early in the evenings</td>
<td>701</td>
<td>96.4</td>
</tr>
<tr>
<td>Installing screening in ventilators and open eaves</td>
<td>576</td>
<td>79.2</td>
</tr>
<tr>
<td>Installing screening in windows</td>
<td>569</td>
<td>78.3</td>
</tr>
</tbody>
</table>

### Table 5.3 Malaria prevention methods that households would not use in the integrated approach

<table>
<thead>
<tr>
<th>Methods categorised by target</th>
<th>Frequencies (n = 228)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeping under untreated mosquito net</td>
<td>18</td>
<td>7.9</td>
</tr>
<tr>
<td>Sleeping under ITN</td>
<td>83</td>
<td>36.4</td>
</tr>
<tr>
<td>Spraying house with insecticides</td>
<td>83</td>
<td>36.4</td>
</tr>
<tr>
<td>Using mosquito coils</td>
<td>121</td>
<td>53.1</td>
</tr>
<tr>
<td>Indoor residual spraying</td>
<td>142</td>
<td>62.3</td>
</tr>
<tr>
<td>Using body mosquito repellents</td>
<td>185</td>
<td>81.1</td>
</tr>
<tr>
<td><strong>Mosquito breeding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearing overgrown vegetation around homes</td>
<td>45</td>
<td>19.7</td>
</tr>
<tr>
<td>Removing mosquito breeding sites</td>
<td>74</td>
<td>32.5</td>
</tr>
<tr>
<td>Larviciding in water pools</td>
<td>144</td>
<td>63.2</td>
</tr>
<tr>
<td><strong>Entry of mosquitoes into houses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing windows and doors early in the evenings</td>
<td>29</td>
<td>12.7</td>
</tr>
<tr>
<td>Installing screening in ventilators and open eaves</td>
<td>83</td>
<td>36.4</td>
</tr>
<tr>
<td>Installing screening in windows</td>
<td>88</td>
<td>38.6</td>
</tr>
</tbody>
</table>
From the FGDs, participants generally supported the use of several methods in a holistic approach to prevent malaria in their households. However, the participants were concerned about the cost involved in implementing some methods such as ITNs, installing screening in windows and ventilators, larviciding, spraying insecticides, and use of mosquito repellents.

“Owning mosquito nets wouldn’t be a problem but people do not have the means of buying them. That is why if they have any slight hope that the Government is to provide them with nets, they would wait for them not knowing that this could delay and they may even fall sick as they still wait for those free nets.” Male participant, FGD 3

“We have seen insecticides in shops but they are not used because we cannot afford to buy them. In this village, you may find that there is only one person who uses Doom®. In fact, I can’t even find a single can of Doom® in my house.” Male participant, FGD 1

“The use of larvicides in ponds of water is a good option to prevent malaria in our village but they are too expensive. If one tries to calculate the amount of larvicides required for the numerous water ponds resulting from brick making we have in this area, it is almost impossible to afford.” Female participant, FGD 4

Lack of knowledge about some of the methods in the integrated approach was also identified as a limitation in using them. This included practices which were known but not thought to contribute towards malaria prevention such as installing screens in windows and ventilators, and methods which had not been heard at all notably skin repellents.
“I did not know that putting screening in windows was important to prevent mosquito entry into houses. We are actually not familiar with this malaria prevention method. All we do is only install iron bars in our windows to prevent thieves from entering our houses. I am therefore learning this for the first time.” Male participant, FGD 2

“We do not know about use of substances smeared on our skin [repellents] to chase away mosquitoes. Can these substances be available? Many of us do not know about those things unless you bring us some samples. However, don’t those substances have any side effects when used by people?” Female participant, FGD 6

There were also concerns about the potential side effects to health of some methods hence being reluctant to use them. The methods that were feared to have health effects when used were IRS, body repellents, mosquito coils, and spraying houses with insecticides.

“We were told that mosquito coils have side effects on our health and that the smoke from them can be harmful. They said it requires smoldering them before entering the house but some of us may enter when the coil is still burning. Those coils may just not work for us.” Female participant, FGD 4

“Isn’t that chemical used to spray on the walls [IRS] harmful to our health and wellbeing? In our homes, we have children who like playing and they may touch sprayed walls and then hold whatever they are eating. Wouldn’t those chemicals affect them when ingested?” Female participant, FGD 5
“Besides insecticides being expensive, some people say they could be harmful to our health just like DDT [Dichloro-diphenyl-trichloroethane]. Isn’t that true?” Female participant, FGD 6

