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SCHOOL of
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**Household determinants of durability and use of insecticide treated
nets in Tanzania**

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of**

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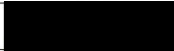
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Abstract

With increasing donor fatigue, it is crucial that the lifespan of existing insecticide-treated nets (ITNs) is maximized. Effectiveness and longevity (durability) of ITNs is enhanced by appropriate use and personal responsibility to maintain bednets in good condition. Factors associated with durability and overall maintenance are identified in order to reinforce current efforts to extend universal coverage of ITNs to its maximum potential. This study investigated the changes of net ownership, access and use within households over time and assessed how household members define and practice net care and repair activities.

Data was collected through a mix of qualitative and quantitative research methods. First, a household survey was conducted to assess the status of mosquito net coverage in Tanzania, two years after the last mass campaign in 2011 to investigate how households adapt when nets are not continuously distributed. The households were given new ITNs to cover all sleeping spaces identified in the household. Twenty-two months post distribution, another household survey was conducted to determine 1) how households allocate nets to sleeping spaces in the face of diminishing access and/or as new nets arrive in households, and 2) the effect of the number of people sleeping under an ITN on net use and serviceability of ITNs. Through a mix of in-depth interviews, focus group discussions and participatory activities, local perceptions influencing net care and repair practices were also investigated.

The average rate at which households in Tanzania lose nets was higher than the rate at which they receive nets. Study findings indicate that when ITNs are available, household members use them and sometimes more people sleep under the same ITN. A linear trend was observed that as the number of people under a net increased so was the level of damage. This insight on how household members adapt to changing population access to nets provides crucial information to policy makers supporting an increased frequency of keep-up campaigns and appropriate behavioural change campaign messaging. Qualitative findings indicated that net care was not directly associated with prevention of damage and net repair was performed as a temporary measure. Targeted health education through health facilities and community change agents were reported as potential means to overcome barriers to net care and repair.

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“For I know the plans I have for you,” declares the LORD, “plans to prosper you and not to harm you, plans to give you hope and a future” ~ Jeremiah 29:11

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“Only if we understand, can we care. Only if we care, we will help. Only if we help, we shall be saved.”

~Dr Jane Goodall

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1. Research Paper Cover Sheets
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List of Abbreviations

ANC: Antenatal Clinic Campaign

ATSB: Attractive Targeted Sugar Baits

BCC: Behavioural-Change Communication

FGDs: Focus Group Discussions

GMAP: Global Malaria Action Plan

GMEP: Global Malaria Elimination Program

HBM: Health Belief Model

IDI: In-Depth Interview

IHI: Ifakara Health Institute

IRS: Indoor-Residual Spraying

ITN: Insecticide-treated Nets

JH CCP: John Hopkins Centre for Communication Programs

LLINs: Long-lasting insecticidal net

LSHTM: London School of Hygiene and Tropical Medicine

MDG: Millennium Development Goals

MERG: Roll Back Malaria Monitoring and Evaluation Reference Group

MIS: Malaria Indicator Survey

NIMR: National Institute for Medical Research

NMCP: National Malaria Control Program

ODK: Open Data Kit

PA: Participatory Activity

PCA: Principal Component Analysis

pHI: Proportionate Hole Index

PMI: U.S President's Malaria Initiative

PQT: WHO Prequalification Team

SAVVY: Sample Vital registration with Verbal Autopsy

SES: Socio-economic Status

SNP: School-Net Program

SPD: Sentinel Panel of Districts

SSA: Sub-Sahara Africa

STPH: Swiss Tropical and Public Health Institute

TASAF: Tanzania Social Action Fund

THMIS: Tanzania HIV/AIDS and Malaria Indicator Survey

TNVS: Tanzania National Voucher Scheme

U5CC: Under-Five Catch-up Campaign

UCC: Universal Coverage Campaign

UMB: Norwegian University of Life Sciences

URC: Universal Replacement Campaign

USAID: U.S Agency for International Development

UTN: Untreated net

WHO: World Health Organization

PART ONE

1 INTRODUCTION

1.1 Malaria Burden in Sub-Saharan Africa

The burden of malaria in Sub-Saharan Africa (SSA) received unprecedented attention in the year 2000 leading to the Abuja Declaration where African Heads of States declared continental commitment of resources and an enabling environment for malaria control efforts [1]. The year 2000 has since served as the benchmark of progress in the fight against malaria [2, 3]. Owing to the United Nations Millennium Developmental Goals (MDG) call for concerted international commitment, specifically through MDG Target 6c, to “*halt and begin to reverse the incidence of malaria and other diseases by 2015,*” the Roll Back Malaria Partnership, through the Global Malaria Action Plan (GMAP), documented a strategy to achieve disease prevention and access to treatment to all endemic countries [4]. The GMAP framework detailed strategies and resources required for each region to deliver effective protection and treatment to all populations at risk [4]. Reports from a variety of routine surveys such as the Malaria Indicator Surveys that have been consolidated by the World Health Organization (WHO) since 2008, in the annual World Malaria Reports have recorded health gains and investments accorded to each endemic country.

The widespread distribution and use of interventions that target the mosquito vectors of malaria such as insecticide-treated nets (ITNs), indoor residual spraying (IRS), and interventions that target the malaria parasite including early detection and diagnosis have contributed to the decrease of malaria morbidity and mortality [5, 6]. Disease prevalence among children age 2-to-10 years have witnessed a dramatic decrease from 33% to 16% with a majority of this progress recorded post-2005 [5, 6]. As a result, malaria was no longer the leading cause of death among children following the decrease in mortality rates by the end of MDG period (2000-2015) [6]. Reducing malaria mortality rates contributed to the attainment of MDG 4 target of “*reducing under-5 mortality rate*

by two thirds between 1990 and 2015” [7, 8]. Unfortunately, twenty years later, endemic countries in SSA still account for over 90% of the global malaria disease burden [9]. The highest burden of malaria remains among the poorest nations concentrated in SSA as illustrated in Figure 1 [5, 6, 8, 9].

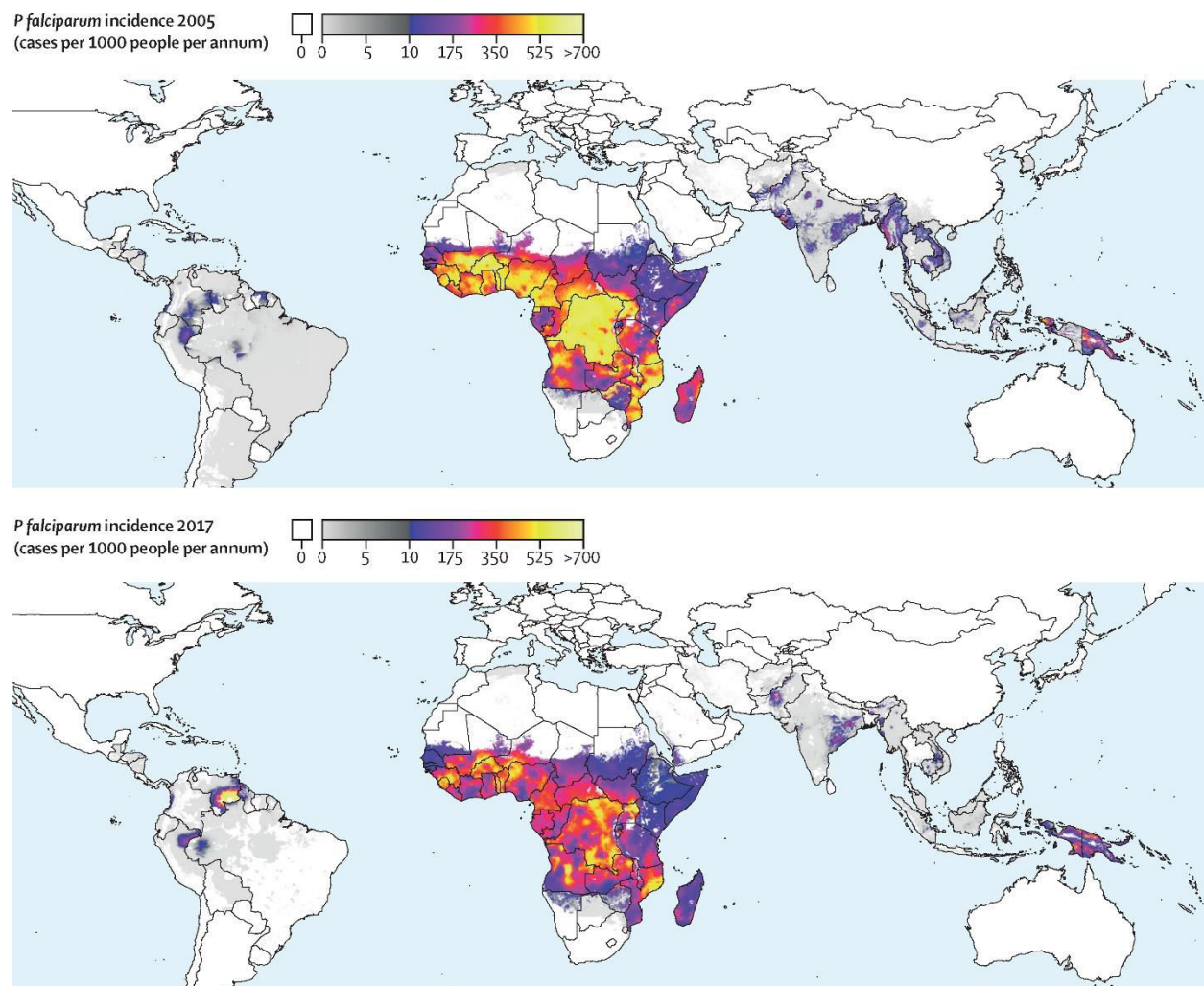


Figure 1. Spatio-temporal distribution map of *Plasmodium falciparum* clinical incidence estimates (per 1000 people per annum) in 2005 (top) and 2017 (bottom) as illustrated by Weiss et al [10]. Data from routine surveillance of parasite prevalence was converted to represent estimates of clinical incidence using established prevalence-disease relationship models [11].

Social interactions across borders allow for malaria parasites to maintain disease prevalence in populations [12]. Approaches such as the “*high burden to high impact*” which aim to provide a

concerted effort in the countries bearing the highest burden of malaria (10 sub-Saharan countries plus India = 10 plus 1), are crucial to sustain an aggressive focal force against the disease [13]. Joint efforts in the fight against malaria will aid in steady and continued shrinking of the malaria footprint preventing imported malaria cases [14]. The establishment of partnerships such as the African Leader's Malaria Alliance in 2009 also reflect a deepening regional and political commitment to fight against malaria [15].

1.2 The costs of malaria control

The cost of reducing malaria mortality and incidence rates by 90% in 2030 is estimated to be USD 101.8 billion in 2015 [16]. However, despite continued funding for malaria, the USD 2.7 billion invested in 2016 only accounted 41% of the required investment [17], and while access to interventions such as ITNs continued to rise many endemic countries reported stagnation or reduction in malaria funding in the following years [9, 18]. While high, the return of investment of lives saved and increased productivity is higher and warrants immediate and continuous investment [16]. Governments of all at-risk populations ought to increase their funding allocation (approximated at USD 0.9 billion annually) to the national malaria programmes as international donor fatigue rises [19]. Funding, particularly domestic from government or private sector has the potential to increase development and adoption of innovations that are locally and culturally appropriate [19]. A large portion of international funding towards malaria initiatives are spent on interventions such as ITNs and not on strengthening weak health systems [6]. Additional political commitment to strengthen health systems is essential in achieving 2030 goals [16, 20]. Furthermore, means of optimising existing interventions and delivery of those interventions is ever more crucial to maximise the return on investment.

1.3 Malaria Control

Malaria is an infectious disease caused by parasitic protozoa of the genus *Plasmodium*. Five known species, namely; *Plasmodium falciparum*, *P. malariae*, *P. ovale*, *P. vivax* and *P. knowlesi*, cause disease in humans and are spread by the females of several *Anopheles* species mosquitoes [21, 22]. About 30 to 40 *Anopheles* species that transmit *Plasmodium* occur across the world [22, 23]. The most efficient malaria vectors including the *Anopheles gambiae* and *An. funestus* complexes co-exist throughout sub-Saharan Africa [24]. The parasite and vector have co-evolved along with humans and are extremely well adapted to humans [25, 26]. The female mosquito feeds on blood to nourish her eggs, whilst the parasite undergoes a propagation within the liver and blood cells. Through just one successful human bite, the anopheline may incidentally ingest in the blood meal or inoculate via saliva adequate parasites to sustain their growth cycle [21].

Malaria exposure confers adaptive humoral and cellular immunity that attenuates disease severity, but decays with time in the absence of repeated infection. Consequently, malaria can lead to loss of life in low immunity individuals and thus clinical episodes and mortalities are disproportionately high among infants, convalescents, expectant mothers and visitors to endemic areas [21]. Malaria thrives in hot-humid climates where mosquitoes breed optimally, typical of the tropical regions of the world. But even in the endemic world, the disease transmission intensity varies considerably, often associated with rainfall and other ecological factors that impact on mosquito breeding [27]. Nonetheless, malaria is not an inevitable burden as it is adequately preventable through killing vectors or interrupting contact between humans and vectors and is treatable through drugs [4, 21].

Vector control interventions reduce human exposure to infectious malaria vectors through killing vectors in the larval or adult stages or preventing contact between humans and vectors. The WHO

divides vector control into core interventions such as ITNs and IRS which have the greatest body of evidence to support their efficacy in all endemic areas [6, 28], and supplementary interventions, which include larviciding and personal protection with repellents, and are suitable for deployments in some specific scenarios (Table 1) [29]. Additional interventions are also under development including Attractive Targeted Sugar Baits (ATSB), housing modification, systemic endectocides and genetic techniques [30, 31] although these will not be available for between 5 to 20 years. There is evidence that housing improvements are reducing malaria [32]. Unfortunately, due to high installation costs for housing modifications, there is barely any support from governments or other agencies even though the modifications have potential to provide long lasting malaria protection. Insecticide-treated Nets and IRS have been extensively adopted in endemic settings of SSA as stand-alone or in combination depending on the severity of malaria transmission in the area [33]. Indoor biting and resting malaria vectors such as *Anopheles gambiae s.s* and *Anopheles funestus* are among vectors most efficiently controlled by consistent use of ITNs [34].

Table 1: Malaria Control Interventions

Malaria Control Interventions		
<p>Core Interventions</p> <ul style="list-style-type: none"> • Insecticide-treated nets (ITNs) • Indoor residual spraying (IRS) 	<p>Supplementary Interventions</p> <ul style="list-style-type: none"> • Larval source management • Spatial and topical repellents 	<p>Interventions under development</p> <ul style="list-style-type: none"> • Attractive Targeted Sugar Baits (ATSB) • Housing modifications • Systemic endectocides • Genetic techniques

Massive investments into the deployment and adoption of malaria prevention and treatment interventions have been in effect in the past two decades [9, 35]. Between 2000 and 2014, the proportion of the population with access to malaria vector control interventions increased from 1%

to 59% [6]. The rise of insecticide and drug resistance, changing disease epidemiology and rapid population growth threaten current health gains and calls for immediate action to maximize utilization of existing tools while promoting progressive development of new tools to sustain and/or accelerate health gains [2, 36, 37]. Therefore, continued investment to ensure the suppression of the disease is key in the journey towards a malaria-free world [16]. The occurrence of malaria within communities affects not only the health and wellbeing of members but spreads into the wider global development agenda thereby requiring interdisciplinary and multi-sectorial action [16]. The goal of reducing malaria mortality and incidence rates by 90% in 2030 is achievable, although it is broadly ambitious and will require a united global movement [16, 20]. Reviewing the health gains since the year 2000 against malaria report a decline of over 40% in incidence of clinical diseases by 2015 [5]. This decline has since stalled to an annual decrease of approximately 10% in the incidence of clinical cases each subsequent year thereafter but with more countries moving towards elimination [9, 17, 18], a possibility suggested as early as 2007 [38]. Sharing the same timeframe with the Sustainable Development Goal (2016-2030) [39], the WHO Global Technical Strategy for Malaria [20] and the Action and Investment to defeat Malaria 2016-2030 [16] advocate for a continued concerted global movement against malaria through a multi-sectorial approach [40].

1.4 Malaria Control in Tanzania

Malaria control in Tanzania dates back to the early 1900s in the era of the Global Malaria Eradication Program (GMEP) mainly targeting urban areas in both Zanzibar and the then Tanganyika mainland [41,42]. The main interventions focused on disease surveillance and targeting the mosquito itself through oiling, draining standing water and filling in potential breeding sites [41]. The malaria burden witnessed dramatic reductions for as long as interventions

were deployed and returned to original intensity and mortality at the end of the control interventions [41], and at the rise of insecticide resistance [36, 43, 44]. The two decades following attainment of independence in 1961, the government focused its efforts in establishing its healthcare system and community-based primary care with presumptive treatment of fevers using antimalarials as the main intervention [41]. The burden of malaria in Tanzania is mostly hyper-endemic, intense but seasonal (3 to 6 months) transmission, as illustrated in figure 2 [45], with a national average of 7% malaria prevalence reported in the 2017 Tanzania Malaria Indicator Survey (MIS) [46]. The main malaria vectors in Tanzania are *Anopheles gambiae s.s.*, *Anopheles funestus* (both indoor resting) and *Anopheles arabiensis* and *Anopheles merus* (both outdoor resting) [34, 41, 47-49]. Upon stratification, 40% of the population live in councils that would be considered of very low and low malaria risk strata while 23% of the population live in councils of moderate malaria risk and 37% in councils of the high malaria risk [50]. Other interventions deployed by the government also include improved access to appropriate diagnosis, early treatment, provision preventative therapies to vulnerable groups such as pregnant women, and disease surveillance. All interventions are supported by dissemination of information, education and communication about malaria prevention and curative services and, efficient programmatic and financial management of partnerships and resources [45, 47].

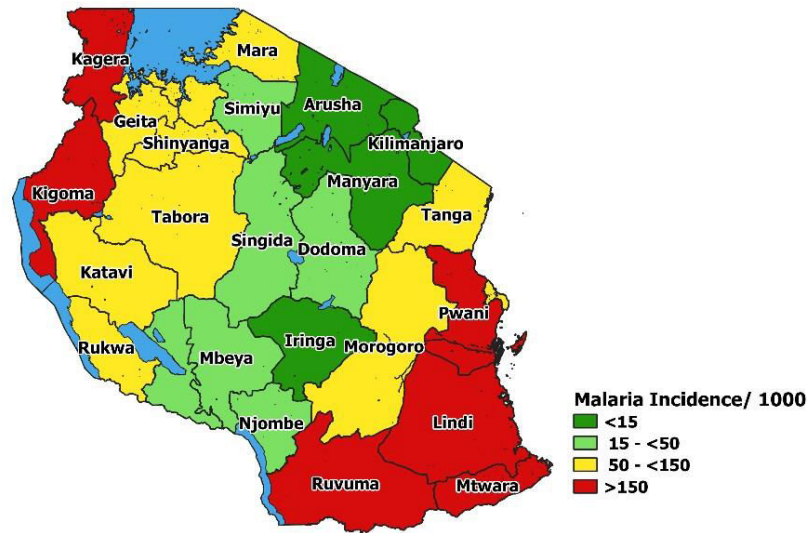


Figure 2: Spatial distribution of malaria incidence (per 1000 people per district) in Tanzania as reported by the National Malaria Control Program [45].

The Tanzanian population is informed of malaria, its public health risks and available interventions [51, 52] following the launch of “*Malaria Haikubaliki* (malaria is unacceptable)” campaign in 2010 by national and international partners under the flagship of the National Malaria Control Program (NMCP) Behavioural Change Campaign (BCC) working group [53]. The Tanzanian population has been accustomed to ITNs as a preventative measure against malaria mosquitoes since the early stages of the development of the intervention. The intervention has evolved with the people and for the people such that when adherence to regular retreatment of mosquito nets seemed unlikely [54, 55], long-lasting insecticidal nets were introduced [35, 56-58]. Similarly, other regions of Tanzania are also accustomed to IRS as a complementary intervention against malaria [41, 45]. The combination of ITN and IRS remains the main course of control intervention in high prevalence districts in the North West and Lake Zone of the country [45, 59].

Access to malaria control interventions still varies across the country with those in hard-to-reach areas being disadvantaged by distance and adequate infrastructure despite the government's efforts to reach them [47, 57]. Migrant populations are also still a challenging group to target as the means to adopt current frontline interventions such as ITNs or IRS while on the move are unavailable making it difficult for the NMCP to provide for this population [47, 57]. Current malaria control strategy relies heavily on the use of ITNs particularly among pregnant women and infants [35, 47, 57]. Recently, the distribution of free ITNs expanded to school-going children to targets the growing human reservoir of malaria transmission [60, 61], as well as the rapid population growth. Other control measures adopted include IRS [59, 62] and larviciding [63, 64]. All these control measures are highly donor funded due to lack of adequate local resources [65]. With that, the program lacks consistency in its deployment, particularly IRS and larviciding to many areas that would have benefitted from the combination of ITNs and IRS or larviciding [33].

1.5 Insecticide-treated nets (ITNs) for malaria control

While ITNs are at the core of global efforts against malaria their effectiveness depends on people having access to nets and regularly using them every night. Access to ITNs within households in SSA reported an increase from 7% in 2005 to 67% in 2015 while ITN use rose from 2% in 2000 to 55% in 2015 [6]. The World Health Organisation (WHO) recommends distribution of one net to every two household members living in malaria endemic countries to achieve universal coverage (80%). Targeting at least 80% of the community with access to an ITN (universal coverage) provides adequate protection through mass effect where mosquito population control is achieved at a level where malaria control can be maintained [66]. Largely at three-year replacement intervals [35], mass campaigns have been the primary source of nets for the majority of people at-risk of malaria [5, 67]. Three-yearly replacement intervals are also supported by a study done in Senegal

[68] that saw a rise in malaria incidence during year three after ITN distribution. The continued replacement of ITNs is needed as they wear out from wear and tear in the household including tears, rips and damage to seams [69]. There are also concerns of reduced anti-*Plasmodium* immunity among the growing population due to increase in ITN use since birth, reducing their exposure to malaria mosquitoes and the risk of clinical attacks from malaria [68, 70].

Universal coverage, which translates to ~80% utilization of ITNs, must be maintained for all populations at risk. To ensure there is no rebound in malaria, local field research should provide evidence that alternative distribution mechanisms such as those that target high-risk areas and specific populations do not pose the risk of a generalised resurgence. Populations in hard-to-reach areas also remain a cause for concern as they too need to be reached during ITN distribution to achieve zero malaria [14].

Alternative distribution mechanisms to fill existing coverage gaps from mass distribution include, Antenatal Clinic Campaigns (ANC), School-Net programmes (SNP), Under-Five Catch-Up campaigns (U5CC) and commercial markets [65, 71]. Each of these distribution mechanisms is faced with challenges and/or influenced in reaching its target population for a variety of reasons such as poor registration to receive ITN, limitations on maximum number nets a household can receive at a time, not attending school and willingness to pay/availability of funds [51, 72, 73]. Therefore, a combination of several distribution mechanisms is typically deployed to effectively maximize universal coverage of ITNs to all at risk populations [65, 71].

Vulnerable populations, in particular infants and pregnant women, are priority groups to receive ITNs [35, 74]. Recognizing the growing concern in the increase of age in the population most at risk of malaria [14, 70], the WHO currently recommends universal coverage with ITNs to all

populations at risk irrespective of age and gender [75]. School-going children and adults are becoming a growing reservoir of malaria transmission due to inconsistent and delayed net use [68, 76].

Continued generation of knowledge exposes emerging risk factors associated with the durability of ITNs. With an estimated budget of USD 673 million towards malaria research and development [16], funding research and development studies is crucial to the generation of context-specific knowledge to aid evidence-based decision and policy making [77]. Efforts to reduce malaria transmission and promote evidence-based decision making rely on progressive disease surveillance through the periodic national health surveys and research projects albeit limited in time and space [16].

1.5.1 The effective life of a net within a household

Underpinning the resource allocation and implementation of malaria control using ITNs is in determining how long an ITN lasts within a household, and whether it remains effective throughout its time in the household. After all, an ITN can only be considered effective for as long as it can be used for protection against malaria mosquitoes [78]. There are no standard criteria for what make a net effective, and they vary between the WHO Prequalification Team (PQT), research scientists and the end-users themselves. The PQT [78] requires each ITN to withstand 20 standard washes in order to be listed. The WHO also recommends that to estimate functional survival of a net; net retention (presence of ITNs) at the time of the survey and the physical integrity (number, size and location of holes) of the ITN should be considered [79]. Research scientists [80, 81] have shown that even with the presence of holes there remains enough chemical residue on the ITN to ensure its effectiveness in protection against malaria, although currently under the threat of insecticide

resistance [9, 82, 83]. Other studies have shown that increased washing frequency desired by users could affect the physical integrity of the fabric and surpass the PQT recommended cut-off of 20 standard washes to maintain the active ingredient in the chemical content [52, 84, 85]. Most importantly, as the recipient and user of the ITN, personal prerogative on when a net is or no longer is effective remains the main determinant of ITN effectiveness [86].

Several studies have reported that the majority of nets discarded were identified as being too torn [80, 87, 88]. Irrespective of the number of ITNs distributed, net loss is inevitable with time and use. Access is typically high directly after a mass campaign and then declines as nets wear out, often to 50% or less, until the next campaign [73]. This fluctuating pattern of coverage, caused by nets wearing out, is seen across the African region [89]. As nets are lost from households, household members are forced to make adjustments in accordance with available resources. Households with readily available income can purchase new nets from the commercial sector, those with pregnant women or infants benefit from free ITNs distributed from through ANC clinics, and school-going children in select districts receive from the SNP while the rest others are forced to adjust sleeping patterns to accommodate the lost net until the next mass campaign. Continued monitoring of coverage and the status of disease burden in the context of control measures deployed into the community is crucial to assess progress in the achievement of global targets against malaria [16]. This thesis therefore assumed that ultimately there are two major components in assessing effectiveness; 1) net retention (presence of ITN) and access to those living in the household, and 2) physical integrity to provide continued protection against malaria mosquitoes, both of which can be done at large scale through household surveys [90]. Upon ensuring the presence of an ITN since distribution, it is essential to confirm that the population living in the household has access to the net as access is a key determinant to net use [91, 92].

1.5.1.1 ITN Indicator Outcomes

The Roll Back Malaria Monitoring and Evaluation Reference Group (MERG) developed the ITN indicator outcomes to assess and compare achievements of ITN interventions in and across countries at risk of malaria [90, 93]. The standardization of the ITN indicators aids comparison of information across endemic countries [94, 95] further facilitating a united regional and global assessment of achievements of the ITN strategy. Insecticide-treated net indicator outcomes determine; 1) how population and household access changes as nets are lost as well as, 2) how households respond to the decline in access through shifts in net use [90].

The MERG indicators used to assess ITN indicators are [90, 93]:

- 1) Proportion of households with at least one ITN (*Ownership*)
- 2) Proportion of households with at least one ITN for every two people (*Access*).
- 3) Proportion of the population with access to an ITN within their household (assuming each ITN is used by two people) (*Access*)
- 4) Proportion of the population that slept under the ITN the previous night (*Use*)
- 5) Proportion of children under the age of five who slept under an ITN the previous night (*Use*)
- 6) Proportion of pregnant women who slept under an ITN the previous night (*Use*)
- 7) Proportion of existing ITNs used the previous night (*Use*)

Table 2 illustrates an analysis of the of the Roll Back Malaria Monitoring and Evaluation Reference Group as indicators of ownership, access and use.

Table 2: An analysis of ownership, access and use of ITNs as indicators for ITN coverage success

Ownership	
Strengths & Opportunities	Weaknesses & Threats
Able to capture the spatial extent of distribution coverage	Does not account for size of household with only one net
Provides a measure of households yet to be reached	Is not a measure of individual protection against malaria mosquitoes
Access	
Strengths & Opportunities	Weaknesses & Threats
Accounts for the household size with potential to be covered by nets currently available in household	Assumes each ITN covers two people irrespective of ITN size
	Access to ITNs for population groups that do not sleep together i.e. uncle and niece is not captured
	Excludes households with more than enough ITNs to cover its members (assumes each ITN is used by two people)
Use	
Strengths & Opportunities	Weaknesses & Threats
Highlights protection among vulnerable and/or targeted populations	Relies of user recall
Identifies population groups to be targeted by future distribution mechanisms	Biased by season data was collected
Accounts for all covered irrespective of their access measure	It is only a measure of use the previous night and not year-round use
Can be used to assess behavioural gap of those who did not use a net yet but had access	
Can be used to assess non-use due to lack of access to a net in household	
Can be used to advice Behavioural Change Communication messages and target populations	

This thesis acknowledges that there are three sub-components in assessing the ability of an ITN to provide protection against malaria mosquitoes apart from the social reasons mentioned in Table 2. These are bio-efficacy (the ability of a net to kill/repel mosquitoes), chemistry (the active ingredient embedded in the insecticide embedded in the ITN fabric) and physical integrity (presence, size and location of hole damage) [78]. The WHO has documented clear guidelines on the operating procedures while conducting these ITN durability assessments to ensure comparability between sites [78].

However, there remains a challenge in finding a composite response that can combine all three indicators assessed for ITN effectiveness into one measurement for functional survival [79]. Therefore, durability of ITNs is often represented as a combination of the findings on the net retention and the physical integrity, and/or bio-efficacy of a sub-sample of ITNs [79]. Assessment of the insecticidal activity through bio-efficacy and chemistry tests remains a challenge as cut-off points designated are to guide optimal levels and not to determine end-life or minimum performance levels of ITNs [79]. Both bio-efficacy and chemical content tests also require nets to be taken away from the household to a well-equipped laboratory to perform hence additional follow-up on nets is impossible.

Assessment of physical integrity through the documentation of the number, size and location of holes can be done on-site during a household visit and followed up periodically using the WHO durability guidelines [78, 96]. Observed repairs and modifications are documented. Repairs documented include stitches, knots/ties and/or patches while modifications can include changes in the shape, length or reinforcement of the net material. Prior to a household survey, it is recommended that all field enumerators are trained and provided with folders containing standard operating procedures for ITN hole assessments in the field adapted from the WHO guidelines [78, 96]. Unfortunately, due to logistic issues, only a subset of ITNs can be assessed during any household survey visit without being an inconvenience to the household members and compromising the survey financially.

1.5.2 Extending the life of a net within a household

It is essential to focus on the user who at best or worst determines the end life of a net. The decision to end the life of a net while it may vary between households is primarily influenced by the physical integrity of the net currently in possession [83, 86]. A model-based analysis by Pulkki-Brannstrom

et al [97] demonstrated that extending the physical life of a net within a household even for a year, can have significant cost-saving in the ITN strategy. In Ethiopia, increasing access to adequate information of how to care and repair was associated with positive perception score towards net care and repair [98]. In Nigeria [99], personal responsibility was deemed essential and achievable through appropriate Behavioural-Change Campaigns (BCC). Therefore, it is crucial to not only understand causes of damage to net fabric that lead to early net loss but develop strategies to optimize care of ITNs to prolong the lifespan of a net within a household.

Main causes of net damage are either rodents [100], ripped by the bed frame during tucking and untucking, source of fire in the room with the net, over-washing, toe nails or children playing with the net [101-103]. Net repair in Kenya was observed on only 21% of nets found with holes and, was reported to be the responsibility of the female spouse/household head and rarely by any other member of household [101]. While net repair does not improve the overall condition of a net [101, 104], it is still an integral part of net maintenance processes that should not be ignored in BCC messaging as it helps ITNs last longer within households. Promoting daily preventative behaviour such as not storing food in sleeping spaces that could attract rodents and other insects, carefully tucking and untucking net, tying up the net and keeping it away from playing children is crucial to protect the net from damage which in turn will extend the life of a net within a household. Differences in net care practices were observed across different environmental settings in Kenya, emphasizing the need for context-specific BCC messaging [105]. Therefore, incorporating locally appropriate messages in the BCC is essential for the NMCP to maximize the impact of care practices in slowing the process of net damage and/or loss and this can only be achieved with a clear understanding of the respective user perceptions.

Studies assessing ITN user perceptions [84, 86, 100, 106-108] conducted through qualitative research methods allow the expressions of each interviewee to be captured in their own words before the assessment of themes and patterns of similar responses among study participants [109, 110]. The choice of qualitative research methodology is necessary because of the exploratory nature of the research questions. Qualitative research methods are exploratory and committed to seeing the social world from the point of view of the study participant [111]. Data collection tools include Focus Group Discussions (FGDs) and In-Depth Interviews (IDIs). Qualitative interview methods are people-oriented, allowing the interviewee to present their own accounts of experiences by describing and explaining their lives in their own words [112]. Findings from qualitative studies while localized and relevant to the study population provide a rich encounter of user interactions with ITNs including gender-based disparities that can be used to reinforce BCC messages across regions with similar customs to help extend the life of a net within a household.

1.6 Overview of the PhD research

1.6.1 Rationale

Maximizing the benefits of ITNs as a malaria intervention depends on widespread access, appropriate use and personal responsibility to preserve nets in good condition for year-round protection against malaria mosquitoes. Despite the increased distribution of ITNs to populations-at-risk observed through the years, reaching at least 80% of the population with ITNs while accounting for population growth remains an unmet target [20, 94, 95]. Delivery mechanisms have limitations that may have contributed to this gap [28, 113]. Periodic monitoring and evaluation of current NMCP strategies are essential to avoid malaria resurgence, and to identify emerging risk factors that hinder progressive health gains. With growing concerns of limited resource availability, maximizing existing interventions such as ITNs through sub-national stratification is

inevitable [20]. It is therefore important to understand how populations at risk of malaria adapt to diminished and/or lost access to ITNs. Risk factors, emerging and evolving, associated with overall maintenance of ITNs need to be identified to appropriately reinforce current efforts to maximize net lifespan and duration of protection against malaria mosquitoes. Understanding the significance of the risk factors and avenues that have potential to influence progressive change such as appropriate BCC messaging, can help extend the average effective life of a net within a household, reducing the frequency of net replacements. This will save government and donor funding required for ITN procurement and distribution.

Findings of this PhD study are set on two research projects conducted in Tanzania between 2013 and 2017. The research studies were titled:

1. The useful life of bed nets for malaria control in Tanzania: Attrition, Bio-efficacy, Chemistry, Degradation and Insecticide Resistance (ABDCR Project) [114].
2. Decoding perceptions, barriers and motivators of net care and repair in Tanzania (The Net Care and Repair project) [52].

The PhD study applied quantitative and qualitative research methods. Collectively, the study sampled across seven of the eight geographical zones of Tanzania excluding the Northern Zone (Arusha, Kilimanjaro, Manyara districts – Fig. 2), which documented low malaria prevalence during the study period. Study sites were selected from the Sentinel Panel of Districts (SPD), Sample Vital registration with Verbal Autopsy (SAVVY) project hosted at the Ifakara Health Institute [115]. The Tanzania National Bureau of Statistics selected the SPD using probability proportional to size (PPS) sampling on the 2002 Population and Housing Census Data [116].

1.6.1.1 The ABCDR Project

The ABCDR project was a collaborative research project between the Ifakara Health Institute (IHI), the London School of Hygiene & Tropical Medicine (LSHTM), the Swiss Tropical and Public Health Institute (STPH), the Tanzanian National Institute of Medical Research (NIMR) and the Norwegian University of Life Sciences (UMB). As described in the study protocol by Lorenz *et al* [114], the project assessed and compared the durability of three ITN brands (Olyset[®], PermaNet[®]2.0 and NetProtect[®]) from 2013 to 2017 across eight districts in Tanzania (**Figure 3**). Evaluation of ITNs followed WHO durability guidelines [78, 96], assessing attrition (net loss), bio-efficacy (ability of nets to repel or kill mosquitoes), chemistry (active insecticidal ingredient in the net fabric) and physical integrity (presence/absence of damage on fabric).

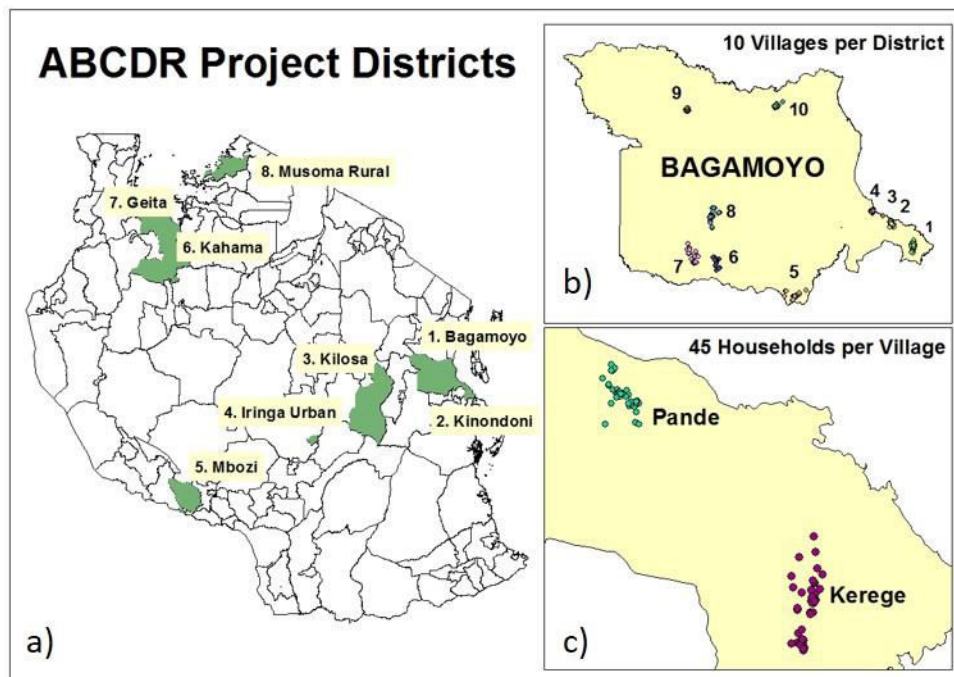


Figure 3: a) Spatial distribution and geo-referencing of participating ABCDR households across study sites. b) an example of how within each district, there were 10 participating villages and, c) is an example of household distribution of villages 1 and 2 in Fig 3b showing the 45 households enrolled in Bagamoyo district.

In line with other durability studies [80, 85, 117-119], the functional survival of the three ITNs products tested by the ABCDR project were observed to be less than 3 years, varied between net products which in turn significantly affected the cost-per-year of each product [120]. The project therefore recommends continued assessment of effective life of ITNs, particularly as new products emerge and resources for procurement are stringent.

The current PhD study, as will be discussed in detail onwards, focused on the household determinants of durability and use of ITNs based on the data collected in the ABCDR project. Human interactions with ITNs were assessed to decipher allocation of ITNs to household members in the face diminishing and renewed ITN access.

1.6.1.2 The Net Care and Repair Project

The project was a collaborative effort between the Ifakara Health Institute (IHI), the London School of Hygiene & Tropical Medicine (LSHTM), the Tanzanian National Malaria Control Program (NMCP), the Swiss Tropical and Public Health Institute (STPH), PMI, VectorWorks, John Hopkins Centre for Communication Programs (JH CCP) and the U.S. President's Malaria Initiative, U.S. Agency for International Development (USAID), Tanzania. The project explored local perceptions and practices of net care and repair including dissecting the roles assumed by men and women of Kilimahewa (peri-urban) and Makanjiro (rural) villages in Ruangwa District, Lindi Region (**Figure 4**) [52].

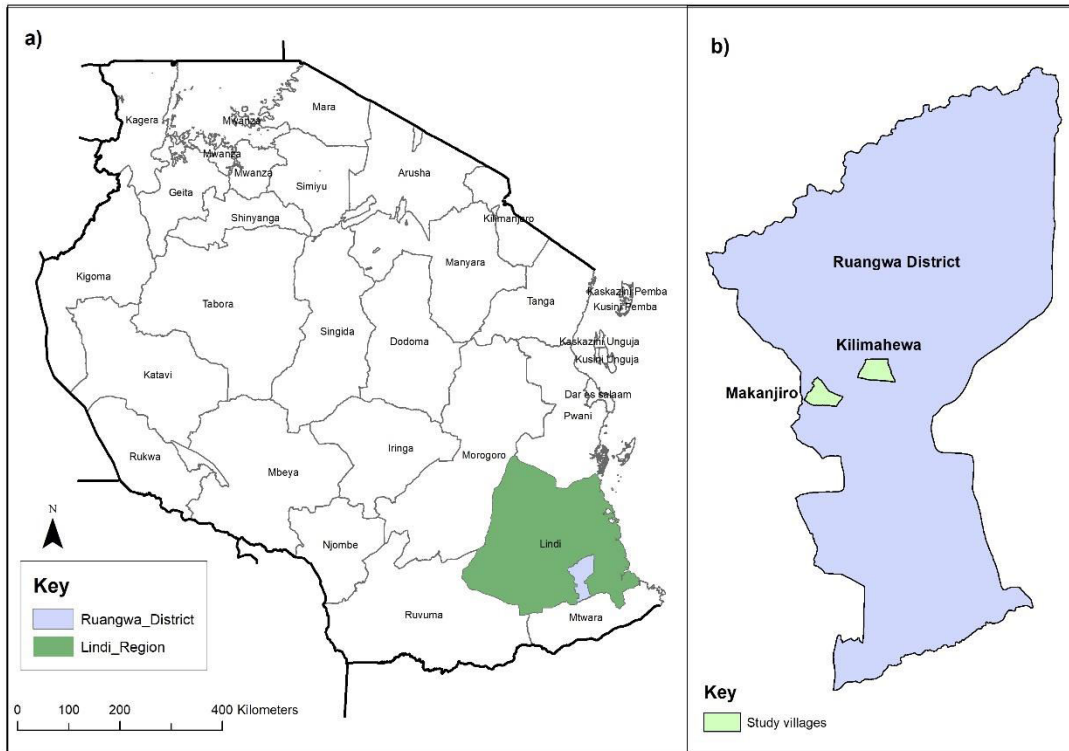


Fig. 4 – A map of the net care and repair study sites: a) The map of Tanzania with reference to the study region, b) Study villages in Ruangwa district

Since 2013, Lindi Region and the wider Southern Zone of Tanzania receive free ITNs from the government through the School Net Programme (SNP). The SNP was introduced as a continuous ITN distribution mechanism to maintain universal coverage of ITNs between mass campaigns. Optimizing the high enrolment of children in primary schools in Tanzania [71], the program annually distributes ITNs to children in alternating classes 1, 3, 5, 7 at school for use at home. However, since inception of the program in 2013 to 2016 when this study was conducted, all primary school classes and secondary students in forms 2 and 4 had received ITNs. The irregularity of the SNP program during its inception may have potentially created a false sense of expectation of receiving new free ITNs each year among families with school-going children and influenced their net care and repair practices.

This PhD study also aligns with two objectives of the Tanzania National Malaria Strategic Plan 2014-2020 [47]: *“Reduce malaria transmission by scaling up and maintaining effective and efficient vector control interventions”* (No.1) and *“Provide timely and reliable information to assess progress in achieving established global and national targets, to ensure that resources are used in the most cost-effective manner and to account for investments made in malaria control”* (No. 4). The findings of this thesis support evidence-based policy-making and adoption to ensure the global goal of reducing malaria mortality and incidence rates by 90% in 2030 is attainable [121].

1.6.2 Specific objectives

1. To assess the status of mosquito net coverage in Tanzania in 2013, two years after the last mass campaign in 2011, to investigate how households adapt when nets are not continuously distributed.
2. To assess how household members, allocate nets to sleeping spaces as 1) ITNs are lost and/or the physical status of nets declines after 2 years of ownership; and 2) new free ITNs are introduced.
3. To explore local perceptions, motivators and barriers to net care and repair in southern Tanzania.
4. To explore roles of men and women in net care and repair activities at the household level

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PART TWO

2 MOSQUITO NET COVERAGE IN YEARS BETWEEN MASS DISTRIBUTIONS: A CASE STUDY OF TANZANIA, 2013

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2.1 Abstract

Background: The Government of Tanzania is the main source of long-lasting insecticidal nets (LLINs) for its populations. Mosquito nets (treated and untreated) are also available in the commercial market. To sustain investments and health gains in the fight against malaria, it is important for the National Malaria Control Programme to monitor LLIN coverage especially in the years between mass distributions and to understand what households do if their free nets are deemed unusable. The aim of this paper was to assess standard LLIN indicators by wealth status in Tanzania in 2013, 2 years after the last mass campaign in 2011, and to extend the analysis to untreated nets (UTNs) to investigate how households adapt when nets are not continuously distributed.

Methods: Between October-December 2013, a household survey was conducted in 3398 households in eight districts in Tanzania. Using Roll Back Malaria indicators, the study analysed: (1) household net ownership; (2) access to nets; (3) population net use and (4) net use:access ratio. Outcomes were calculated for LLINs and UTNs. Results were analysed by socio-economic quintiles and by district.

Results: Only three of the eight districts had household LLIN ownership of more than 80%. In 2013, less than a quarter of the households had one LLIN for every two people and only half of the population had access to an LLIN. Only the wealthier quintiles increased their net ownership and access to levels above 80% through the addition of UTNs. Overall net use of the population was low (LLINs:32.8%; UTNs:9.5%) and net use:access ratio was below target level (LLINs: 0.66; UTNs: 0.50). Both measures varied significantly by district.

Conclusions: Two years after the last mass campaign, the percentage of households or population with access to LLINs was low. These findings indicate the average rate at which households in

Tanzania lose their nets is higher than the rate at which they acquire new nets. The wealthiest households topped up their household net ownership with UTNs. Efforts to make LLINs available through commercial markets should be promoted, so those who can afford to buy nets purchase LLINs rather than UTNs. Net use was low around 40% and mostly explained by lack of access to nets. However, the use:access ratio was poor in Mbozi and Kahama districts warranting further investigations to understand other barriers to net use.

Keywords: Long-lasting insecticidal nets (LLINs), Untreated nets, Universal coverage, Net ownership, Net access, Net use, Tanzania

2.2 Background

Since the global resurgence of interest in malaria control about 20 years ago, insecticide-treated nets (ITNs) have been the most widely distributed intervention against malaria and account for a 68% decline in *Plasmodium falciparum* infection prevalence in sub-Saharan Africa [1].

Universal coverage as recommended by the World Health Organization (WHO) is defined as “universal access to, and use of, long-lasting insecticidal nets (LLINs)” of all people at risk of malaria, and is defined operationally as one net for every two people [2]. Tanzania has a long-standing record in the deployment of mosquito nets as an intervention for malaria control [3-7]. The use of ITNs in Tanzania has been associated with the reduction of malaria morbidity and mortality, particularly in children under the age of five [8, 9].

Mass distribution campaigns are the primary source of LLINs in most malaria endemic countries and aim to ensure equitable distribution across all socio-economic groups [1, 10-12]. Given the increasing distribution of large numbers of mosquito nets in communities, the Roll Back Malaria Monitoring and Evaluation Reference Group (MERG) developed indicators to assess and compare LLIN interventions in countries at risk of malaria [13]. Household surveys are widely used to measure the MERG indicators, which determine achievements of universal coverage of LLINs following mass distributions [13].

Between 2004 and 2014, the Government of Tanzania distributed nets to pregnant women and infants at a subsidised cost during their routine antenatal and immunization clinic visits through the Tanzania National Voucher Scheme (TNVS) [14-16]. Nationwide, children under the age of 5 received nets free of charge through the Under-Five Catch-up Campaign (U5CC) between 2009 and 2010 [17], and a Universal Coverage Campaign (UCC) was implemented in 2010 and 2011 to reach all remaining uncovered sleeping spaces [18]. Another mass universal replacement

campaign (URC) was conducted between 2015 and 2017 to achieve universal coverage in most of the country. Since 2013, the School Net Programme (SNP) has been ongoing in the Southern Zone to explore sustainable continuous “Keep Up” mechanisms to distribute nets into the community [19-21].

In addition, both insecticidal and untreated mosquito nets (UTNs) are available through the private sector at varying costs [22]. A to Z Textile Mills Ltd. holds the biggest market share for mosquito nets in Tanzania, but their commercial market is currently restricted to UTNs (Safinet) and supplies to international funders for mass LLIN campaigns (Olyset and Miranet) within the region and elsewhere (Nick Brown, Business Development Manager, *pers. comm.*). There are three more local manufacturers of UTNs than LLINs in Tanzania, which increases the accessibility and availability of UTNs in the commercial markets at a cheaper cost [22]. Though not as efficient as LLINs for protection against malaria, UTNs do provide physical protection against mosquitoes if in relatively good condition [8, 23-25].

While many studies focus on evaluating the achievements of the LLIN distributions usually immediately following mass campaigns [12, 26-30], this study provides, 1) data on LLIN coverage at a unique time between mass campaigns, and 2) an account of how households adapt when nets are not freely distributed, including the acquisition of UTNs. Using the MERG indicators, LLIN and UTN ownership, access and use was assessed to investigate the net landscape of Tanzania two years since the last mass campaign with particular emphasis on how the population responds to loss of free LLINs and whether this is affected by socio-economic status. The National Malaria Control Programme (NMCP) could use these data to predict current LLIN coverage following the URC in 2015-2017 to better assess target areas and populations for continuous net distribution strategies.

2.3 Methods

Study sites and population sampling

The study was conducted in eight districts in Tanzania (Fig. 1) between October and December 2013, during the baseline survey of a long-term LLIN durability study [31]. The eight districts were selected from twenty-three districts enrolled in the Sentinel Panel of Districts (SPD) for the Sample Vital registration with Verbal Autopsy (SAVVY) project [32], a demographic surveillance platform based at the Ifakara Health Institute (IHI). The eight districts were selected to represent six of the eight geographical zones of Tanzania with varying malaria prevalence across study sites, excluding the Southern Zone (ongoing SNP) and the Northern Zone (low malaria prevalence at the time) [33]. This study was conducted leading into the short rainy season when transmission is usually lowest. Of the eight districts, two (Kinondoni and Iringa) were urban while the other six were rural. Ten villages in each district were selected for inclusion except for Kinondoni district where only six villages were available. In each selected village, 45 households were randomly selected from the SAVVY database, giving a total of 3,420 households. The sample size calculation was for the overall long-term LLIN durability study outcomes [31].

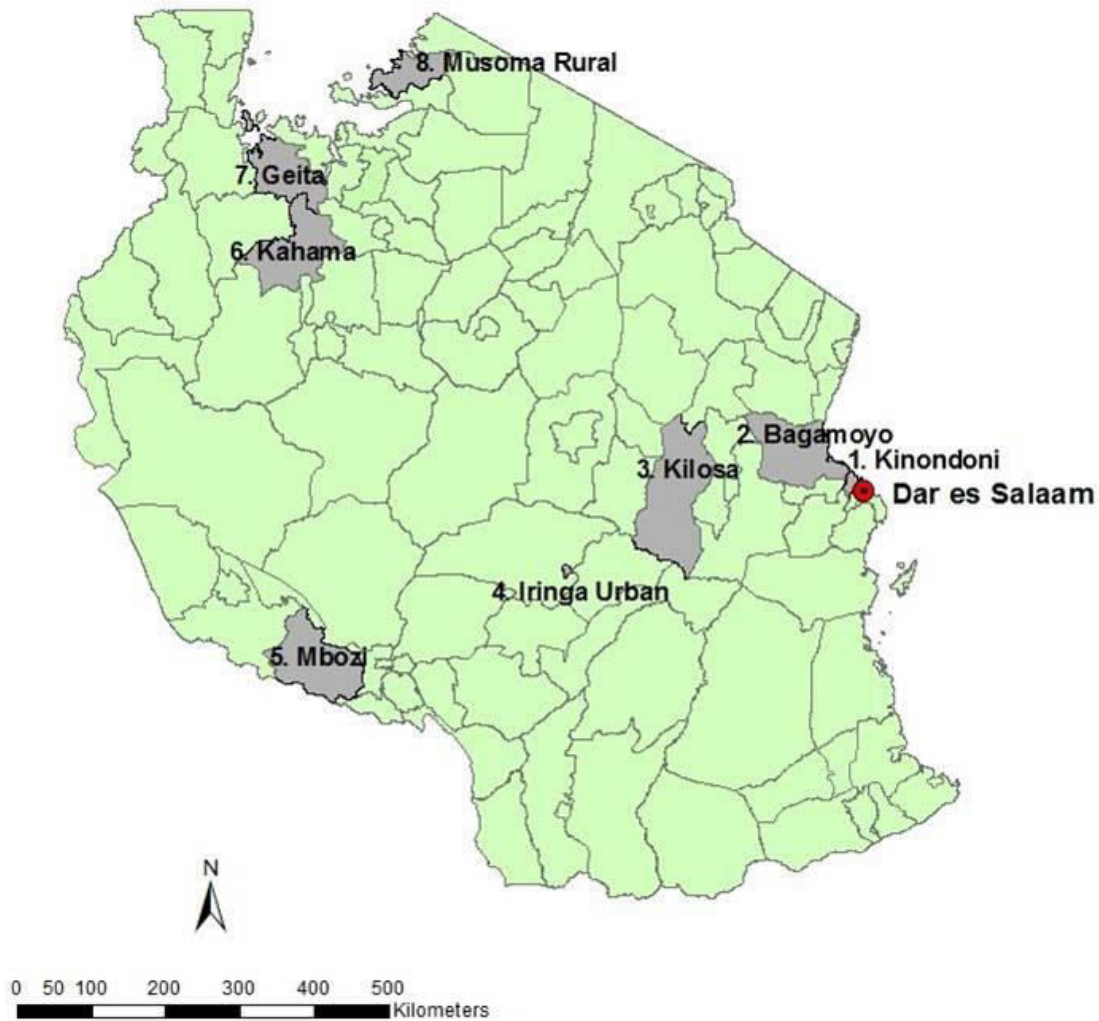


Figure 1: Geographical distribution of the eight districts in Tanzania sampled for this study. The eight districts sampled in this study were: 1) Kinondoni, 2) Bagamoyo, 3) Kilosa, 4) Iringa Urban, 5) Mbozi, 6) Kahama, 7) Geita, and 8) Musoma Rural.

Data collection

A cross-sectional household survey was conducted. The household questionnaire was programmed using Open Data Kit (ODK) [34] and administered using Google Nexus tablet computers. The questionnaire included a household member roster and questions about the mosquito net(s) owned and whether the net(s) had been used the previous night. The number of sleepers under each net the previous night was recorded. Each mosquito net identified in the household was assigned a

unique barcode. All participating households were provided with new LLINs to cover all sleeping spaces as part of their enrolment into the net durability study [31]. All mosquito nets present in these households were collected and returned to the IHI laboratories in Bagamoyo where they were sorted by colour, size, product label and manufacturing date (creating a “net database”). The insecticide treatment status of each net was identified using its attached product label and categorized as either LLIN, UTN or unknown (if label was missing). The net database was linked to the questionnaire data using the unique barcode assigned to each mosquito net collected.

Data analysis

Mosquito net indicators

This study used the MERG indicators to report the status of Tanzania’s mosquito net coverage in 2013 (Table 1) [13]. Household net ownership, which is defined as the percentage of households owning at least one net, one LLIN or UTN, was determined. The percentage of households with at least one net for every two people in its household (“households with enough nets”) was also determined for LLINs, any net and UTNs. “Population access,” i.e., the percentage of the population with potential to be protected by a net within their household, assuming a net can be used by two people was determined for LLINs, any net and UTNs (values were corrected to a maximum value = 1 to ensure the value for potential users does not exceed the number of actual household members [A. Kilian pers. comm.]). Population access was calculated using the following equation:

$$\text{Population Access} = \frac{\text{Number of nets present in household} * 2}{\text{Number of people who slept in the household the previous night}}$$

The proportion of the population that reported to have used a net, an LLIN or UTN, the previous night was calculated.

The use:access ratio was calculated by dividing the percentage of the population that reportedly used a net the previous night by the percentage of the population that had access to a net. The mean number of sleepers per net was calculated by multiplying the use:access ratio by two, assuming each net should be used by two people. The net use gap (“1-use:access ratio” [28]), i.e. the proportion of the population who had access to a net within their household, assuming each net is used by two people, but did not sleep under one, was also determined. The net use gap indicates whether people made a choice not to sleep under a net despite having access or whether they were without access to nets in their households [28].

Table 1: Descriptions of mosquito net indicators used

Mosquito net indicator	Indicator description
Household ownership ¹	Percentage of households owning at least one net, one LLIN, or one untreated net.
Household with enough nets ²	Percentage of households with at least one net, one LLIN, or one untreated net, for every two people.
Population access ³	Percentage of the population with access to any net, LLIN, or untreated net within their household, assuming each net is used by two people.
Population net use ⁴	Percentage of the population that used any net, any LLIN, or any untreated net the previous night.
Net use:access ratio ⁵	Percentage of the population that used a net the previous night divided by the percentage of the population that had access to a net
Net use gap	The proportion of the population who had access to a net within their household, assuming each net is used by two people, but did not sleep under one (1-use:access ratio).

Socio-economic status

The socio-economic status (SES) of each participating household was calculated by creating a wealth index based on measures such as the materials used to construct the house, household amenities and assets owned [35]. Questions to measure assets were adapted from the WHO sample questionnaire for monitoring LLIN durability under operational conditions [36] to fit the current local context. Using Principal Component Analysis (PCA) [37], a weighted score was calculated for each household and the whole population divided into five quintiles, following the methods described by the Demographic Health Survey Comparative Report No. 6 [38].

Statistical analysis

Data analysis was carried out using statistical software package STATA 13.1 (StataCorp LP, College Station, TX). Using the survey suite of commands to account the clustered sampling design, a single-stage sampling scheme designated the variable ‘village’ as the primary sampling unit. This was done to account for the highest level of clustering (village) to give the correct standard errors even if the lower levels of clustering (household) were not explicitly modelled [39]. Statistical analysis focused on the effect of socio-economic status on the variation between access to and use of any net (treated and untreated) and LLINs. Logistic regressions were performed to analyse the effect of SES on the following dependent variables: 1) ownership of at least one net (any type), 2) ownership of at least one LLIN, 3) ownership of at least one UTN, 4) households with enough nets (any type), 5) households with enough LLINs, 6) households with enough UTNs, 7) population access to any net within the household, 8) population access to an LLIN within the household, 9) population access to an UTN within the household, 10) population net use the previous night, 11) population LLIN use the previous night, 12) population use of UTNs the previous night, 13) any net use:access ratio, 14) LLIN use:access ratio, and 15) UTN use:access ratio, adjusting for district variation (Table 2).

Variations between net use and access among different districts was assessed for LLINs only. This is because the WHO specifically recommends universal coverage with LLINs [2].

Table 2: Number (%) of households by socio-economic quintiles (SES) in the eight districts in Tanzania, 2013.

District	Socio-economic quintiles (SES)					Total
	Poorest	Second Poorest	Medium	Wealthier	Wealthiest	
Bagamoyo (R)	66 (15.0)	77 (17.5)	114 (26.0)	126 (28.8)	55 (12.6)	438 (100)
Kinondoni (U)	0 (0.0)	0 (0.0)	2 (0.7)	25 (9.3)	242 (90.0)	269 (100)
Kilosa (R)	124 (27.6)	80 (17.8)	85 (18.9)	118 (26.3)	42 (9.4)	449 (100)
Iringa (U)	0 (0.0)	4 (0.9)	24 (5.4)	144 (32.1)	277 (61.7)	449 (100)
Mbozi (R)	49 (10.9)	125 (27.8)	162 (36.1)	95 (21.2)	18 (4.0)	449 (100)
Kahama (R)	164 (36.6)	113 (25.2)	70 (15.6)	64 (14.3)	37 (8.3)	448 (100)
Geita (R)	131 (29.2)	131 (29.2)	120 (26.7)	65 (14.5)	2 (0.5)	449 (100)
Musoma (R)	146 (32.7)	150 (33.6)	102 (22.8)	43 (9.6)	6 (1.3)	447 (100)
Total	680 (20.0)	680 (20.0)	679 (20.0)	680 (20.0)	679 (20.0)	3398 (100)

*R = Rural; U= Urban

2.4 Results

A total of 6,529 nets were collected from 3,398 households from 76 villages across eight districts in Tanzania [40]. Seventy-seven percent of nets were LLINs, 16% UTNs, and 7% had no labels attached (Fig. 2). The predominant net product was Olyset (74.2%). Other LLIN products included PermaNet (1.5%) and BASF (0.9%). Untreated net products included Safinet (13.5%), SupaNet (1.5%) and Health Net Ltd (0.5%). Seventy-three percent of all nets collected were identified by their colour to have come from a government distribution mechanism (TNVS, U5CC or UCC) (Fig. 2). Of the 3,986 campaign nets identified, only 1,063 could be distinguished by

manufacturing date (U5CC: 135, UCC: 928), the rest had lost their manufacturing label. Of the 6,529 nets collected, 85% were single size (3 x 6 feet) while 15% were double size (4 x 6 feet) in dimensions. Eighty-five percent of the single size nets were LLINs. Fifty-one percent of the double-sized nets were UTNs, 35% were LLINs and 14% unknown. Ninety-seven percent of nets were square in shape while 3.3% were conical-shaped. Seventy-one percent of the conical-shaped nets were UTNs.

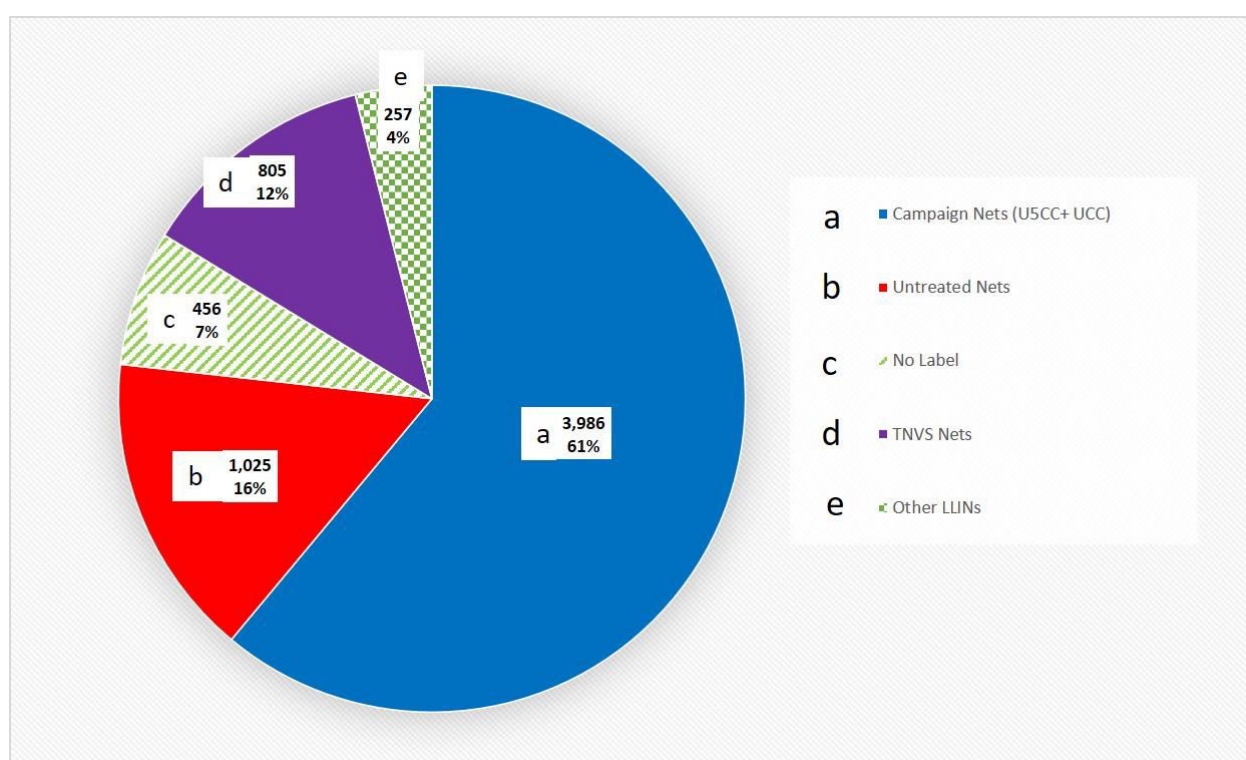


Figure 2: Assessment of 6,529 nets collected from households. a) Campaign Nets: Under-Five Catch-Up Campaign (U5CC) and Universal Coverage Campaign (UCC); b) Untreated Nets; c) No label; d) Tanzania National Voucher Scheme (TNVS); and e) Other LLINs

Most of the households in Kinondoni and Iringa (urban districts) ranked among the wealthiest SES quintile while none ranked among the poorest quintile (Table 2). Household ownership of at least one government-distributed LLIN (TNVS, U5CC or UCC) was almost twice as high among

the poorest quintile at 90.0% [95% CI 86.2-92.8%] compared to the wealthiest quintile at 47.3% [95% CI 42.1-52.6%]. Thirty-five percent of households owned both an LLIN and a UTN.

Net ownership

Overall, 85.0% [95% CI 82.3-87.4%] of households owned at least one net (any type) while 74.5% [95% CI 71.0-77.7%] and 36.7% [95% CI 32.6-41.0%] of households owned at least one LLIN and at least one UTN, respectively (Fig. 3). The wealthiest quintiles had the highest percentage of household net ownership at 89.3% [95% CI 85.3-92.3%] but the lowest percentage of households owning at least one LLIN at 66.6% [95% CI 59.2-73.2%] (Fig. 3). The poorest quintile had the lowest household ownership of any net at 78.1% [95% CI 70.8-84.0%] while the middle quintile had the highest LLIN ownership at 78.6% [95% CI 72.8-83.5%]: (Fig. 3). Ownership of UTNs increased with the increase of wealth quintile.

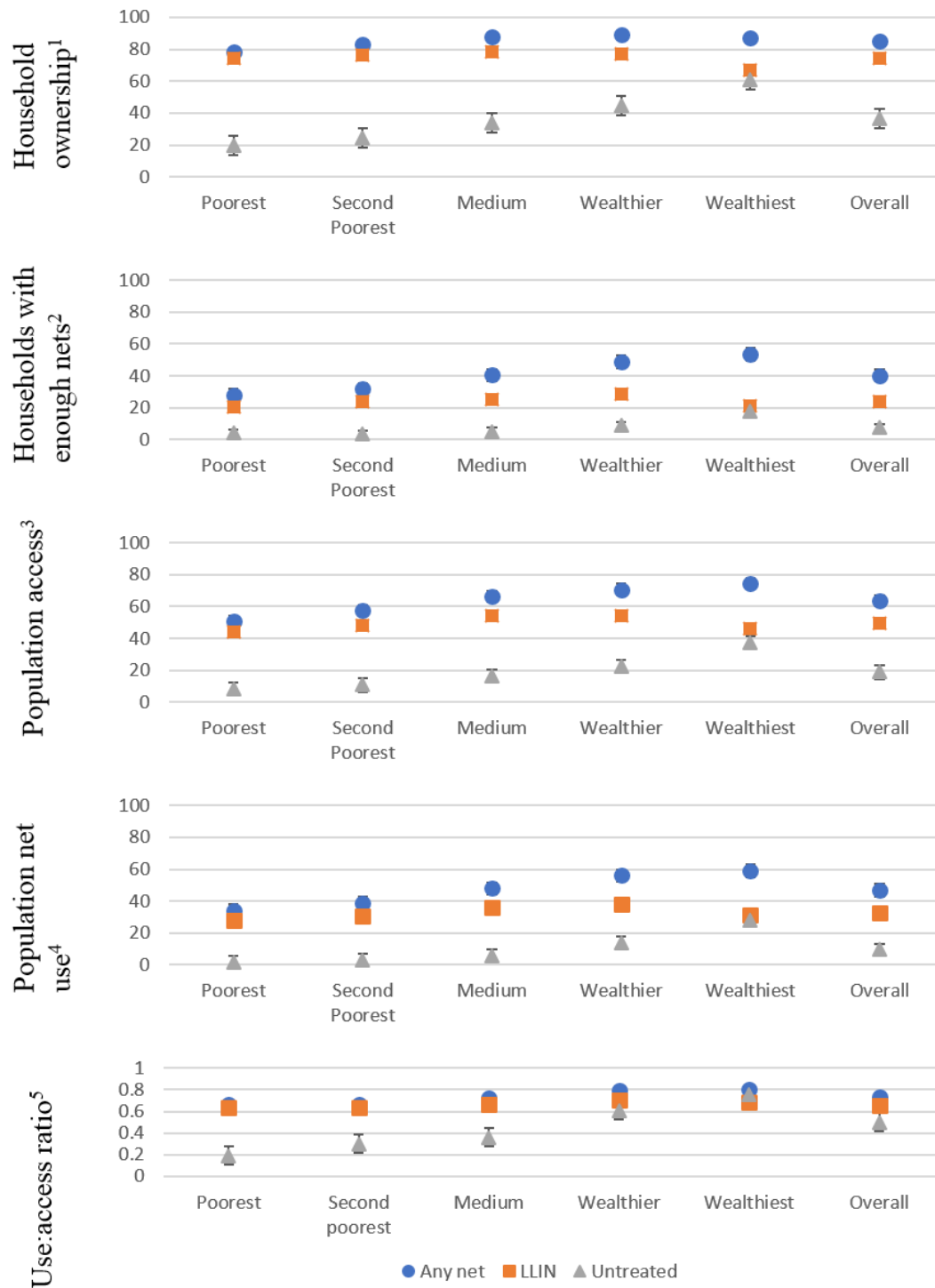


Figure 3: Ownership, access, and use of any nets, LLINs and UTNs by socio-economic quintile. The mean percentage household ownership, access and use of any nets, LLINs and UTNs by socio-economic quintile in Tanzania, October – December 2013 (also see Additional File 2 for tabulated data). Error bars represent 95% confidence intervals. Definitions of mosquito net indicators used are listed in Table 1.

Socio-economic status was significantly positively associated with ownership of any net (Table 3). For those in the wealthiest quintile, the odds of owning a net was 2.62 times the odds of owning any net for those in the lowest quintile. There was no statistically significant association between SES and LLIN ownership. However, the odds of the middle quintile to own an LLIN was 1.47 times the odds of owning an LLIN for those in the lowest quintile. Socio-economic status was significantly positively associated with ownership of UTNs. The odds of the wealthiest quintile to own a UTN was 6 times the odds of owning an UTN for those in the lowest quintile (Table 3).

Table 3: The effect of SES on mosquito net indicators for any net, LLINs and untreated nets

Mosquito Net Indicator	Variable	SES	Unadjusted Odds Ratio (95% CI)	P- value	Adjusted Odds Ratio* (95% CI)	P-value
Household ownership ¹	Any net	Poorest	1	0.013	1	0.005
		Second Poorest	1.38		1.53	
		Medium	2.01		2.33	
		Wealthier	2.33		2.61	
		Wealthiest	1.86		2.62	
	LLIN	Poorest	1	0.070	1	0.053
		Second Poorest	1.13		1.25	
		Medium	1.29		1.47	
		Wealthier	1.15		1.26	
		Wealthiest	0.7		0.87	
	Untreated net	Poorest	1	0.000	1	0.000
		Second Poorest	1.31		1.36	
		Medium	2.08		2.18	
		Wealthier	3.24		3.35	
		Wealthiest	6.19		6.95	
Household with enough nets ²	Any net	Poorest	1	0.000	1	0.001
		Second Poorest	1.2		1.22	
		Medium	1.76		1.67	
		Wealthier	2.46		2.04	
		Wealthiest	2.97		2.47	
	LLIN	Poorest	1	0.039	1	0.121
		Second Poorest	1.18		1.21	
		Medium	1.27		1.2	
		Wealthier	1.53		1.29	
		Wealthiest	1.04		0.92	
	Untreated net	Poorest	1	0.000	1	0.002
		Second Poorest	0.88		0.81	
		Medium	1.31		1.10	
		Wealthier	2.30		1.78	
		Wealthiest	5.09		3.41	
Any net	Poorest	1	0.005	1	0.005	

		Second Poorest	1.40		1.53	
		Medium	2.06		2.31	
		Wealthier	2.58		2.68	
		Wealthiest	1.92		2.43	
Population access ³	LLIN	Poorest	1	0.039	1	0.021
		Second Poorest	1.15		1.24	
		Medium	1.31		1.44	
		Wealthier	1.26		1.25	
		Wealthiest	0.7		0.77	
	Untreated net	Poorest	1	0.000	1	0.000
		Second Poorest	1.33		1.35	
		Medium	2.15		2.17	
		Wealthier	3.51		3.40	
		Wealthiest	6.52		6.68	
Population net use ⁴	Any net	Poorest	1	0.000	1	0.000
		Second Poorest	1.23		1.3	
		Medium	1.8		1.93	
		Wealthier	2.49		2.52	
		Wealthiest	2.82		2.92	
	LLIN	Poorest	1	0.009	1	0.002
		Second Poorest	1.13		1.19	
		Medium	1.44		1.51	
		Wealthier	1.54		1.56	
		Wealthiest	1.18		1.23	
Untreated net	Poorest	1	0.000	1	0.000	
	Second Poorest	2.05		2.25		
	Medium	3.82		4.08		
	Wealthier	9.62		8.17		
	Wealthiest	23.47		18.89		
Use:access ratio ⁵	Any net	Poorest	1	0.014	1	0.050
		Second Poorest	1.04		1.23	
		Medium	1.13		1.28	
		Wealthier	1.62		1.77	
		Wealthiest	1.85		1.7	
	LLIN	Poorest	1	0.771	1	0.899

Second Poorest	0.83	0.94
Medium	0.88	0.99
Wealthier	1.01	1.11
Wealthiest	1.07	0.97

Untreated net	Poorest	1	0.721	1	0.321
	Second Poorest	1.31		3.47	
	Medium	1.97		1.25	
	Wealthier	2.02		0.69	
	Wealthiest	2.37		0.76	

*Adjusted for district

¹⁻⁵ Descriptions of mosquito net indicators are listed on Table 1

Households with one net for every two people

Overall, the percentage of households with enough LLINs to cover every two of its household members was low (Fig. 3). Only in the wealthiest quintile did more than half of the households have enough nets (any type) for everyone in the household at 53.3% [95% CI 48.7-57.9%]. The percentage of households with at least one LLIN for every two people was below 30% across all socio-economic quintiles. The odds of the wealthiest quintile to have households with enough nets of any type was 2.47 times the odds for those in the lowest quintile, but there was no statistically significant effect of SES on household access to LLINs (Table 3). There was a significantly positive association between SES and households with enough UTNs (Table 3).

Population access

The wealthier quintiles had the highest percentage of their population with access to a net (any net: 74.3% [95% CI 69.2-79.4%]; LLINs: 54.3% [95% CI 49.5-59.0%]; UTNs: 60.5% [95% CI 55.4-65.9%]) (Fig. 3)). Socio-economic status was significantly associated with population access to all

nets (treated and untreated) (Table 3). For LLINs, the middle quintile had the highest odds of its populations having access while the wealthiest had the lowest odds.

Population net use

The average number of people sleeping under any net was 1.8 with 43.1% of nets having only 1 sleeper while 54.5% with 2-3 sleepers under one net. The average number of people sleeping under an LLIN was 1.8 with 31.4% of the LLINs having only one sleeper while 39.4% of LLINs had 2-3 sleepers. The mean number of sleepers under UTNs was 1.7 with 34.5% having only one sleeper under it while 38.1% had 2-3 sleepers.

Population net use was lowest in the poorest quintile regardless of the net's insecticide-treatment status (any net: 33.9% [95% CI 27.9-39.8%]; LLIN: 28.2% [95% CI 23.2-33.2%]; UTNs: 1.6% [95% CI 0.6-2.6%] (Fig. 3)). Socio-economic quintile was significantly associated with population net use. The odds of the wealthiest households compared to the odds of the poorest households using nets was 3 times for any net, 1.2 times for an LLIN and 18.89 times for a UTN (Table 3).

Use:access ratio and net use gap

The overall proportion of people that had access to a net and slept under it the previous night was 0.73 for any net, 0.66 for LLINs, and 0.50 for UTNs (Fig. 3). The net use gap ranged between 0.20-0.33 for any net, 0.30-0.36 for LLINs, and 0.25-0.81 for UTNs depending on the socio-economic quintile (Fig. 3). The odds of the wealthiest individuals to sleep under any net if they had access to it was 1.7 times the odds of sleeping under any net for the poorer individuals. There

was no statistically significant association between socio-economic status and LLIN use:access ratio (Table 3).

District variation of LLIN coverage

Overall, households with enough LLINs for every two of its household members were 23.8% [95% CI 21.2-26.7%], the percentage of the population with access to an LLIN within their household was 49.2% [95% CI 46.3-52.0%], and the percentage of the population that used an LLIN the previous night was 38.2% [95% CI 29.9-35.8%] (Fig. 4). The overall use:access ratio of LLINs was 0.66 and in turn the LLIN use gap was 0.34.

Only three districts, namely Bagamoyo, Kilosa and Musoma had more than 80% of households owning at least one LLIN (Fig. 4). Kinondoni district had the lowest percent of household ownership of LLINs at 62.5% [95% CI 40.5-80.3%] while neighbouring Bagamoyo had the highest at 83.3% [95% CI 74.3-89.6%]. Geita, had the lowest percentage of households with enough LLINs at 16.0% [95% CI 12.2-20.8%] and low population access at 45.6% [95% CI 40.7-50.5%]. Mbozi and Kahama districts, who have the lowest household ownership of LLINs, had the lowest LLIN use:access ratios of 0.39 and 0.52 respectively while the Musoma district had the highest at 0.80 (Fig. 4).

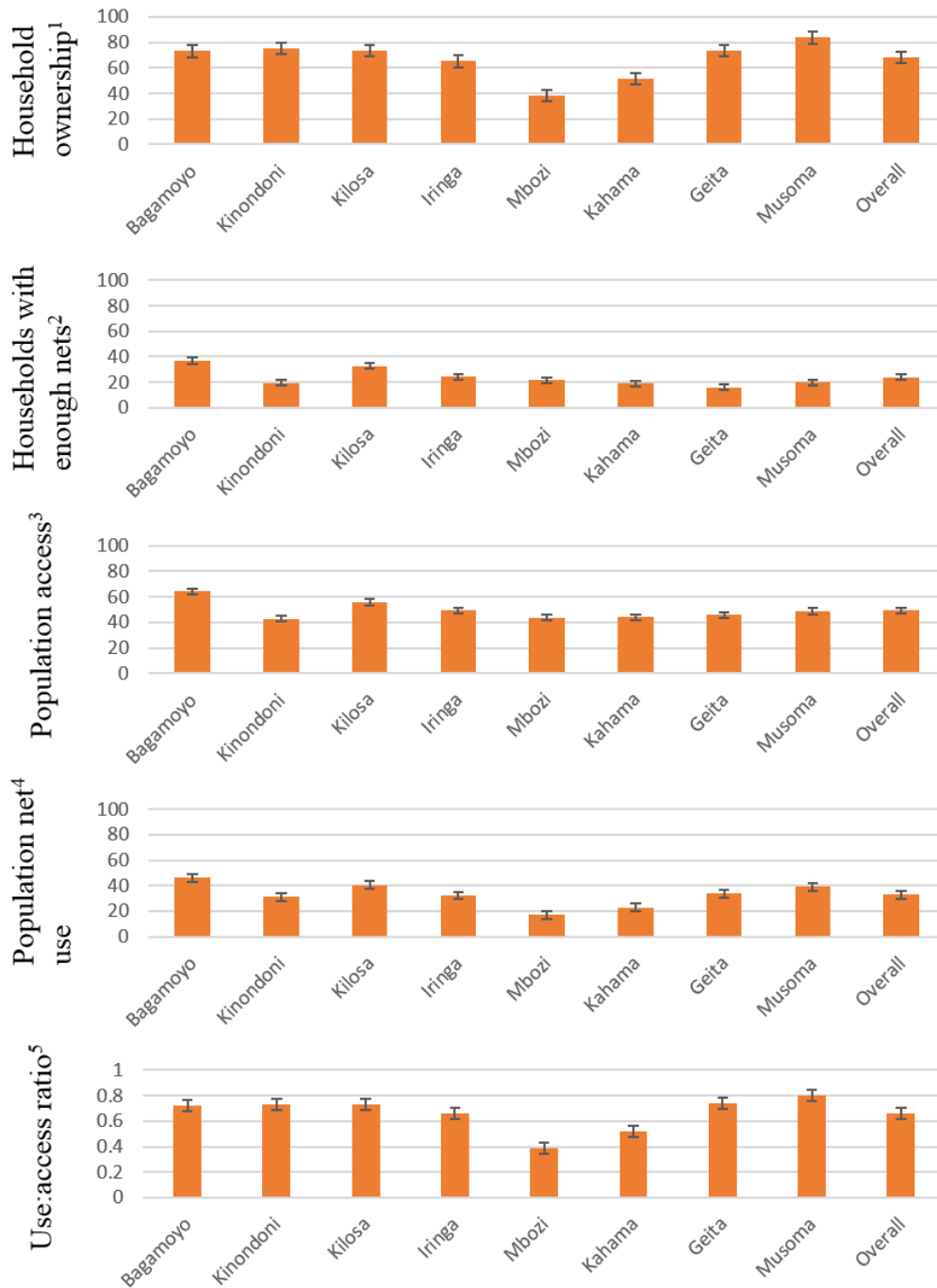


Figure 4: Ownership, access, and use of LLINs by district in Tanzania, October – December 2013. The mean percentage household ownership, access and use of LLINs by district in Tanzania, October – December 2013 (also see Additional File 1 for tabulated data). Error bars represent 95% confidence intervals. Definitions of mosquito net indicators used are listed in Table 1.