5.2.3 Practices on individual malaria prevention methods, and integrated malaria prevention

Households that owned at least one mosquito net (ITN or untreated) were 64.8% (471/727) with a mean number of nets owned of 2.6 (standard deviation - SD ± 1.9) compared to a mean household size of 5.0 (SD± 3.0). Over two thirds of participants (70.8%, 515/727) used untreated mosquito nets to prevent malaria in their households while ITNs were used by 15.8% (115/727) of households. Most of the mosquito nets owned by households were LLINs particularly of PermaNet® brand (net 1: 46.1% - 217/471; net 2: 42.4% - 132/311; net 3: 43.8% - 77/176) and provided by the Government (net 1: 52.9 - 249/471; net 2: 49.8% - 155/311; net 3: 47.2% - 83/176). Although there was high use of nets the night before collecting data (net 1: 88.7% - 418/471; net 2: 85.2 - 265/311; net 3: 85.8 - 151/176), the main reason for their non-use was nets being too old / having many holes (net 1: 58.5% - 31/53; net 2: 50% - 23/46; net 3: 52% - 13/25) (Table 5.4).

Other methods in the integrated approach such as destroying mosquito sites (24.9%, 181/727) and use of body repellents (1.0%, 7/727) were used by few households. Among the participants,
Table 5.4 Details of mosquito nets owned by households

<table>
<thead>
<tr>
<th>Variable</th>
<th>Net 1 (n = 471) (%)</th>
<th>Net 2 (n = 311) (%)</th>
<th>Net 3 (n = 176) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source of net</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>249 (52.9)</td>
<td>155 (49.8)</td>
<td>83 (47.2)</td>
</tr>
<tr>
<td>Shop / market / hawker</td>
<td>181 (38.4)</td>
<td>136 (43.7)</td>
<td>81 (46.0)</td>
</tr>
<tr>
<td>Other</td>
<td>29 (6.2)</td>
<td>10 (3.2)</td>
<td>6 (3.4)</td>
</tr>
<tr>
<td>Do not know</td>
<td>12 (2.5)</td>
<td>10 (3.2)</td>
<td>6 (3.4)</td>
</tr>
<tr>
<td><strong>Type of net</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PermaNet®</td>
<td>217 (46.1)</td>
<td>132 (42.4)</td>
<td>77 (43.8)</td>
</tr>
<tr>
<td>Duranet®</td>
<td>18 (3.8)</td>
<td>13 (4.2)</td>
<td>6 (3.4)</td>
</tr>
<tr>
<td>Other long lasting nets*</td>
<td>41 (8.7)</td>
<td>26 (8.4)</td>
<td>12 (6.8)</td>
</tr>
<tr>
<td>Non-long lasting nets**</td>
<td>9 (1.9)</td>
<td>5 (1.6)</td>
<td>3 (1.7)</td>
</tr>
<tr>
<td>Do not know</td>
<td>186 (39.5)</td>
<td>135 (43.4)</td>
<td>78 (44.3)</td>
</tr>
<tr>
<td><strong>Net was used the previous night</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>418 (88.7)</td>
<td>265 (85.2)</td>
<td>151 (85.8)</td>
</tr>
<tr>
<td>No</td>
<td>51 (10.8)</td>
<td>42 (5.8)</td>
<td>23 (13.1)</td>
</tr>
<tr>
<td>Not sure</td>
<td>2 (0.4)</td>
<td>4 (1.3)</td>
<td>2 (1.1)</td>
</tr>
<tr>
<td><strong>Reason for non-use of net</strong></td>
<td>(n = 53) (%)</td>
<td>(n = 46) (%)</td>
<td>(n = 25) (%)</td>
</tr>
<tr>
<td>Net too old / had holes</td>
<td>31 (58.5)</td>
<td>23 (50.0)</td>
<td>13 (52.0)</td>
</tr>
<tr>
<td>Net not hang</td>
<td>17 (32.1)</td>
<td>19 (41.3)</td>
<td>9 (36.0)</td>
</tr>
<tr>
<td>Caused discomfort due to increased heat</td>
<td>4 (7.5)</td>
<td>1 (2.2)</td>
<td>1 (4.0)</td>
</tr>
<tr>
<td>Other reason</td>
<td>-</td>
<td>2 (4.3)</td>
<td>2 (8.0)</td>
</tr>
<tr>
<td>Do not know</td>
<td>1 (1.9)</td>
<td>1 (2.2)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Number of people who used net the previous night</strong></td>
<td>(n = 418) (%)</td>
<td>(n = 407) (%)</td>
<td>(n = 221) (%)</td>
</tr>
<tr>
<td>1</td>
<td>131 (31.3)</td>
<td>147 (55.5)</td>
<td>90 (59.6)</td>
</tr>
<tr>
<td>2</td>
<td>204 (48.8)</td>
<td>103 (38.9)</td>
<td>55 (36.4)</td>
</tr>
<tr>
<td>≥3</td>
<td>83 (19.9)</td>
<td>15 (5.7)</td>
<td>6 (4.0)</td>
</tr>
<tr>
<td><strong>Category of people who used net the previous night</strong></td>
<td>(n = 788) (%)</td>
<td>(n = 407) (%)</td>
<td>(n = 221) (%)</td>
</tr>
<tr>
<td>Children under 5 years</td>
<td>248 (31.5)</td>
<td>135 (33.1)</td>
<td>56 (25.3)</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>49 (6.2)</td>
<td>10 (2.5)</td>
<td>3 (1.4)</td>
</tr>
<tr>
<td>Others</td>
<td>491 (62.3)</td>
<td>262 (64.4)</td>
<td>162 (73.3)</td>
</tr>
</tbody>
</table>