2.5 Discussion

Overall, the percentage of households with one LLIN for every two people was below 30%. This finding indicates that two years after the mass distribution, many households were without enough nets to cover their populations leading to low population access to LLINs (below 50%). This emphasizes that the URC was long overdue by 2013. Recent national surveys suggest that malaria prevalence in Tanzania may have increased from 9.2% in 2011-2012 to 14.4% in 2015-2016 [33, 41], which could be attributed to poor LLIN indicators although the difference in malaria prevalence could also be attributed to varying transmission intensity between the survey years [42, 43]. The WHO currently recommends mass distribution campaigns to be conducted at three-year intervals unless there is reliable data to justify longer replacement intervals or as per locally available investments to accommodate population growth and intermittent net loss [2]. This study emphasizes the need for continuous malaria intervention especially during the gap years between mass distributions, Geita district, for example, recorded the highest malaria prevalence (38.4%) in 2015-2016 [41] and lowest percentage of households with enough LLINs (16%) in this study. It is currently profiting from the expansion of SNP to the Western and Lake Zone since late 2016 to maintain high net coverage [44].

Generally, household ownership of any type of net was highest among the wealthiest quintile (89.3%). Sixty percent of the wealthiest households owned at least one UTN, most probably acquired from the commercial market. This indicates willingness to purchase affordable nets for continued protection against mosquitoes in the absence of free net distributions. A literature review by Koenker and Yukich [45] found that households tend to use the nets available to them irrespective of net characteristics (colour, shape, size or texture), probably because they are restricted to what is distributed or what they have access to. Purchasing their own nets, however,

allowed households to exercise choice regarding treatment status, material and size of net. This assessment found that 51% of the double-size nets and 71% of the conical-shaped nets were UTNs. The inequalities observed across socio-economic quintiles in the acquisition of UTNs was similar to what was observed in Nigeria [46]. The wealthiest households, situated in the urban districts of Kinondoni and Iringa, increased their household access to nets through the commercial markets. Access to a variety of products and affordable prices have been shown to have a significant association with willingness to purchase mosquito nets in Ethiopia [47]. Remotely-located districts are often disadvantaged by increased costs to cover transport charges [16]. This study found that household ownership of at least one government-distributed LLIN (TNVS, U5CC, UCC), distributed two-to-four years prior to this study, was almost twice as high in the poorest quintile (90%) compared to the wealthiest quintile (47%). This indicates that households belonging to the lower socio-economic quintiles relied mostly on campaign LLINs and kept them for longer. Hence, there is a need to identify pro-poor methods of targeting net distributions such as the SNP to lower socio-economic quintiles to ensure households have enough nets to cover all members.

It will be important to identify locally and culturally appropriate avenues for behavioural-change campaigns (BCC) to motivate increased purchasing of LLINs while strengthening the local production of LLINs through private-public partnerships [22, 48, 49]. It is also useful to explore factors associated with net retention and how those can be incorporated in the BCC in districts with high net loss. Household net ownership of at least one LLIN in Mbozi district, dropped by 28.8% from what was reported by the THMIS 2011-2012, 10 months prior to this study [33].

Population net use of any net type and LLINs was low across all socio-economic quintiles. Any net use was highest among the wealthiest quintile but was still below 60%. Overall, LLIN use:access ratio of 0.66 indicated that not all of the nets collected from households were used [29].

Previous studies have identified reasons for net non-use include lack of access to nets [50, 51] or discomfort, low mosquito density, or sleeping elsewhere [52, 53]. Across districts, the LLIN use:access ratio was lowest in Mbozi at 0.39 (mean number of people per net was 0.7). Mbozi district is in the Southern Highlands, a hypo-endemic zone (with less than 3 months of transmission a year, <10% malaria prevalence in children 2-9 years old) [54, 55]. Thus, people might not see malaria as a public health threat, explaining the low use rate. Further studies need to be conducted to understand the barriers to net use in specific geographical areas especially following the informative “Hang Up” campaign by the Tanzania Red Cross Society after the UCC [56].

This study was unable to match net use with user characteristics such as age and gender from the household member roster. Therefore, it was not possible to analyse the person-type most and least likely to sleep underneath a net, to understand those most likely to remain uncovered that ought to be targeted in future net distributions [57-59]. The uneven distribution of SES quintiles observed after PCA analysis where most of the households in Kinondoni and Iringa (urban districts) ranked among the wealthiest while no household ranked among the poorest (Table 2), is an important limitation of this study. However, statistical analysis controlled for the variation observed between districts. Decision-makers should adjust by district SES-focused interventions and consult with the Tanzania Social Action Fund on the modalities of pro-poor focused interventions [60].

2.6 Conclusions

In 2013, two years after the last mass campaign and two years before the URC, the percentage of households or populations with access to LLINs, assuming each LLIN is used by two people was low (<30% and <50%, respectively). These findings indicate that the average rate at which households in Tanzania lose their nets is higher than the rate at which they acquire new nets. There is a need for continuous distribution of LLINs especially during gap years between mass

distributions. The NMCP is currently implementing continuous “Keep Up” strategies delivering LLINs free of charge through the expanding SNP, and through routine health care to pregnant women at their first antenatal clinic (ANC) and at an infant’s first vaccination clinic. Household ownership of any type of net was highest among the wealthier quintile (89.3%), who topped up their ownership with UTNs. Efforts to make LLINs available through commercial markets should be promoted, so that those who can buy nets from the market purchase LLINs rather than UTNs. Targeted BCC is crucial to motivate net use among those with access to nets within their households. Further investigation is recommended to understand barriers to net use and what can be done to ensure year-round net use.

2.7 Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ifakara Health Institute (Ref: IHI/IRB/No: 19-2013), the National Institute of Medical Research, Tanzania (Ref: NIMR/HQ/R.8a/Vol I/285) and the London School of Hygiene & Tropical Medicine (Ref: 6333). The household questionnaire was administered upon written informed consent by interviewees above 18 years of age. Initials were used in the household member roster to ensure anonymity. All participating households were given new LLINs in replacement of all nets collected from the household or to cover every sleeping space. This manuscript is published with the permission of the Director-General of the National Institute of Medical Research (NIMR), Tanzania.

Consent for publication

Nick Brown has reviewed and approved the publication of this manuscript.

Availability of data and materials

The datasets analysed in this current study are available in part in the supplementary information files but also from the corresponding author on reasonable request.

Competing interests

The authors declare that that they have no competing interests.

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Authors' contribution

HJO, SM, JM, KK and LML conceived and designed the study. ZM, DM collected the data. ZM, JB, LML analysed the data. ZM wrote the manuscript. HJO, SM, JM, JB, KK, JL and LML critically reviewed the manuscript. All authors read and approved the final drafts of this manuscript.

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2.9 Additional Files

Additional file 1: Tabulated data representing household ownership, access and use of any nets, LLINs and UTNs by socio-economic quintile in Tanzania, October – December 2013 also presented in Figure 3.

Table 1: Ownership, access, and use of nets (any type) by socio-economic quintile in Tanzania, October – December, 2013

Socio-economic quintile	Household ownership ¹	Households with enough nets ²	Population access ³	Population net use ⁴	Use:access ratio ⁵
Poorest	78.1 (70.8-84.0)	27.8 (22.5-33.8)	50.8 (44.7-56.9)	33.9 (27.9-39.8)	0.67
Second Poorest	83.1 (79.5-86.1)	31.6 (27.4-36.1)	57.7 (54.0-61.4)	38.6 (33.5-43.7)	0.67
Medium	87.8 (84.2-90.7)	40.4 (35.9-45.0)	66.3 (62.6-70.0)	47.9 (42.3-53.6)	0.72
Wealthier	89.3 (85.3-92.3)	48.7 (42.1-55.3)	70.7 (66.0-75.4)	56.0 (50.2-61.8)	0.79
Wealthiest	86.9 (82.0-90.6)	53.3 (48.7-57.9)	74.3 (69.2-79.4)	59.1 (53.6-64.5)	0.80
Overall	85.0 (82.3-87.4)	40.3 (36.5-44.3)	63.8 (60.2-67.3)	43.5 (39.2-47.8)	0.73

¹⁻⁵ Descriptions of mosquito net indicators are listed on Table 1

Table 2: Ownership, access, and use of LLINs by socio-economic quintile in Tanzania, October – December, 2013

Socio-economic quintile	Household ownership ¹	Households with enough nets ²	Population access ³	Population net use ⁴	Use:access ratio ⁵
Poorest	74.1 (67.0-80.2)	20.7 (16.2-26.2)	44.0 (38.8-49.2)	28.2 (23.2-33.2)	0.64
Second Poorest	76.5 (71.8-80.6)	23.5 (19.9-27.6)	48.4 (44.8-52.0)	30.8 (26.7-35.0)	0.64
Medium	78.6 (72.8-83.5)	24.9 (21.3-28.9)	54.0 (49.9-58.1)	36.1 (31.3-41.0)	0.67
Wealthier	76.8 (71.7-81.1)	28.5 (23.9-33.6)	54.3 (49.5-59.0)	37.8 (33.3-42.4)	0.70
Wealthiest	66.6 (59.2-73.2)	21.4 (17.2-26.2)	45.8 (40.7-51.0)	31.6 (28.2-35.0)	0.69
Overall	74.5 (71.0-77.7)	23.8 (21.2-26.7)	49.2 (46.3-52.0)	32.8 (29.9-35.8)	0.66

¹⁻⁵ Descriptions of mosquito net indicators are listed on Table 1

Table 3: Ownership, access, and use of untreated nets by socio-economic quintile in Tanzania, October – December, 2013

Socio-economic quintile	Household ownership¹	Households with enough nets²	Population access³	Population net use⁴	Use:access ratio⁵
Poorest	19.9 (16.1-24.2)	4.0 (2.6-6.0)	8.3 (6.3-10.2)	1.6 (0.6-2.6)	0.19
Second Poorest	24.6 (20.4-29.3)	3.5 (2.0-6.1)	10.9 (8.8-13.0)	3.3 (1.7-4.9)	0.30
Medium	34.0 (28.9-39.5)	5.2 (3.1-8.4)	16.4 (13.3-19.5)	5.9 (3.4-8.5)	0.36
Wealthier	44.6 (39.7-49.5)	8.7 (6.4-11.5)	22.6 (19.9-25.4)	13.7 (9.7-17.7)	0.61
Wealthiest	60.5 (55.4-65.4)	17.4 (14.1-21.2)	37.4 (33.9-40.9)	27.9 (23.1-32.8)	0.75
Overall	36.7 (32.6-41.0)	7.7 (6.1-9.7)	18.9 (16.0-21.9)	9.5 (6.8-12.2)	0.50

¹⁻⁵ Descriptions of mosquito net indicators are listed on Table 1

Additional file 2: Tabulated data representing household ownership, access and use of LLINs by district in Tanzania, October – December 2013 also presented in Figure 4.

Table 1: Ownership, access and use of LLINs by district in Tanzania, October - December, 2013

District	Household ownership ¹	Households with enough nets ²	Population access ³	Population net use ⁴	Use:access ratio ⁵
Bagamoyo	83.3 (74.3-89.6)	36.8 (28.7-45.6)	64.3 (56.3-72.3)	46.0 (38.4-53.6)	0.72
Kinondoni	62.5 (40.5-80.3)	19.3 (12.5-28.6)	42.6 (27.8-57.4)	31.1 (22.2-39.9)	0.73
Kilosa	81.3 (72.5-87.7)	32.5 (23.7-42.7)	55.7 (45.6-65.9)	40.5 (29.2-51.8)	0.73
Iringa	70.6 (62.1-77.9)	24.1 (16.9-33.0)	49.1 (42.9-55.4)	32.3 (28.1-36.5)	0.66
Mbozi	63.3 (49.7-75.0)	21.6 (14.8-30.5)	43.7 (33.4-54.1)	16.9 (8.7-25.0)	0.39
Kahama	72.5 (60.0-82.3)	18.8 (13.2-26.0)	44.1 (34.5-53.7)	22.8 (15.6-30.1)	0.52
Geita	77.3 (66.5-85.4)	16.0 (12.2-20.8)	45.6 (40.7-50.5)	33.6 (28.4-38.8)	0.74
Musoma	80.8 (74.1-86.0)	20.0 (13.8-27.9)	48.6 (42.9-54.4)	39.0 (32.0-46.0)	0.80
Overall	74.5 (71.0-77.7)	23.8 (21.2-26.7)	49.2 (46.3-52.0)	32.8 (29.9-35.8)	0.66

¹⁻⁵ Descriptions of mosquito net indicators are listed on Table 1

3 THE CONSEQUENCES OF DECLINING POPULATION ACCESS TO INSECTICIDE TREATED NETS (ITNs) ON NET USE PATTERNS AND PHYSICAL DEGRADATION OF NETS AFTER 22 MONTHS OF OWNERSHIP

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3.1 Abstract

Background: As the number of insecticide-treated nets (ITNs) in households (access) declines when nets wear out, some household-members are prioritised to use the remaining ITNs. This study assessed how nets are allocated within households to individuals of different age categories as ITNs are lost or damaged and as new ITNs are obtained. The study also explored how ITN allocation affects ITN durability.

Methods: A cross-sectional household survey and ITN durability study was conducted among 2,875 households across Tanzania to determine the proportion of nets that remain protective (serviceable) twenty-two months after net distribution aiming for universal coverage. Allocation of study nets within houses and re-allocation of ITNs when new Universal Replacement Campaign (URC) nets arrived in study households in Musoma District was also assessed.

Results: Only 57.0% [95% CI: 53.9-60.1%] of households had enough ITNs for every household member (assuming one net covers every 2 members). In households with enough nets, 77.5% of members slept under ITNs. In households without enough nets, pregnant women (54.6%), children <5 (45.8%) and adults (42.1%) were prioritised, with fewer school-age children 5-14 (35.9%), youths 15-24 (28.1%) and seniors >65 (32.6%) sleeping under ITNs. Crowding (≥ 3 people slept under nets) was twice as common among people residing in houses without enough nets for all age groups apart from children <5. Nets were less likely to be serviceable if ≥ 3 people slept under them (OR=0.50 [95%CI 0.40-0.63]); if nets were used by school-age children (OR=0.72 [95%CI 0.56-0.93]) and if the net product was Olyset[®]. One month after the URC, only 23.6% [95%CI 16.7-30.6%] had access to an URC ITN in Musoma district. Householders in Musoma district continued the use of old ITNs even with the arrival of new URC nets.

Conclusions: Users determined the useful life of ITNs and prioritized pregnant women and children < 5 to serviceable ITNs. When household net access declines, users adjust by crowding under remaining nets, which further reduces ITN lifespan. School-age children that commonly harbour gametocytes that mediate malaria transmission are compelled to sleep under unserviceable nets, crowd under nets or remain uncovered. However, they were accommodated by the arrival of new nets. More frequent ITN delivery through the school-net program in combination with mass distribution campaigns is essential to maximize ITN effectiveness.

Keywords: Insecticide treated nets (ITNs), access, net allocation, net prioritization, crowding, ITN serviceability, malaria

3.2 Background

Insecticide-treated nets (ITNs) are impactful in the fight against malaria in sub-Saharan Africa [1]. In Tanzania the previous decade, mass distribution campaigns of ITNs have been conducted every four years (2010-2011, 2015-2016 [2, 3]). Through mass distribution, coupled with targeted campaigns, approximately 80 million ITNs have been distributed in Tanzania since 2000 [2-6], resulting in a 12% reduction in malaria deaths and 15% reduction in cases per capita at risk since 2010 [7, 8]. These gains against malaria in Tanzania can also be attributed to early implementation of successful Behavioural Change Communication that has encouraged appropriate and sustained net use among populations at risk of malaria [9].

Effective malaria protection by ITNs is achieved when at least 80% of household members have access to, and sleep under ITNs [10]. The World Health Organization (WHO) recommends the combination of mass campaigns and targeted mechanisms to ensure continued universal coverage of at least one ITN to cover every two people in a household, for all populations in malaria-endemic countries irrespective of age or gender [11]. To account for differences in household size, one net for every 1.8 persons is recommended during procurement to ensure universal access to ITNs within households [12]. Despite best efforts, population access to ITNs (the percentage of the population with access to an ITN within their household, assuming each ITN is used by 2 people) remains below the target level of 80% in many malaria endemic areas [13]. According to the 2017 Tanzania Malaria Indicator Survey, 63% of the population had access to an ITN while only 52% slept under an ITN the previous night [14]. ITN access in Tanzania has remained around 50% since 2010 with peak access of 75% in 2011 and 63% in 2017 after mass distribution of ITNs [14]. Access to ITNs tends to generally be high after mass distribution but falls rapidly as nets wear out [15]. With time and use, ITNs in households get

damaged and when they are no longer perceived to be useful, they are discarded by the householders [16-19], resulting in lower population access to nets [20]. Moreover, an ITN is only effective for as long as it remains serviceable i.e. sufficiently physically intact to provide adequate personal protection against malaria [21]. There is good evidence that when used, ITNs provide personal protection against malaria even in areas of high mosquito resistance to insecticide [22]. Therefore, it is important to understand underlying reasons for the loss of nets from households and reasons why they may not be used in order to maximise the longevity and use of existing ITNs in Tanzania.

There are several factors that affect ITN access and use, including household size [23], user characteristics: age, gender, pregnancy status [24-26], and socio-economic status (SES) [27]. So, as nets wear out and access to nets declines, it is likely that households will prioritize who will use the remaining net(s) based on the number of net(s) currently available in the household and their condition [28-30]. Potential consequences of prioritization could be 1) crowding, i.e. more than the two household members assumed to share a net, sleeping under the same net; and/or 2) some household members being left uncovered. It is important for National Malaria Control Programs (NMCPs) in malaria-endemic countries to understand how households decide on who to prioritize for bed net use within households, so they can inform behavioural change communication strategies, design targeted ITN delivery mechanisms for at risk groups or, if needed, increase the frequency of mass ITN campaigns. This study assessed how nets are allocated within households to individuals of different age categories as ITNs are lost or damaged; and as new ITNs are obtained. In addition, it explores how ITN allocation among houses without enough ITNs further impacts ITN durability.

3.3 Methods

In 2015, a cross-sectional household survey was conducted in 2,875 households across eight districts enrolled in a 3-year ITN durability study in Tanzania [31, 32]. The survey was conducted between October and December just before the short rainy season when malaria transmission is usually low. The households randomly received one type of ITN from a pool of three products (referred hereafter as *study nets*): Olyset[®], NetProtect[®], PermaNet[®], to cover every sleeping space identified during enrolment in 2013. Study nets were identifiable by their colour (white) and with a durable waterproof label to allow longitudinal follow up. The average number of sleeping spaces per household among the study population was 3.1 and each household received an average of 3 study nets. Study-net dimensions were of double size (190cm x 180cm x 150cm) assumed to fit two people under each net similar to those distributed by the NMCP (Ikupa Akim, pers. comm).

The data presented here are from a survey conducted 22 months after ITN distribution, which coincided with the government's Universal Replacement Campaign (URC) in 2015, creating an opportunity to see how nets are allocated as new nets are received among households. The URC took place in Musoma, one of the eight study districts, one month prior to the study survey. PermaNet[®] 2.0 was the net product distributed during the URC with a maximum of five ITNs distributed per household among households with ten or more members (Ikupa Akim, *pers. comm*). PermaNet[®] 2.0 ITNs distributed by the URC were also identifiable by their blue colour. Additional nets (*non-study nets*) acquired by household members within those 22 months (regardless of their source) were assessed and all ITNs were included in the analysis. Data was collected using a questionnaire (Additional file 1) on household members and their characteristics (age, gender, pregnancy status and SES), 2) access to and net use including

number of people sleeping under a net the previous night, and 3) the physical status (serviceability) of a maximum three study nets per household.

ITN physical degradation (serviceability)

Over time, nets become torn with repeated use. While the inclusion of pyrethroid insecticides helps to prevent mosquitoes entering nets to some extent [33], the more holes in a net, the more mosquitoes will enter the net and reduce the protection given to a net user [34]. It is important to understand how much of the net surface area is available for mosquitoes to pass through. This is often done using a standard metric, the proportionate hole index (pHI), which provides an easy means of comparing this damage by calculating the approximate holed surface area of the net. The study assessed the physical condition of a maximum of three study nets per household. The number and size of holes was assessed at household level using a portable frame [31], following WHO hole categorization [35]. The pHI was calculated for each ITN, and thereafter categorized as either serviceable (pHI: 0-642) or unserviceable (pHI: 643+). A net that is defined as unserviceable has been shown to offer reduced protection from mosquito bites and malaria [36].

Net prioritisation

An in-depth assessment of some of the Roll Back Malaria Monitoring and Evaluation Reference Group (MERG) indicators [37, 38] as well as characteristics of ITN users (Table 1), was performed by the study team in all 8 study districts to understand 1) which users (age category, gender and pregnancy status) were prioritized when ITNs are lost or damaged and 2) how ITN allocation among houses without enough ITNs further impacts ITN durability (age, number of occupants). Data from Musoma where the URC had been conducted was used to understand

which users (age, gender and pregnancy status) were prioritized for the allocation of new nets and which users continued to use the older “*study nets*”. Age categories in years were children under the age of 5, school-age children 5-14, youth 15-24, adults 25-65 and seniors 65+.

Table 1. Roll Back Malaria Monitoring and Evaluation Reference Group (MERG) ITN indicators assessed [37, 38].

ITN indicator	Indicator description
Household with enough ITNs	Percentage of households with at least one ITN for every two people.
Population access	Percentage of the population with access to an ITN within their household (assuming each net is used by two people).
Population ITN use	Percentage of the population that used an ITN the previous night.
ITN use:access ratio	Percentage of the population that used an ITN the previous night divided by the percentage of the population that had access to an ITN

Statistical analysis

Data analysis was carried out using statistical software package STATA 14.1 (StataCorp LP, College Station, TX). Survey weights were used to compensate for unequal sampling units, adjust for non-response, and a multi-level modelling approach. Net use and the proportion of serviceable and unserviceable study nets by user age category, among houses with and without enough nets for every two members, are presented as frequencies and percentages. Statistical analysis of the effect of crowding (more than two people sleeping under a net) on net serviceability were done using logistic regression models with crowding as the main exposure. Other predictor variables specified *a priori* were user characteristics (age, gender), SES and net product. A forward-selection procedure was applied for modelling and the selection was based on change in main exposure effect estimate (mean square error). The procedure involved three main steps: a) descriptive analysis and preliminary investigations for association between variables while paying attention to the sizes of effects as well as two-sided p-values at 95% significance level; b) variables

selection; from prior knowledge, age and sex were considered as forced variables in the model. Then, one variable at a time from a list of candidate variables obtained from univariate analysis was included in the model with and without adjustment of forced variables to understand the effect of forced variables. The choice of the “best” predictor to be included in the model was then decided based on the change in exposure effect estimate. Each time a new variable was added in the model, evidence of confounding and multicollinearity was assessed by comparing the effect estimates and standard errors between the “univariate” and “multivariate” models estimates; and c) multivariable models were fitted by adding explanatory variables that were removed from the models in step “b” one at a time to explore their effect when added to the model in presence of other variables in the model. Variables that resulted in positive changes in the mean square error were then included in the model. The process was repeated until all variables that provided precise estimates of exposure variables were selected.

3.4 Results

A total of 2,875 households were visited from eight study districts. Mosquito nets were found in 2,801 (97.4%) households of which, 1,668 (58.0%) had only study nets, 1,126 (39.2%) had both study and non-study nets, and 7 households (0.2%) had only non-study nets. Overall, 9,178 mosquito nets were found, of which 5,899 were in households with enough ITNs and 3,288 in households without enough ITNs. Of these mosquito nets, 6,938 (75.6%) were identified as “*study nets*” and 2,249 (24.5%) as “*non-study nets*” since they were obtained from other sources. Of the non-study nets, 712 (31.7%) were identified as ITNs based on their product label. Therefore, a total of 7,650 ITNs (study and non-study) were identified and included in the analyses presented.

ITN access

In 2013, as part of the study design, 100% of sleeping spaces were covered by study nets and this fell to 42.6% of sleeping spaces covered by study nets after 22 months. Including study nets and non-study ITNs, 57% [95% CI: 53.9-60.1%] of the participating households still had enough ITNs i.e. one ITN for every two household members assuming each ITN is used by two people. Eighty-four percent [95% CI: 82.4-86.4%] of the population living in the participating households had access to an ITN, assuming each ITN was used by two people, and 53.2% [95% CI: 52.4-54.0%] of those with access used an ITN the previous night (Table 2). Population access to ITNs among larger households (>10 household members) was 79.0% [95% CI: 72.7%-85.4%] while in smaller households (\leq 10 household members) was 93.2% [95% CI: 91.8%-94.5%]. This data is broadly similar to data collected by the Tanzania Malaria Indicator Survey, two years after the URC (Table 2), indicating that ITNs last around 2 years in Tanzania.

Table 2: Comparison of ITN use and access indicators across study districts in 2015, 2 years after study ITN distribution versus the Tanzania Malaria Indicator Survey in 2017, two years after the Universal Replacement Campaign

District	Households with enough ITNs*		Population Access to ITNs*		Population ITN use		ITN use:access ratio****	
	Study** (95% CI)	Malaria Indicator Survey***	Study** (95% CI)	Malaria Indicator Survey***	Study** (95% CI)	Malaria Indicator Survey***	Study**	Malaria Indicator Survey***
Bagamoyo	61.1 (54.1-67.8)	61.8%	82.7 (78.2-86.9)	76.5%	63.5 (61.3-65.6)	83.7%	0.76	1.09
Geita	40.8 (34.2-47.9)	26.8%	70.3 (66.0-74.7)	51.5%	47.6 (45.7-49.6)	78.0%	0.68	1.51
Iringa	71.2 (64.4-77.2)	36.8%	87.7 (83.4-91.9)	55.2%	57.4 (55.0-59.8)	78.1%	0.66	1.41
Kahama	48.1 (38.7-57.7)	28.0%	72.9 (66.4-79.4)	49.1%	42.6 (40.8-44.5)	65.9%	0.58	1.34
Kilosa	61.8 (57.8-65.6)	57.5%	83.8 (80.9-86.7)	73.7%	62.3 (60.0-64.5)	76.7%	0.74	1.04
Kinondoni	53.6 (46.4-60.7)	55.3%	75.1 (67.2-83.0)	70.8%	47.1 (43.6-50.5)	78.2%	0.63	1.10
Mbozi	56.4 (49.8-62.8)	47.7%	79.4 (74.3-84.4)	61.9%	32.1 (30.0-34.3)	44.6%	0.4	0.72
Musoma	61.8 (56.5-60.1)	46.9%	86 (83.2-88.7)	71.8%	71.2 (69.3-72.9)	69.1%	0.83	0.96
Total	57.0 (53.9-60.1)	45.4%	84.4 (82.4-86.4)	62.5	53.2 (52.4-54.0)	66.7%	0.63	1.06

* Assuming each net is used by two people

** Denominator is 7,650 ITNs (study and non-study ITNs) found in all participating households

*** Findings from the 2017 Tanzania Malaria Indicator Survey (TMIS) [14]

**** Colour codes for use:access ratio; Green = good (≥ 0.80); Yellow = below target level ($\geq 0.60 - <0.80$); and Red = poor (<0.60)

The effect of household access on ITN prioritisation

Pregnant women and children under 5 years were most likely to sleep under an ITN irrespective of the household's ITN access, while young adults (15-24 years) contributed the lowest percentage of ITN users (Fig 1a). Household access to nets clearly affected how nets were allocated within households. In houses with enough nets 77.5% of members slept under ITNs compared to 37.5% of members in households without enough nets. There was prioritisation for children <5 and pregnant women in both access scenarios, but in houses without enough nets this prioritisation was more pronounced (Fig 1a).

In households with enough nets, 91.1% of pregnant women slept under ITNs, 13.6% higher than the household average of 77.5% use. In houses without enough nets, a 17%-point increase in net use among pregnant women was observed when compared to the average household use (54.6% versus 37.4%). For children <5years, 82.9% slept under an ITN, 5.4% higher than the household average of 77.5%. In houses without enough nets, 45.8% of children <5years slept under ITNs, which is 8.4% higher than the household average use of 37.4%. A slightly smaller proportion of children 5-14 years slept under ITNs compared to the household average in both houses with enough nets (75.7% versus 77.5%) and in households without enough nets (35.9% versus 37.4%). Youth were also less likely to be prioritised to ITNs in houses with enough nets (5% lower than household average) and this was more pronounced in houses without enough nets (9.3% lower than household average). Seniors were less likely to be prioritised to ITN use in houses without enough ITNs, with only 32.6% of them sleeping under nets which was 4.8% lower than the household average, although this was not seen in houses with enough ITNs.

The variation observed in net use across user categories was related to sleeping space allocations. In descending order; seniors, youths and adults reported the highest percentages of users that

slept alone under a net irrespective of whether the household had or did not have enough nets (Fig 1b). Children under the age of 5 and pregnant women were most likely to share a net with another sleeper (Fig 1b).

The effect of household access on the number of people sleeping under an ITN

A total of 2,177 households (1,314 with and 863 without enough ITNs) had ITNs that were used last night. Of the 3,288 mosquito nets found in households without enough ITN's, 25.1% [95% CI: 23.0-27.3] were used by three sleepers while 8.8% [95% CI:8.0-9.7] of the 5,899 nets found in households with enough ITNs were used by three or more people. The proportion of three or more household members sleeping under one net was higher in households without enough ITNs (62.1% [95% CI 60.7-63.6]) compared to those with enough ITNs (30.5% [95% CI 29.2-31.7] (Table 3)). Similarly, use:access ratio of >1 (Table 2) which implies more than 2 people slept under these ITNs [23], was observed in the majority of districts during the TMIS survey, and was more pronounced in Geita, Iringa and Kahama districts which had lower proportions of houses with enough ITNs. When the population net use by three or more sleepers was explored by age category, the trend of crowding in households without enough nets doubled that of households with enough nets for all age categories except for under-fives who are more likely to sleep with their parents (Table 3).

Table 3: Population ITN use by 3 or more people by household access

	Households with enough ITNs			Households without enough ITNs		
Number of households with ITNs used last night	1,314			863		
Number of nets found in households	5,899			3,288		
Number of nets used by three or more people	519			824		
% of nets used by three or more people [95%CI]	8.8(8.0-9.7)			25.1 (23.0-27.3)		
Age in years	n₁	n₂	Crowded** (95% CI)	n₁	n₂	Crowded ** (95% CI)
Under 5	612	389	63.6 (59.7-67.3)	814	687	84.4 (81.8-86.8)
5-14	1,446	441	30.5 (28.2-32.9)	1,256	756	60.2 (57.4-62.8)
15-24	945	185	19.6 (17.2-22.2)	630	313	49.7 (45.8-53.6)
25-64	1,880	539	28.7 (26.7-30.8)	1,391	844	60.7 (58.1-63.2)
64+	331	34	10.3 (7.4-14.0)	155	38	24.5 (18.4-31.9)
Total	5,214	1,588	30.5 (29.2-31.7)	4,246	2,638	62.1 (60.7-63.6)
* Assuming each net is used by two people						
** Net use by three or more sleepers						
n ₁ =Number of people who slept under net last night						
n ₂ = Number of people who were crowded						

ITN serviceability

Holes were counted in 4,783 (68.9%) of the 6,938 study nets 22 months after distribution. Of these, 3,735 (78.1%) nets were still serviceable while 1,048 (21.9%) were unserviceable. Only 3,622 (75.7%) of the 4,783 ITNs assessed for physical damage were used the previous night. Furthermore, 847 (80.8%) of unserviceable nets and 2,775 (74.3%) of serviceable nets were used last night. Prioritisation of serviceable nets was also observed. On average, 32.6% people slept under serviceable ITNs last night whereby, around 7% more pregnant women (40.5%), adults (39.2%), seniors (39.3%) and 5% fewer children 5-14 (27.8%), and 6% fewer youth 15-24 (26.6%) slept under a serviceable ITN (Fig 1c). Pregnant women reported the highest use of nets irrespective of serviceability (54.2%) followed by adults (49.2%) and children under-five

(47.5%) (Fig 1c). Children (5-14 years) and young adults (15-24 years) were less likely to sleep under an ITN and if they did sleep under an ITN it was more likely to be unserviceable (Fig 1c).

Fig 1a) Use by household access to ITNs

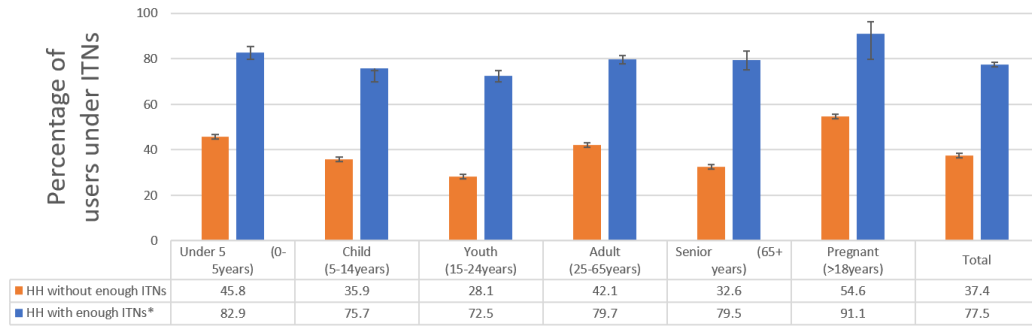


Fig 1b) Percentage of users that slept alone under an ITN by household access to nets

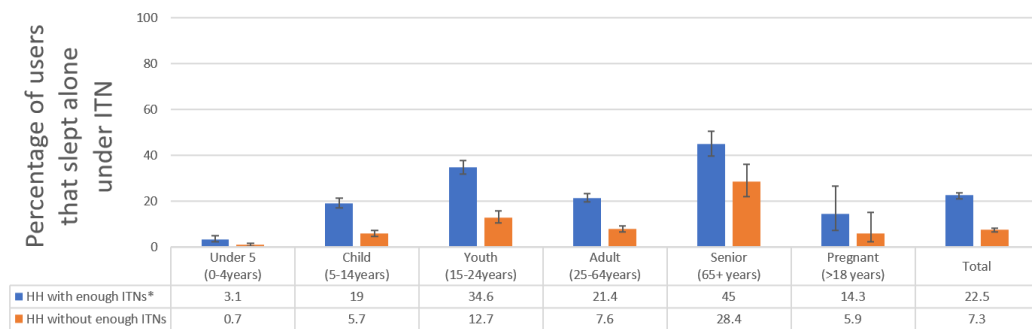
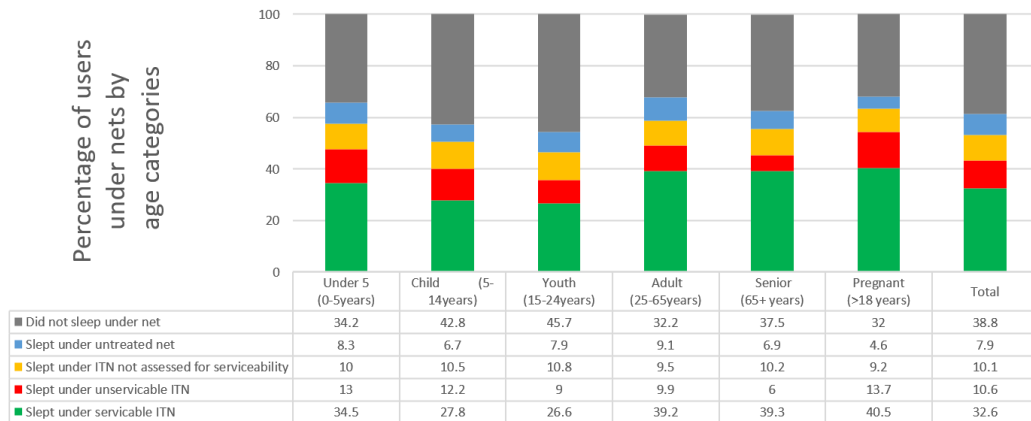


Fig 1c) User categories under ITNs by serviceability



*Assuming each net was used by two people

~Error bars represent the uncertainty of the corresponding point estimate (95%CI)

Fig 1: ITN use assessment by user categories and serviceability: 1a) the denominator used is 7,650 ITNs found in the participating households; 1b) while some sleepers slept under an ITN their appropriate age could not be accounted for; and 1c) denominator includes all 9,178 nets found in households during the survey.

Results of univariable and multivariable analyses exploring the consequences of net allocation on ITN serviceability are presented in Table 4. The number of people that slept under an ITN, the age category of net users, and socio-economic status were all significantly associated with ITN serviceability ($p < 0.001$) in the univariate analysis. The odds of NetProtect® nets being serviceable was two times the odds of Olyset® nets. 2.08 [95% CI 1.68-2.58], $p < 0.001$. ITNs used by children (5-14years) had lower odds of being serviceable compared to those used by under-fives 0.72 [95% CI 0.56-0.93], $p < 0.001$. Controlling for net product and user characteristics (age, gender and socio-economic status), crowding was significantly associated with unserviceable ITNs ($P < 0.001$). Compared to one person under a net, having two people under the net reduced the odds of serviceability to OR=0.75 [95% CI: 0.60-0.83] and having three people under the net further reduced the odds of serviceability to OR=0.50 (95% CI: 0.40-0.63).

Table 4: Univariable and multivariable analysis of factors associated with serviceability of study ITNs

	N	Number serviceable, n (%)	Crude Estimates		Adjusted Estimates*	
			OR (95% CI)	P-Value	OR (95% CI)	P-Value
# of people under net						
1	1254	1006(80.2)	1	<0.001	1	<0.001
2	866	611 (70.6)	0.60 (0.46-0.77)		0.75 (0.60-0.83)	
3+	788	497 (63.1)	0.45 (0.33-0.59)		0.50 (0.40-0.63)	
User characteristics						
Age (years)						
Under 5	450	312 (69.3)	1	<0.001	1	<0.001
5-14	786	493 (62.7)	0.74 (0.58-0.95)		0.72 (0.56-0.93)	
15-24	392	286 (73.0)	1.19 (0.88-1.61)		1.06 (0.78-1.45)	
25-65	1118	879 (78.6)	1.63 (1.27-2.08)		1.29 (0.99-1.68)	
65+	162	144 (88.9)	3.54 (2.08-6.01)		2.62 (1.51-4.54)	
Socio-economic Status						
Poorest	640	479 (74.8)	1	0.009	1	0.012
Poor	550	393 (71.5)	0.84 (0.65-1.09)		0.85 (0.66-1.11)	
Middle	510	365 (71.6)	0.85 (0.65-1.10)		0.81 (0.62-1.06)	
Wealthy	635	435 (68.5)	0.73 (0.57-0.93)		0.71 (0.55-0.91)	
Wealthiest	537	442 (77.1)	1.13 (0.87-1.48)		1.09 (0.83-1.43)	
Gender						
Male	1,338	951 (71.1)	1	0.070	1	0.081
Female	1,570	1,163 (74.1)	1.16 (0.99-1.37)		1.16 (0.98-1.38)	
Net product						
Olyset®	1520	1066 (70.1)	1	<0.001	1	<0.001
PermaNet®	1667	1317 (79.0)	1.26 (1.04-1.53)		1.32 (1.08-1.61)	
NetProtect®	1596	1349 (84.5)	1.95 (1.58-2.40)		2.08 (1.68-2.58)	

*adjusted for other factors in the table

Universal Replacement Campaign in Musoma

A total of 398 households were visited in Musoma district by the study team in 2015 of where seven households were found with no nets. The average number of sleeping spaces per household was found to be 3.3 and the average number of people per household was 6.1. Forty-four percent [95% CI: 38.8-48.8%]) of households had at least one URC net with an average of 1.4 URC nets per household. Ten percent [95% CI: 9.2-12.6%] of the households had “enough” URC nets, 23.6% [95% CI 16.7-30.6%] of the population in those households had access to a

URC and 27.7% [95% CI 25.9-29.5%] of the population used a URC net the night before the survey (Additional file 2). Of the 1,971 total nets identified in Musoma district, 48.4 % were distributed by the study, 17.0% from URC, 1.9 % from Shop/Market, 0.9% from non-governmental/charity organizations and 31.9% from other sources (unknown to the respondent at the time of the survey). Overall, 84.1% of 1,971 nets were used in the night preceding the survey indicating a use:access ratio of 0.78.

Houses with enough nets

In households with enough nets in Musoma district, 85.0% of the nets used were study nets (Table 5). Adults (25-64 years) and children under five reported the highest use of study nets. Youth (15-24) were the main users of nets from other sources when households had enough nets while children (5-14 years) had the highest URC net use (Table 5).

Houses without enough nets

Sixty-four out of 398 households in Musoma district did not have enough nets. All of these households were among the lowest two SES groups. Majority of these household members were reported to have slept under a study net (75.0%) the previous night in comparison to the 13.0% under URC nets and 12.0% under nets acquired from other sources (Table 5). Among the study nets used by households that do not have enough nets, Olyset® product was the most used at 36.0% (Table 5). Houses without enough nets had a lower percentage of use of URC nets at 13.0% compared to 18.9% of houses with enough nets and a lower proportion of nets from other sources at 12.0% compared to 35.3% of houses with enough nets.

Table 5: Net use by source of net in Musoma District

	Number of households	Total Nets	Nets used last night (%)	Study Nets N (%)			Total Study nets	URC N (%)	Other N (%)
				Olyset®	PermaNet®	NetProtect®			
Households with enough ITNs*	334	1833	1558 (85.0)	231 (32.3)	240 (33.6)	243 (34.0)	714 (45.8)	294 (18.9)	550 (35.3)
Households without enough ITNs	64	145	100 (72.5)	27 (36.0)	25 (33.0)	23 (30.7)	75 (75.0)	13 (13.0)	12 (12.0)

*Assuming each net is used by two people

3.5 Discussion

Twenty-two months post ITN distribution, 57% of households still owned enough ITNs and 84% of the population had access to an ITN within their household assuming each net was used by two household members. These results agree well with a multi-country survey assessment [39] and shows that, distributing nets to cover sleeping spaces identified in the households or limiting the number of nets a household can receive has potential to ensure most of the population have access to a net. However, it results in a low percentage of households with enough nets for all household members, which has ramifications for ITN durability. In Mozambique [40], assumptions on user characteristics, such as age and gender, to assess the likelihood of sharing a sleeping space were used by the NMCP to guide allocation of nets per sleeping spaces available in a household. This model was highly effective in achieving high access to households, but is logistically unrealistic for large countries without good census data. For Tanzania, it may be more practicable to deliver nets at a higher ratio than 1.8 to ensure all users, even those who sleep alone to have access to an ITN.

This study also showed evidence that as the number of people sleeping under an ITN increases (“crowding”), the number of serviceable nets in a household decrease. Eighty percent of household members were observed to sleep under a net when the person:net ratio was 3:1 and this decreased to 50% of the population using a net when four or more people slept under a single net with the remaining 50% being left uncovered [30]. While the use:access ratio observed in Table 2 may vary due to season of data collection, the high (>1) ratio indicates that as access to nets decreases within households, crowding increased which in turn will hasten net damage and increase risk of malaria incidence. In Yemen, non-use of ITNs was associated with ownership of multiple damaged nets [41]. In Liberia [24], a 32% reduction in ITN use was

associated with increase in household size while having three or more nets was associated with increased odds of ITN use. Importantly, mosquitoes are more attracted to households with a large family [42], so family size does need to be considered in the design of ITN distribution campaigns. Higher parasitaemia was observed among those with low ITN use in Tanzania [43] while malaria incidence in Senegal [44] rose after the third year when ITNs ownership had declined. Therefore, it may be more cost effective to distribute slightly too many nets rather than too few nets to ensure households have enough serviceable ITNs to cover the population available to slow the process of net damage as the protective effect of ITNs declines through time as nets accumulate damage [45].

Physical degradation of the net products was also observed to vary by product after 22 months of ownership. NetProtect® was two times more likely to be serviceable when compared to Olyset® in this setting. When compared to PermaNet®, Olyset® nets have been observed to have more holes in both Mozambique [46], Zambia [47] and Zanzibar [48] and mainland Tanzania [32]. In Madagascar [49], 55.6% of NetProtect® ITNs were in good condition after a year when compared to Royal Sentry® (56.8%) and Yorkool® (69.2%), which is lower than in the current study, indicating the importance of considering location when estimating ITN durability as cultural influences, net care and attitudes as well as the physical environment all impact on the expected life of ITNs. In fact, an analysis of PMI-country surveys found that the variation of overall durability of ITNs was larger between countries than among net types, although the durability of net types does vary within countries [50, 51]. A literature and data review by Koenker and Yukich [52] found that product attributes do not affect use, agreeing with this study which shows NetProtect® was used equally to the other products but was only found to be more durable in Tanzania.

The Tanzania NMCP should consider procuring the most appropriate longer-lasting ITN product to be distributed to ensure those nets distributed last for the intended interval between campaigns. Population access was 84.4% just prior to the URC campaign in the study population with the exception of Musoma district who had already received their campaign nets, which, in addition to study nets, increased access to 94.3%. Unfortunately, despite the URC that was conducted August 2015 - Jan 2017, none of the participating districts recorded an increase in population access according to the Tanzania Malaria Indicator Survey [14] that was conducted October-December, 2017, two years after the first district received their URC nets (Ikupa Akim, *pers Comm*). A 10% annual decrease in population access was also observed by Odufuwa et al [53] in both Ulanga and Bagamoyo districts in Tanzania. These findings suggest that the current 4-year universal coverage distribution intervals are too widely spaced, not in line with the WHO recommendations for mass distribution campaigns [11], and will provide suboptimal impact of ITNs for malaria control in Tanzania. Mass distribution campaigns distribute one ITN for every two household members, and generally result in lower than recommended access so it may be worth following the WHO recommendation of 3-year intervals to maintain malaria control gains, in addition to selecting the optimal ITN for the Tanzanian setting. Fortunately, Tanzania has adopted continuous distribution channels through the antenatal and immunization clinics, and the school-program [54], which will be essential to maintain universal coverage as also recommended by WHO [11]. The school-net distribution program is particularly important as the current study found that children of school age are most likely to be unprotected with either no net at all, or an unserviceable net and this age group is significant to malaria control as school age children are an infectious reservoir [55-57]. That children of school age are most likely to be unprotected is not a new finding as it was shown as early as 2009 that school age children are not

prioritised for ITNs [58]. However, it was seen that in houses with enough nets when families do not have to prioritise nets all age groups are likely to have access to ITNs. It is therefore prudent to maximise household ITN access during mass campaigns to ensure that all household members use nets and are not forced crowding under nets that is associated with decreased net serviceability.

Increasing access to nets within a household increases net use, which in turn will eliminate inequalities between age and gender [29]. Contrary to the study by Tsuang *et al* [30], where infants were prioritized to use new nets, in Musoma, children and youth had the highest use of newly acquired URC or nets from other sources. Therefore, while the school-aged children were less prioritized to use existing study nets irrespective of the household's access to enough nets, they were accommodated by the arrival of new nets. Both studies observed that each targeted group was reached by its respective distribution mechanism (Tanzania National Voucher Scheme reached pregnant women and infants) [59, 60] and SNP reached school aged children[5, 54, 61]) while the lack of sufficient access to nets in the households left older children to use unserviceable nets or remain uncovered.

Study limitations

The study distributed one ITN for every sleeping space identified during enrolment instead of using the recommended practice of one ITN for every two household members. While this distribution mechanism may have prevented distribution of excess ITNs to household members without unique sleeping spaces, it biased household and population access to ITNs to higher levels than would be achieved by national campaigns from enrolment.

There is also a challenge in the definition and measurement population access in assuming each ITN is used by two people. For example, if a woman of 25 years old is living with her uncle and they have only one net, in principle as per the MERG indicators for measuring household mosquito net distribution, population access is complete. However, in practice, these two people are unlikely to sleep under the same net, leaving one household member uncovered and population access incomplete. Therefore, this was a challenge while assessing population access that couldn't be changed or controlled for.

While even torn nets still offer chemical protection against mosquitoes [62, 63], including unserviceable nets (which are extensively damaged) in the calculation of population access, overestimates the proportion of household members with access to a net that is fully protective within their household.

A maximum of only three nets per household were assessed for their physical condition for logistical reasons. The three nets were randomly chosen potentially missing out 1) the most damaged nets in households, and 2) how sleeping arrangements of the population are affected by the physical status of the other nets. Quantifying all the ITNs would further inform the prioritization of net use in larger households with more than 3 nets.

3.6 Conclusion

Twenty-two months post ITN distribution, over 50% of sleeping spaces did not have access to a study net, despite complete coverage at baseline. However, the percentage of the population with access to ITNs was above the target of 80% while 57% of households had enough ITNs. The URC mass campaign helped to further maintain universal access to ITNs in Musoma district. These findings indicate that households hold on to their ITNs despite the arrival of new ones. Crowding under ITNs was associated with lower ITN serviceability most likely due to physical

stress on the ITN fabric that causes physical damage to occur faster, thereby reducing the serviceable life of the net. When households have enough nets, around 80% of members from all age categories have access to a net. However, when there are insufficient nets, children (5-15years) and youth (15-24years) were least likely to use any ITN or have access to a serviceable ITN. This is of significant biological importance since school-aged children carry gametocytes that cause transmission of malaria from humans to mosquitoes and maintain malaria transmission. Therefore, there is a need to refine delivery strategies to ensure households, including larger households to receive enough nets to cover all sleeping spaces. Hence, more frequent and more informed ITN distribution through keep up strategies such as the school-net program is essential to address these coverage inequalities and ensure continued protection against malaria transmission for all household members.

3.7 Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ifakara Health Institute (Ref: IHI/IRB/No: 19-2013), the National Institute of Medical Research, Tanzania (Ref: NIMR/HQ/R.8a/Vol I/285) and the London School of Hygiene & Tropical Medicine (Ref: 6333). The household questionnaire was administered upon written informed consent by interviewees above 18 years of age.

Consent for publication

This manuscript is published with the permission of the Director-General of the National Institute of Medical Research (NIMR), Tanzania.

Availability of data and materials

The datasets analysed in this current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that that they have no competing interests.

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Authors' contribution

HJO, LML, JM, and SJM conceived and designed the study. ZMM, DM collected the data. ZMM, CF, and JB analysed the data. ZMM wrote the manuscript. HJO, LML, JM, JB, WK, RM, IA, JL and SJM critically reviewed the manuscript. All authors read and approved the final drafts of this manuscript.

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3.9 Additional Files

Additional file 1: Prospective household questionnaire used to collect data for the study

PROSPECTIVE HOUSEHOLD QUESTIONNAIRE

“The useful life of bednets for malaria control in Tanzania: Attrition, Bioefficacy, Chemistry, Durability and insecticide Resistance”

Introduction: Hello, my name is “.....”. I am from IHI and work on a project investigating how long bed nets last in Tanzania. Maybe you remember my team from last year when we visited.

To be filled in before the interview

0.0 Household Identification number |__|__|__|__|__|__|

0.1 Repeat Household Identification number |__|__|__|__|__|__|

0.2 Code of interviewer |__|__|

0.3 Date of interview |__|__| / |__|__| / |__|__|__|__| (Day/Month/Year)

0.4 Name of district |_____|

0.5 Name of village |_____|

0.6 GPS coordinates of household: S: |__|__|__|__|__|__| E |__|__|__|__|__|__|

0.7 Is this the same family that was visited last year? Yes

No

0.8 Is this household currently away on travels? Yes – STOP

No

0.9 INFORMED CONSENT OBTAINED: Yes

No – STOP

Section 1: "I would like to ask you (head of household or adult > 18 years) some questions about your household"

Section 1.1: Household listings

"I would first like to ask you some information about the members of your household and any temporary visitors to your household."

Nr	First name (residents + visitors)	Relationship to head of household?	Gender (1...Male, 2...Female)	Age (years), if less than 1 year: 00	Age (months) if less than 1 year	Highest level of education	Usual resident or temporary visitor?	Currently pregnant? (01...Yes, 00...No, 99...Don't know/NA)	Used a net last night? (1...Yes, 0...No 99...Don't know)
1.1	1.2	1.3 - code	1.4	1.5	1.6	1.7 - code	1.8 - code	1.9	1.10
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
11									
12									
13									
14									
<u>Codes for relationship to head of household (1.3):</u> 01...Head of household			<u>Codes for highest level of education (1.7):</u> 01...Never attended school			<u>Codes for usual resident or visitor (1.8):</u> 1...Usual resident			

02...Spouse	02...Some primary school	2...Temporary visitor
03...Son or daughter	03...Completed primary school (grade 7)	
04...Son-in-law or daughter-in-law	04...Some secondary school	
05...Grandchild	05...Completed secondary school O-level (Form 4)	
06...Parent	06... Completed secondary school A-level (Form 6)	
07...Parent-in-law	07...Higher education (university/college/vocational training)	
08...Brother or sister	99...Don't know	
09...Nice or nephew		
10...Other relative		
11...Adopted/foster/stepchild		
12...Not related		

"Just to make sure that I have a complete listing, are there any other persons living in your household that we have not listed, such as small children or infants?"

▢ *Go through list with respondent*

▢ *If yes, add these individuals to table above*

"Are there any other people living or staying here who may not be members of your family, such as visitors or friends or temporary workers?"

▢ *If yes, add these individuals to table above*

Section 1.2: Household characteristics

"Now I would like to ask you some general questions about this household."

Q #	Questions and filters	Coding category	Answer (enter coding categories)
1.11	Who is responding to the questions?	01...Head of household 02...Partner of household head 03...Other adult in household	_ _
1.12	How old is the respondent?	Age in years	_ _ if less than 18, STOP
1.13	What is the main source of income in the household head?	01...Salary 02...Business 03...Farming/livestock keeping	_ _ _____

		04...Skilled labour/Entrepreneurship (fundi, tailor) 05...Casual labour (kibarua) 06...Fishing 07...Driver/taxi/bajaji 08...Student 09...Pension 10...No source of income 11...Other, specify	
1.14	What is the main material of the roof? Observe	01...Grass /palm thatch 02...Corrugated iron sheets 03... Other metal, e.g. korie 04... Tembe house (roofed with soil) 04... Other, specify	_ _ <hr/>
1.15	What is the main material of the walls? Observe	01...Mud and sticks 02...Burned bricks 03...Cement bricks 04...Mud bricks (Matofali mabichi) 05...Other, specify	_ _ <hr/>
1.16	What is the main material of the floor? Observe	01...Earth 02...Cement 03...Tiles 04...Carpet 05...Wood 06...Other, specify	_ _ <hr/>
1.17	Are any of the windows screened with netting? Observe	01...Yes 00...No, go to 1.18	_ _
1.17a	What are the windows screened with? Observe	01...Wire mesh (metal/plastic) 02...Old bednet 03...Glass	_ _

		04...Bags / cloth 05...Other material, specify	_____
1.18	Does the house have an open eave gap? Observe	01...Yes 00...No	_ _
1.19	Does this house have a ceiling? Observe	01...Yes 00...No	_ _
1.20	What type of fuel does your household mainly use for cooking?	01...Electricity 02...Gas 03... Kerosene 04... Diesel-powered generator 05...Charcoal 06...Firewood/straw 07...Other, specify	_ _ _____
1.21	Does your house use any of the following sources of light? Prompt each category.	01...Yes 00...No	Electricity _ _ Hurricane lamp _ _ Candle _ _ Traditional lamp _ _ Fire _ _ Battery/solar torch _ _ None _ _
1.22	What is the principal type of toilet facility used by members of the household?	01...Own flush toilet 02...Shared flush toilet 03...Own pit latrine 04...Shared pit latrine 05...Bush/forest/field	_ _
1.23	What is the principal household source of drinking-water?	01...Piped water in home or yard/bottled water	_ _

		02...Rain water collection 03...Own well/pump 04...Shared well/pump 05...River/stream/pond/lake 06...Water truck/cart 07...Other, specify	
1.24	Does your household possess any of the following items? Prompt each category	01...Yes 00...No	Mobile phone __ _ Radio __ _ Refrigerator/freezer __ _ Electric Fan __ _ Television __ _ Satellite Dish/Cable __ _ Generator __ _ Air conditioner __ _ None of the above __ _
1.25	Does the household (any member) have any of the following means of transport? Prompt each category	01...Yes 00...No	Bicycle __ _ Motorbike __ _ Car/Truck __ _ Bajaji __ _ Animal/Cart __ _ Boat/Canoe/Jahazi __ _ None of the above __ _
Section 2: "Now I would like to ask you some questions about your bednets."			
2.1	How many sleeping places are there in your household? Include all sleeping spaces where a net could be hung up, or has ever been hung up, including if there is more than one sleeping space in each room used for sleeping		Indoors __ _ Outdoors __ _

2.1a	How many sleeping places <u>were used</u> last night in your household?		Indoors _ _ Outdoors _ _
2.2	How many mosquito nets that can be used for sleeping does your household have in total? Probe for nets not in use: stored, saved, unopened		_ _
2.3	In the past 6 months, have you heard or seen any messages or information about malaria?	01...Yes 00...No	_ _
2.4	What was the content of the message(s)? Select all that apply	01...Hang your net 02...Sleep under the net 03...Use the net all year round 04...Make sure others in your community have nets 05...Go quickly for treatment if the child has fever 06...Pata Pata jingle 07...Pregnant women should get SP 08...Care for/repair your nets	_ _
2.5	Where did you hear or see this/these messages?" Select all that apply	01...Radio 02...Television 03...Health worker 04...Newspaper 05...Billboards 06...Soccer match 07...Concert 08...Social event 09...Road shows/mobile video 10...T-shirt/caps 11...Friend/neighbour/family member 12...Tire cover	_ _

		13...Calendar 14... Poster/sticker 15...Community outreach worker (VEO, community change agent,CBO staff etc)	
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Section 2.1: Prospective roster.

Interviewer to find household list in household folder and enter first net serial number into PDA.

“Now could you please show me the nets in your household. I will need access to the barcode that is attached to the net.”

Q #	Questions and filters	Coding Category	Net 1	Net 2	Net 3
2.6	Net serial number <i>(from household list in household folder)</i>		_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _
2.6a	Re-enter net serial number <i>...once net is identified.</i>	<i>If net is no longer present, re-enter from household list.</i>	_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _
2.7	Net still in possession of the household	01...Yes, go to 2.9 00...No, go to 2.8 02...Temporarily away from house, go to 2.7a	_ _	_ _	_ _
2.7a	Where has this net been taken to? Go to NEXT NET or if there are no more ABCDR nets, to Section 5	01...Farm / forest 02...Taken to another house 03...To school / college 04...Temporary travelling 05...Other, specify	_ _ _____	_ _ _____	_ _ _____
2.8	If no, why not?	01...Net thrown away Go to 2.8.1 02...Net used for something else Go to 2.8.5	_ _	_ _	_ _

		03...Net was given away Go to 2.8.7 04...Net was sold Go to 2.8.10 05...Net was stolen Go to 2.8.10 06...House/room collapsed Go to 2.8.10 99...Don't know Go to 2.8.10			
2.8.1	Why was the net thrown away?	01...Too damaged for sleeping under Go to 2.6.2 02...Did not like the net for sleeping under Go to 2.6.3 03...Do not use nets for cultural reasons Go to 2.6.1a	_ _	_ _	_ _
2.8.1a	Please specify the cultural reason for non-use of mosquito nets.	Specify	_____	_____	_____
2.8.2	How was the net damaged? <i>Do not prompt. Record all reasons that the person mentions.</i> Go to 2.6.4	01...By fire 02...Rodents 03...Children 04...Wear and tear 05...Other, specify 99...Don't know	_ _ _____	_ _ _____	_ _ _____
2.8.3	Why did you not like the net? <i>Do not prompt. Record all reasons that the person mentions.</i>	01...Too hot 02...Net too small 03...Net too big 04...Mesh size too big 05...Don't like the feel of the material	_ _	_ _	_ _

	Go to 2.8.4	06...Don't like the colour 07...Net too dirty / infested with bedbugs 08...Don't like the smell 09...Net makes me sneeze, itch, head ache 10...Net has too many holes 11...Doesn't protect against mosquitoes 12...For cultural reasons, go to 2.8.3a			
2.8.3a	Please specify the cultural reason for non-use of mosquito nets.	Specify _____	_____	_____	_____
2.8.4	How did you discard of the net? Go to 2.8.10	01...Burned inside the house 02...Burned outside the house 03...Buried 04...Threw away as rubbish, <u>specify where</u> 05...Recycled 99...Don't know	_ _ _____	_ _ _____	_ _ _____
2.8.5	Why did you use the net for something else?	01...Too damaged for sleeping under 02...Did not like the net for sleeping under 03...More useful things to do with it 04...For cultural reasons, go to 2.8.5a	_ _ 	_ _ 	_ _
2.8.5a	Please specify the cultural reason for non-use of mosquito nets.	Specify _____	_____	_____	_____
2.8.6	If used for something else,	01...Screen windows/doors 02...Screen or fence toilet	_ _ 	_ _ 	_ _

	<p>what was it used for?</p> <p>Go to 2.8.10</p>	<p>03...Protect garden (fence in or cover crops from birds)</p> <p>04...Protect animals (chickens or ducks)</p> <p>05...Fishing</p> <p>06...Mattress/pillow</p> <p>07...Agriculture, e.g. dry cassava</p> <p>08...Make rope</p> <p>09...Stored for visitors</p> <p>10...Other, specify</p>	_____	_____	_____
2.8.7	If given away, to whom?	<p>01...Neighbours</p> <p>02...Other wife</p> <p>03...Children going to school/college</p> <p>04...Children getting married/starting a family</p> <p>05...Parents</p> <p>06...Other relatives</p> <p>07...Others, specify</p> <p>99...Don't know</p>	_ _	_ _	_ _
2.8.8	If given away, why?	<p>01...Too many nets in household Go to 2.8.10</p> <p>02...Someone else needed net more Go to 2.8.10</p> <p>03...Replaced it with a better net Go to 2.8.9</p> <p>04...I do not like to use nets Go to 2.8.10</p> <p>05...Other, specify Go to 2.8.10</p>	_ _	_ _	_ _

2.8.9	<p>If replaced by a better net, why did you like the replacement net more?</p> <p>Do not prompt. Record all reasons that the person mentions.</p>	<p>01...Colour, specify which colour is preferred</p> <p>02...Less damaged</p> <p>03...Cleaner</p> <p>04...More suitable size, specify size (smaller or larger)</p> <p>05...More suitable length , specify length (shorter or longer)</p> <p>06...Nicer texture / material</p> <p>07...It was free</p> <p>08... Other, specify</p> <p>99...Don't know</p>	<p> </p> <p>_____</p>	<p> </p> <p>_____</p>	<p> </p> <p>_____</p>
2.8.10	<p>When was the net lost from the household?</p> <p>Go to NEXT NET or if there are no more ABCDR nets, to Section 5</p>	<p>01...less than 1 month ago</p> <p>02...between 1 and 3 months ago</p> <p>03...between 4 and 6 months ago</p> <p>04...more than 6 months ago</p> <p>05...more than 1 year ago</p> <p>99...Don't know</p>	<p> </p>	<p> </p>	<p> </p>
2.9	<p>Where is the net located?</p> <p>Observe</p> <p>Go to 2.10 unless option "6" was chosen</p>	<p>01...Hanging loose over a sleeping space</p> <p>02...Hanging and folded up or tied</p> <p>03...Stored inside a bag</p> <p>04...Stored but not in a bag</p> <p>05...Washed / drying</p> <p>06...Net used for alternative purposes Go to 2.9.1</p>	<p> </p> <p>_____</p>	<p> </p> <p>_____</p>	<p> </p> <p>_____</p>

2.9.1	Why did you use the net for something else?	01...Too damaged for sleeping under 02...Did not like the net for sleeping under 03...More useful things to do with it	_ _	_ _	_ _
2.9.2	If used for something else, what was it used for? Go to NEXT NET or if there are no more ABCDR nets, to Section 5	01...Screen windows/doors 02...Screen or fence toilet 03...Protect garden (fence in or cover crops from birds) 04...Protect animals (chickens or ducks) 05...Fishing 06...Mattress/pillow 07...Agriculture, e.g. dry cassava 08...Make rope 09...Stored for visitors 10...Other, specify	_ _	_ _	_ _
2.10	Is this net currently used for sleeping?	01...Yes Go to 2.11 00...No	_ _	_ _	_ _
2.10a	Why is this net not currently used for sleeping? Do not prompt. Record all reasons that the person mentions. Go to 2.22	01...Save the net for visitors 02...Save the net for future use 03...No place or materials to hang up 04...Currently have enough nets in use 05...Only used during the rainy season 06...User did not sleep here 07...Net washed / drying 08...No malaria now	_ _	_ _	_ _

		<p>09...No mosquitoes</p> <p>10...Net too old or too torn</p> <p>11...Net is dirty / full of bedbugs</p> <p>12...Net too hot</p> <p>13...Net too small</p> <p>14...Net too big</p> <p>15...Does not prevent mosquito bites</p> <p>16...Don't like the material</p> <p>17...Don't like the colour</p> <p>18...Net made me ill (sneeze, itch, headache)</p> <p>19...Net not used after death / funeral</p>			
2.11	What type of bed is the net used with?	<p>01...Wooden or iron bedframe (improved) [mbao, chuma, kimetengenezwa na fundi]</p> <p>02...Stick bedframe [mjiti, kimetengenezwa huko]</p> <p>03...No bedframe</p> <p>04...Other, specify</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>
2.11a	What type of mattress/sleeping material is used with this net?	<p>01...Nothing</p> <p>02...Reed mat (mkeka)</p> <p>03... Clothes/other net/material</p> <p>04...Foam/spring mattress</p> <p>05... Hammock</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>

		06...Other, specify			
2.12	What is the main material of the roof in this room? Observe	01...Grass /palm thatch 02...Corrugated iron sheets 03... Other metal, e.g. korie 04... Tembe house (roofed with soil) 04... Other, specify	_ _ _____	_ _ _____	_ _ _____
2.13	What is the main material of the walls in this room? Observe	01...Mud and sticks 02...Burned bricks 03...Cement bricks 04...Mud bricks (Matofali Mabichi) 05...Other, specify	_ _ _____	_ _ _____	_ _ _____
2.14	What is the main material of the floor in this room? Observe	01...Earth 02...Cement 03...Tiles 04...Carpet 05...Other, specify	_ _ _____	_ _ _____	_ _ _____
2.15	Who used this net last night?	Drop down menu with names from household roster 1.2. Follow up with “Is [name] x years old?” Allow multiple choices	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
2.16	During the previous week, how many times has the net been used?	01...Every night 02...5-6 nights 03...1-4 nights	_ _ 	_ _ 	_ _

2.17	Do you use any of the following sources for cooking, heating or lighting in the same room as the net?	01...Yes 00...No	Firewood Charcoal Gas Hurricane lamp Candle Koroboi Cigarettes	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2.18	In the last 6 months, have you seen any rats or mice in this room or their traces (faeces or damage)?	01...Yes 00...No 99...Don't know		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2.19	Do cats have access to this room?	01...Yes 00...No 99...Don't know		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2.20	During which periods of the year is this net used to sleep under?	01...All year 02...Rainy season only 03...Dry season only 99...Don't know		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2.21	Do you tuck the net in at night?	01....Yes, go to 2.22 00....No		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2.21a	Why do you not tuck the net in?	01...Net not long enough 02...Nothing to tuck under		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

		03...Feel too closed in / too hot 04...Too much effort / forgot 05...No need to tuck it 06...Other, specify	_____	_____	_____
2.22	Measure the net from the top to where it is tucked in.	Enter length in cm.			
2.23	Has the net ever been washed?	01....Yes 00....No, go to 2.27 99....Don't know, go to 2.27	_ _	_ _	_ _
2.23a	How many times did you wash the net in the last year?	01...Once 02...Once every 6 months 03...Once every 3 months 04...Every month 99....Don't know	_ _	_ _	_ _
2.23b	When was the last time you washed the net?	01...less than 1 month ago 02...between 1-3 months ago 03...between 4-6 months ago 04...between 6-12 months ago 05...more than 1 year ago 99...Don't know	_ _	_ _	_ _
2.24	What type of soap was used?	01....None 02....Local soap bar 03....Detergent powder 04....Mix (bar and detergent)	_ _	_ _	_ _

		05....Bleach 99....Don't know			
2.25	Was the net scrubbed hard or beaten on a hard surface?	01....Yes 00....No 99....Don't know	_ _	_ _	_ _
2.26	Where was the net dried?	01....Outside in the direct sun light 02....Outside in the shade 03....Inside 99....Don't know	_ _	_ _	_ _
2.27	Have you tried to fix any of holes in this net?	01....Yes 00....No, go to 2.29	_ _	_ _	_ _
2.28	How did you repair the hole? Go to 2.30	01...Stitched 02...Knotted/tied 03...Patched 04...Other way, specify	_ _ _____	_ _ _____	_ _ _____
2.29	If not, what was the main reason?	01...Too busy/no time 02...Not necessary, the net is still good 03...Don't know how to fix 04...Too damaged to fix 05...Other, specify	_ _ _____	_ _ _____	_ _ _____
2.30	Has the net been modified?	01...Yes 00...No, go to Section 3	_ _	_ _	_ _
2.31	How was the net modified?	01...Shape was changed 02...Material was added to lengthen	_ _	_ _	_ _

		03...Material was added to reinforce			
		04...Other, specify	_____	_____	_____
Section 3					
<i>"I am going to read a series of statements to you and I would like you to tell me how much you agree with them"</i>					
3.1	Which of these statements does best describe your net?	01... This net is still in a good condition and can be used without restrictions 02... This net is beginning to fall apart and should be replaced really soon 03... This net is no longer usable and definitely needs to be replaced	_ _	_ _	_ _
Section 4 Net inspection					
<i>"Now I will have a look at your nets and count the number of holes. The net will be returned to you and hung up again if you wish. We need to mount the net on a frame in order to find all the holes."</i>					
<i>Interviewer to mount net 1 on net frame for hole counting. Make sure that only one net is done at a time and enter the data directly from tally sheet into the PDA.</i>					
4.1	Does this net have any holes?	01...Yes 00...No, go to Section 5	_ _	_ _	_ _
4.2	What type of holes are observed? Answer every category	01...Yes 00...No	Horizontal tears at bottom Holes at hanging points Open seams Burn holes Holes from rodents Whole section missing	_ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _

4.3	Number of holes in zone 1	Size 1 (finger)	_ _	_ _	_ _
		Size 2 (fist)	_ _	_ _	_ _
		Size 3 (head)	_ _	_ _	_ _
		Size 4 (larger than head)	_ _	_ _	_ _
4.4	Number of holes in zone 2	Size 1 (finger)	_ _	_ _	_ _
		Size 2 (fist)	_ _	_ _	_ _
		Size 3 (head)	_ _	_ _	_ _
		Size 4 (larger than head)	_ _	_ _	_ _
4.5	Number of holes in zone 3	Size 1 (finger)	_ _	_ _	_ _
		Size 2 (fist)	_ _	_ _	_ _
		Size 3 (head)	_ _	_ _	_ _
		Size 4 (larger than head)	_ _	_ _	_ _
4.6	Number of holes in zone 4	Size 1 (finger)	_ _	_ _	_ _
		Size 2 (fist)	_ _	_ _	_ _
		Size 3 (head)	_ _	_ _	_ _
		Size 4 (larger than head)	_ _	_ _	_ _
4.7	Number of holes in the roof	Size 1 (finger)	_ _	_ _	_ _
		Size 2 (fist)	_ _	_ _	_ _
		Size 3 (head)	_ _	_ _	_ _
		Size 4 (larger than head)	_ _	_ _	_ _
Section 5 Additional Nets In Household					
<i>"This part is about any additional nets apart from the ones you received from our study team last October you may have inside your household. Please could you show us the nets and spare some time to answer the subsequent questions."</i>					
5.1	Do you own any additional nets in addition to the ones	01... Yes	_ _		

	distributed by our study team?	00... No, Go to NEXT SECTION			
5.2	How many additional nets do you have?	Enter number	_ _		
			Net 1	Net 2	Net 3
5.3	Where is the net located? Observe, if unsure – ask Go to 5.4 unless option “6” was selected	01...Hanging loose over a sleeping space 02...Hanging and folded up or tied 03...Stored inside a bag 04...Stored but not in a bag 05...Washed / drying 06...Net used for alternative purposes Go to 5.3.1	_ _ _____ 	_ _ _____ 	_ _ _____
5.3.1	Why did you use the net for something else?	01...Too damaged for sleeping under 02...Did not like the net for sleeping under 03...More useful things to do with it	_ _ 	_ _ 	_ _
5.3.2	If used for something else, what was it used for? END	01...Screen windows/doors 02...Screen or fence toilet 03...Protect garden (fence in or cover crops from birds) 04...Protect animals (chickens or ducks) 05...Fishing 06...Mattress/pillow 07...Agriculture, e.g. dry cassava 08...Make rope 09...Stored for visitors	_ _ _____ 	_ _ _____ 	_ _ _____

		10...Other, specify			
5.4	Is this net currently used for sleeping?	01...Yes Go to 5.5 00...No	_ _	_ _	_ _
5.4a	Why is this net not currently used for sleeping? <i>Do not prompt. Record all reasons that the person mentions.</i> Go to 5.17	01...Save the net for visitors 02...Save the net for future use 03...No place or materials to hang up 04...Currently have enough nets in use 05...Only used during the rainy season 06...User did not sleep here 07...Net washed / drying 08...No malaria now 09...No mosquitoes 10...Net too old or too torn 11...Net is dirty / full of bedbugs 12...Net too hot 13...Net too small 14...Net too big 15...Does not prevent mosquito bites 16...Don't like the material 17...Don't like the colour 18...Net made me ill (sneeze, itch, headache) 19...Net not used after death / funeral	_ _	_ _	_ _
5.5	What type of bed is the net used with?	01...Wooden or iron bedframe (improved) [mbao, chuma, kimetengenezwa na fundi]	_ _	_ _	_ _

		02...Stick bedframe [mjiti, kimetengenezwa huko] 03...No bedframe 04...Other, specify	_____	_____	_____
5.5a	What type of mattress/sleeping material is used with this net?	01... Nothing 02...Reed mat (mkeka) 03... Clothes/other net/material 04... Foam/spring mattress 05... Hammock 06...Other, specify	_ _	_ _	_ _
5.6	Who used this net last night?	Drop down menu with names from household roster 1.2. Follow up with “Is [name] x years old?” Allow multiple choices	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
5.7	During the previous week, how many times has the net been used?	01...Every night 02...5-6 nights 03...1-4 nights	_ _	_ _	_ _
5.8	How long ago did you start using this net?	01...Less than 1 week ago 02...Between 1 week and 1 month ago	_ _	_ _	_ _

		03...Between 1-6 months ago 04...Between 6-12 months ago 05...More than 1 year ago 06...Never used 99...Don't know			
5.9	What is the colour of the net? Observe	01...White 02...Light blue 03...Blue & white stripes 04...Dark blue 05...Green 06...Other	_ _	_ _	_ _
5.10	What is the shape of the net?	01...Round 02...Rectangular	_ _	_ _	_ _
5.11	What is the size of the net?	01...Single 02...Double 03...Extra-large	_ _	_ _	_ _
5.12	What is the brand of the net? Check label if present	01...Olyset 02...Safinet 03...PermaNet / Vestergaard Frandsen 04...Netprotect / BestNet 05...Interceptor / BASF 06...LifeNet / Bayer 07...Yorkool 08...DawaPlus / Tana Netting	_ _	_ _	_ _

		09...Duranet / Clarke 10...Royal Sentry 11...MAGNet 12...Afy Janet 13...Health net Ltd / Net health Ltd 14...Other, specify 99...Don't know, no label			
5.13	How long ago did you obtain this net?	01...Less than 1 week ago 02...Between 1 week and 1 month ago 03...Between 1-6 months ago 04...Between 6-12 months ago 05...More than 1 year ago 99...Don't know	_ _	_ _	_ _
5.14	Where did you obtain this net from?	01...Gift from relative /friend/neighbour 02...Shop/market 03...Hospital/dispensary 04...NGO/charity 05...Government campaign 06...Other, specify 99...Don't know	_ _	_ _	_ _
5.15	Did you pay money for this net?	01...Yes 00...No 99...Don't know	_ _	_ _	_ _

5. 16	Did you use a voucher to obtain this net?	01...Yes 00...No 99...Don't know		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.17	Does the net have any open holes/tears/seams? Observe inside the house	01...Yes 00...No, Go to END		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.18	What type of holes are observed? Observe inside the house Answer every category	01...Yes 00...No	Horizontal tears at bottom Holes at hanging points Open seams Burn holes Holes from rodents Whole section missing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.19	Is there any evidence of repair of the net? Observe inside the house	01...Yes 00...No		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

***** END OF THE QUESTIONNAIRE *****

Please write whether there were any comments about the study or the nets / any messages from the households.

.....
.....

Additional file 2: Coverage of nets in Musoma district by net source

	Households with enough nets* (95% CI)	Population Access to nets* (95% CI)	Population net use (95% CI)	Net use: access ratio**
URC nets only	10.8 (9.2-12.6)	26.9 (22.0-31.8)	27.7 (25.9-29.5)	1.03
Other nets only	32.9 (25.2-41.6)	48.6 (36.8-60.4)	4.3 (3.6-5.2)	0.09
Study nets only	39.7 (35.2-44.3)	72.2 (69.6-74.6)	41.3 (39.3-43.3)	0.57
Any net (Study + URC + Other nets)	83.9 (79.2-87.8)	94.3 (91.8-96.8)	73.3 (71.5-75.1)	0.78

* Assuming each net is used by two people

**Colour codes for use:access ratio; Green = good (≥ 0.80); Yellow = below target level (≥ 0.60 - <0.80); and Red = poor (<0.60)

4 “FOR THE POOR, SLEEP IS LEISURE” – UNDERSTANDING PERCEPTIONS, BARRIERS AND MOTIVATORS TO MOSQUITO NET CARE AND REPAIR IN SOUTHERN TANZANIA

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4.1 Abstract

Introduction: The rate of physical deterioration of long-lasting insecticidal nets (LLINs) varies by household practices, net brand and environment. One way to sustain the protection provided by LLINs against malaria is through day-to-day care and repairing holes as and when they occur. To ensure LLIN coverage is high between mass campaigns and as international donor funds decrease, personal responsibility to maintain nets in good condition is becoming more important. This study aimed to understand local barriers and motivators to net care and repair in southern Tanzania in a community that receives free LLINs through a school-based distribution mechanism.