* Other long lasting net brands were Interceptor®, Netprotect®, Dawanet® and Iconlife®.

** Non-long lasting net brands were KO net®, Kooper net®, Iconet®, Safi net®, Century® and Victoria®.
14.4% (105/727) said their households were not using any method to prevent the occurrence of malaria (Figure 5.1). Households that had undergone indoor residual spraying (IRS) in the previous twelve months were 5.8% (42/727) which was mainly done by household members (66.7%; 28/42). Other houses were sprayed through Government programmes (7.1%; 3/42) or private companies (16.7%; 7/42). Over half of the households (52.4%; 22/42) paid for IRS. Only 17.7% (129/727) of houses had ever been sprayed with insecticides to kill mosquitoes. Among these houses that had ever been sprayed, the frequency of spraying was mainly whenever there was need (59.7%; 77/129). Other houses were sprayed weekly (14.7%; 19/129), monthly (12.4%; 16/129) or fortnightly (6.2%; 8/129). Among households that normally opened windows on their houses (70%; 509/727), 43.2% (220/509) closed them before 6.00 pm.

Among the households, 33.0% (240/727) were using integrated malaria prevention which was defined as using at least two methods by a household. Use of integrated malaria prevention at households was associated with reading newspapers (AOR 0.34; 95% CI 0.22 – 0.53), and ownership of a motorcycle/car (AOR 1.75; 95% CI 1.03 – 2.98). Households with a family size of three to five members were less likely to use integrated malaria prevention compared with those with one to two members (AOR 0.55; 95% CI 0.37 – 0.83) (Table 5.5). Variables that were not associated with integrated malaria prevention in the crude analysis were: age, religion, household income, watching TV, having electricity in the house, and socio-economic status.
From the FGDs, only some of the methods in the integrated approach were used for prevention of malaria. The most used methods were sleeping under mosquito nets, removing potential mosquito breeding sites, and clearing overgrown vegetation near houses. The community had previously received ITNs from the Government mainly for children under five years of age and pregnant women. However, it was noted that some of the nets were not used for the intended purpose. For instance, some people sold the nets, while those that were initially used had since become old hence discarded.
Table 5.5 Crude and multivariable analysis for use of integrated malaria prevention at households

<table>
<thead>
<tr>
<th>Variables</th>
<th>Use integrated malaria prevention</th>
<th>Crude analysis</th>
<th>Multivariable analysis&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>% [95% CI]</td>
<td>Odds ratio [95% CI]&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>All households</td>
<td>240</td>
<td>33.0 [29.6-36.4]</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>92</td>
<td>39.3 [33.2-45.7]</td>
<td>Reference</td>
</tr>
<tr>
<td>Female</td>
<td>148</td>
<td>30.0 [26.1-34.2]</td>
<td>0.66 [0.48-0.92]</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>86</td>
<td>29.8 [24.8-35.3]</td>
<td>Reference</td>
</tr>
<tr>
<td>≥30</td>
<td>154</td>
<td>35.3 [30.8-39.8]</td>
<td>1.28 [0.93-1.76]</td>
</tr>
<tr>
<td><strong>Household size</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>48</td>
<td>42.9 [34.0-52.2]</td>
<td>Reference</td>
</tr>
<tr>
<td>3-5</td>
<td>98</td>
<td>28.2 [23.7-33.2]</td>
<td>0.52 [0.34-0.82]</td>
</tr>
<tr>
<td>≥6&lt;sup&gt;3&lt;/sup&gt;</td>
<td>94</td>
<td>35.1 [29.6-41.0]</td>
<td>0.72 [0.46-1.13]</td>
</tr>
<tr>
<td><strong>Pregnant woman in household</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>209</td>
<td>34.5 [30.8-38.4]</td>
<td>Reference</td>
</tr>
<tr>
<td>Yes&lt;sup&gt;4&lt;/sup&gt;</td>
<td>31</td>
<td>25.6 [18.6-34.2]</td>
<td>0.65 [0.42-1.02]</td>
</tr>
<tr>
<td><strong>Reading newspapers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>130</td>
<td>49.8 [43.7-55.9]</td>
<td>Reference</td>
</tr>
<tr>
<td>No</td>
<td>110</td>
<td>23.6 [20.0-27.7]</td>
<td>0.31 [0.23-0.43]</td>
</tr>
<tr>
<td><strong>Vehicle ownership</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>116</td>
<td>27.5 [23.4-32.0]</td>
<td>Reference</td>
</tr>
<tr>
<td>Bicycle&lt;sup&gt;5&lt;/sup&gt;</td>
<td>57</td>
<td>38.8 [31.2-46.9]</td>
<td>1.67 [1.13-2.48]</td>
</tr>
<tr>
<td>Motorcycle/car</td>
<td>67</td>
<td>42.4 [34.9-50.2]</td>
<td>1.94 [1.33-2.84]</td>
</tr>
</tbody>
</table>