Methods: Qualitative research methods were applied in a rural and peri-urban village in Ruangwa district. Focus Group Discussions (FGDs) were conducted for five groups of 8-12 participants; 1) key informants, 2) young men (18-24 years old), 3) women (>18 years) with children under the age of five, 4) older men (>25 years), and 5) older women with or without children (>25 years). In each village, five men, five women with or without children, and five women with children under the age of five were recruited for In-Depth Interviews (IDIs). After each IDI and FGD with women with young children, participants were guided through a participatory activity. The study also counted the number and size of holes in nets currently used by IDI participants to determine their physical degradation status.

Results: A general willingness to care and repair mosquito nets was observed in Ruangwa district for the love of a good night's sleep free of mosquito bites or noises. Net care was preferred over repair, especially among women who were the primary caretakers. The main motivation to look after nets was protection against mosquito bites and malaria. Washing nets occurred as frequently as every other week in some households to ensure cleanliness, which prevented other dirt-related problems such as sneezing and headaches. Barriers to net care included care not being a priority

in the day-to-day activities and lack of net retreatment kits. Net repair was reported to be a temporary measure and necessary as soon as a hole was identified. However, during the net assessment and participatory activity, it became clear that people did not actually repair smaller holes. Protection against mosquitoes, malaria and cost saving from replacing nets were identified as motivators for net repair. Barriers to net repair included it not being a priority to repair holes that could be tucked under the mattress and lack of knowledge on when to repair nets.

Conclusion: In Ruangwa, net care was defined as overall net maintenance, such as cleanliness, and not directly associated with the prevention of damage as reported in other studies. Net repair was reported as a temporary measure before the acquisition of a new net, hence not a priority in a busy household. Inconsistencies were observed between reported intentions to repair mosquito nets and current net condition. Targeted education through health facilities and community change agents are potential means to overcome barriers to net care and repair.

Keywords: Long-Lasting Insecticidal Nets (LLINs), mosquito net, net care, net repair, malaria, Tanzania, Health Belief Model

4.2 Background

The Government of Tanzania has made considerable effort in achieving universal coverage for its population with Long-Lasting Insecticidal Nets (LLINs) through a number of continuous and keep-up distribution mechanisms [1-3]. The physical deterioration of the net, while inevitable with time, varies by product type, household practices (e.g. use, washing) and environment (e.g. type of sleeping space) [4-8]. One of the ways to sustain the protection provided by LLINs is through personal responsibility of households to care for LLINs day-by-day [9]. Extending the lifespan of LLINs is important to reduce the frequency of net replacements and maintain high access to LLINs between distributions, to ensure continuing health gains from the use of nets [5].

The World Health Organization Pesticide Evaluation Scheme (WHOPES), now replaced by the Prequalification Team (PQT), recommends that LLINs remain effective after 20 standard washes and last three years under field conditions [10]. Manufacturers instruct specific care practices to prolong the useful life of the LLIN, such as hanging the net low enough to touch the ground or tucking underneath the mattress, washing gently with soap and water but not bleach, drying nets in the shade and avoiding direct sunlight, keeping net away from direct flames and repairing holes as soon as possible [11]. However, it is unclear how many households receive their nets with the packaging or if those who receive the instructions on the packaging understand and practice them.

Net care (i.e. hanging of net, daily storage/tying up net over sleeping space, washing, drying, seasonal storage) and repair (i.e. sewing, knotting, patching) practices are similar across communities, but vary in priority between households [12-14]. In Senegal [13], Nigeria [14] and Mali [12], net care was preferred and more common than repair. In Uganda [5], nets perceived too torn were most likely to be repurposed for alternative uses around the house rather than repaired. In urban Dar-es-Salaam, requesting users to reduce washing frequency to maintain enough

insecticide on nets was deemed impractical [15]. Accounting for variation in priority of performing net care and repair practices emphasizes the need to integrate local and culturally-fitting messaging with ongoing malaria interventions rather than promoting blanket universal recommendations across all endemic countries [16].

This study was conducted in southern Tanzania (Ruangwa district, Lindi region; Fig. 1) in 2016 after the third round of continuous LLIN distribution through the School Net Programme (SNP) conducted in 2015. Malaria prevalence in children under five in the Lindi Region remains high at 17.4% as per the 2015-2016 national health survey [17]. Starting in 2013, the SNP was introduced as a pilot “keep-up” strategy to supplement mass distribution campaigns as a means to maintain universal coverage of LLINs prior to its national roll-out [18, 19]. The programme distributes LLINs each year to school-going children in alternating classes (primary classes 1, 2, 3, 4, 5 and 7, secondary classes/forms 2 and 4) [18, 20, 21]. Ninety-eight percent of all registered students and teachers in Ruangwa district received LLINs through the SNP program [20]. Generally in Lindi region, ownership of at least one LLIN was 70% while ownership of at least one LLIN for every two people who slept in the household the night prior to the survey was 47% according to the 2015-2016 National Health Survey [17]. Specifically, monitoring of SNP rounds 1 and 2 recorded ownership of at least one LLIN in all the SNP participating regions (Ruvuma, Lindi and Mtwara) to be 76% and 79% respectively [21]. The analysis of the third mosquito net distribution is still ongoing. The SNP also promoted sharing of surplus nets with neighbours who did not own mosquito nets. Long-lasting insecticidal nets were to remain available to pregnant women and infants during antenatal and immunization visits at their attending health facility through the Tanzania National Voucher Scheme (TNVS) [18, 19]. The TNVS was discontinued in 2014 and a replacement system (free nets distributed during antenatal and immunization visits (ANC/EPI))

was not implemented until June 2016 (pers. Comm. Ikupa Akim, National Malaria Control Program) [21, 22]. Alternative sources of mosquito nets (treated and untreated) are through the commercial sector (local market, kiosks) for those without school-going children.

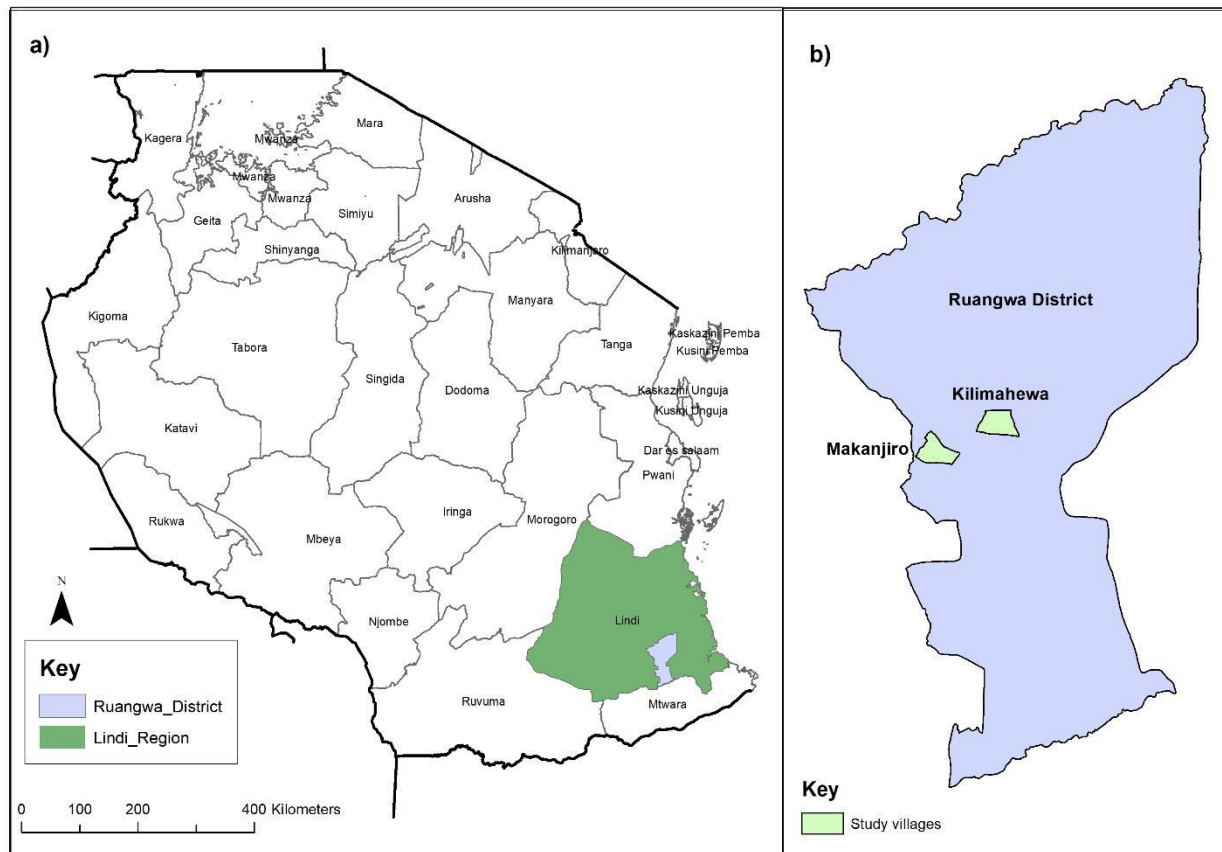


Fig. 1 – A map of the study sites: a) The map of Tanzania with reference to the study region, b) Study villages in Ruangwa district

The objective of this study was to explore local perceptions and practices of net care and repair in a community that continuously receives LLINs. Specifically, actions associated with different levels of net damage, motivators and barriers associated with net care and repair, and perceptions on how to overcome those reported barriers were assessed. The study approach was based on the Health Belief Model (HBM) [23], which has been useful to explain and predict human-disease

interactions in previous studies [13, 24]. The model assumes that individuals will a) opt to care for and repair their LLINs because of their perception that malaria is a major threat to their health (perceived severity and susceptibility), b) identify themselves as capable to perform day-to-day care and repair activities (self-efficacy) based on modifying factors such as personal and net characteristics and external and internal cues to action, and c) maintain nets as a means to protect themselves against malaria (perceived benefits increasing likelihood of action) (Fig. 2).

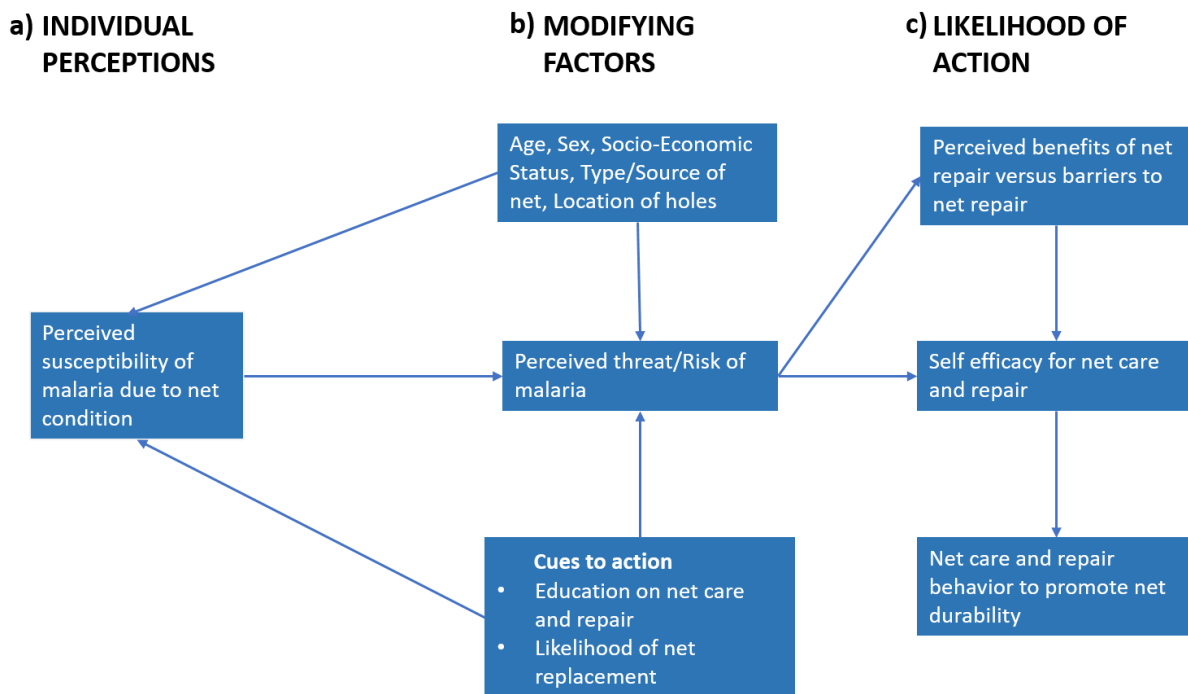


Fig. 2 – A conceptual model for net care and repair behaviours according to the Health Belief Model [23] The model assumes a) individual perceptions that malaria is a major public health threat; b) modifying factors identify users as capable to perform day-to-day care and repair activities; and c) likelihood of action to maintain nets as a means to protect themselves against malaria.

Understanding variations in local perceptions, motivators and barriers to net care and repair is key for the National Malaria Control Programme (NMCP) to optimize cost-effectiveness with fewer net replacements through suitable Behaviour-Change Communication (BCC). Exposure to effective BCC about net care and repair has been observed to improve overall net condition [25, 26]. However, repairs alone were not found sufficient to improve physical condition [25, 26], leading to the U.S President's Malaria Initiative (PMI) to change their policy to support only net care initiatives promoting BCC that protects nets from damage and improve net use [27]. Reinforcing Tanzania's BCC strategy to include relatable positive messages could inspire appropriate net care actions. The study expected participants to put high value on net care and repair to maintain intact nets as a valuable commodity that protects them against malaria, which they see as a major threat to their health (Fig. 2).

4.3 Methods

Study Site

The study was conducted in Makanjiro (rural) and Kilimahewa (peri-urban) villages in Ruangwa District, Lindi Region (Fig. 1). Ruangwa District was one of two districts in Southern Zone enrolled in the population arm of the Sentinel Panel of Districts (SPD), Sample Vital registration with Verbal Autopsy (SAVVY) project based at the Ifakara Health Institute (IHI) [28]. Makanjiro and Kilimahewa villages were randomly selected from a pool of 15 villages enrolled in the SAVVY project. The primary malaria vectors in Tanzania are *Anopheles gambiae s.s.*, *An. funestus* (both vectors indoor resting) and *An. arabiensis* (outdoor resting) [19, 29-32]. Lindi region has one major rainy season per year (March-May) at the end of which peak malaria transmission occur [19].

Ethical approval and consent to participate

Ethical approval was obtained from the Ifakara Health Institute (Ref: IHI/IRB/No: 015-2016), and the National Institute of Medical Research, Tanzania (Ref: NIMR/HQ/R.8a/Vol. IX/2193). The study was only administered to participants above 18 years of age upon written informed consent.

Data Collection

Data was collected through a mix of qualitative research methods, namely Focus Group Discussions (FGDs), In-Depth Interviews (IDIs) and a Participatory Activity (PA). Study participants were selected purposively with the assistance of village leaders. Participants were eligible if they were above 18 years of age, had lived in the village for a minimum of 12 months, and owned at least one LLIN in their household.

In 2016, a pilot study was conducted in Pemba Mnazi (rural Dar-es-Salaam) to ensure research tools were locally appropriate. All FGDs and IDIs were conducted in Kiswahili language and audio-recorded with hand-held digital devices. In addition, notes were taken during each interview. Interviews were guided by a topic guide containing *a priori* themes identified through literature and based on the theoretical framework of the HBM model (Fig. 2). Participants were encouraged to narrate their day-to-day activities regarding care and repair of LLINs. The topic guide was used to probe where necessary. The sample size of 30 IDIs and 10 FGDs were determined by reviewing similar studies [5, 13, 14] to capture variation of responses from different participant groups. Response saturation [33] was reached after three FGDs and five IDIs, but sampling was continued to ensure emerging themes were not missed.

Structured Participant Questionnaire

Prior to the start of any FGD or IDI, researchers administered a simple structured questionnaire to collect non-identifying socio-demographic information about each participant, including sex, age, education, number of children, participation in the SNP and exposure to BCC messaging in the past six months.

Focus Group Discussions

Five FGDs were conducted in each village. Four FGDs were conducted with community members and one with key village informants (i.e. religious, traditional/village leaders, and influential people). The community members were split into four groups of 8-12 participants each. Focus Group Discussions were conducted separately for young men (18-24 years old), women (>18 years) with children under the age of five, older men (>25 years), and older women with or without children (>25 years old).

In-Depth Interviews

In each of the two villages, five men, five women with or without children, and five women with children under the age of five were recruited for IDIs. In-Depth Interviews were conducted primarily at the study participant's home or space of comfort with minimal distraction from children and neighbours to provide a confidential environment for them to discuss in detail their attitudes and actions towards net care and repair.

Participatory Activity and Mosquito Net Assessment

After each IDI and the FGD with women with children under the age of five, participants were guided through a participatory activity (PA). Study participants were shown individually labelled nets with different levels of damage and repair (Table 1) and were asked to decide between four

actions for each net: 1) do nothing and continue to use; 2) repair and continue to use; 3) no longer use net but use it for something else in the household; or 4) no longer use it and discard the net. The level of damage and evidence of repair presented during the PA was to mimic observations from other field studies [34, 35]. Study participants were asked to make two choices for each net to explore current actions and understanding of net care and repair with social norms and discuss the reasons for their choices; 1) what they *would* do; and 2) what they think they *should* do.

To compare reported intentions during the PA with actual behaviour, the net used by the person being interviewed was assessed onsite at the end of each IDI. The number, size and location of holes and evidence of repair were recorded, and participants were asked to reflect on the status of their nets and their reported attitudes to care and repair. The holes were assessed using the World Health Organization (WHO) hole size descriptions and categorized as either “good” (<79cm² hole surface area), “damaged” (80-789cm²) or “too torn” (>790cm²) [10].

Table 1: Responses for action on nets with different damage and repair attributes presented in the Participatory Activity

Net ID	Number of holes	Hole sizes ¹	Hole location ²	Repair ³	Category ⁴	Common “ <i>would do</i> ” response	Common “ <i>should do</i> ” response
1	1	“Size 2”	Bottom	No	Good	Repair and continue to use	Repair and continue to use
2	1	“Size 2”	Roof	No	Good	Repair and continue to use	Repair and continue to use
3	18	15 x “Size 1”, 3 x “Size 2”	Mix	No	Damaged	Discard; or use it for alternative purposes	Repair and continue to use
4	9	8 x “Size 1”, 1 x “Size 3”	“Size 1” top, “Size 3” bottom	No	Damaged	Repair and continue to use	Repair and continue to use
5	2	1 x “Size 2”, 1 x “Size 4”	“Size 4” roof, “Size 2” bottom	No	Damaged	Repair and continue to use	Repair and continue to use
6	2	1 x “Size 2”, 1 x “Size 4”	“Size 4” roof, “Size 2” bottom	Partial (Size 4)	Damaged	Repair and continue to use	Repair and continue to use
7	25	22 x “Size 1”, 1 x “Size 2”, 2 x “Size 3”	Mix	No	Damaged	Repair and continue to use; Discard; or use it for alternative purposes	Repair and continue to use

¹Hole size categories based on the WHO guidelines [10]: “Size 1”: smaller than a thumb (0.5–2 cm), “Size 2”: larger than a thumb but smaller than a fist (2–10 cm), “Size 3”: larger than a fist but smaller than a head (10–25 cm) and “Size 4”: larger than a head (> 25 cm).

²Each side panel split into top half and bottom half.

³Type of repair: Sewing with needle and thread (as per SNP BCC messaging)

⁴Physical damage categories based on total hole surface area[10]: Good: <79cm², and Damaged: 80-789cm²

Data management and analysis

All audio-recorded data from the FGDs and IDIs were transcribed and spot-checked by both the interviewer and note-taker involved in the interview. Following approval of transcripts, interview summaries were written for each FGD and IDI. Data analysis was conducted following thematic

framework analysis procedures [36] to specifically explore study objectives. The thematic framework analysis included familiarization of data, identification of the thematic framework, indexing, charting, mapping and interpretation [37-40]. An initial coding framework was created using the topic guide. All four researchers who participated in the data collection then independently conducted an inductive thematic analysis of the interview summaries and a preliminary coding framework was established including sub-themes relevant to study objectives. Names and all individual identifiers were removed from transcripts.

The transcripts were then entered into NVivo 11 Pro software (QSR International Pty Ltd, Australia) for final data management, indexing, and identification of associated narratives to the study objectives. Data collected were organised by coding responses under each theme identified in the final codes to allow within and between participant group analysis. Result themes and sub-themes were then translated from Kiswahili to English and illustrated with verbatim quotes. Data from the structured questionnaires was summarised. Triangulation was done to compare a) responses given during the PA, b) observations made in the mosquito net assessment, and c) participant reflections of their current net status to provide in-depth context and to validate findings.

4.4 Results

A total of 118 individuals from the two villages were interviewed (male: n=56; female: n=62). Fifty-eight people were from the village of Makanjiro (rural) and 60 from the village of Kilimahewa (peri-urban). The highest level of education attained by the majority of the study participants (n=87) was completion of primary school. Ninety-one participants reported to have received their LLIN from the SNP while 27 nets were purchased from local stores. There are no

data on whether shop-bought nets were treated or untreated. Eighty-six of the 263 children of the study participants were attending primary school and therefore eligible for a mosquito net through the SNP. On average, the study participants received 0.5 SNP nets per year. Of the 118 interviewed participants, 87 had been exposed to BCC about malaria in the past six months. The most recalled BCC messages were to hang the net, sleep underneath the net and use the net all year round.

Perceived threat

Malaria was unanimously perceived to be a major public health threat in Ruangwa. The disease was mainly associated with death, miscarriage and poverty. Illness forced individuals to be away from the workforce while malaria treatment increased household costs. The disease was reported to weaken the bodies of those who suffered from it, and the repercussions would be worse if the head of household fell ill as reiterated by a woman in Kilimahewa.

“Yes, I am unable to perform any of my tasks because I am sick. I am unable to care for my children or work. If the father, who is the head of household, falls sick, it is even worse as there is no-one to provide.” (IDI participant, Woman with child under the age of five, Kilimahewa)

Generally, the importance of mosquito nets for protection against malaria mosquitoes was reported as the main driver of motivation to care and repair nets by the majority of the study participants.

“The net protects me so that a mosquito who would bite and infect me with malaria cannot reach me.” (IDI participant, Man, Kilimahewa)

Participants reported a high risk of being bitten by mosquitoes and valued the protection of the nets from mosquitoes which aided better sleep.

“For the poor, sleep is leisure. If you hear noises from such insects, you will not sleep.”

(FGD Participant, Makanjiro, Older man)

Mosquito nets used by children, especially those under the age of five, were most likely to be repaired first. This was because young children were reported to be most vulnerable to the disease and not able to care for or repair their own nets. Male key informants and older men reported their own personal nets to be of top priority for repair as they were the breadwinners of the family. Older women specifically reported to repair damaged household items, including nets and clothes, in one sitting rather than repairing each item soon after each hole was identified.

Nails on bedframe edges were reported as the primary cause of damage because of the daily tucking and untucking from underneath the mattress. Other causes of damage included children playing with the net, pulling the net too much to fit a bed that is bigger than the net, edges of the wooden frame “besela” used to hang the net, and household pests and rodents.

Net care

Net care was primarily defined as washing, tying up the net over the sleeping space in the morning and lowering it in the evening for use, and seasonal storage. Upon probing, hanging nets after washing and drying nets inside or outside the household were acknowledged as other practices associated with care.

Nets were usually washed within the household compound in a basin or bucket with soap and water as soon as the net was perceived to be dirty. Most participants reported washing their nets every other week. Washing the net ensured cleanliness, which also prevented other dirt-related problems such as sneezing and headaches. Tying up nets over the sleeping space in the morning and lowering it in the evening for use was done to avoid mosquitoes and other insects from hiding

inside the net during the day. Seasonal storage, a result of seasonal net use, differed between the two villages. Kilimahewa (peri-urban) residents reported using mosquito nets throughout the year whereas Makanjiro (rural) residents only used their nets during the rainy season when mosquito prevalence increased, except for households with children under the age of 5.

“We use mosquito nets during rainy season, because there are a lot of swamps and mosquitoes, but during the dry season, there are no mosquitoes. We store the nets.” (FGD participant, Older Woman. Makanjiro)

When describing barriers to net care or repair, study participants were quick to separate themselves from the subject and started speaking in the third person. Reported barriers to net care included care not being a priority in the day-to-day activities, “negligence” and lack of “Ngao” (net retreatment kits that used to be sold over the counter but were discontinued in 2009 after the introduction of LLINs). Women attributed being pre-occupied by other household activities such as sweeping and cooking, which left them too exhausted by the end of the day to then take particular care of the net. It was also reported difficult to keep up with small children who would play and tug on the nets if tied above the sleeping space.

“Other people do not have time to relax at home because they are so preoccupied by other household activities that they even forget to tie up nets in the morning.” (IDI Participant, Woman, Kilimahewa)

The majority of participants reported that other community members were negligent as they did not clean or care for their personal items. These community members were not expected to make the time to wash or care for the nets provided to them. There were concerns that nets needed to be re-treated with insecticides after each wash to activate the insecticide for continued protection as

was previously recommended with “*Ngao*” net retreatment kits. The lack of net retreatment kits at the markets left many heads of households in dilemma of how frequently to wash their nets.

“For most residents here, our households are of dirt floors, so when you sweep the house, in no time your net is dirty.” (FGD Participant, Older Men, Kilimahewa)

Key informants reported poverty as the underlying barrier to net care. The general household environment such as mud floors and grass/thatch roofs makes it difficult to care for one’s net every day. Resources such as a wooden frame “*besela*” required to hang up the net during the day were also not available for all.

“For many it is about their general standard of living. It is not only difficult to care for their nets but also for other household items such as clothes.” (FGD Participant, Young Man, Kilimahewa)

Net repair

Net repair was reported necessary as soon a hole was identified and defined as either sewing and/or tying knots (Fig. 3). Upon probing, adding patches to holes was dismissed as an option for net repair. Though patches of old clothes were easy to find, sewing them on the net reduced the airflow inside the net, and was hence not seen as a practical solution for repair.

Blocking the entry of mosquitoes into the net was crucial, because, *“if mosquitoes enter the net because I do not repair it, the children will get malaria and I will have to stop doing everything else to take care of them and maybe even get malaria myself.”* (IDI participant, Woman with child under the age of five, Makanjiro).

Study participants generally echoed their huge dependence on freely-distributed nets as the primary source and means of protection against malaria. While nets were available at the local shops, the costs were perceived too high even for untreated nets (approximately TZS 10,000, USD\$4.50). Replacement schedules of the free SNP nets were largely unclear to residents in the study villages so extending the life of a net until a replacement net arrives, free or bought, was reported crucial to ensure household members remain protected for as long as possible.

Net repair was perceived a social responsibility for all LLIN recipients. Through net repair, community members, who are the workforce to build the Tanzanian nation, would be protected from the deadly disease of malaria.

“When we join forces and work together, we create a workforce that a village such as ours depends on for development. But when community members fall sick with malaria, we lose the workforce in the village, and also as a nation.” (FGD participant, Key Informant, Makanjiro)

Net repair was largely reported as a temporary measure before the acquisition of a new net, hence not a matter of priority. Some participants reported sewing a net as too much work, while others reported not knowing how to sew a net given the varying material type and mesh size of the net itself. The lack of educational sessions on when to repair nets was also reported as a barrier. When holes were not repaired, the number and size of holes increased until nets were perceived to be “too torn” to be worth repairing.

“Some do not know what to do when they identify a hole on the net. Some do not even recognize that the hole should be repaired to adequately protect themselves from malaria.”

(IDI participant, Woman, Kilimahewa)

Mechanistic problems reported included regular needles being too small to grip properly and close the hole whereas tying a knot was only feasible for some types of holes (Fig. 3). Lack of self-initiative to explore and find alternative solutions, for example using bigger needle and thicker thread to repair the net, was reported as a potential barrier for others to repair their nets. Some participants also reported lack of sewing kits (needle and thread) for net repair readily available in their households. Key informants highlighted that some tailors refused to mend nets as nets were perceived as too personal to be repaired by them.

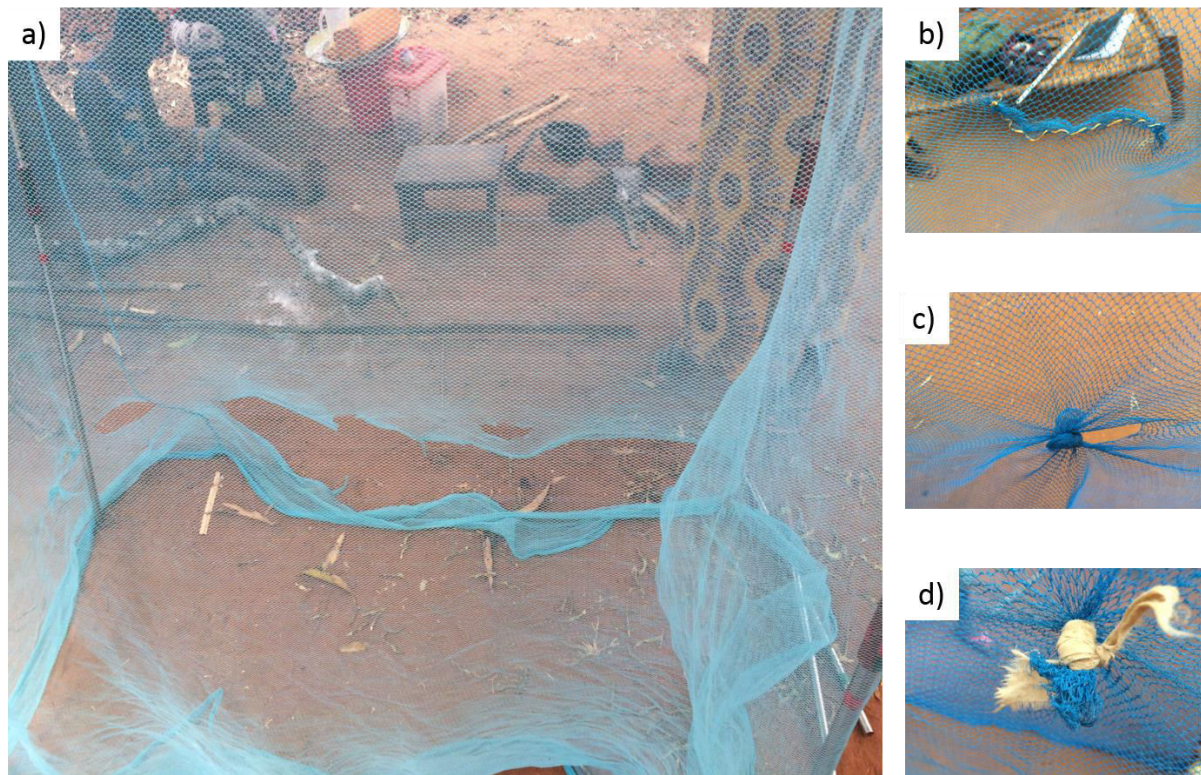


Fig. 3: Mosquito net assessment a) An illustration of the mosquito net assessment on a collapsible frame outside the household; b) Net repair by sewing; c) Partial net repair by tying a knot and d) Complete net repair by tying a knot.

Self-efficacy to care for and repair nets

Both men and women reported their capabilities to perform all the basic care and repair practices such as washing, hanging, tying up the net above sleeping space, storing it away and knotting. However, the wife or woman was seen as the one solely responsible for net care and repair in households irrespective of her economic role (i.e. whether she was head of household or also worked). The man's main contributions were to act as the catalyst (proposing when care actions such as washing should be performed) and the financial decision-maker (net repair and/or replacement decisions). In the absence of a woman (unmarried, widowed or travelling wife), men reported to care for and repair their own nets but in the confines of their household in seclusion from the public. Children aged 13 and above, irrespective of their gender, could take responsibility of their own nets. Parental check-up became less common due to cultural norms that refrain mothers from entering their sons' room and the father a daughter's room once the children reached puberty.

Mosquito net assessment

Of the nets presented during the Participatory Activity (PA), the following five net IDs from the PA; 1, 3, 4, 5 and 7 (Table 1), were most comparable to those from participating households in terms of level of damage and lack of repair (Table 2). All participants reported they *would* repair the single hole identified at the bottom of net ID 1. The horizontal tear was perceived easy to sew together if sewing materials were readily available in their households. Alternatively, participants suggested that the hole located at the bottom could be tucked under the mattress. Most study participants reported they would discard Net ID 3 (18 holes) or use it for alternative purposes around the household such as an additional cushion under the mattress or fencing the flower

garden. The holes were perceived to be too many and too scattered to repair. As with Net ID 1, the hole located at the bottom of Net ID 4 (9 holes) was reported to be either repaired or tucked underneath because “*it [the single hole] is located at the bottom. After tucking the net under the mattress, mosquitoes cannot get through.*” (IDI participant, Older Man, Kilimahewa).

Very few of the small holes located at the top were noticed by participants, and those that did identify them, did not mention any action to repair them. Participants responded they would either repair and continue to use net ID 5 (2 holes) or use it for alternative purposes around the house depending on their financial status when the holes were identified. A few reported they would seek out the local tailor to repair the large hole at the top. Responses for net ID 7 (25 holes) were mixed with some ready to use it for alternative purposes while others would repair and continue to use it. However, it was unanimously echoed that all the nets presented in the PA were still usable and *should* be repaired as the holes were not overwhelming in number or size. Study participants did not perceive any of the nets presented to be too torn; therefore, they *should* all be repaired for continued use of protection against malaria, particularly when left with no money to acquire a new net (Table 1).

Generally, mosquito nets assessed in peri-urban Kilimahewa were in “good” condition (n= 10) while the remaining handful of nets (n=5) were “damaged” as per WHO hole sizes categories [10] (Table 2). The condition of nets assessed in Makanjiro varied much more: Two nets were in as good as new condition (no holes), four nets had some holes but were still in “good” condition, five nets were “damaged”, and four nets were “too torn” (Table 2). Of the 30 nets assessed across the two villages, only five nets in Kilimahewa and three nets in Makanjiro showed any evidence of repair by sewing or knotting.

The most common response during the PA was to repair and continue to use nets, and everyone reported they should repair and continue to use. However, actual evidence of repair in nets from households was scarce (Table 2). When asked, the main reasons given for not repairing nets were; 1) not being able to identify most of the holes while inside the households due to poor lighting, and 2) tucking holes located at the bottom underneath the mattress. Study participants did indicate that the net assessment exercise encouraged them to repair the holes in their nets and that they would assess all other nets present in their households for damage following the end of the interview.

Table 2: Mosquito net assessment findings by In-Depth Interview participant groups and village.

Village/Participant Group	Net Type	Number of Holes	Hole Sizes¹	Hole location²	Repair³	Category⁴
<i>Kilimahewa (peri-urban)</i>						
<i>Man</i>	LLIN	3	3 x “Size 1”	Bottom	0	Good
<i>Man</i>	LLIN	3	3 x “Size 1”	Bottom	0	Good
<i>Man</i>	LLIN	36	17 x “Size 1”, 19 x “Size 2”	Top, bottom, roof	5	Damaged
<i>Man</i>	Unknown	31	16 x “Size 1”, 14 x “Size 2”, 1 x “Size 3”	Top, Bottom	1	Damaged
<i>Man</i>	Untreated	3	3 x “Size 1”	Bottom	0	Good
<i>Woman</i>	LLIN	9	8 x “Size 1”, 1 x “Size 2”	Top, Bottom	0	Good
<i>Woman</i>	LLIN	1	1 x “Size 2”	Bottom	0	Good
<i>Woman</i>	LLIN	1	1 x “Size 1”	top	0	Good
<i>Woman</i>	LLIN	7	6 x “Size 1”, 1 x “Size 2”	Bottom	2	Good
<i>Woman</i>	LLIN	21	19 x “Size 1”, 2 x “Size 2”	Top, Bottom	0	Damaged
<i>Woman with under 5</i>	Unknown	106	98 x “Size 1”, 8 x “Size 2”	Top, bottom, roof	2	Damaged
<i>Woman with under 5</i>	Untreated	4	2 x “Size 1”, 2 x “Size 2”	Bottom	0	Good
<i>Woman with under 5</i>	LLIN	2	2 x “Size 1”	Top, Bottom	0	Good
<i>Woman with under 5</i>	LLIN	13	2 x “Size 1”, 10 x “Size 2”, 1 x “Size 3”	Bottom	0	Damaged
<i>Woman with under 5</i>	LLIN	4	1 x “Size 1”, 3 x “Size 2”	Top, Bottom	2	Damaged
<i>Makanjiro (rural)</i>						
<i>Man</i>	LLIN	4	2 x “Size 2”, 1 x “Size 3”, 1 x “Size 4”	Top, Bottom	0	Too torn
<i>Man</i>	LLIN	12	12 x “Size 1”	Bottom	0	Good
<i>Man</i>	LLIN	21	8 x “Size 1”, 13 x “Size 2”	Bottom	5	Damaged
<i>Man</i>	LLIN	2	2 x “Size 1”	Bottom	1	Good
<i>Man</i>	LLIN	4	1 x “Size 1”, 1 x “Size 2”, 2 x “Size 3”	Top, Bottom	0	Damaged
<i>Woman</i>	LLIN	0	-		0	Good

<i>Woman</i>	LLIN	0	-		0	Good
<i>Woman</i>	LLIN	17	5 x “Size 1”, 6 x “Size 2”, 2 x “Size 3”, 4 x “Size 4”	Top, Bottom	0	Too torn
<i>Woman</i>	Unknown	29	25 x “Size 1”, 3 x “Size 2”, 1 x “Size 4”	Top	1	Too torn
<i>Woman</i>	LLIN	8	4 x “Size 1”, 4 x “Size 2”	Bottom	0	Damaged
<i>Woman with under 5</i>	LLIN	3	2 x “Size 1”, 1 x “Size 2”	Bottom	0	Good
<i>Woman with under 5</i>	LLIN	3	3 x “Size 1”	Bottom	0	Good
<i>Woman with under 5</i>	LLIN	38	23 x “Size 1”, 12 x “Size 2”, 3 x “Size 3”	Top, Bottom	0	Too torn
<i>Woman with under 5</i>	LLIN	44	40 x “Size 1”, 4 x “Size 2”	Top, Bottom	0	Damaged
<i>Woman with under 5</i>	LLIN	1	1 x “Size 3”	Top	0	Damaged

¹Hole size categories based on the WHO guidelines [10]: “Size 1”: smaller than a thumb (0.5–2 cm), “Size 2”: larger than a thumb but smaller than a fist (2–10 cm), “Size 3”: larger than a fist but smaller than a head (10–25 cm) and “Size 4”: larger than a head (> 25 cm).

²Each side panel split into top half and bottom half.

³Number of holes repaired on the net. Type of repair varied as per Fig. 3 including sewing and knotting.

⁴Physical damage categories based on total hole surface area [10]: Good: <79cm², Damaged: 80-789cm² and Too Torn: >790cm²

Cues to action

Given that the SNP was the primary source of nets in the study villages, it was suggested that parents should be invited to the schools for educational sessions on net care and repair so that they could engage better daily in the maintenance of LLINs to prevent malaria.

It was proposed that Community Health Workers and other experts from the district headquarters should train people on the importance of nets, how to care for nets and when to repair them.

However, there were some participants that cautioned,

“Mosquito nets are private items that one has to have self-initiative to take care of. Educational sessions on such sensitive matters can be deemed offensive by the recipient of the net” (FGD participant, Older Man, Makanjiro).

The women generally echoed that men were equally as capable to perform both care and repair duties within households, hence should also participate in day-to-day activities. Net manufacturing companies were requested to produce stronger nets. It was also requested that net retreatment kits “*Ngao*” should be restocked in the commercial markets as it was reassuring to retreat a net after each wash to ensure it would repel or kill mosquitoes upon contact.

Upon probing, mass washing sessions, inclusion of leaflets and sewing kits in the packaging, and road shows were perceived as other measures to encourage net maintenance and general cleanliness. However, it was emphasized that the leader of the mass washing initiative should be someone not associated with the village to avoid passing judgement and spreading gossip of the status of nets within the village.

Information on leaflets attached on the packaging of nets was received with mixed reviews. While those in Kilimahewa received it well, study participants in Makanjiro worried for the illiterate who were perceived to be the majority in the village despite previous distributions including leaflets with pictorial demonstrations. Interactive educational sessions by community health workers and experts during road shows were proposed to be more informational.

4.5 Discussion

Though not unanimously actioned, there was a general readiness to care for and repair mosquito nets in southern Tanzania for the love of a good night’s sleep free of mosquito bites or noises, as

observed in other studies across sub-Saharan Africa [5, 12-14]. Response saturation was reached quickly in our study among participant groups and between villages, and responses of motivators and perceived challenges were similar to those of other studies in sub-Saharan Africa. This implies that general motivators and barriers to net care and repair are comparable across a range of cultural settings. These results are discussed using the theoretical framework presented in Figure 1 and based on the HBM [23]. This study found that malaria was perceived to be a major threat and that mosquito nets were considered a useful tool against mosquito bites and to reduce health expenses associated with disease (individual perceptions; Fig. 2). Most people felt they were able to take good care of their nets and repair them when necessary (self-efficacy), although net repair was most commonly seen as a temporary measure and net care was performed mainly to keep nets clean and free of insects rather than to specifically prolong the lifespan of the net (potential barriers). A discrepancy was found between what people reported they did or knew they should do and actual condition of the nets. This highlights potential gaps in knowledge and uncovers the lack of an important motivator to care and repair: the better the net condition, the better the protection against malaria (likelihood of action).

Study participants much preferred net care over repair, which was similar to studies in West and East Africa [5, 12-14]. In the study villages, the motivation for net care was generally associated with overall net maintenance such as cleanliness and preventing mosquitoes and other insects from hiding inside the net, and not directly associated with the prevention of damage as in other studies. Similarly, to other studies, however, dirty nets were perceived harmful to one's health and shameful to society [5, 13-15]. Clean nets were seen as aesthetically pleasing and a show of a responsible woman. Some net owners reported to wash their nets almost every other week (approximately 26 washes a year) as was also observed in Uganda [5] and Peru [41]. Tanzania's

School Net Programme BCC messaging currently lacks a recommendation for washing frequency and only states to “*wash your net when it gets dirty and dry it in the shade to preserve the effectiveness of the insecticide of the net*” (Pamela Kweka [John Hopkins Centre for Communications Programs in Tanzania] *pers. comm.*). The existing BCC also does not address the fact that LLINs do not require the “Ngao” net retreatment kits. Households were left in a dilemma as they wanted clean nets, yet also wanted to maintain the active chemical content. If they did not wash the nets, they got negative reactions from family members. If they did wash their nets frequently, the nets were deemed ineffective to sleep under after about a year. In Kenya, increased washing frequency was associated with decreased physical condition of nets [8]. In Tanzania, 45% of nets were in bad condition after washing them four to seven times a year and insecticidal content was also observed to be low [42].

Behavioural Change Communication should be updated to include a realistic recommendation regarding washing frequency as was done in Peru [41], keeping in mind that expecting people to refrain from washing their subjectively dirty nets is unrealistic [15]. Behaviour Change Communication should also highlight the importance of preventing damage on nets while promoting preventative net maintenance behaviours such as tying up the net over the sleeping space or storing nets safely away from children or rodents when not in use [23].

Although participants stated that nets were important to protect against malaria, net repair was only seen as a temporary measure before acquisition of a new net as was also found in Senegal [13, 43]. People much preferred receiving brand-new nets for free and only uncertainty around distribution schedules motivated net repair. Although people reported that net repair was necessary as soon as a small hole was identified, inconsistencies were observed between such reported intentions and the physical condition of nets observed inside households [5, 14]. The lack of

priority to repair nets led to the accumulation of holes with time. Nets observed to be “too torn” showed no more evidence of repair and were from households of women (self-reported primary caretakers) (Table 2). Households with poor lighting, which were the majority in the study villages, have more difficulty in identifying holes for repair. Using a frame, which stretched the material as was done in this study, allowed participants to easily identify the smallest of holes. This, however, is an unlikely method for household members to regularly assess their own nets so they can determine the appropriate action. When the net is removed from its hanging place, it is normally crumpled together in a ball of fabric, making it difficult to identify small holes. Many larger holes were observed at the bottom of the nets and respondents most often said they would tuck those holes underneath the mattress. The convenience of tucking holes underneath the mattress fostered neglect for other holes. Thus, holes that could not be tucked underneath the mattress were stretched and became larger over time.

Mechanistic challenges may have contributed to the low occurrence of repairs. Net repairs by sewing was largely dependent on other household items requiring sewing, was time consuming and needed financial investment of a bigger needle and thicker thread (Fig 3b). Alternatively, knotting was either partial or pulled a lot of net material together depending on the size of the hole, potentially creating other mosquito entry points (Fig. 3c and d). In Nigeria, net repairs were not sufficient to improve overall status, i.e. shift nets from the “damaged” to the “good” WHO category [25] , irrespective of the increase in proportion of repairs on torn nets [44].

Lack of knowledge or misconceptions (e.g. Ngao) were identified as key barriers to effective care and repair practices. Existing SNP BCC primarily targeted primary and secondary school children through posters and a weekly radio program called “Pata Pata” jingle. Children were advised to inform their parents or caretakers of care and repair practices. Subsequently this may have created

a knowledge gap where some parents and caretakers received limited or diluted information from their children. Workshops engaging parents, who have primary responsibility of taking care of the nets, were requested. Behavioural Change Communication for SNP should build on existing practices around the villages to share public health information of the developments of malaria control interventions such as the transition from use of untreated nets, retreatments kits and now LLINs [45] to ensure appropriate continued community-wide engagement in net maintenance. Women of Makanjiro village reported increased motivation to care for their LLINs following a Community Change Agent's educational session in their small group "Vikoba" meetings. Community-wide engagements in Ghana [46], Cambodia [47] and Madagascar [48] have had positive effects on promoting interactions with malaria control interventions and should become a more regular feature as part of continuous net distribution mechanisms in Tanzania.

The BCC messages that were recalled by household members emphasize the proper use of LLINs. It is therefore important to evolve the BCC strategy to include positive social norms, e.g. the personal responsibility to maintain nets in good condition [5, 13], especially as the SNP is now embedded into the NMCP LLIN strategy and expands its distribution to the Lake Zone [27]. Messages should incorporate net care as part of a daily routine and not as an additional burden to ensure that the luxury from a good night's sleep and health gains are maintained.

Study limitations

Though sampling was continued even after response saturation was reached, these findings only reflect the attitudes and actions of those interviewed and not the entire Lindi region or other zones in Tanzania where residents with school-going children continuously receive nets from the SNP. Although the researchers explained they were not health workers or involved in the SNP

distribution process, there remains a possibility that study participants missed the distinctions, potentially biasing responses to be favourable towards mosquito nets and reported care and repair behaviours. The mosquito net assessment and PA were done outside the house on a frame that stretched the netting in a way that even the smallest holes could be identified. The study did not follow-up to assess whether any of the nets observed with damage were repaired as per study participant claims, and how they were repaired.

4.6 Conclusion

There was willingness to both care and repair mosquito nets in Ruangwa district although net care was more likely to be performed than repair. Promotion of care practices as means to prevent net damage including realistic recommendations for washing frequency need to be included in the BCC messaging to prevent over-washing of nets. Discrepancies were observed between reported intentions to repair mosquito nets and current net condition, which further reinforces the findings of previous studies that demonstrated no substantial benefit to promoting net repair. Targeted education through health facilities, particularly workshops for parents, and engagement with community change agents were recommended as potential means to overcome barriers to net care by the study community.

4.7 Declarations

Competing interests

The authors declare that that they have no competing interests.

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article and available from the corresponding author on reasonable request.

Author's contributions

ZMM and LML conceived the study. ZMM, GG, KK, AD and LML designed the study. ZMM and AD collected and analyzed the data. ZMM wrote the manuscript. AD, GG, KK, HK and LML critically reviewed the manuscript. All authors read and approved the final drafts of this manuscript.

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5 “TO BE HONEST, WOMEN DO EVERYTHING” –

UNDERSTANDING ROLES OF MEN AND WOMEN IN NET CARE AND REPAIR IN SOUTHERN TANZANIA

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5.1 Abstract

Background: In Tanzania, the roles of men and women are classified based on the local cultural context. While men are usually the breadwinners, women are traditionally responsible for most domestic chores. Particularly for malaria prevention, studies in Africa have revealed women as being responsible for daily up-keep of the net. Using social role theory, this study explored the role of men and women in net care and repair and gender-related motivation and barriers to net care and repair in Tanzania.

Methods: The study was conducted in the two villages of Ruangwa district in Lindi Region. The study applied qualitative approaches and carried out in-depth interviews and focus group discussions with men, women, women with children under the age of five and village key informants.

Results: Mosquito nets were valued by all participants as a protection measure against mosquitoes. Study findings indicate that net care and repair fall under a woman's daily household responsibilities. While men were said to assist in stitching damaged nets, washing dirty bed nets was regarded inappropriate for men and not traditionally accepted. Motivation for net care and repair was reported to come from both men and women; for a woman keeping the net clean defined a caring and responsible woman, while men indirectly promoted net washing when complaining about nets being dirty. Women reported that men could do everything that women do regarding net care and repair, but that it does not fit into societal norms.

Conclusion: With increased globalisation in Tanzania, more women are becoming part of the workforce, which may limit their full commitment to net care and repair activities, leading to increased net damage, malaria incidences and higher costs for malaria treatment. The National Malaria Control Programme should consider incorporating research-informed gender-

transformative messages into their Behaviour Change Communication on mosquito nets and work closely with trusted Community Health Workers to inform communities about the importance of sharing responsibilities in net care and repair. It is acknowledged that changing people's behaviour and practices is a long process, which will require a deep cultural and political shift.

Keywords: Gender roles, Men, Women, Mosquito Net, Net care, Net repair, Malaria

5.2 Background

In Tanzania, like everywhere else, the roles of men and women are classified based on the local cultural context. Tanzanian society is largely patriarchal and in many communities, women are under the control of men and often accorded to a lower social status [1]. Gender roles have, therefore, been stereotyped as being masculine and feminine, which affects the division of labour and resources within the household [2, 3]. Following the impact of globalisation and the country's efforts in addressing gender inequalities, more women in urban and rural areas are becoming involved in economic activities and going out to work to earn money [4]. The current expectations of their roles at household level, however, remain the same: after work, women are expected to cook, fetch water and conduct all household chores as usual [5], but it is unclear for how much longer women can focus on both demands as carefully as required.

Several studies have looked at the gender role division in traditional households when it comes to general well-being of family members [6, 7]. In Tanzania, for example, women are considered responsible for all domestic duties ranging from cooking, collecting water, taking care of patients and serving men [5, 8]. Studies on treatment-seeking behaviour for children indicate that women are the first ones to recognize illness symptoms because they spend most of their time with the children. The husband becomes involved in treatment-seeking when it needs to be sought outside the home as it is usually him who pays for treatment [9, 10].

When it comes to household gender roles in disease prevention, particularly against malaria, women are more likely to use mosquito nets than men as they tend to share nets with their young children and are more vulnerable to the disease when they become pregnant [11-13]. A recent study in Kenya, found that male-headed households adopted more prevention measures, including mosquito net use, than female-headed households, potentially due to their higher purchasing power

and increased access to health information and knowledge [14].

Long-lasting Insecticidal Nets (LLINs) are one of the most effective tools to reduce malaria morbidity and mortality [15, 16]. In addition to nets being used, they must also be maintained in good condition to avoid the development of holes and tears, which will render the net less useful against mosquito bites [17, 18] and lead to the discarding of nets [19-21]. Net maintenance entails activities that aim to prolong its durability, particularly those related to care and repair [22-24]. As per WHO definition, bed nets are designed to retain satisfactory amounts of insecticide to last for up to 20 washes and survive up to 3 years [24]. While caring is defined as washing, drying, proper hanging, careful tucking and untucking from underneath the mattress and net storage, net repair encompasses stitching holes with needle and thread, knotting or patching [22-24]. Studies indicate that women are primarily responsible for the daily up-keep of the nets including washing and stitching when damage occurs [22-24]. In Uganda and Nigeria, men were reported to take part in repair to some extent but not caring for nets [23, 24]. We are not aware of any studies from Tanzania about household roles in net maintenance.

Tanzania's National Malaria Control Program (NMCP) Behaviour Change Communication (BCC) strategy focuses on the value of nets, the importance of sharing nets with others, the appropriate use of nets, careful handling of nets and methods of net repair [25], but there is still an important gap between the messages and people's actions [26]. Understanding household dynamics and gender roles in net care and repair may inform appropriate interventions geared towards addressing gender-related challenges that currently inhibit net care and repair with the overall aim of increasing the life span of mosquito nets.

This study investigates the role gender plays in net care and repair behaviours in southern Tanzania

through the lens of social role theory. Social role theory argues that household distribution of activities is based on societal expectations and stereotypes that are socially constructed, thus producing gender roles [2]. Such roles have been the main source of discrimination, which have been accepted by society at large. Eagly [2] divides gender roles into *communal* and *agentic*. The communal role is characterised by attributes of emotional and physical nourishment, commonly associated with domestic activities, and ascribed to women more than men. The agentic role, on the other hand, is characterised by features of confidence and forceful behaviour in public activities and is more likely to be associated with men.

Thus, the study aims to explore the roles of men and women in net care and repair activities at the household level in the context of perceived malaria risk and benefit of bed net use. The theory guided us in exploring gender-related motivation and obstacles to net care and repair; and gender-associated decisions in care and repair.

This study took place in the two villages of Southern Tanzania, which are part of the School Net Program (SNP), a continuous distribution mechanism that uses school-going children as a means for delivering nets into the community [27]. The findings from the study aim to help the NMCP BCC to come up with relevant gender-related care and repair messages for men and women to be targeted more effectively.

5.3 Methods

Study area

The study was conducted in two villages in Ruangwa district (Lindi region, southern Tanzania) where SNP has been ongoing annually since 2013 [27]. Malaria prevalence in children aged 6-59

months in the Lindi region was 17.4% according to the 2015-16 Tanzania Demographic and Health Survey and Malaria Indicator Survey [28]. The study villages were randomly selected from the Sample Vital registration with Verbal Autopsy (SAVVY) database [29]. SAVVY had randomly selected 15 villages within Ruangwa using probability proportional to size (PPS) sampling. For this study, one rural (Makanjiro) and one semi-urban (Kilimahewa) village was randomly selected using the 'sample' command in STATA 14.

Study design and participant selection

Focus Group Discussions (FGDs) and In-Depth Interviews (IDIs) were used to collect information from study participants. Interview methods took an inductive approach that allowed participants to report issues related to household roles in net care and repair while probing for necessary information [30]. The study participants were purposively selected with assistance from village leaders to ensure that we obtained relevant information to answer the study objectives and capture differences in responses among the study groups. The sample size was determined using a combination of saturation sampling [31, 32] and reviewing similar studies [22-24].

In each village, a total of five FGDs was carried out; four with community members (young men (18-24 years old), women with children under the age of five (18+ years), older men (>25 years), older women with or without children (>25 years old)), and one FGD with village key informants (village, religious and traditional leaders and influential people aged 18 and above). The number of FGD participants ranged between 8 to 12 participants per group. In each village, 15 IDIs were conducted. The IDIs consisted of five men, five women with or without children, and five women with children under the age of five. In each village, response saturation was reached after three FGDs and five IDIs, but sampling was continued to ensure no more new themes emerged.

Participants had to fulfil the following inclusion criteria: resident in study site for a minimum of 12 months, at least 18 years of age and owner of at least one Insecticide Treated Net (ITN).

Data collection procedures

Prior to data collection, the study team carried out a pilot exercise in Pemba Mnazi, a rural village in Dar es Salaam region. One FGD and four IDIs were conducted with purposively selected residents to pilot the topic guides to check if they were locally appropriate. Based on the pilot study, the FGD and IDI guides were revised. FGDs were conducted at village offices while IDI participants were visited in their homes. All interviews and FGDs were conducted in Kiswahili language. The senior social scientist participating in the study conducted quality check of the IDIs by revisiting some of the households. Audio-recording devices were used while research assistants also took notes during each interview. All recorded interviews were transcribed.

Data management and analysis

NVivo 11 Pro software was used for data management. Transcripts were coded, and the list of codes were reviewed and grouped into categories and themes for analysis. From the codes, patterns and themes in the data were identified that answered the specific study objectives. Analysis was undertaken by comparing themes that answered key issues related to our study objectives and checking for inconsistencies across different data sources. After analysis, data from the two study villages, and IDIs and FGDS, were combined because of the similarity of the findings.

Ethical considerations

Ethical clearance was sought from Ifakara Health Institute, and the Tanzanian National Institute for Medical Research (NIMR). Local authorities where the study took place were also informed. An information sheet about the study was drawn up in Kiswahili, explaining the study rationale

and participant's rights. Written consent was obtained from participants and a thumb print for those who could not write. Measures were taken to ensure privacy, respect and dignity of all participants. Identities of participants in the FGDs and IDIs remain anonymous.

5.4 Results

Perceived risks of malaria among men and women

Most of the study participants were both net owners and users. Study participants primarily used mosquito nets as a preventive measure against malaria. Mosquito nets were valued by participants in both villages as malaria was perceived to be a dangerous disease associated with economic and health risks. All participants perceived two distinct groups at the highest risk of malaria: (1) Children under the age of 5 and (2) adults. Most women also said that pregnant women and their unborn babies were at higher risk than other groups. Both men and women see malaria as a disease leading to poverty: costs associated with treatment, sickness and death were their main concern. In addition, men also worried about their ability to perform their daily activities and feed the family when infected with malaria; once a man, usually the head of household, falls sick, the whole family will be in trouble as he will not be able to feed the family or pay for his children's school fees.

“Malaria is not a joke, you will be in bed for more than a week, joint pain, no energy, while you are supposed to work and fight so that the family survives.” (Male IDI participant, Makanjira)

Family roles in net care

Net care was defined as keeping nets clean and tidy by washing, drying and hanging nets back over sleeping spaces after drying. In addition, daily net maintenance behaviours such as careful

tucking and untucking from underneath the mattress after a night's use and tying nets up during the day, were mentioned. Net care in the household was perceived to be the responsibility of women, usually the wife. This was confirmed by all male and female participants. Women were said to be responsible because they mainly remain at home taking care of the family when men go out to work. The roles and responsibilities of working women remained the same inside the house, including net up-keep.

“The woman is the one who is more responsible to look after bed nets, she manages the house. As for me, I have to go and work to feed the family” (Male FGD participant, Kilimahewa)

“Women know when the net is dirty and needs to be washed, they are involved in daily up-keep of the net, men can only remind you to wash the net” (Female FGD participant, Kilimahewa)

Looking further into the roles of men in daily net care, participants reported that men could only assist in “hanging the net after washing” and “tucking and untucking from under the mattress”. However, even these activities were said to be optional.

“To be honest, women do everything, as for us men, majority of us wake up like 5am in the morning and come back in the evening, we, however, somehow assist our wives in hanging a net when it is dried” (Male Key Informant FGD, Makanjiro)

“Maybe when I ask him to assist and only if he agrees, he can hang it back on the hanger”
(Female IDI participant, Kilimahewa)

However, most participants in both study villages reported that in situations where women were not available or travelling, men do take care of the nets, particularly hanging, tucking and untucking from under the mattress but not washing. Net washing was considered inappropriate for men and not traditionally accepted.

“They do not wash net, oho, if people see your husband washing net, they would think you have bewitched him, people will also think that you have control over your husband”
(Female FGD participant, Makanjiro)

Family roles in net repair

Net repair was defined as stitching holes with needle and thread, whereas knotting was described only as a temporary repair measure awaiting stitching in the coming few days. As with net care, most male and female participants reported net repair to be a female chore because women are the ones most likely to identify a hole during the daily net up-keep. However, women also acknowledged that men do assist in stitching holes. Male participants also reported to help their wives stitch nets whenever they identified a hole big enough to allow mosquitoes to enter the net.

“It is us women who stitch, most of the time it is us, yes men do assist when they have time, they stitch” (Female IDI participant, Kilimahewa)

Probing on why men were more willing to stitch than wash a net and the common theme was that net repair can be done more privately than net care. A man helping with net repair is more common

than helping with net care possibly because net repair can be performed inside the house unlike net care, an activity performed outside the house.

“In fenced houses, men can stitch a net, but with our environment people can pass anytime and see a man washing, so they stitch inside the house because no one will see them” (Male Key Informant FGD, Kilimahewa)

This was also supported in IDIs: *“Men help us to stitch but not wash nets, if they wash it means they have to take it to the rope and dry it outside, people will see them, but stitching, they can do it inside the house”* (Female IDI participant, Makanjiro)

Related to the study objective, the role of children was investigated in their engagement in all activities related to net care and repair as most of the nets within households had been obtained through the School Net program. The responsibilities of children were said to depend on the age of the child. Starting from about age 13, some children were said to assist their parent in washing and stitching holes.

Gender-related motivators and barriers to net care and repair

Motivation to care for and repair the damaged net was reported to come from both the husband and wife in the household. The study noted that women respondents were more interested in washing and keeping the net clean than stitching holes. Keeping the net clean was considered a good practice that defines a caring and responsible woman.

“Yes, we wash our nets, when your husband wants to sleep and finds the net dirty and dusty, he complains, and it will look like you do not properly manage your duties” (Female IDI participant, Makanjiro)

The same was reported by men during their FGD: for things to run smoothly in the household, the man has the say, and men remind their wives to keep nets clean and free from dirt to avoid other health problems such as respiratory infections.

Being over-occupied with household tasks was mentioned as the main reason for women not remembering to repair nets. Others reported their own ‘laziness’ as a contributing factor to not repairing mosquito nets. Women were of the view that it is more convenient to wash nets than to repair them because washing is already part of their daily household routine. They must wash their husband’s clothes and children’s school uniforms; in doing so, it is easy to also remember washing the mosquito nets. Stitching clothes, on the other hand, is done much less frequently.

“Washing can be easier and more convenient than stitching, when you wash family clothes it is easy to remember that a net is dirty and wash it too, but with stitching, you know, it is not done every day, you see the hole on your net and say, I will stitch later, later becomes later, and it is already a new day” (Female FGD participant, Kilimahewa)

Women revealed that the cost of repairing a net is very small, involving 200 Tanzanian Shilling (0.10 US\$) to buy a needle and thread which can be used for many years. Most study participants reported they did not take their damaged nets to a tailor. Taking a net to be repaired by a tailor was regarded as awkward, as a bed net is considered a private item that needs to be repaired within the household. Moreover, for a woman to take a net to be repaired by the tailor was considered irresponsible and shameful.

“You know bed net is something private, not everyone should see your net, it should be stitched inside, how can a woman take her net to the tailor, that’s shame, big shame, if you cannot stitch your net, what can you do, you better leave it with holes than taking it to the tailor” (Female FGD participant, Makanjira)

Gender of the main income earner was said not to affect responsibilities and choices when it comes to net care and repair. Even when a woman is the one working and earning money for the family, she remains responsible for household activities including net care and repair. Most male and female participants did report that men have the ability to do everything when it comes to net care and repair (washing, hanging, tucking and untucking from under the mattress, stitching holes, etc.), but that they would be perceived differently by other village members if they performed these household duties regularly.

“Sure, they can do everything, they can wash net, hang it, tuck it, there is nothing that they can’t do, it is just that it is not within our norm. Those are regarded as women’s responsibilities” (Female FGD participant, Kilimahewa)

“Yes, we can wash and stitch, but you know those are women duties, we are busy looking for money” (Male FGD participant, Kilimahewa).

“You make me laugh, even if she is the breadwinner and I have no job, I cannot perform those tasks, unless I choose to help her, those are her duties” (Male FGD participant, Makanjira)

5.5 Discussion

In most traditional African societies, the role of women within the household are rooted in culture, laws and social norms [33]. Study findings indicate that net care and repair in this area of Tanzania falls under a woman's daily household responsibilities like in other Sub-Saharan African countries [22-24]. In contrast to men, women tend to spend more of their time at home while taking care of all household duties. Even in cases where women also work and leave early in the morning, or are the main income earner for the family, their role in net care and repair remains the same. Despite the recent employment transition where more women have become employed in traditionally male-dominated sectors, the average hours women work on domestic chores vastly exceeds that of men [34]. An in-depth study of women in Tanzania showed that women were overwhelmed with household duties, but that even after long days on the farm, a woman would still cook, collect water and perform other household-related duties [35]. Women in this study reported that they were often too busy to repair nets, leading to low net repair rates [36]. Thus, an important measure to protect against mosquito bites and malaria transmission falls by the way side due to the increasing demands of women – an issue that needs to be addressed by NMCPs.

Feinstein [5] argues that culture is an integral part of people's life and changing such an important part of society is very difficult. In the Tanzanian context, women are brought up to do household duties like washing clothes, cleaning and cooking. If a man is found performing a woman's duty, he is diverging from social norms and acting against the local culture. Study results fall along the lines of cultural expectations: men support and report to perform those net care and repair activities that are restricted to inside the house (e.g. hanging nets after drying, stitching holes) when their wives are not around, but they would not perform net-related household chores in view of others,

e.g. washing of nets [23]. On the outside, people can see him and perceive him differently as he is acting against societal norms [35]. Additionally, many tailors in Tanzania are men and thus stitching is less considered a ‘woman’s’ activity and is more acceptable within society.

In most traditional African societies, men are still the main decision makers for family matters at large [37]. Interestingly, women report that men are able to do everything that women do regarding net care and repair, and that men prompt women to maintain the nets, particularly when they go to bed and realise that the net is not clean. Women know that men and women are the same and what a woman can do, a man can also do, but to put this knowledge into action, good communication between a husband and wife is required [5]. Gender-related interventions could work better among male-headed households where motivation to net care and repair comes from men. However, there is no published data showing men in net care-related duties would lengthen the lifespan of nets or decrease the vulnerability to malaria. This will need to be studied in the future.

The findings from this study reflect what is argued in the social role theory [2]. There is a clear difference between men and women when it comes to household chores, in this case net maintenance activities. This is something that has been accepted by the study communities. Once one deviates from what is expected of her/him, it is therefore regarded as abnormal. In Tanzania, like other developing countries, the social position of women exposes them to bear a higher portion of the work than men while being deprived of resources and decision-making power. While gender roles did not seem to hinder net care and repair activities in this study, it is important to note that, with increased globalisation, women in Tanzania are becoming an ever-increasing part of the workforce [38]. This may limit their full involvement in domestic chores including those related to net care and repair, which, in turn, may lead to increased net damage and malaria attacks in the family. A study in Tanzania revealed how women are overwhelmed with both farming and

domestic chores [35]. Since women acknowledge that men can also do everything that women do with regard to net care and repair and study findings reveal that men do take part in repair activities, it is important that programs sensitise the involvement of men in care and repair activities for the health benefits of the family.

This is the first investigation in Tanzania into behaviours around LLINs through a “gender-aware” lens [39]. Understanding gender culture and attitudes towards net care and repair in this local context will allow NMCPs to create programs that aim to transform ingrained gender norms rather than reinforce existing stereotypes (e.g. the man pays for treatment and the woman nurses the sick) or ignore differences based on gender. The current NMCP BCC materials do not include specific gender-related information on net care and repair but their pictures solely focus on women interacting with mosquito nets on behalf of their families. According to the Gender Equality Continuum Tool [39], to be truly gender-transformative and create equal and enabling environments, positive norms need to be strengthened. Changing people’s behaviour and practices is a long journey and will require a deep cultural and political shift, effected by research-informed and situationally-tailored BCC interventions. Community programs should highlight the burden women and men will face when they or their child catches malaria: loss of monetary income, paying for treatment which will make household economy fluctuate, longer-term sickness and potential death. Thus, it is the responsibility of the whole family to avert the dangers of malaria, for example maintaining clean and intact mosquito nets. Men are already privately performing net care and repair activities. Reframing net care and repair from a household chore to something that protects the economic stability of the households may allow men to start exhibiting such behaviours more publicly. At the same time, women should be encouraged to ask for help and

support from their children (both boys and girls) and their husbands, so that social norms are rebuilt from within households.

While this transition to equality is taking place, it is important that women are empowered by programs to conduct high quality net care and repair. Learning from Donner *et al.*, [40], strategies to involve women in indoor residual spraying (IRS) activities in some African countries significantly increased the number of women employed in the program. This ensured safety for women in their working place, encouraged women to apply for supervisory roles and guaranteed security of women during pregnancy. Women should receive more support to make net care and repair a priority for the benefit of their family and society at large.

5.6 Conclusions

This study provides an in-depth look at household roles in net care and repair behaviours in southern Tanzania. While findings are consistent with what is reported elsewhere in Africa and other developing countries, this is the first study in Tanzania to investigate gender roles in net care and repair attitudes and actions. Currently, net care and repair activities fall under a woman's domain of household chores while men choose to assist when and how they want (mostly repairing nets behind closed doors). As an effect of globalisation, women in Tanzania are slowly becoming part of the work force. This may limit their involvement in household chores including those related to net care and repair, leading to increased net damage, frequent malaria incidences and higher costs for malaria treatment. Since men are already participating in repair activities, the NMCP should consider incorporating research-informed gender-transformative messages into their BCC activities on mosquito nets to reduce gender-related barriers to net care and repair. The BCC promotion should focus on the importance that men,

women and children take responsibility for the upkeep of their mosquito nets and develop positive norms for men to perform maintenance activities not just inside the privacy of their own homes but also publicly assisting each other in case the spouse is occupied with other tasks. The NMCP would benefit from working closely with Community Health Workers, because they are well trusted and may be good agents to inform communities about the importance of sharing responsibilities in net care and repair. The gender-inclusive messaging aims to enhance current maintenance practices to prolong net durability.

5.7 Declarations

Ethics Approval and consent to participate

Permission to conduct the study was obtained from the National Health Research Ethics Subcommittee of the National Institute for Medical Research in Tanzania, with reference number NIMR/HQ/R.8a/Vol. IX/2193. Written consent to participate from the study was obtained from all study participants.

Consent for publication

The consent to publish the findings was obtained from individual participants. All participants signed consent forms that allowed publication of findings. Moreover, we have removed identifiers from the data presented, so it cannot be linked to any particular participants.

Availability of data and materials

All data supporting the findings is contained within the manuscript. Anonymized transcripts are available upon request from the authors.

Competing Interests

The authors declare that they have no competing interests.

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Author's Contributions

AD, ZMM and LML designed the study. AD, ZMM and LML drafted and finalized the manuscript. AD and ZMM collected and analysed the data. GG contributed to the design of the study and commented on the manuscript. All authors have read and approved the final version of this manuscript.

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PART THREE

6 GENERAL DISCUSSION AND CONCLUSION

6.1 Overview

According to the World Malaria Report of 2019, Tanzania contributes to 5% of all global malaria deaths, ranking among the top 3 affected countries in sub-Saharan Africa after Nigeria (24%) and the Democratic Republic of Congo (11%) [1]. This is unfortunately the case due to many reasons including; 1) the environment and temperatures are suitable for year round malaria transmission; 2) the presence of three highly efficient malaria vector species; 3) poverty which remains high leading to inadequate access to treatment and drugs, and unimproved housing to limit mosquito entry or contribute to rapid ITN degradation; 4) rapid population growth that is outstripping the deployment of malaria control interventions such as ITN distributions. As ITNs are the most widespread and cost-effective malaria control intervention, they have a crucial role to play in the continued fight against malaria [2]. Therefore, utilization of appropriate distribution mechanisms maximizing coverage of ITNs to ensure the growing population maintains adequate access in tandem with BCC messaging promoting day-to-day care activities, to help maintain ITNs in serviceable condition are needed to maximize ITN effectiveness and provide extended protection against malaria.

6.2 Synthesis and discussion of findings

The PhD thesis aimed to explore and understand household determinants of durability and use of ITNs in Tanzania. Collectively, the thesis findings are consistent with what was reported elsewhere in Africa and other developing countries, emphasizing that users determine the lifespan of a net within a household. Key findings are discussed below:

Finding 1: *ITN access falls rapidly*

Two years after mass ITN distribution via the UCC campaign [3], ITN access had fallen from 56.2% [4] to 23.8% in 2013 during participant enrolment for the ABCDR study [5] (Chapter 2), and by 2015 only 57.0% of the participating households had enough ITNs (Chapter 3). The decline by almost 50% of study nets after 22 months provides evidence of net loss occurring within the first two years of ownership [6, 7]. In a review of 88 national and regional health surveys in sub-Saharan Africa [8], only Lindi region in Tanzania [2011-2012 Tanzania HIV/AIDS-MIS [4]] documented 80% households with enough nets even with the assessments occurring soon after a mass campaign [8], despite the worldwide call for universal coverage with ITNs for all populations at risk. Even at 57% household access, 84% of the population had access to a net within their household (Chapter 3). While below the target level of 80%, this finding suggests that household access is an important MERG indicator in the measure of ITN coverage. As household size is a key determinant that needs to be considered to maximize household access [8], and sleeping space availability a predictor of net use [9], it is important to note that households do not expand and shrink the number of sleeping spaces or rooms based on its current population. Therefore, distribution mechanisms should consider distributing more nets than are needed to cover the sleeping places as it was observed in 2013 [5] (Chapter 2) and 2015 (Chapter 3) that householders have adapted to retain and continue to use nets freely distributed even when new nets arrive. Limitations in the definition and measurement of households with enough nets (1 net/2 people) should also be re-evaluated so households with more than enough ITNs can be accounted for.

Finding 2: *With lower ITN access, households prioritize net allocation*

This thesis also found that when household access to nets declines households prioritize and modify sleeping space allocations to maximize net use. School-aged children, young adults and seniors were least likely to sleep under an ITN in the face of diminished access to nets (Chapter 3). Delivery strategies have underlying limitations that may have contributed to this gap. The 4-year interval gap between mass distribution campaigns in Tanzania is longer than the WHO recommended 3-year gap [10] to adequately accommodate the growing population, hence it has potential to compromise efforts against malaria interventions especially as most nets are lost within the first two years of ownership. The expansion of free continuous ITN distribution mechanisms especially to school-aged children in high malaria prevalence zones to keep up universal coverage is timely and crucial in the fight against malaria in Tanzania [11, 12]. School-aged children continue to be reported as less prioritized for net use and as a growing reservoir for persistent malaria [13-15].

Finding 3: *With lower access people crowd under nets, which diminishes ITN lifespan*

Furthermore, crowding (more than two sleepers under the same net) in households without enough nets doubled (62%) compared to households with enough nets (31%) across all age categories except for children <5 who were more likely to sleep with their parents (Chapter 3). Consequently, the number of people that slept under an ITN, age category of the net users and socio-economic status were significantly associated with a reduction in ITN serviceability (Chapter 3). Although continuous distribution of ITNs will cost more, it will increase cost-effectiveness in the long run because it will reduce crowding which causes physical damage to occur faster and make the nets last longer. While BCC messaging should focus on discouraging

crowding under nets, procurement of large nets that accommodate more sleepers should be considered where appropriate to reduce speed of wear and tear of the net fabric. The cost of a double size net is just 10 cents higher than a smaller net [16] and may assist in prolonging the useful life of ITNs.

Finding 4: *Socio-economic status affects ITN use*

Beyond access [17], higher socio-economic status was significantly associated with population ITN use in Tanzania [5] (Chapter 2) and low parasite prevalence was observed among the wealthiest households [15]. A study in Dar-es-Salaam (an urban city) reported sleeping arrangements, bed sharing and delayed net use as reasons for high malaria prevalence despite net use [18]. Therefore, the current BCC medium of communication needs to be modified to reach the poorest households [19], and use of alternative malaria control interventions such as repellents when not under a net [20, 21] and/or net modification to accommodate sleeping arrangements or increased number of sleepers under a net. Challenges hindering net use by these poor populations also needs to be assessed as was done in Bangladesh [22] and Zanzibar [23] to provide local context on how best to reinforce the current BCC strategy.

Finding 5: *Household members do not repair ITNs*

Inconsistencies were observed between reported intentions to repair and current conditions of ITNs found [24] (Chapter 4) highlighting important household attitudes and actions that determine the lifespan of nets within households. The location of holes at the bottom of the net contributed to those holes not being of priority for repair as these holes could be tucked under the mattress [24] (Chapter 4). Accumulation of holes begins as early as three months post distribution as was observed in Ethiopia [25]. Therefore, lack of repair of a few small holes leads

to an accumulation of more holes with continued net use, eventually leading to too many holes for the net to be of use. In addition, women/primary caretakers of households reported being overwhelmed with other household and societal duties so that net care and repair activities were not a priority within households [26, 27] (Chapter 5). It is therefore essential for the NMCP to revise the BCC guidelines to include gender and age appropriate messages that encourage men and children to inclusively participate in everyday care activities to extend the life of serviceable nets within households. This will in turn limit premature disposal of nets that leads to school-aged children and youth being uncovered or crowding under available nets. The BCC messaging should focus on care recommendations which can be incorporated in the day-to-day activities to prevent the occurrence of damage in the first place.

Finding 6: *ITN product lifespan varies*

Serviceability of ITNs has also been observed to vary by product type but more significantly across various locations [28]. Procurement of NetProtect would be the recommended net product for Tanzania [29], as even at regular field use (minimum net care and/or without any repair) the cost-per-functional year within a household was longer compared to Olyset and PermaNet.

Unfortunately, NetProtect did not receive full WHO recommendation and was in turn removed from the market after the study commenced [30, 31]. PermaNet was reported to perform better than to Olyset nets in Mozambique [32] and Zambia [33] and Zanzibar [34] and mainland Tanzania [29]. Therefore, procurement of the longer lasting and approved net product should be considered for Tanzania to maximize impact against malaria.

Finding 7: *Net use is still insufficient*

Irrespective of net product type, insufficient use of serviceable nets across all age categories (average 27.3%) was observed after just 2 years of net ownership (Chapter 3). Children <5 who shared sleeping spaces with their parents in Uganda were more likely to sleep under a net than those who did not share a sleeping space [35]. Other reported reasons for net non-use include availability of suitable place to hang the net [9], available sleeping space [36], and educational level of the head of household [37]. Therefore, beyond promoting year-round ITN use, there is a need for tailored and interpersonal communication with parents and primary caretakers through visits by Community Health Workers to ensure they are well-informed of the importance of continued net use among household members to address insufficient use of serviceable nets. As observed in Nigeria [38], mass BCC may not necessarily have positive influence to use nets as community-based interventions such as house visits that are personal and foster social support for net use compliance.

6.3 Limitations and Lessons Learnt

Study limitations have been discussed in the respective results chapters. Here we reiterate major study limitations and lessons learnt.

Study Limitations

Core to this thesis study is the assumption that participants, who may have assumed that the study investigators were health workers or involved in the ITN distribution process, did not have their behavior affected by being in the study. Although participants were informed that the team was of researchers who did not influence their likelihood of receiving nets from the government

or any other sources, it is possible that some did not heed this message. This is especially true since upon enrolment, we informed all recruited households that we would be returning at some point within the next three years to assess the study nets distributed. The Hawthorne effect, a consequence of participating households knowing they are being monitored, may have potentially biased responses to be favorable towards mosquito nets, affected net retention, and reported care and repair behaviors. The long-term prospective nature of the assessment of the consequences of changing population access after 2 years in Chapter 3, may have influenced study participants to keep nets longer than they would normally do unobserved [33]. Therefore, net retention reported after 22 months of ownership (Chapter 3) may be an overestimate of what happens in an unobserved setting [5] (Chapter 2).