<sup>*</sup> p-value <0.05
<sup>1</sup> Multivariable analysis included all the 727 households
<sup>2</sup> 95% CI estimated using robust SE.
<sup>3</sup> Without account for clustering, 95% CI = 0.37-1.00, p-value = 0.05
<sup>4</sup> Without account for clustering, 95% CI = 0.39-0.98, p-value = 0.04
<sup>5</sup> Without account for clustering, 95% CI = 0.99-2.30, p-value = 0.05
“Several people used to sleep under mosquito nets provided to them by the Government many years ago to prevent getting malaria. These nets have now become old hence the need to buy new ones which requires resources or hope that the Government can give us new ones very soon as promised.” Female participant, FGD 5

“The most common malaria prevention method used in this village is sleeping under mosquito nets but this method is not widespread and there are individuals who got nets from Government and have not used them. I have evidence on this as some of the people sold the nets they received to buy alcohol. So regarding prevention of malaria, we need to think of other ways we can fight the mosquitoes that transmit the disease.” Male participant, FGD 1

“Residing near water ponds also leads to being close to the mosquitoes and this would lead to being bitten frequently especially when there are also bushes around. To avoid this, we drain all water from water ponds around our homes and slash the bushes. This ensures that the mosquitoes are kept away from us and we can then be able to prevent malaria.” Male participant, FGD 3

5.2.4 Environmental risk factors related to malaria, and structural condition of houses

Environmental factors that favour mosquito breeding found at households included presence of vessels in compounds that could potentially hold water for mosquito breeding (56.9%; 414/727), and presence of overgrown vegetation within five metres of houses (76.3%; 555/727). Several
structural deficiencies on houses that promote entry of mosquitoes were found such as lack of screening in ventilators (94.7%; 645/727), external doors not fitting perfectly into the walls hence potential for mosquito entry (42.0%; 305/727), and presence of other openings on houses where mosquitoes could pass (36.5%; 265/727) (Table 5.6).

Table 5.6 Environmental risk factors, and structural condition of houses

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequencies (n = 727)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stagnant water present in compounds</td>
<td>144</td>
<td>19.8</td>
</tr>
<tr>
<td>Presence of vessels that could potentially hold water for mosquito breeding</td>
<td>414</td>
<td>56.9</td>
</tr>
<tr>
<td>Presence of overgrown vegetation within five metres of houses</td>
<td>555</td>
<td>76.3</td>
</tr>
<tr>
<td>Houses with windows lacking complete shutters</td>
<td>192</td>
<td>26.4</td>
</tr>
<tr>
<td>Houses with windows not fitting perfectly into wall (with space for possible mosquito entry)</td>
<td>244</td>
<td>33.6</td>
</tr>
<tr>
<td>Houses lacking screening in windows to prevent mosquito entry</td>
<td>698</td>
<td>96.0</td>
</tr>
<tr>
<td>Windows found open lacking screening to prevent mosquito entry (n = 371)</td>
<td>345</td>
<td>93.0</td>
</tr>
<tr>
<td>Houses with ventilators lacking screening to prevent mosquito entry (n = 681)</td>
<td>645</td>
<td>94.7</td>
</tr>
<tr>
<td>Houses with open eaves lacking complete screening to prevent mosquito entry (n = 194)</td>
<td>190</td>
<td>97.9</td>
</tr>
<tr>
<td>Houses with open eaves lacking ceilings (n = 194)</td>
<td>179</td>
<td>92.3</td>
</tr>
<tr>
<td>External doors lacking complete shutters</td>
<td>160</td>
<td>22.0</td>
</tr>
<tr>
<td>External doors not fitting perfectly into wall (with space for possible mosquito entry)</td>
<td>305</td>
<td>42.0</td>
</tr>
<tr>
<td>Other opening on house (such as hole in wall) where mosquitoes could pass to enter house</td>
<td>265</td>
<td>36.5</td>
</tr>
</tbody>
</table>
5.3 Study II Discussion