While even torn nets offer chemical protection against mosquitoes [39, 40], including unserviceable nets (which require replacement soon) in the calculation of population access overestimates the proportion of household members with access to a net that is fully protective within their household.

Lessons learnt

Net use data collected in 2015 (Chapter 3) is reported with increased precision due to assigning household members to specific nets during the survey ensuring no-one person could be recorded as having slept under two nets the previous night. This coding was different compared to the standard population-use indicator which relies on recall of the interviewee without ensuring same users are recorded under multiple nets [41, 42]. Unfortunately, household survey data is static in time and does not account for seasonal variation of net use especially with diminishing

serviceability of ITNs. As has been previously reported in other studies [23, 43, 44], low perception of risk to get sick with malaria due to the perceived decrease of cases of severe malaria in the community, inconsistent sleeping arrangements, cultural events and heat affect net use. Understanding net use during the high malaria transmission season in the face of diminishing number of serviceable nets in the community is essential for the NMCP to grasp as that is when the health impact is most required to maintain gains against malaria.

Inconsistencies noted in the reported intentions to repair ITNs and the actual condition of nets observed during mosquito net assessments highlighted that; 1) the method used to for hole assessments [24, 27] (Chapter 4 and 5) was unconventional but, 2) even when holes were identified by household members, net repair was only a temporary measure while they explored options for a new net. Therefore, BCC messages should focus on incorporating net care activities in day-to-day activities to prevent damage from occurring in the first place as net repair is unlikely.

6.4 Implications of findings and recommendations for future studies

Recommendation 1: *Deliver more nets with each replenishment to maximize access*

Only 10.8% of households in Musoma district received enough URC nets, assuming each net was used by 2 people (Chapter 3). These findings are further supported by the TMIS results where only 45.4% of households in Tanzania reported to have enough nets merely 11 months after the last district received nets [45]. There is a need to re-evaluate mass distribution strategies to understand the root causes of these coverage gaps. The influence of the current limitation of a maximum of five nets per household with ten or more members (Ikupa Akim, *pers. comm*) needs to be assessed as population access in larger households (>10 household members) was 14.2% lower than smaller

households (≤ 10 household members) (Chapter 3). The thesis also recommends that ITN distribution mechanisms to consider procuring nets with unique features such as a different color of yarn on seams for each year and/or distribution scheme so that future studies can assess net attrition (presence or absence of nets) with precision and accuracy.

Recommendation 2: *ITN keep-up delivery strategies are both essential and appropriate*

This thesis provides additional evidence in support of the SNP distribution mechanism as it targets a crucial group in onward malaria transmission for the continued and sustainable fight against malaria. The extension to cover school-going children in other high malaria prevalence regions in Tanzania coupled with BCC messaging encouraging the children to participate in care activities has potential of sustaining efforts across generations eliminating crowding and premature disposal of ITNs (Chapter 4). Modalities to target the poorest SES quintile such as those applied by the Tanzania Social Action Fund (TASAF) could be adopted as yet another keep up ITN distribution mechanism for households without school-going children. Increasing keep-up distribution schemes and the availability of ITNs in the commercial market may then justify the wide 4-year gap between mass campaigns.

Recommendation 3: *NMCP to procure the best net for the Tanzanian setting*

Procurement of longer lasting net products is a crucial decision that requires evidence. As provided by this thesis (Chapter 3) and the longitudinal ABCDR project findings [29], NetProtect and PermaNet appear to be the most durable nets in Tanzania. Provisions for larger nets should also be considered in an effort to ensure the net can accommodate more than 2 people comfortably in the event of crowding. Larger households (> 10 household members) should also by default receive additional nets instead of too few nets to ensure appropriate access irrespective of sleeping space

availability. To account for the uncovered population (who slept alone or who and how many shared a sleeping space), future studies including the national Malaria Indicator Survey should consider including a sleeping space roster as well to account for all sleeping spaces (covered and uncovered by a net).

Recommendation 4: *NMCP to reinforce the BCC messages to be gender and age inclusive*

Lastly, recognizing that citizens of Tanzania are the end-users of ITNs and decision-makers of what the life of a net within a household is, altering their behavior and cultural norms is a long process requiring deep cultural and political change. The thesis had extensive engagement with the NMCP and the respective BCC sub-committees throughout the study to ensure relevant programmatic data was collected and results shared in a timely manner to leverage evidence-based decision making. Utilization of existing platforms such as Community Health Workers and regular informal gatherings such as “Vikoba” were repeatedly suggested as means to disseminate information and demonstrations to educate community members on net maintenance issues. Behavioral-communication messages should focus on day-to-day care activities as they easily applicable and carry the most significance in the ITN strategy. Prevention of damage from occurring in the first place is crucial to prevent accumulation of holes and in turn premature net loss.

6.5 Conclusions

Although complementary interventions continue to be developed, ITNs will remain the core intervention against malaria for a while to come. It is therefore crucial to ensure at-risk populations have adequate access and information to use and care for their nets to maximize impact of the ITN strategy. The length of time a serviceable ITN survives within a household is dependent on

personal responsibility to care for and repair any damage that occurs, and its usefulness is based on continuous use for protection while present within the household. This thesis informs of end-user (household) behaviours in Tanzania and provides evidence-based recommendations for NMCP action.

The mass distribution campaigns in Tanzania occur at an interval of approximately 4 years which is too wide a gap as households in Tanzania lose their ITNs quickly. Increasing availability of ITNs in the commercial market is essential so those who can afford to purchase nets buy ITNs instead of UTNs. Continuous distribution mechanisms through the ANC and SNP are critical to keep up coverage during these gap years to ensure the growing population is always protected and crowding under nets is not considered as an option for continued protection.

Insufficient use of serviceable nets was observed in this study within households which is another cause for NMCP concern. Understanding sleeping space allocations and barriers to net use in light of decreasing serviceability is key in reinforcing appropriate BCC messaging. Year-round net use needs to be stressed as an important effort to maintain health gains against malaria especially among school-aged children who are most likely to carry gametocytes which result in onward transmission of malaria within the community. While promoting continuous net use, it is important to emphasize that net use by more than two people is not advised as it will most likely cause the net to damage faster.

Lastly, as net care activities are more likely to be implemented than repair and more women are becoming part of the workforce, limiting their time and commitment to net care at the household, it is ever more important to encourage men and children in net maintenance activities. It is not shameful to care for one's health and involving children to participate is ensuring unbiased

continuity in net maintenance to future generations. Decentralizing the burden of net maintenance from women and focusing on day-to-day care activities has potential to decrease the rate of net damage, reduce malaria incidences and save costs for malaria treatment.

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APPENDICES

Appendix 1: Research Paper Cover Sheets



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PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.

SECTION A – Student Details

Student	Zawadi Mageni Mboma
Principal Supervisor	Jo Lines
Thesis Title	Household determinants of durability and use of insecticide treated nets in Tanzania

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	Malaria Journal		
When was the work published?	March 1st, 2018		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	n/a		
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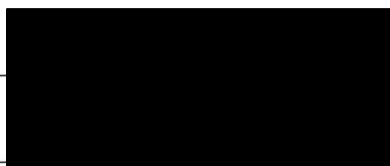
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Where is the work intended to be published?	
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Stage of publication	Choose an item.

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I collected and analysed the data. I prepared the first draft of the paper.
--	---

Student Signature: _____



Date: 11/09/2020

Supervisor Signature: _____

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Student	Zawadi Mageni Mboma
Principal Supervisor	Jo Lines
Thesis Title	Household determinants of durability and use of insecticide treated nets in Tanzania

If the Research Paper has previously been published please complete Section B, if not please move to Section C

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Where was the work published?			
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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	Malaria Journal
Please list the paper's authors in the intended authorship order:	Zawadi Mboma, Charles Festo, Lena Lorenz, Dennis Massue, William Kisinza, John Bradley, Jason Moore, Renata Mandike, Ikupa Akim, Jo Lines, Hans Overgaard, and Sarah Moore
Stage of publication	Submitted

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I collected and analysed the data. I prepared the first draft of the paper.
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Student	Zawadi Mageni Mboma
Principal Supervisor	Jo Lines
Thesis Title	Household determinants of durability and use of insecticide treated nets in Tanzania

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	Malaria Journal		
When was the work published?	October 22nd, 2018		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	n/a		
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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	
Stage of publication	Choose an item.

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I conceived and designed the study. I collected and analyzed the data. I wrote the first draft of the paper.
--	--

Student Signature: _____

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Student	Zawadi Mageni Mboma
Principal Supervisor	Jo Lines
Thesis Title	Household determinants of durability and use of insecticide treated nets in Tanzania

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SECTION B – Paper already published

Where was the work published?	Malaria Journal		
When was the work published?	December 7th, 2018		
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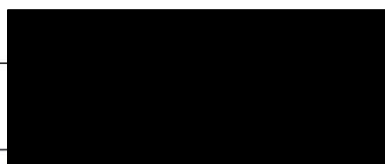
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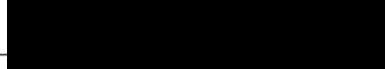
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--	--

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Date: 11/09/2020

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Date: 11/09/2020

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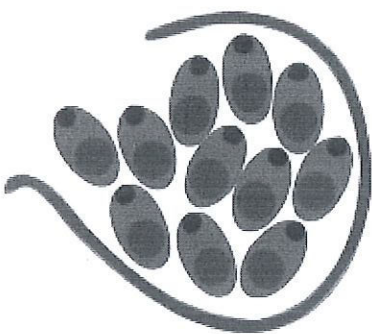
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Appendix 2: Ethical Clearance Certificates



Observational / Interventions Research Ethics Committee

Lena Lorenz
Research Fellow in Medical Entomology
DC/ ITD
LSHTM

18 February 2013

Dear Dr. Lorenz,

Study Title: The useful life of bednets for malaria control in Tanzania: attrition, bioefficacy, chemistry, durability and insecticide resistance
LSHTM ethics ref: 6333

Thank you for your letter of 13 February 2013, responding to the Interventions Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

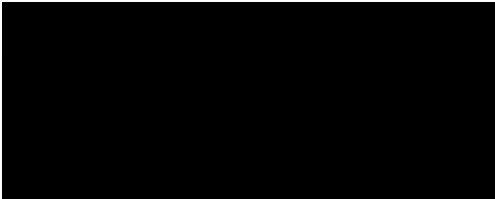
Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	Version	Date
LSHTM ethics application	n/a	
Protocol		
Appendix 3 - Information Sheet & Consent form – Survey (in English and Kiswahili)		
Appendix 3 – Information Sheet & Consent form - Experimental Hut Evaluations (in English and Kiswahili)		
Appendix 4 - Questionnaire (in English and Kiswahili)		

After ethical review

Any subsequent changes to the application must be submitted to the Committee via an E2 amendment form. All studies are also required to notify the ethics committee of any serious adverse events which occur during the project via form E4. An annual report form (form E3) is required on the anniversary of the approval of the study and should be submitted during the lifetime of the study. At the end of the study, please notify the committee via form E5.



Professor Andrew J Hall
Chair

ethics@lshtm.ac.uk

<http://intra.lshtm.ac.uk/management/committees/ethics/>



Observational / Interventions Research Ethics Committee

Dr. Lena Lorenz
DC/ITD
LSHTM

17 July 2014

Dear Dr. Lorenz,

Study Title: THE USEFUL LIFE OF BEDNETS FOR MALARIA CONTROL IN TANZANIA: ATTRITION, BIOEFFICACY, CHEMISTRY, DURABILITY AND INSECTICIDE RESISTANCE

LSHTM Ethics Ref: 6663-02

Thank you for your application of 18 June 2014 for the above amendment to the existing ethically approved study and submitting revised documentation. The amendment application has been considered by the Interventions Committee.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above amendment to research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval for the amendment having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Other	Ethics application_LSHTM_final.docx	11/12/2012	v01
Other	ABCDR Ethics Amendment Cover LSHTM 6333.pdf	14/08/2013	01
Other	ABCDR Ethics Protocol June2014.docx	04/09/2013	02
Other	Appendix 4 v03 Questionnaire.pdf	18/06/2014	03
Other	Appendix 3 v03 Informed Consent.pdf	18/06/2014	03

After ethical review

Any further changes to the application must be submitted to the Committee via an Amendment form on the ethics online applications website. The Principal Investigator is reminded that all studies are also required to notify the ethics committee of any serious adverse events which occur during the project via an Adverse Event form on the ethics online applications website. An annual report form is required on the anniversary of the approval of the study and should be submitted during the lifetime of the study on the ethics online applications website. At the end of the study, please notify the committee via an End of Study form on the ethics online applications website. Ethics online applications website link: <http://leo.lshtm.ac.uk>

Yours sincerely,



Professor John DH Porter
Chair

ethics@lshtm.ac.uk
<http://www.lshtm.ac.uk/ethics/>



Observational / Interventions Research Ethics Committee

Dr. Lena Lorenz
Post-doctoral research fellow in medical entomology
Department of Disease Control (DCD)
LSHTM

30 July 2015

Dear Dr. Lorenz

Study Title: ABCDR project: THE USEFUL LIFE OF NETS FOR MALARIA CONTROL IN TANZANIA: ATTRITION, BIOEFFICACY, CHEMISTRY, DURABILITY AND INSECTICIDE RESISTANCE

LSHTM Ethics Ref: '6333 - 3'

Thank you for your application for the above amendment to the existing ethically approved study and submitting revised documentation. The amendment application has been considered by the Interventions Committee.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above amendment to research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval for the amendment having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Other	ABCDR Ethics Protocol amended v03 2015	27/05/2015	3
Other	IRB IHI ABCDR ammendment for holed nets approval 2015	01/06/2015	1
Other	Appendix 7 Brochure_K-OTab	02/06/2015	1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: <http://leo.lshtm.ac.uk>

Additional information is available at: www.lshtm.ac.uk/ethics

Note from committee: The committee suggests moving the Budget to an Appendix so that changes do not affect the protocol.

Yours sincerely,

**Professor John DH Porter
Chair**

ethics@lshtm.ac.uk
<http://www.lshtm.ac.uk/ethics/>

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LONDON
SCHOOL of
HYGIENE
& TROPICAL
MEDICINE



Observational / Interventions Research Ethics Committee

Dr Lena Lorenz
LSHTM

4 February 2016

Dear Lena,

Project Title: ABCDR project: THE USEFUL LIFE OF NETS FOR MALARIA CONTROL IN TANZANIA: ATTRITION, BIOEFFICACY, CHEMISTRY, DURABILITY AND INSECTICIDE RESISTANCE

Project ID: 9159

Thank you for your annual report application for the continuation of your research dated 01/02/2016, which has now been considered by the Chair on behalf of the Interventions Committee.

Confirmation of ethical opinion

This application is approved by the committee for a further year.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

After ethical review

Any changes to the application must be submitted to the committee via an Amendment form.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reaction (SUSARs) which occur during the project by submitting a SUSAR and Protocol Violation form.

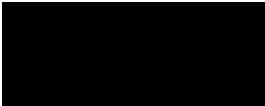
An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at <http://leo.lshtm.ac.uk>.

Additional information is available at: www.lshtm.ac.uk/ethics.

Yours sincerely,



Professor John DH Porter
Chair

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LONDON
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& TROPICAL
MEDICINE



Observational / Interventions Research Ethics Committee

Dr Lena Lorenz
LSHTM

2 March 2017

Dear Lena,

Project Title: ABCDR project: THE USEFUL LIFE OF NETS FOR MALARIA CONTROL IN TANZANIA: ATTRITION, BIOEFFICACY, CHEMISTRY, DURABILITY AND INSECTICIDE RESISTANCE

Project ID: 9159

Thank you for your annual report application for the continuation of your research dated 23/02/2017, which has now been considered by the Chair on behalf of the Interventions Committee.

Confirmation of ethical opinion

This application is approved by the committee for a further year until 02/03/2018.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

After ethical review

Any changes to the application must be submitted to the committee via an Amendment form.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reaction (SUSARs) which occur during the project by submitting a SUSAR and Protocol Violation form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at <http://leo.lshtm.ac.uk>.

Additional information is available at: www.lshtm.ac.uk/ethics.

Yours sincerely,


Professor John DH Porter
Chair

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National Institute for Medical Research
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26th September, 2013

Sarah Moore
Ifakara Health Institute
P O Box 78373
Dar Es Salaam

Ref: IHI/IRB/AMM/ No. 12-2013

AMMENDMENT 1 APPROVAL (Version of 22nd August 2013)

On 6th September 2013, the Ifakara Health Institute Review Board (IHI IRB) reviewed Amendment 3 to a study titled "*The useful life of bednets for malaria control in Tanzania: attrition, bioefficacy, chemistry, durability and insecticide resistance*", submitted by Principal Investigator Dr Sarah Moore. The study with previous approval number IHI/IRB/No 19-2013 dated on 24th May 2013.

Amendment includes:

1. The number of districts was reduced from **15 to eight** for the ABCD components of the bed net study. The following districts were dropped from the study: Ruangwa, Mtwara Urban, Songea Urban, Arusha, Kondo, Singida Rural and Kasulu
2. The number of households per district was **increased from 330 households per district to 450 households per district**. This was to account for the loss of households in the seven districts that were dropped. In each district, 10 villages will be selected as mentioned early. Thus, 45 households from each village will be randomly selected to participate in the study ($450/10=45$). Each of the three net products will be given to 15 households per village ($45/3=15$) rather than 11 households as described in the initial study protocol.
3. The Long-Lasting Insecticidal Net **LifeNet® (Bayer) was replaced by Netprotect® (BestNet)** due to delivery problems. The study will now compare Netprotect®, which contains 63 mg/m² of deltamethrin incorporated into polyethylene fibres, against Olyset® and PermaNet®2.0.
4. The timing of the follow-up field work was changed slightly. **The 6 month follow-up was dropped and replaced by an additional follow-up after 30 months**. Therefore, the durability of LLINs will be measured after 12 months, 24 months, 30 months and 36 months of field use.
5. The study had initially relied upon the provision of a master list of households that received Olyset® LLINs during the U5 and UCC campaigns from MEDA. However, the study team was informed that no such household list exists and had therefore to **change the**



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6. **methodology so that all households in each selected village would have an equal chance of being selected to be included in the study.** The questionnaire was then adapted in a way that will make it easier to identify which nets came from government campaigns and which nets had come from different sources.
7. The questionnaire used for field work to assess LLIN ownership and use has changed significantly as attached in Appendix 4.
8. The methodology to measure the C-component (chemical residue analysis) was changed from sonication at London School of Hygiene & Tropical Medicine to a **CIPAC approved methodology which allows extraction of active ingredients from incorporated nets.** This will now be performed at a WHO Collaborating Centre for Quality Control of Pesticides (Walloon Agricultural Research Centre; CRA-W).
9. In the previous protocol, assessment of the physical degradation of LLINs (D-component; holes and tears in nets) was only performed on a sub-sample of 75 LLINs for each net product. Methodology has been changed so that the **field staff will be trained to perform hole index analyses in the field using a recently developed tool kit by USAID/NetWorks-supported K4Health (new Appendix 7).** Now, **all nets will be investigated for Dcomponent at all four follow-up time points.**
10. p.3 The associations to institutions of some of the investigators has changed. Dennis Massue is now associated with IHI (1), NIMR (2) and Swiss TPH (3); Zawadi Mageni is now associated with IHI (1), NIMR (2) and LSHTM (4); Sarah Moore is now associated with IHI (1) and Swiss TPH (3).
11. Other detailed changes are highlighted in the protocol

The IRB reserves the right to undertake field inspections to check on the protocol compliance


IRB Secretary

Beverly Msambichaka



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6th July, 2014

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Email; headquarters@nimr.or.tz

Dr Sarah Moore
Ifakara Health Institute
P O Box 74
Bagamoyo

Ref: IHI/IRB/AMM/ No: 07- 2014

AMMENDMENT APPROVAL

On 1st July 2014, The Ifakara Health Institute Review Board (IHI-IRB) reviewed and approved the study titled "*The useful life of bednets for malaria control in Tanzania: attrition, bioefficacy, chemistry, durability and insecticide resistance*", submitted by Principal Investigator Sarah Moore. The above named study had a previous approval number IHI/IRB/No: 19-2013 dated on 24 May 2013.

Amendment includes:

1. Devised a new questionnaire for the prospective data collection of household survey data: English questionnaire BRTC_ABCDR_020_APP03_V05 and Swahili questionnaire BRTC_ABCDR_020_APP04_V05
2. Updated the informed consent forms for the protective data collection of household survey data: English BRTC_ABCDR_019_APP05_V01 and Kiswahili BRTC_ABCDR_019_APP06_V02
3. Developed informed consent forms for volunteers sleeping underneath bednets collected from the field in a semi-field tunnel system. English BRTC_ABCDR_019_APP07 and Kiswahili BRTC_ABCDR_019_APP08_V01

The IRB reserves the right to undertake field inspections to check on the protocol compliance

Deputy IRB Secretary

Dr Mwifadhi Mrisho



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1st June, 2015

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Dr Sarah Moore
Ifakara Health Institute
P O Box 74
Bagamoyo

Ref: IHI/IRB/AMM/ No: 06- 2015

AMMENDMENT 2 APPROVAL

On 29th May 2015, The Ifakara Health Institute Review Board (IHI-IRB) reviewed and approved the study titled ***"The useful life of bednets for malaria control in Tanzania: attrition, bioefficacy, chemistry, durability and insecticide resistance"***, submitted by Principal Investigator Sarah Moore. The above named study had a previous approval number IHI/IRB/No: 19-2013 dated on 24 May 2013.

Amendment includes:

Added a standard controlled assay to the Ifakara Tunnel Test Component of the study to compare against the nets that are tested from home throughout Tanzania. The team will test polyester nets, intact and artificially hold using scissors with holes in four sizes, crossed with five insecticide concentrations (K O Tab, registered and widely used in Tanzania)

The IRB reserves the right to undertake field inspections to check on the protocol compliance



Deputy IRB Secretary

Dr Mwifadhi Mrisho



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03rd July, 2017

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Dr Sarah Moore
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Bagamoyo.

IHI/IRB/EXT/11 - 2017

EXTENSION APPROVAL

On 30th June, 2017, the Ifakara Health Institute Review Board (IHI-IRB) renewed Annual Extension application to a study titled: *“The Useful Life of Bednets for Malaria Control in Tanzania: Attrition, Bioefficacy, Chemistry, Durability and Insecticide”* submitted by P.I Fredrick Haraka. The Annual Extension extends from 18th July 2017 to 19th July 2018. The above-named study had a previous approval number IHI/IRB/No: 19 - 2013 dated 24th May 2013.

The IRB reserves the right to undertake field inspections to check on the protocol compliance.

Deputy IRB Secretary



Dr. Mwifadhi Mrisho



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02nd April, 2013

Dr. William Kisinza
NIMR Amani Centre
P. O. Box 81
MUHEZA
TANGA

**CLEARANCE CERTIFICATE FOR CONDUCTING
MEDICAL RESEARCH IN TANZANIA**

This is to certify that the research entitled: The useful life of bed nets for malaria control in Tanzania (Kisinza W. *et al.*) has been granted ethical clearance to be conducted in, Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health & Social Welfare and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Approval is for one year: 02nd April, 2013 to 01st April, 2014.

Name: Dr Mwelecele N Malecela

Signature

CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Dr Donan Mmbando

Signature

ACTING CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, SOCIAL
WELFARE

CC: RMO
DMO



THE UNITED REPUBLIC OF
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NIMR/HQ/R.8c/Vol. I/ 329

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17 December 2014

Dr William Kisinza
NIMR Amani Centre
P O Box 81, MUHEZA, Tanga

APPROVAL FOR PROTOCOL AMENDMENT

This letter is to confirm that your application for Amendment 02 on the study entitled: the Useful Life of Bednets for Malaria Control in Tanzania: Attrition, Bioefficacy, Chemistry, Durability and Insecticide Resistance (Kisinza W *et al*), NIMR/HQ/R.8a/Vol. IX/ 1510., dated 02 April 2013, NIMR/HQ/R.8c/Vol. I/ 285 dated 27th September 2013, has been granted approval to be conducted in Tanzania

The Principal Investigator of the study must ensure that the approval is for the following amendments:

1. Devised a new questionnaire for the prospective data collection of household survey data: English questionnaire. BRTC_ABCDR_020_APP03_V05 and Kiswahili questionnaire BRTC_ABCDR_020_APP04_V05.
2. Amendment on informed consent forms for volunteers sleeping underneath bednets collected from field in a semi-filed tunnel system. English BRTC_ABCDR_019_APP07_V02 and Kiswahili, BRTC_ABCDR_019_APP06_V02

Other condition for approval is as per original approval.
Approval is up to 01st April 2015.

Name: Dr Mwelecele Malecela

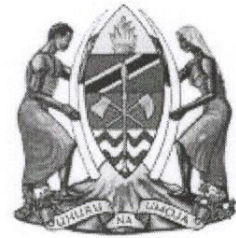
Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Dr Margaret E Mhando

Signature
Ag. CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH & SOCIAL WELFARE



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NIMR/HQ/R.8c/Vol. I/ 452

03rd January 2017

Dr William Kisinza
NIMR AMANI
P O Box 81 MUHEZA

APPROVAL FOR PROTOCOL AMENDMENT

This letter is to confirm that your application for Amendment 03 on the study entitled: The Useful Life of Bednets for Malaria Control in Tanzania: Attrition, Bioefficacy, Chemistry, Durability and Insecticide Resistance Kisinza W *et al*, has been granted ethical clearance to be conducted in Tanzania. Ref. NIMR/HQ/R.8a/Vol. IX/1510, dated 02 April 2013.

The Principal Investigator of the study must ensure that the approval is for the following amendments:


1. We have added a standard controlled assay to the Ifakara Tunnel Test Component of the study to compare against the nets that are tested from homes throughout Tanzania. We will test polyester nets, intact and artificially holed using scissors with holes in four sizes, crossed with five insecticide concentrations (K O Tab, registered and widely used in Tanzania, Appendix 7) in a semi-factorial design in semi-field experimental studies. The three standard (i.e. currently used for net durability studies) hole sizes are: finger size (4 cm square cuts), fist size (100 cm), and head size (625 cm) holes. Further, a size of 250 cm will be tested. Four holes of this intermediate size create a total holed surface of 1000 cm, a currently proposed rectangular hole total threshold of "too torn" nets. As is commonly seen in the field a 1000cm² "too torn" category will also be made with 50 x 4cm cuts on each side of the net and on the roof.
Untreated nets will be dipped in four concentrations of K O Tab, resulting in the following concentrations on the net: 0 mg/m, 5 mg/m, 15 mg/m, 25 mg/m, and Permethrin 2.0 as a comparison long lasting insecticidal net. To study the possible effect of hole location, nets will be holed either in the roof panel or the side panels due to species-specific net entry. Nets with holes will have one hole in each of the four side panels or four holes in the roof panel. Data will be compared against nets from the field that have been naturally worn to more fully understand the relative importance of holes versus insecticide for malaria mosquito control.

Other condition for approval is as per original approval.
Approval is up to 01st April 2017

Name: Dr Julius J Massaga

Name: Prof. Muhammad Bakari Kambi.

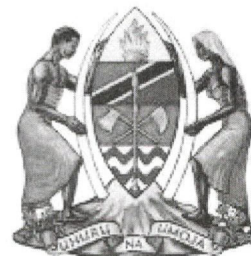
Signature 
Ag CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Signature 
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY
DEVELOPMENT, GENDER, ELDERLY
& CHILDREN

CC: RMO: TANGA
DMO: MUHEZA



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NIMR/HQ/R.8c/Vol. II /784

17th May 2017

Dr. William Kisinza
NIMR Amani
P.O. Box 81
Muheza, TANGA

APPROVAL FOR EXTENSION OF ETHICAL CLEARANCE

This letter is to confirm that your application for extension on the already approved proposal: The useful life of bednets for malaria control in Tanzania: Attrition, bioefficacy, chemistry, durability and insecticide resistance (Kisinza W. *et al*) has been approved.

The extension approval is based on the progress report dated 31st March 2017 on the project, Ref. NIMR/HQ/R.8a/Vol. IX/1510 dated 2nd April 2013. Extension approval is valid until 1st April 2018.

The principal investigator (PI) must ensure that other conditions of approval remain as per ethical clearance letter. The PI should ensure that progress and final reports are submitted in a timely manner.

Name: Prof. Yunus Daud Mgaya

Name: Prof. Muhammad Bakari Kambi

**Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE**

**Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY
DEVELOPMENT, GENDER, ELDERLY
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4th April, 2016

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Zawadi Mageni
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Dar es Salaam

IHI/IRB/No: 015-2016

INSTITUTIONAL CLEARANCE CERTIFICATE FOR CONDUCTING HEALTH RESEARCH

On 1st April, 2016, the Ifakara Health Institute Review Board (IHI-IRB) reviewed from study titled: ***“Decoding Perceptions, Barriers and Motivators of Net Care and Repair in Tanzania”*** submitted by P.I Zawadi Mageni.

The following documents were reviewed:

1. Protocol
2. Informed Consent Forms
3. Budget
4. Data collection tools
5. CVs

The study has been approved for implementation after IRB consensus. This certificate thus indicates that; the above- mentioned study has been granted an Institutional Ethics Clearance to conduct the above named study in Tanzania (Pemba Mnazi (Dar), Makanjiro and Kilimahewa (Ruangwa) villages).

The Principal Investigator of the study must ensure that, the following conditions are fulfilled during or after the implementation of the study:

1. PI should submit a six month progress report and the final report at the end of the project
2. Any amendment, which will be done after the approval of the protocol, must be communicated as soon as possible to the IRB for another approval
3. All research must stop after the project expiration date, unless there is prior information and justification to the IRB.
4. There should be plans to give feedback to the community on the findings
5. Any publication needs to pass through the IRB
6. The approval is valid until 3rd April, 2017

The IRB reserves the right to undertake field inspections to check on the protocol compliance


Deputy Chairperson
Dr Saidi Mpendu


IRB Secretary
Beverly Msambichaka



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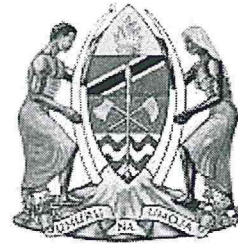
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NIMR/HQ/R.8a/Vol. IX/2193

09th May 2016

Zawadi Mageni
Ifakara Health Institute
P.O. Box 78373
Dar es Salaam.

CLEARANCE CERTIFICATE FOR CONDUCTING
MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Decoding Perceptions, Barriers and Motivators of Net Care and Repair in Tanzania (Mageni *Z et al*), has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Ruangwa District.

Approval is for one year: 09th May 2016 to 08th May 2017.

Name: Dr Mwelecele N Malecela

Name: Prof. Muhammad Bakari Kambi

Signature

CHAIRPERSON
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COORDINATING COMMITTEE

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MINISTRY OF HEALTH, COMMUNITY
DEVELOPMENT, GENDER, ELDERLY
& CHILDREN

CC: RMO
DED
DMO



*Tulane Human Research Protection Program
Institutional Review Boards
Biomedical
Social Behavioral
FWA00002055*

DATE: April 26, 2016

TO: Joshua Yukich, MPH, PhD
FROM: Tulane University Biomedical IRB

STUDY TITLE: [881306-1] DECODING PERCEPTIONS, BARRIERS AND MOTIVATORS OF NET CARE AND REPAIR IN TANZANIA

IRB REFERENCE #: 16-881306IAA
SUBMISSION TYPE: New Project

ACTION: ACKNOWLEDGED

EFFECTIVE DATE: April 26, 2016

IRB EXPIRATION DATE: April 3, 2017
REVIEW TYPE: FACILITATED REVIEW

Thank you for your submission of New Project materials for this research study. This submission has received Facilitated Review. The Tulane University IRB has acknowledged the opening of this protocol. All research must be conducted in accordance with this approved submission.

The IRB of record for this project is Ifakafa Health Institute IRB but Tulane University IRB remains responsible for issues of local context therefore it is necessary that all modification requests (Amendments) and continuing review applications are submitted to the Tulane University IRB and that local reporting requirements are adhered to.

The Tulane University IRB acknowledges the following documents submitted within this submission:

- Consent Form - Informed Consent (UPDATED: 03/29/2016)
- Cover Sheet - Cover Sheet-Letter request for deferral.docx (UPDATED: 04/25/2016)
- Investigator Agreement - Individual Investigator Agreement -Yukich.doc (UPDATED: 03/9/2016)
- Letter - IHI Approval Letter (UPDATED: 04/18/2016)
- Other - Institutional Agreement for Deferral (UPDATED: 03/22/2016)
- Protocol - Protocol (UPDATED: 03/9/2016)
- Tulane - Application for Human Subjects Research, Part 1 - Tulane - Application for Human Subjects Research, Part 1 (UPDATED: 03/10/2016)

The Tulane University Biomedical IRB has provided a facilitated review and acknowledges the activation of the above referenced, minimal risk study, in accordance with 45 CFR 46.114.

The Ifakafa Health Institute IRB is the IRB of record; IHI/IRB/No: 015-2016. IRB approval for this study will expire April 3, 2017.

Proposed changes to the research must be submitted to the IRB for review and approval prior to implementation, unless such a change is necessary to avoid immediate harm to subjects.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of their signed consent form unless this requirement has been waived by the IRB.

Any Unanticipated Problems involving Risk to Subjects or Others, Deviations from the approved research, Non-Compliance, and Complaints must be reported to the IRB in accordance with Tulane HRPP policies and procedures. If this study includes ongoing oversight by a Data Safety Monitoring Board (DSMB) or other such committee, reports generated by the DSMB or oversight committee must be submitted to the IRB.

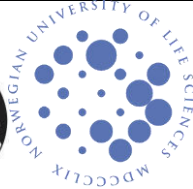
Continuations must be submitted in accordance with Tulane HRPP policies and procedures. The federal regulations provide for no grace period. Failure to obtain approval for continuation of your study prior to the expiration date will require discontinuation of all research activities for this study, including enrollment of new subjects.

If you have any questions, please contact the HRPO at (504) 988-2665 or irbmain@tulane.edu.

Sincerely,
Tulane University Human Research Protections Office
1440 Canal St, Suite 1705, TW-36
New Orleans, LA 70112

Please note that the actual signature by the IRB Chair(s) is not required for this document to be effective since it is generated by IRBNet pursuant to the IRB Chair's electronic signature and approval. This process is consistent with Federal Regulations and Tulane standard operating policies with respect to the IRB and Human Research Protection Office, which consider electronically generated documents as official notice to sponsors and others of approval, disapproval or other IRB decisions. Please refer to the HRPO website at <http://tulane.edu/asvpr/irb> to refer to Tulane's Electronic Signatures and Records Policy.

Appendix 3: ABCDR Project Research Tools



INFORMED CONSENT FORM – Survey

Name of project: The useful life of bednets for malaria control in Tanzania

Part 1. Information sheet

My name is < _____ > and I work for Ifakara Health Institute.

Malaria is still a problem in Tanzania and we want to work with you to find ways to stop malaria. Malaria is transmitted by the bite of an infected mosquito that bites after sunset. A good way to stop malaria is to use a strong bednet that has insecticide to kill mosquitoes that try to bite while you are sleeping. Therefore, in 2009 and 2010, the government of Tanzania provided everyone in the country with a strong bednet. These bednets have been shown to last for three years without getting many holes and we want to make sure that bednets are still working to kill mosquitoes after this time in all the areas of Tanzania so we can tell the government if the nets are still good and helping to stop malaria.

We first discussed this project with the mwenyekiti and he decided that we were allowed to work in this village. Then, we drew lots from the list of all households in the village. Your house is one of those that was chosen. If you agree, we would like to ask you some questions about your household and to see your bednets to see if they are still good enough to use, how many holes they have and what you think about the bednets you were given.

We will take all your old bednets and then we will give you a new bednet for each sleeping space in your household. We will put a number on the wall of your house so that we know when we came to visit you and then we might come back to your house again at least one more time some time in the next three years to ask you some more questions about the new bednets that we have given you. We will draw lots again to see which households we will visit.

Risks

There is no risk in participating in this study. All the bednets that we will give to replace your old nets have been approved for use by the government of Tanzania. You must make sure you follow the instructions on the packet to make sure the bednets works very well to kill mosquitoes and we will talk to you about the instructions if you have any questions.

Benefits

You will receive a new bednet for each sleeping space in your house at no cost to stop getting mosquito bites so you will be safer from malaria. You will also be helping the government of Tanzania provide its citizens with better healthcare because all the information we collect will be used to help the government buy the best bednets and replace them when it is necessary to make sure everyone is protected from malaria.

Your participation is voluntary. You can look at the list of questions and you can refuse to answer any questions if you do not want to answer it, and you can choose to stop at any time. All of the answers are secret because we will not put your name on the questionnaire, we will use a number and initials of each household member instead. If you decide that you do not want to continue with the study then you are free to stop taking part at any time. The questions will take **about 45 minutes** and will help us understand more about how many years the bednets last to stop mosquito bites in this area of Tanzania. I will also need to see the bednet, so I can see how much it has worn. You can talk to a relative before you decide to take part in the study if you want to.

If you have any questions about this study at any time, contact Dennis Massue the project leader at NIMR (Telephone: 0754-542698).

Informed consent record for the participant

I clearly understand the aims of the project entitled "Useful life of bednets in Tanzania". I agree for myself and all the people in my family to take part in the study. I understand that

- 1) I will be asked some questions about my household and will give all my bednets to the project
- 2) I can choose not to answer any question if I don't want to answer
- 3) I will be given a new bednet for every sleeping space in my house
- 4) Someone from the project might visit my house again some time in the next three years and ask me some more questions about the bednets I have been given

We will give you a copy of this consent form to keep.

Participant Name: _____

Participant Signature: _____ Date _____

Witness Name: _____

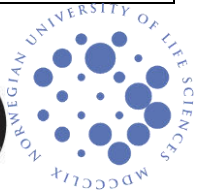
Witness signature: _____ Date _____

Household identification No.: _____

Interviewer Identification No.: _____

Investigators: Dr Hans J Overgaard; Dr William Kisinza; Dr Renata Mandike; Dr Sarah J Moore; Dr Lena M Lorenz

Organizations: Ifakara Health Institute (IHI), National Institute of Medical Reserach (NIMR), London School of Hygiene & Tropical Medicine (LSHTM), University of Life Sciences Norway (UMB)



RETROSPECTIVE HOUSEHOLD QUESTIONNAIRE

“The useful life of bednets for malaria control in Tanzania: Attrition, Bioefficacy, Chemistry, Durability and insecticide Resistance”

Introduction: Hello my name is “.....” I am from IHI / NIMR

Do you agree to take part in the questionnaire?

INFORMED CONSENT OBTAINED: Yes

No - STOP

Household Identification number |__|__|__|__|__|__|__|

0.1 Code of interviewer |__|__|

0.2 Date of interview |__|__| / |__|__| / |__|__| (Day/Month/Year)

0.3 Name of district

|_____|

0.4 Name of ward

|_____|

0.5 Name of village/street

|_____|

0.7 GPS coordinates of household:

N |__|__|__|__|__|

E |__|__|__|__|__|

SECTION 1. HOUSEHOLD and HOUSE CHARACTERISTICS

A: First, please would you list the people who usually sleep in this household?
Please start by listing household heads and older people, then younger people.

1.1 In total, how many people sleep in this household? |_|_|

1.2 Now please list the people who usually sleep in this household. We will only take the first letter of each name and not the full name. Please estimate the age to your best knowledge.