The study established that there was very high awareness of most malaria prevention methods that are part of the integrated approach including ITNs (97.5%), space spraying with insecticides (93.5%), and early closing of doors and windows (96.4%). There was also high willingness (68.6%) to use the integrated approach when trained on the various methods. However, the main reasons for dislike of the integrated approach were methods being too many and costly as also established in study I (phases 1 and 3). Poverty has been shown to affect malaria prevention practices in several studies including use of ITNs (Berthélemy et al., 2013; Ingstad et al., 2012). Since many communities in Uganda have faced challenges in using single malaria prevention methods due to cost, it could be a barrier to using the integrated approach in which some of the methods require finances. However, cost should not be a hindrance to applying some of the practices in the integrated approach such as early closing of windows and doors, and removing mosquito breeding sites. It is therefore important that communities implement measures in the integrated approach that they have the capacity to do so. The difference in low knowledge of malaria prevention methods established in study I phase 1 (baseline) and high awareness of the various methods in study II could be due to the prompting that was used in this study. Although it may not be feasible for every household to use all methods in the suggested approach, it is evident that integrated vector control contributes to greater reductions in malaria transmission than single methods (Fillinger et al., 2009). Indeed, integrated malaria interventions led to control of malaria in Zambia (Utzinger et al., 2001) and elimination of mosquito species from Brazil (Soper & Wilson, 1943) and Egypt (Shousa, 1948). It is therefore prudent to continue promoting integrated malaria prevention in ongoing and future malaria control programmes in Uganda and other endemic countries.
The most unpopular methods of malaria prevention in the integrated approach were mosquito repellents, larviciding, IRS and mosquito coils. There were concerns expressed by participants on potential effects on human health through the use of these methods which was also established in study I phase 3 (evaluation), and previously reported (Babu et al., 2007; Hlongwana et al., 2013) which can affect their use in integrated malaria prevention. Adequate information on the various practices in the integrated approach is therefore crucial to promote use of multiple methods in communities. Lack of knowledge on some methods, such as screening of windows and ventilators, is an obstacle to using the integrated approach being investigated. Indeed, inadequate knowledge on malaria prevention methods negatively affects practices in communities (Fernando et al., 2008; Hill et al., 2013; Sharma et al., 2001).

Promotion of the various methods in the integrated approach through sensitisation is therefore likely to improve community practices hence reduction in occurrence of malaria in endemic communities.

Ownership of at least one mosquito net by households was relatively high (64.8%) though the national figure of households owning an ITN is currently 90% (UBOS, 2015). From the research, it is evident that the number of mosquito nets owned was not sufficient for members of the households with a mean number of nets of 2.6 compared to a mean household size of 5.0. Although use of available nets in households the night prior to the study was high (86.6%), many individuals are likely to be exposed to mosquito bites due to the low ownership of nets. Since use of ITNs is the most advocated method for malaria prevention globally (WHO, 2014), there is need for its increased coverage and utilisation. One of the barriers identified for the low ownership of mosquito nets particularly in low income countries is the high cost of buying them.
(Aleme et al., 2014). Indeed, most of the nets owned by the households in this study were provided by the Government free of charge. These free nets have been distributed by MOH mainly targeting pregnant women and children under five years of age through mass campaigns and antenatal visits (Yeka et al., 2012). For increased coverage of mosquito nets, the Government needs to intensify efforts of availing them to the population.

Although IRS is a key global method for malaria prevention, its use in the study was low (5.8%) as also established in study I phase 1 (0.5%). Studies done in other malaria endemic countries have also found low coverage of IRS (Eyobu et al., 2014; Jima et al., 2010; Noland et al., 2014). Community acceptance of IRS has been impeded by insecticide smell, mess left by the sprayers, inconvenience of removing household items from houses before spraying, increased prevalence of other insects, perceived ineffectiveness and side effects (Govere et al., 2000; Kaufman et al., 2012; Rodriguez et al., 2006). These barriers need to be addressed so as to increase utilisation of IRS for malaria prevention. Use of insecticide sprays was also found to be low in this study (17.7%) as was the case in other studies (Dery et al., 2015; Hlongwana et al., 2009; Rhee et al., 2005; Ziba et al., 1994). Such sprays are known to be costly, hence may not be used by poor populations. In addition, there are concerns about the potential impact on health and the environment that using insecticides might cause (Bonds, 2012). In this study, less than half of households (43.2%) that normally opened their windows closed them before 6.00pm despite high awareness (96.4%) on early closing of doors and windows as a malaria prevention method. As endophagic malaria transmitting mosquitoes are known to start entering houses in the early hours of the evening (Pates & Curtis, 2005; Suwonkerd et al., 2013; White, 1974), it is ideal that windows should be closed before that time (Parmet et al., 2007). However, this simple practice
of closing windows at an appropriate time to limit mosquito entry is unknown in other communities (Bamaga et al., 2014; Byron et al., 2014; Ndira et al., 2014). Therefore, there is need for various stakeholders such as health practitioners and community health workers to continue promoting early closing of doors and windows among communities to limit mosquito entry into houses.

The most used method in the integrated approach to prevent malaria was mosquito nets (untreated – 70.8%; ITNs – 15.8%). Some of the ITNs could have been reported as untreated as LLINs (including those provided to the community by Government) are pre-treated hence users do not have to treat them which could have led to the misclassification. This widespread use of mosquito nets can be attributed to national campaigns including net distribution and publicity in Uganda (WHO, 2013a) as is the case in other malaria endemic countries (WHO, 2014). However, the low use of other methods in the integrated approach by households in this study is an indication that they are given lower priority for malaria prevention even with considerable knowledge about them. As the methods in the integrated approach have been shown to individually contribute towards malaria prevention (CDC, 2008; Debboun & Strickman, 2013; Ng’ang’a et al., 2008; Tusting et al., 2015; Walker & Lynch, 2007), it is necessary that malaria control programmes in endemic countries such as Uganda include them in their packages.

The use of integrated malaria prevention in households involved in this study was low, with only 33.0% using two or more methods to prevent malaria. Indeed, the use of other malaria prevention methods beyond ITNs has been found to be limited in Uganda and elsewhere (Musoke et al.,
2013; Ruberto et al., 2014). Given the several methods in the integrated approach available for use by communities, it is ideal that households use multiple methods to prevent malaria as opposed to single ones. Reading newspapers was associated with a three-fold increase in the use of integrated malaria prevention (AOR 0.34; 95% CI 0.22 – 0.53). This finding emphasises the importance of information as a key factor in promoting health practices including on malaria prevention. Indeed, it has been found in several studies that increased knowledge through access to information is associated with desirable malaria prevention practices (De Allegri et al., 2013; Hwang et al., 2007; Owusu et al., 2014). Although these studies were assessing practices on individual malaria prevention methods notably ITNs, it is likely to be similar to use of multiple methods. To increase use of the integrated approach to prevent malaria, it is important that ministries of health and other stakeholders involved in malaria control such health practitioners sensitise the public about the several malaria prevention methods through various communication channels including mass media. This could include use of newspapers, radio and television, and targeting facilities such as schools, hospitals, churches and mosques. Although high socio-economic status may promote use of malaria prevention methods such as ITNs (De Allegri et al., 2013) due to increased purchasing power, it has not been demonstrated as having a substantial effect on the use of various malaria prevention methods (Onwujekwe et al., 2014) as established in this study. However, ownership of a motor cycle / car, which may relate to household income, was found to be associated with use of integrated malaria prevention (AOR 1.75; 95% CI 1.03 – 2.98). Nevertheless, the socio-economic status index used in this study, which was developed using several household facilities and parameters, is a better measure of household wealth (Filmer & Pritchett, 2001; Neuman et al., 2013; Vyas & Kumaranayake, 2006). Therefore, increase in socio-economic status in the community alone may not necessarily
improve malaria prevention practices especially when barriers at individual or household level do exist.

Malaria transmitting mosquitoes are known to breed in pools of water (Salem et al., 2013) and harbour in vegetation (Manh et al., 2010; Warrel & Giles, 2002), both often found near houses especially in rural communities in endemic countries. This study found that 56.9% of houses had vessels in their compounds that could potentially hold water for mosquito breeding, and 76.3% had overgrown vegetation within five metres. This is an indication that risk factors that support mosquito breeding are allowed to exist in rural communities. Although environmental management practices such as removing mosquito breeding sites have shown promise in vector control, they have often received little attention by malaria control stakeholders (Raghavendra et al., 2011). Given that the burden of malaria remains high particularly in sub-Saharan Africa (Murray et al., 2014) even after extensive promotion of LLINs and IRS for many years, it is prudent that other malaria prevention strategies are widely promoted to complement existing ones. Indeed, a holistic approach to malaria prevention encompassing several strategies and interventions is likely to have greater public health benefits.

Malaria transmitting mosquitoes particularly in sub-Saharan African mainly bite humans indoors at night (Huho et al., 2013) hence enter houses through openings such as ventilators and open eaves (Animut et al., 2013). In many rural communities in malaria endemic countries, houses have poor structure that promotes entry of mosquitoes hence malaria transmission indoors (Liu et al., 2014; Lwetoijera et al., 2013). Indeed, this study found several structural defects on houses
such as lack of screening in ventilators (94.7%) and open eaves (97.9%), and external doors not fitting perfectly into the wall hence having space for possible mosquito entry (42%). Although houses with open eaves but have ceilings would observe reduced mosquito entry (Kirby et al., 2009; Lindsay et al., 2002), 92.3% of such houses in this study lacked ceilings. Houses with screening to prevent mosquito entry have been found with reduced incidence of malaria among occupants (Bradley et al., 2013). In addition, screening of houses not only protects all household members from malaria but also other vector borne diseases transmitted indoors such as dengue and yellow fever. It is therefore important that the structural condition of houses in malaria endemic countries is improved to reduce mosquito entry. This is particularly important in communities with low ownership and use of mosquito nets, and other malaria prevention methods.

5.3.1 Study II Limitations

A limitation of this study is that ownership and use of mosquito nets, as one of the methods in the integrated approach, could have been under reported as the community was anticipating to receive free LLINs from Government. This implies that some of those who had nets may not have disclosed so in fear of missing out during the Government programme. However, this was minimised by clearly explaining to the participants the purpose of the research before seeking consent hence participation in the study. It was also stressed that personal details such as name of household head that could be used to associate information given to respective households were not required.
In this study, utilisation of integrated malaria prevention was defined as use of at least two methods at a household out of the probable twelve. This was because of the low use of other malaria prevention methods besides mosquito nets. However, it is desirable that households use not only two but as many methods as possible and feasible under the circumstances to have a cumulative protective effect against mosquitoes in the integrated approach. Future studies may use a higher cut-off in terms of the number of methods while assessing utilisation of integrated malaria prevention. It is also worth noting that some methods in the integrated approach are more effective in preventing malaria than others hence do not have equal protective effect.

Another limitation of this study is that although both treated and untreated mosquito nets were assessed, ITNs particularly LLINs are recommended by the World Health Organization (WHO, 2013b) because of their ability to not only prevent mosquito bites but also kill mosquitoes. In addition, LLINs retain their biological activity for a long period hence can be used for up to three years without retreatment (WHO, 2007). Nevertheless, even untreated mosquito nets provide a protective barrier against mosquitoes which alone is a prevention method. In addition, as most of the nets were received from the Government which provided ITNs, the non-treated nets were likely to be minimal. Challenges have also been realised in distinguishing untreated nets from ITNs (Eisele, 2006; Vanden et al., 2010), and observing those already hang in houses is often impractical.
CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter provides the conclusions and recommendations from study I phase 1 (baseline), study I phase 2 (intervention), study I phase 3 (evaluation), and study II. It also suggests areas for future research on the integrated approach to malaria prevention in Uganda and other endemic countries.

6.2 Conclusions

Besides mosquito nets, knowledge and practices on other malaria prevention methods was low in study I phase 1 (baseline). Use of IRS, another core malaria prevention strategy, was also low in the baseline. Therefore, there is still need to increase coverage and utilisation of IRS and ITNs as the current major malaria prevention methods in Uganda. Popularity of mosquito nets was due to their being the most promoted malaria prevention method in Uganda, with less emphasis on other practices in the integrated approach. There is potential to improve practices on malaria prevention in endemic communities by targeting other methods beyond ITNs, such as installing screening in windows and ventilators. Therefore, the integrated approach to malaria prevention, which advocates the use of several methods in a holistic manner, should be further explored to improve practices on malaria prevention in Uganda.

The intervention (study I phase 2) that promoted the integrated approach to malaria prevention by training community volunteers, community sensitisation, and establishing demonstration
households was well perceived by the study community. The general population in the community benefitted from the sensitisation carried out during the intervention phase, health education carried out by the trained volunteers, as well as learning from the practices of the demonstration households that were using the integrated approach. With the success of the pilot project intervention, a wider population could benefit from similar interventions promoting use of multiple malaria prevention methods at households in Uganda and beyond.

Following the interventions implemented in study I phase 2, there was increase in knowledge and improved practices on malaria prevention in the community. This included knowledge and practices on methods such as screening of houses, and early closing of doors and windows which are not core malaria prevention strategies in Uganda and globally. However, knowledge of multiple malaria prevention methods in the evaluation in comparison to the baseline was not statistically significant. It is therefore important that future programmes aimed at promoting integrated malaria prevention have a strong behaviour change strategy including community sensitisation so as to increase knowledge and practices on use of multiple malaria prevention methods.

Community volunteers trained on the integrated approach to malaria prevention played a key role in promoting the strategy in the community. It is therefore evident from study I phase 3 (evaluation) that such volunteers are instrumental in promoting use of multiple malaria prevention methods in Uganda which could be utilised in other endemic countries. However, due to the finding from the evaluation that laziness and complacency were limiting use of some of
the malaria prevention methods, more effort is still needed to change these negative attitudes among communities. Improvement in attitudes towards malaria prevention is likely to lead to improved practices hence reduce morbidity and mortality caused by the disease in Uganda and other endemic countries.

The use of the integrated approach to malaria prevention benefitted the demonstration households mainly through observed reduction in mosquito population indoors and occurrence of malaria as established in the evaluation (study I phase 3). These changes among the demonstration households are attributed to the interventions implemented during the intervention phase (study I phase 2) including screening in windows and ventilators, and provision of LLINs. In addition, the other practices in the integrated approach implemented by the households such as early closing of doors, and removal of stagnant water contributed to the positive outcomes observed. However, further studies to quantify the protective effect of the integrated approach among households particularly regarding malaria prevalence, and contribution of each of the methods are required.

Awareness on various malaria prevention methods in the integrated approach was high, and perceptions on use of integrated malaria prevention were promising in study II. However, there were concerns about the many methods in this approach, cost implication and potential health effects of the insecticide based measures such as IRS and space spraying. Practices on integrated malaria prevention were low in study II as mosquito nets were predominantly used as a single method. The use of the integrated approach can be improved by promoting use of multiple
malaria prevention methods in communities through various communication channels such as mass media including newspapers and radio.

It was established in study II that environmental risk factors associated with malaria such as presence of stagnant water in compounds were present in the community. In addition, several structural deficiencies on houses were observed that promote entry of mosquitoes. These housing deficiencies included lack of screening in ventilators and open eaves, and external doors not fitting perfectly hence space for possible mosquito entry. Environmental conditions that favour mosquito breeding, and poor housing structure increase the risk of malaria transmission in communities. It is therefore important that malaria prevention strategies including environmental management, and improving structural conditions of houses are strengthened to complement existing malaria prevention approaches in Uganda.

6.3 Recommendations

- Stakeholders involved in malaria control especially the Ministry of Health should intensify efforts of promoting other prevention methods in addition of ITNs and IRS. Behaviour change communication campaigns targeting multiple methods are recommended to improve knowledge and practices on malaria prevention.

- Projects to promote the use of integrated malaria prevention should be scaled up by researchers and other partners such as non-governmental organisations so as to benefit
other areas since the intervention implemented in this research had positive outcomes to households and the community.

- Community volunteers particularly those that exist in rural communities such as community health workers should be empowered by health practitioners to promote use of multiple methods in the prevention of malaria.

- The use of the integrated approach can be improved by stakeholders involved in malaria control such as Ministry of Health and non-governmental organisations through promoting use of multiple malaria prevention methods in communities through various communication channels such as mass media including newspapers and radio.

- Health practitioners and other stakeholders involved in malaria control should increase community sensitisation so as to reduce complacency on malaria prevention, and minimise the negative perceptions about malaria prevention methods that use insecticides as well as increase their use.

- There is need for the Ministry of Health to particularly promote environmental management including removing mosquito breeding sites as a key strategy in the prevention of malaria in rural communities in Uganda.

- Environmental health practitioners and other professionals concerned with health need to encourage improvement in structural conditions of houses in rural communities to limit mosquito entry into houses as a complementary strategy in the prevention of malaria in endemic areas.
### 6.4 Areas for further research

More rigorous studies, such as randomised controlled trials (RCTs), are recommended to further explore the public health impact of the integrated approach to malaria prevention in communities. Before an RCT on the integrated approach to malaria prevention is conducted, research on the feasibility of the RCT is recommended. This feasibility study would involve use of qualitative research methods to assess the community’s willingness to participate in the RCT. Focus group discussions could be used to collect data from household heads while key informant interviews employed for stakeholders such as local leaders, health practitioners and community health workers. The cost of implementing all methods in the integrated approach per household in the Ugandan context could also be established. Such a feasibility study could also involve development of the protocol for the RCT. The protocol would include the sample size calculation, randomisation procedure, applying the intervention, measurement of the outcome, analysis plan, ethical issues and quality control measures.

The RCT would quantitatively measure the actual protective effect of use of integrated malaria prevention at households and in communities. Such research would establish the contribution of each of the methods in the integrated approach to malaria prevention. Evidence on the protective effect of each of the methods is important while prioritising the various practices when using integrated malaria prevention in communities. Future research assessing the integrated approach to malaria prevention could involve more villages hence households, as well as use a control population for purposes of impact evaluation of interventions. In addition, baseline and
evaluation surveys should be carried out at the same time of the year due to seasonality of risk factors for malaria occurrence such as presence of stagnant water.
References


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Appendices