<i>Number of the person</i>	<i>Initials of Person</i>	<i>Sex 1=M 2=F</i>	<i>Age (in full years)</i>	<i>Did the person sleep in the household last night? 1 = Yes 0 = No</i>

B: I would now like to ask you some questions about the head of household, the people living here and assets

Q #	Questions and filters	Coding category		Answer (enter coding)
1.3	Who is responding to the questions?	Head of household	1	<input type="checkbox"/>
		Wife of household head	2	
		Other adult	3	
1.4	Sex of person responding to questionnaire	Male	1	<input type="checkbox"/>
		Female	2	
1.5	Age (in full years) of person responding to questionnaire			<input type="text"/> <input type="text"/>
1.6	What is the highest level of education of the head of the household	None	1	<input type="checkbox"/>
		Primary school	2	
		Secondary school	3	
		Higher education (University/College)	4	
		Other, specify	5	
1.7	What is the main source of income for the household	Salary	1	<input type="checkbox"/>
		Business	2	
		Farming	3	
		Livestock	4	
		Service (barber, tailor etc)	5	
		Casual labour	6	
		Fishing	7	
		Other, specify	8	
1.8	What is the main material of the roof? Observe	Grass / banana leaves	1	<input type="checkbox"/>
		Thatch	2	
		Iron sheets	3	
		Tiles	4	
		Other, specify	5	
1.9	What is the main material of the walls? Observe	Grass	1	<input type="checkbox"/>
		Mud	2	
		Burnt bricks	3	
		Cement bricks	4	
		Other, specify	5	
1.10	What is the material of the floor? Observe	Earth or sand	1	<input type="checkbox"/>
		Cement	2	
		Tiles	3	
		Carpet	4	
		Other, specify	5	
1.11	What is the main source of light in your house?	Electricity	1	<input type="checkbox"/>
		Hurricane lamp	2	
		Candle	3	
		Traditional lamp	4	
		Rechargeable battery	5	
		Torch	6	
		None	7	
1.12	What is the main source of energy	Fire wood	1	

	used for cooking?	Charcoal	2	<input type="checkbox"/>																																	
		Kerosene	3																																		
		Gas	4																																		
		Electricity	5																																		
1.13	What is the principal type of toilet facility used by members of the household?	Own flush toilet	1	<input type="checkbox"/> 																																	
		Shared flush toilet	2																																		
		Own pit latrine	3																																		
		Shared pit latrine	4																																		
		Bush or field	5																																		
		Other, specify	6																																		
1.14	Where is the water source located?	In own dwelling	1	<input type="checkbox"/> If answer is 1 or 2, proceed to Qu 1.16																																	
		In own yard/plot	2																																		
		Elsewhere	3																																		
1.15	How long does it take to go there, get water and come back?	0 – 30 Minutes	1	<input type="checkbox"/>																																	
		31 – 59 Minutes	2																																		
		Over one hour	3																																		
		Don't know	99																																		
1.16	Does your household possess any of the following items? Prompt each category		Yes	No	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>																																
		1. Mobile phone	1	0																																	
		2. Radio	1	0																																	
		3. Refrigerator	1	0																																	
		4. Electric fan	1	0																																	
		5. Electric iron	1	0																																	
		6. Television	1	0																																	
		7. Satellite dish	1	0																																	
1.17	Does the household (any member) have any means of transport? Prompt each category		Yes	No	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>																																
		1. Bicycle	1	0																																	
		2. Motorbike	1	0																																	
		3. Car or Truck	1	0																																	
		4. Animal and/or cart	1	0																																	
		5. Canoe, boat / ship	1	0																																	
		6. Bajaj	1	0																																	
1.18	Number of livestock animals the household owns. Prompt each category. Write 000 if none.	1. Chicken			<table border="1" style="border-collapse: collapse; width: 100px; height: 100px;"> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td></tr> </table>																																
2. Ducks and turkeys																																					
3. Goats and sheep																																					
4. Pigs																																					
5. Cows																																					
6. Donkeys																																					
7. Other, specify.																																					
1.19	Does your household own land used for farming?	Yes	1	<input type="checkbox"/>																																	
		No	0																																		
		Don't Know	99																																		
				If answer is 0 or 99, go to Qu 1.25																																	

1.20	Indicate approximate size of land for farming in acres		_____ . ____		
1.21	Which type of farming system is practiced on your land? Multiple answers allowed	Household garden	1	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
		Subsistence farming	2		
		Cash crop farming	3		
		Other. Specify	4		
1.22	Which type of crops do you grow on your farming systems? Multiple answers allowed	Vegetables	1	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
		Fruit	2		
		Grains (rice, millet, sorghum...)	3		
		Cassava	4		
		Maize	5		
		Pulses (beans, nuts)	6		
		Other. Specify	7		
1.23	Do you use any chemical products in your farm?	Yes	1	<input type="checkbox"/>	
		No	0		
		Don't know	99		
1.24	If YES, What is this chemical used against? Observe chemical product bottles, note Name the most important products according to respondent. Purpose: 1= Insects, 2=Plants 3=Fungi 4=other	#	Name of product	Purpose	Times/year
		1		<input type="checkbox"/>	<input type="checkbox"/>
		2		<input type="checkbox"/>	<input type="checkbox"/>
		3		<input type="checkbox"/>	<input type="checkbox"/>
		4		<input type="checkbox"/>	<input type="checkbox"/>
		5		<input type="checkbox"/>	<input type="checkbox"/>
1.25	At any time in the past 12 months has anyone come into your dwelling to spray the interior walls against mosquitoes?	Yes	1	<input type="checkbox"/> If 0 or 99, go to Qu 1.28	
		No	0		
		Don't Know	99		
1.26	Who sprayed the dwelling?	Government worker/Program	1	<input type="checkbox"/> If 99, go to Qu 1.28	
		Private Company	2		
		Non-Governmental Organization (NGO)	3		
		Other (<i>Specify</i>)	4		
		Don't know	99		
1.27	How often has this household been sprayed?	Every year	1	<input type="checkbox"/>	
		Every 6 months	2		
		Every 3 months	3		
		Every month	4		
		Don't know	99		
1.28	Do you use household pesticides/chemical products?	Yes	1	<input type="checkbox"/> If 0 or 99, go to Section 2	
		No	0		
		Don't know	99		
1.29	Which household pesticide	#	Name of product	Purpose	Times/month

products are used? <i>Observe pesticide bottles, note</i> Name the most important household pesticide products according to respondent. Purpose: 1=Mosquitoes and flies 2=Cockroaches 3= Other insects, 4=Rodents 5=other (specify)	1		<input type="checkbox"/>	<input type="checkbox"/>
	2		<input type="checkbox"/>	<input type="checkbox"/>
	3		<input type="checkbox"/>	<input type="checkbox"/>
	4		<input type="checkbox"/>	<input type="checkbox"/>
	5		<input type="checkbox"/>	<input type="checkbox"/>

SECTION 2. NETS OWNED AND USED BY THE HOUSEHOLD

I would like to ask you some questions about the nets you own and use in your household.

Q #	Questions and filters	Coding Category	Answer (enter coding)					
2.1	How many sleeping places (that can be used to sleep in) does your household have? (Enter total number of sleeping places)		<input type="text"/> <input type="text"/>					
2.2	Does the household own any mosquito nets for sleeping under?	Yes	1					
		No	0					
			<input type="text"/> If 0, go to Q 2.4					
2.3	How many bednets does this household own?		<input type="text"/> <input type="text"/> Go to Q 2.5					
2.4	Why do you not own a mosquito net? Enter first reason answered	Don't like them	1					
		Nets are not available	2					
		Cultural issues, specify	3					
		Don't need a net, specify	4					
		Nets are expensive	5					
		No mosquitoes	6					
		Other, specify	7					
			<input type="text"/> Go to Section 3					
Q #	Questions and filters	Coding Category	Net 1	Net 2	Net 3	Net 4	Net 5	
2.5	Could you show me the nets in the household? (those that are used and not used)	Observed	1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
		Not observed	0					
2.6	Is this net currently used?	Yes	1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
		No	0					
2.7	Where is the net located? >> Observe	Hanging loose over sleeping place	1					
		Hanging and folded up or tied	2					
		Not hanging but not stored	3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
		Stored away unpacked	4					
		Stored away still in package	5					
		Temporarily taken away	6					
2.8	What type of sleeping place	Bed frame (finished)	1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

	has this net been used for mostly?	Bed frame (sticks)	2					
		Foam mattress (no frame)	3					
		Reed mat (no frame)	4					
		Grass	5					
		Ground	6					
		Never used	7					
2.9	What is the main material of the roof? Observe	Grass / banana leaves	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Thatch	2					
		Iron sheets	3					
		Tiles	4					
		Other, specify	5					
2.10	What is the main material of the walls? Observe	Grass	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Mud	2					
		Burnt bricks	3					
		Cement bricks	4					
		Other, specify	5					
2.11	What is the material of the floor? Observe	Earth or sand	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Cement	2					
		Tiles	3					
		Carpet	4					
		Other, specify	5					
2.12	Do you cook in the room this net is in?	Always	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Sometimes	2					
		Never	3					
		Don't know	99					
2.13	Do you ever store food in the room this net is in?	Yes	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		No	0					
		Don't know	99					
2.14	In the last 6 months, have you seen any rats or mice in this room or their traces (faeces or damage)?	Yes	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		No	0					
		Don't know	99					
2.15	Do cats have access to this room?	Yes	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		No	0					
		Don't know	99					
2.16	What is the shape of the net? (Observe)	Rectangular	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Conical	2					
2.17	What is the colour of the net? (Observe)	White	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Green	2					
		Dark Blue	3					
		Blue & white stripes	4					
		Light Blue	5					
		Other	6					
		Don't know	99					

2.18	How long have you had the net?	Less than 1 month	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		1-6 months	2					
		6-12 months	3					
		1-2 years	4					
		More than 2 years	5					
		Don't know	99					
2.19	Was this net used last night?	Yes → go to Qu 2.21	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		No	0					
		Don't know → go to Qu 2.21	99					
2.20	If no, why not? Go to Qu 2.23	No mosquitoes	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		There is no malaria	2					
		Too hot	3					
		Don't like smell	4					
		Feel "closed in"	5					
		Net too old or torn	6					
		Net too dirty	7					
		Net not available last night (washing)	8					
		Usual user(s) did not sleep here last night	9					
		Too small	10					
		Adverse reaction, (specify)	11					
		Other, specify	12					
		Don't know	99					
2.21	Who slept under this net last night? (Multiple answers per net acceptable)	Number of person (as per household roster)	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Don't Know	99					
2.22	Was this net big enough for the person(s) sleeping under?	Yes	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		No	0					
2.23	How many people usually sleep under this net?			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.24	How many nights has this net been used in the last week?	Every night (7 nights)	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Most nights (5-6)	2					
		Some nights (1-4)	3					
		Not used last week	4					
		Net is not used at all	5					
		Don't know	99					
2.25	Have you ever been given nets for free by the government?	Yes	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		No → go Q 2.29	0					
		Don't know	99					
2.26	Where did you receive the nets from?	Clinic	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Bought at the shop using voucher	2					

		Collected at distributions points set up by government	3					
		Somebody came to my house	4					
2.27	Who were the nets for? (<i>target group</i>)	Children	1	_	_	_	_	_
		Pregnant women	2					
		Everyone in the house	3					
2.28	When did you start using the received nets from the government?	Soon after I received it	1	_	_	_	_	_
		Six months later	2					
		One year later	3					
		Other, specify	4					
		Don't know	99
2.29	<i>If net present, attach barcode and put in bag. Record return barcode (last digit)</i>			_	_	_	_	_
2.30	<i>Give replacement net 1 per sleeping place Record net code number (5 digits)</i>			_	_	_	_	_

SECTION 3. NETS FROM CAMPAIGNS

I would like to ask you some questions about whether you have received bed nets from government campaigns and whether you still own them now.

Q #	Questions and filters	Coding Category	Answer (enter coding)				
3.1	How many nets in total did you receive from a net distribution campaign?	Universal Coverage Campaign	<input type="text"/>				
	If there are 00 and 00, go to Section 4	Under 5's campaign	<input type="text"/>				
3.2	How many of those campaign nets do you still have?		<table border="1"> <thead> <tr> <th>U5</th> <th>UCC</th> </tr> </thead> <tbody> <tr> <td><input type="text"/></td> <td><input type="text"/></td> </tr> </tbody> </table>	U5	UCC	<input type="text"/>	<input type="text"/>
U5	UCC						
<input type="text"/>	<input type="text"/>						
3.3	Can you tell me what happened to the nets, from campaigns that are no longer present?	Net was stolen (go Section 4)	1				
		Net was destroyed accidentally (go Section 4)	2				
		Net was sold (go Qu 3.5)	3				
		Net was given away to relatives (go Qu 3.4)	4				
		Net was given away to others (go Qu 3.4)	5				
		Net was thrown away (go Qu 3.5)	6				
		Material used for other purpose, specify	7				
		Don't know	99				
3.4	If the net was given away to relatives or others, what was the main reason?	I gave it to them as a gift	1				
		They asked for it	2				
		I had too many extra nets	3				
		Other, specify	4				
		Don't know	99				
3.5	If net was discarded, what was the main reason for discarding it? Do not prompt. Enter first reason mentioned.	Net was too torn, too many holes	1				
		Net was too dirty	2				
		Net was not needed at the time	3				
		We did not like the net	4				
		We needed the money	5				
		Other	6				
		Don't know	99				

SECTION 4. NET DISPOSAL AND OTHER BEDNET USES

4.1	How did you generally dispose of an old net? Do not prompt. Enter first reason mentioned.			_ _ _
		Burned	1	
		Buried	2	
		Threw away as rubbish	3	
		Brought to health centre to recycle	4	
		Gave to children to play	5	
		Used in garden	6	
		Other	7	
	Don't know	99		
4.2	Do you use your net for other purposes than for sleeping under?	Yes	1	_ If 0 continue to Section 5
		No	0	
4.3	Please specify what other purposes you use the net for, other than sleeping		
4.4	What is the reason for using it for this other purpose?		

SECTION 5. FEVER

5.1	Has any individual in this household had a fever in the last 48 hours?	Yes	1	<input type="checkbox"/> If 0 → Qu 5.3
		No	0	

5.2 Please specify details below (FEVER 48 HOURS)

Individual no. <i>(This should correspond with number on household roster)</i>	Was it diagnosed?	Where diagnosed?	What was the diagnosis?	Treatment
	1=Yes 0=No	1=Hospital, 2=Clinic 3=Other, specify	1=Malaria 0=No Malaria	1=Admitted at nearby hospital/clinic, 2=Took drugs only, 3= No action, 4=Other, specify

5.3	Has any other individual in this household had a fever in the last 2 weeks?	Yes	1	<input type="checkbox"/> If 0 → END questionnaire
		No	0	

5.4 Please specify details below (FEVER 2 WEEKS)

Individual no. <i>(This should correspond with number on household roster)</i>	Was it diagnosed?	Where diagnosed?	What was the diagnosis?	Treatment
	1=Yes 0=No	1=Hospital, 2=Clinic 3=Other, specify	1=Malaria 0=No Malaria	1=Admitted at nearby hospital/clinic, 2=Took drugs only, 3= No action, 4=Other, specify

***** END OF QUESTIONNAIRE *****

Thank the respondents for their time and cooperation and ask the respondents if they have any questions.

INTERVIEWER NOTES: PLEASE NOTE ANY PROBLEMS YOU HAD WITH COMPLETING THE INTERVIEW FOR THIS HOUSEHOLD.

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PROSPECTIVE HOUSEHOLD QUESTIONNAIRE

“The useful life of bednets for malaria control in Tanzania: Attrition, Bioefficacy, Chemistry, Durability and insecticide Resistance”

Introduction: Hello, my name is “.....”. I am from IHI and work on a project investigating how long bed nets last in Tanzania. Maybe you remember my team from last year when we visited.

To be filled in before the interview

0.0 Household Identification number |_|_|_|_|_|_|_|_|_|_|

0.1 Repeat Household Identification number |_|_|_|_|_|_|_|_|_|_|

0.2 Code of interviewer |_|_|_|

0.3 Date of interview |_|_|_|_| / |_|_|_|_| / |_|_|_|_|_|_|_|_| (Day/Month/Year)

0.4 Name of district |_____

0.5 Name of village |_____

0.6 GPS coordinates of household: S: |_|_|_|_|_|_|_|_| E |_|_|_|_|_|_|_|_|

0.7 Is this the same family that was visited last year? Yes

No

0.8 Is this household currently away on travels? Yes – STOP

No

0.9 INFORMED CONSENT OBTAINED: Yes

No – STOP

Section 1: "I would like to ask you (head of household or adult > 18 years) some questions about your household"

Section 1.1: Household listings

"I would first like to ask you some information about the members of your household and any temporary visitors to your household."

Nr	First name (residents + visitors)	Relationship to head of household?	Gender (1...Male, 2...Female)	Age (years), if less than 1 year: 00	Age (months) if less than 1 year	Highest level of education	Usual resident or temporary visitor?	Currently pregnant? (01...Yes, 00...No, 99...Don't know/NA)	Used a net last night? (1...Yes, 0...No 99...Don't know)
1.1	1.2	1.3 - code	1.4	1.5	1.6	1.7 - code	1.8 - code	1.9	1.10
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
11									
12									
13									
14									

Codes for relationship to head of household (1.3):

01...Head of household
 02...Spouse
 03...Son or daughter
 04...Son-in-law or daughter-in-law
 05...Grandchild
 06...Parent
 07...Parent-in-law
 08...Brother or sister
 09...Nice or nephew
 10...Other relative
 11...Adopted/foster/stepchild
 12...Not related

Codes for highest level of education (1.7):

01...Never attended school
 02...Some primary school
 03...Completed primary school (grade 7)
 04...Some secondary school
 05...Completed secondary school O-level (Form 4)
 06... Completed secondary school A-level (Form 6)
 07...Higher education (university/college/vocational training)
 99...Don't know

Codes for usual resident or visitor (1.8):

1...Usual resident
 2...Temporary visitor

"Just to make sure that I have a complete listing, are there any other persons living in your household that we have not listed, such as small children or infants?"

- Go through list with respondent
- If yes, add these individuals to table above

"Are there any other people living or staying here who may not be members of your family, such as visitors or friends or temporary workers?"

□ If yes, add these individuals to table above

Section 1.2: Household characteristics "Now I would like to ask you some general questions about this household."			
Q #	Questions and filters	Coding category	Answer (enter coding categories)
1.11	Who is responding to the questions?	01...Head of household 02...Partner of household head 03...Other adult in household	_ _
1.12	How old is the respondent?	Age in years	_ _ if less than 18, STOP
1.13	What is the main source of income in the household head?	01...Salary 02...Business 03...Farming/livestock keeping 04...Skilled labour/Entrepreneurship (fundi, tailor) 05...Casual labour (kibarua) 06...Fishing 07...Driver/taxi/bajaji 08...Student 09...Pension 10...No source of income 11...Other, specify	_ _ _____
1.14	What is the main material of the roof? Observe	01...Grass /palm thatch 02...Corrugated iron sheets 03... Other metal, e.g. korie 04... Tembe house (roofed with soil) 04... Other, specify	_ _ _____
1.15	What is the main material of the walls? Observe	01...Mud and sticks 02...Burned bricks 03...Cement bricks 04...Mud bricks (Matofali mabichi) 05...Other, specify	_ _ _____
1.16	What is the main material of the floor? Observe	01...Earth 02...Cement 03...Tiles 04...Carpet 05...Wood 06...Other, specify	_ _ _____
1.17	Are any of the windows screened with netting? Observe	01...Yes 00...No, go to 1.18	_ _

1.17a	What are the windows screened with? Observe	01...Wire mesh (metal/plastic) 02...Old bednet 03...Glass 04...Bags / cloth 05...Other material, specify		_ _ _____
1.18	Does the house have an open eave gap? Observe	01...Yes 00...No		_ _
1.19	Does this house have a ceiling? Observe	01...Yes 00...No		_ _
1.20	What type of fuel does your household mainly use for cooking?	01...Electricity 02...Gas 03...Kerosene 04...Diesel-powered generator 05...Charcoal 06...Firewood/straw 07...Other, specify		_ _ _____
1.21	Does your house use any of the following sources of light? Prompt each category.	01...Yes 00...No	Electricity Hurricane lamp Candle Traditional lamp Fire Battery/solar torch None	_ _ _ _ _ _ _ _ _ _ _ _ _ _
1.22	What is the principal type of toilet facility used by members of the household?	01...Own flush toilet 02...Shared flush toilet 03...Own pit latrine 04...Shared pit latrine 05...Bush/forest/field		_ _
1.23	What is the principal household source of drinking-water?	01...Piped water in home or yard/bottled water 02...Rain water collection 03...Own well/pump 04...Shared well/pump 05...River/stream/pond/lake 06...Water truck/cart 07...Other, specify		_ _
1.24	Does your household possess any of the following items?	01...Yes	Mobile phone	_ _

	Prompt each category	00...No	Radio Refrigerator/freezer Electric Fan Television Satellite Dish/Cable Generator Air conditioner None of the above	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
1.25	Does the household (any member) have any of the following means of transport? Prompt each category	01...Yes 00...No	Bicycle Motorbike Car/Truck Bajaji Animal/Cart Boat/Canoe/Jahazi None of the above	_ _ _ _ _ _ _ _ _ _ _ _ _ _
Section 2: "Now I would like to ask you some questions about your bednets."				
2.1	How many sleeping places are there in your household? Include all sleeping spaces where a net could be hung up, or has ever been hung up, including if there is more than one sleeping space in each room used for sleeping			Indoors _ _ _ Outdoors _ _ _
2.1a	How many sleeping places <u>were used</u> last night in your household?			Indoors _ _ _ Outdoors _ _ _
2.2	How many mosquito nets that can be used for sleeping does your household have in total? Probe for nets not in use: stored, saved, unopened			_ _
2.3	In the past 6 months, have you heard or seen any messages or information about malaria?	01...Yes 00...No		_ _
2.4	What was the content of the message(s)? Select all that apply	01...Hang your net 02...Sleep under the net 03...Use the net all year round 04...Make sure others in your community have nets 05...Go quickly for treatment if the child has fever		_ _

		06...Pata Pata jingle 07...Pregnant women should get SP 08...Care for/repair your nets	
2.5	Where did you hear or see this/these messages?" Select all that apply	01...Radio 02...Television 03...Health worker 04...Newspaper 05...Billboards 06...Soccer match 07...Concert 08...Social event 09...Road shows/mobile video 10...T-shirt/caps 11...Friend/neighbour/family member 12...Tire cover 13...Calendar 14... Poster/sticker 15...Community outreach worker (VEO, community change agent,CBO staff etc)	_ _

Section 2.1: Prospective roster.

Interviewer to find household list in household folder and enter first net serial number into PDA.

"Now could you please show me the nets in your household. I will need access to the barcode that is attached to the net."

Q #	Questions and filters	Coding Category	Net 1	Net 2	Net 3
2.6	Net serial number (from household list in household folder)		_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _ _ _
2.6a	Re-enter net serial number ...once net is identified.	If net is no longer present, re-enter from household list.	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _ _ _
2.7	Net still in possession of the household	01...Yes, go to 2.9 00...No, go to 2.8 02...Temporarily away from house, go to 2.7a	_ _	_ _	_ _
2.7a	Where has this net been taken to?	01...Farm / forest	_ _	_ _	_ _

	Go to NEXT NET or if there are no more ABCDR nets, to Section 5	02...Taken to another house 03...To school / college 04...Temporary travelling 05...Other, specify	_____	_____	_____
2.8	If no, why not?	01...Net thrown away Go to 2.8.1 02...Net used for something else Go to 2.8.5 03...Net was given away Go to 2.8.7 04...Net was sold Go to 2.8.10 05...Net was stolen Go to 2.8.10 06...House/room collapsed Go to 2.8.10 99...Don't know Go to 2.8.10	_ _	_ _	_ _
2.8.1	Why was the net thrown away?	01...Too damaged for sleeping under Go to 2.6.2 02...Did not like the net for sleeping under Go to 2.6.3 03...Do not use nets for cultural reasons Go to 2.6.1a	_ _	_ _	_ _
2.8.1a	Please specify the cultural reason for non-use of mosquito nets.	Specify	_____	_____	_____
2.8.2	How was the net damaged? Do not prompt. Record all reasons that the person mentions. Go to 2.6.4	01...By fire 02...Rodents 03...Children 04...Wear and tear 05...Other, specify 99...Don't know	_ _	_ _	_ _
2.8.3	Why did you not like the net? Do not prompt. Record all reasons that the person mentions.	01...Too hot 02...Net too small 03...Net too big 04...Mesh size too big	_ _	_ _	_ _

	Go to 2.8.4	05...Don't like the feel of the material 06...Don't like the colour 07...Net too dirty / infested with bedbugs 08...Don't like the smell 09...Net makes me sneeze, itch, head ache 10...Net has too many holes 11...Doesn't protect against mosquitoes			
2.8.4	How did you discard of the net? Go to 2.6.10	01...Burned inside the house 02...Burned outside the house 03...Buried 04...Threw away as rubbish, <u>specify where</u> 05...Recycled 99...Don't know	_ _ _____	_ _ _____	_ _ _____
2.8.5	Why did you use the net for something else?	01...Too damaged for sleeping under 02...Did not like the net for sleeping under 03...More useful things to do with it	_ _ 	_ _ 	_ _
2.8.6	If used for something else, what was it used for? Go to 2.6.10	01...Screen windows/doors 02...Screen or fence toilet 03...Protect garden (fence in or cover crops from birds) 04...Protect animals (chickens or ducks) 05...Fishing 06...Mattress/pillow 07...Agriculture, e.g. dry cassava 08...Make rope 09...Stored for visitors 10...Other, specify	_ _ _____	_ _ _____	_ _ _____

2.8.7	If given away, to whom?	01...Neighbours 02...Other wife 03...Children going to school/college 04...Children getting married/starting a family 05...Parents 06...Other relatives 07...Others, specify 99...Don't know	_ _	_ _	_ _
2.8.8	If given away, why?	01...Too many nets in household Go to 2.8.10 02...Someone else needed net more Go to 2.8.10 03...Replaced it with a better net Go to 2.8.9 04...I do not like to use nets Go to 2.8.10 05...Other, specify Go to 2.8.10	_ _	_ _	_ _
2.8.9	If replaced by a better net, why did you like the replacement net more? Do not prompt. Record all reasons that the person mentions.	01...Colour, specify which colour is preferred 02...Less damaged 03...Cleaner 04...More suitable size, specify size (smaller or larger) 05...More suitable length , specify length (shorter or longer) 06...Nicer texture / material 07...It was free 08... Other, specify 99...Don't know	_ _	_ _	_ _
2.8.10	When was the net lost from the household? Go to NEXT NET or if there are no	01...less than 1 month ago 02...between 1 and 3 months ago 03...between 4 and 6 months ago	_ _	_ _	_ _

	more ABCDR nets, to Section 5	04...more than 6 months ago 05...more than 1 year ago 99...Don't know			
2.9	Where is the net located? Observe Go to 2.10 unless option "6" was chosen	01...Hanging loose over a sleeping space 02...Hanging and folded up or tied 03...Stored inside a bag 04...Stored but not in a bag 05...Washed / drying 06...Net used for alternative purposes Go to 2.9.1	_ _	_ _	_ _
2.9.1	Why did you use the net for something else?	01...Too damaged for sleeping under 02...Did not like the net for sleeping under 03...More useful things to do with it	_ _	_ _	_ _
2.9.2	If used for something else, what was it used for? Go to NEXT NET or if there are no more ABCDR nets, to Section 5	01...Screen windows/doors 02...Screen or fence toilet 03...Protect garden (fence in or cover crops from birds) 04...Protect animals (chickens or ducks) 05...Fishing 06...Mattress/pillow 07...Agriculture, e.g. dry cassava 08...Make rope 09...Stored for visitors 10...Other, specify	_ _	_ _	_ _
2.10	Is this net currently used for sleeping?	01...Yes Go to 2.11 00...No	_ _	_ _	_ _
2.10a	Why is this net not currently used for sleeping?	01...Save the net for visitors 02...Save the net for future use	_ _	_ _	_ _

	<p>Do not prompt. Record all reasons that the person mentions.</p> <p>Go to 2.22</p>	<p>03...No place or materials to hang up</p> <p>04...Currently have enough nets in use</p> <p>05...Only used during the rainy season</p> <p>06...User did not sleep here</p> <p>07...Net washed / drying</p> <p>08...No malaria now</p> <p>09...No mosquitoes</p> <p>10...Net too old or too torn</p> <p>11...Net is dirty / full of bedbugs</p> <p>12...Net too hot</p> <p>13...Net too small</p> <p>14...Net too big</p> <p>15...Does not prevent mosquito bites</p> <p>16...Don't like the material</p> <p>17...Don't like the colour</p> <p>18...Net made me ill (sneeze, itch, headache)</p> <p>19...Net not used after death / funeral</p>			
2.11	What type of bed is the net used with?	<p>01...Wooden or iron bedframe (improved) [mbao, chuma, kimetengenezwa na fundi]</p> <p>02...Stick bedframe [mjiti, kimetengenezwa huko]</p> <p>03...No bedframe</p> <p>04...Other, specify</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>
2.11a	What type of mattress/sleeping material is used with this net?	<p>01...Nothing</p> <p>02...Reed mat (mkeka)</p> <p>03... Clothes/other net/material</p> <p>04...Foam/spring mattress</p> <p>05... Hammock</p> <p>06...Other, specify</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>

2.12	What is the main material of the roof in this room? Observe	01...Grass /palm thatch 02...Corrugated iron sheets 03... Other metal, e.g. korie 04... Tembe house (roofed with soil) 04... Other, specify	_ _ _____	_ _ _____	_ _ _____
2.13	What is the main material of the walls in this room? Observe	01...Mud and sticks 02...Burned bricks 03...Cement bricks 04...Mud bricks (Matofali Mabichi) 05...Other, specify	_ _ _____	_ _ _____	_ _ _____
2.14	What is the main material of the floor in this room? Observe	01...Earth 02...Cement 03...Tiles 04...Carpet 05...Other, specify	_ _ _____	_ _ _____	_ _ _____
2.15	Who used this net last night?	Drop down menu with names from household roster 1.2. Follow up with "Is [name] x years old?" Allow multiple choices	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
2.16	During the previous week, how many times has the net been used?	01...Every night 02...5-6 nights 03...1-4 nights	_ _ 	_ _ 	_ _
2.17	Do you use any of the following sources for cooking, heating or lighting in the same room as the net?	01...Yes 00...No Firewood Charcoal Gas Hurricane lamp Candle Koroboi	_ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _

			Cigarettes	_ _	_ _	_ _
2.18	In the last 6 months, have you seen any rats or mice in this room or their traces (faeces or damage)?	01...Yes 00...No 99...Don't know		_ _	_ _	_ _
2.19	Do cats have access to this room?	01...Yes 00...No 99...Don't know		_ _	_ _	_ _
2.20	During which periods of the year is this net used to sleep under?	01...All year 02...Rainy season only 03...Dry season only 99...Don't know		_ _	_ _	_ _
2.21	Do you tuck the net in at night?	01....Yes, go to 2.22 00....No		_ _	_ _	_ _
2.21a	Why do you not tuck the net in?	01...Net not long enough 02...Nothing to tuck under 03...Feel too closed in / too hot 04...Too much effort / forgot 05...No need to tuck it 06...Other, specify		_ _	_ _	_ _
2.22	Measure the net from the top to where it is tucked in.	Enter length in cm.				
2.23	Has the net ever been washed?	01....Yes 00....No, go to 2.27 99....Don't know, go to 2.27		_ _	_ _	_ _
2.23a	How many times did you wash the net in	01...Once		_ _	_ _	_ _

	the last year?	02...Once every 6 months 03...Once every 3 months 04...Every month 99....Don't know			
2.23b	When was the last time you washed the net?	01...less than 1 month ago 02...between 1-3 months ago 03...between 4-6 months ago 04...between 6-12 months ago 05...more than 1 year ago 99...Don't know	_ _	_ _	_ _
2.24	What type of soap was used?	01....None 02....Local soap bar 03....Detergent powder 04....Mix (bar and detergent) 05....Bleach 99....Don't know	_ _	_ _	_ _
2.25	Was the net scrubbed hard or beaten on a hard surface?	01....Yes 00....No 99....Don't know	_ _	_ _	_ _
2.26	Where was the net dried?	01....Outside in the direct sun light 02....Outside in the shade 03....Inside 99....Don't know	_ _	_ _	_ _
2.27	Have you tried to fix any of holes in this net?	01....Yes 00....No, go to 2.29	_ _	_ _	_ _
2.28	How did you repair the hole? Go to 2.30	01...Stitched 02...Knotted/tied 03...Patched	_ _	_ _	_ _

		04...Other way, specify	_____	_____	_____
2.29	If not, what was the main reason?	01...Too busy/no time 02...Not necessary, the net is still good 03...Don't know how to fix 04...Too damaged to fix 05...Other, specify	_ _	_ _	_ _
2.30	Has the net been modified?	01...Yes 00...No, go to Section 3	_ _	_ _	_ _
2.31	How was the net modified?	01...Shape was changed 02...Material was added to lengthen 03...Material was added to reinforce 04...Other, specify	_ _	_ _	_ _

Section 3

"I am going to read a series of statements to you and I would like you to tell me how much you agree with them"

3.1	Which of these statements does best describe your net?	01... This net is still in a good condition and can be used without restrictions 02... This net is beginning to fall apart and should be replaced really soon 03... This net is no longer usable and definitely needs to be replaced	_ _	_ _	_ _
-----	--	--	-----	-----	-----

Section 4 Net inspection

"Now I will have a look at your nets and count the number of holes. The net will be returned to you and hung up again if you wish. We need to mount the net on a frame in order to find all the holes."

Interviewer to mount net 1 on net frame for hole counting. Make sure that only one net is done at a time and enter the data directly from tally sheet into the PDA.

4.1	Does this net have any holes?	01...Yes 00...No, go to Section 5	_ _	_ _	_ _
4.2	What type of holes are observed? <i>Answer every category</i>	01...Yes 00...No	Horizontal tears at bottom Holes at hanging points Open seams Burn holes Holes from rodents	_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _

			Whole section missing			
4.3	Number of holes in zone 1	Size 1 (finger)				
		Size 2 (fist)				
		Size 3 (head)				
		Size 4 (larger than head)				
4.4	Number of holes in zone 2	Size 1 (finger)				
		Size 2 (fist)				
		Size 3 (head)				
		Size 4 (larger than head)				
4.5	Number of holes in zone 3	Size 1 (finger)				
		Size 2 (fist)				
		Size 3 (head)				
		Size 4 (larger than head)				
4.6	Number of holes in zone 4	Size 1 (finger)				
		Size 2 (fist)				
		Size 3 (head)				
		Size 4 (larger than head)				
4.7	Number of holes in the roof	Size 1 (finger)				
		Size 2 (fist)				
		Size 3 (head)				
		Size 4 (larger than head)				
Section 5 Additional Nets In Household						
<i>“This part is about any additional nets apart from the ones you received from our study team last October you may have inside your household. Please could you show us the nets and spare some time to answer the subsequent questions.”</i>						
5.1	Do you own any additional nets in addition to the ones distributed by our study team?	01... Yes				
		00... No, Go to NEXT SECTION				
5.2	How many additional	Enter number				

nets do you have?			Net 1	Net 2	Net 3
5.3	Where is the net located? Observe, if unsure – ask Go to 5.4 unless option “6” was selected	01...Hanging loose over a sleeping space 02...Hanging and folded up or tied 03...Stored inside a bag 04...Stored but not in a bag 05...Washed / drying 06...Net used for alternative purposes Go to 5.3.1	_ _ _ _____	_ _ _ _____	_ _ _ _____
5.3.1	Why did you use the net for something else?	01...Too damaged for sleeping under 02...Did not like the net for sleeping under 03...More useful things to do with it	_ _ _ 	_ _ _ 	_ _ _
5.3.2	If used for something else, what was it used for? END	01...Screen windows/doors 02...Screen or fence toilet 03...Protect garden (fence in or cover crops from birds) 04...Protect animals (chickens or ducks) 05...Fishing 06...Mattress/pillow 07...Agriculture, e.g. dry cassava 08...Make rope 09...Stored for visitors 10...Other, specify	_ _ _ _____	_ _ _ _____	_ _ _ _____
5.4	Is this net currently used for sleeping?	01...Yes Go to 5.5 00...No	_ _ _ 	_ _ _ 	_ _ _
5.4a	Why is this net not currently used for sleeping? <i>Do not prompt. Record all reasons</i>	01...Save the net for visitors 02...Save the net for future use 03...No place or materials to hang up 04...Currently have enough nets in use	_ _ _ 	_ _ _ 	_ _ _

	<p><i>that the person mentions.</i></p> <p>Go to 5.17</p>	<p>05...Only used during the rainy season</p> <p>06...User did not sleep here</p> <p>07...Net washed / drying</p> <p>08...No malaria now</p> <p>09...No mosquitoes</p> <p>10...Net too old or too torn</p> <p>11...Net is dirty / full of bedbugs</p> <p>12...Net too hot</p> <p>13...Net too small</p> <p>14...Net too big</p> <p>15...Does not prevent mosquito bites</p> <p>16...Don't like the material</p> <p>17...Don't like the colour</p> <p>18...Net made me ill (sneeze, itch, headache)</p> <p>19...Net not used after death / funeral</p>			
5.5	What type of bed is the net used with?	<p>01...Wooden or iron bedframe (improved) [mbao, chuma, kimetengenezwa na fundi]</p> <p>02...Stick bedframe [mjiti, kimetengenezwa huko]</p> <p>03...No bedframe</p> <p>04...Other, specify</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>
5.5a	What type of mattress/sleeping material is used with this net?	<p>01... Nothing</p> <p>02...Reed mat (mkeka)</p> <p>03... Clothes/other net/material</p> <p>04... Foam/spring mattress</p> <p>05... Hammock</p> <p>06...Other, specify</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>	<p> _ _ </p> <p>_____</p>
5.6	Who used this net last night?	Drop down menu with names from household roster 1.2. Follow up with "Is [name] x years old?"	<p>_____</p> <p>_____</p>	<p>_____</p> <p>_____</p>	<p>_____</p> <p>_____</p>

		<i>Allow multiple choices</i>	_____	_____	_____
5.7	During the previous week, how many times has the net been used?	01...Every night 02...5-6 nights 03...1-4 nights	_ _	_ _	_ _
5.8	How long ago did you start using this net?	01...Less than 1 week ago 02...Between 1 week and 1 month ago 03...Between 1-6 months ago 04...Between 6-12 months ago 05...More than 1 year ago 06...Never used 99...Don't know	_ _	_ _	_ _
5.9	What is the colour of the net? Observe	01...White 02...Light blue 03...Blue & white stripes 04...Dark blue 05...Green 06...Other	_ _	_ _	_ _
5.10	What is the shape of the net?	01...Round 02...Rectangular	_ _	_ _	_ _
5.11	What is the size of the net?	01...Single 02...Double 03...Extra-large	_ _	_ _	_ _
5.12	What is the brand of the net? Check label if present	01...Olyset 02...Safinet	_ _	_ _	_ _

		03...PermaNet / Vestergaard Frandsen 04...Netprotect / BestNet 05...Interceptor / BASF 06...LifeNet / Bayer 07...Yorkool 08...DawaPlus / Tana Netting 09...Duranet / Clarke 10...Royal Sentry 11...MAGNet 12...Afyenet 13...Health net Ltd / Net health Ltd 14...Other, specify 99..Don't know, no label	_____	_____	_____
5.13	How long ago did you obtain this net?	01...Less than 1 week ago 02...Between 1 week and 1 month ago 03...Between 1-6 months ago 04...Between 6-12 months ago 05...More than 1 year ago 99...Don't know	_ _	_ _	_ _
5.14	Where did you obtain this net from?	01...Gift from relative /friend/neighbour 02...Shop/market 03...Hospital/dispensary 04...NGO/charity 05...Government campaign 06...Other, specify 99...Don't know	_ _	_ _	_ _

5.15	Did you pay money for this net?	01...Yes 00...No 99...Don't know	_ _	_ _	_ _	
5.16	Did you use a voucher to obtain this net?	01...Yes 00...No 99...Don't know	_ _	_ _	_ _	
5.17	Does the net have any open holes/tears/seams? Observe inside the house	01...Yes 00...No, Go to END	_ _	_ _	_ _	
5.18	What type of holes are observed? Observe inside the house Answer every category	01...Yes 00...No	Horizontal tears at bottom Holes at hanging points Open seams Burn holes Holes from rodents Whole section missing	_ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _
5.19	Is there any evidence of repair of the net? Observe inside the house	01...Yes 00...No	_ _	_ _	_ _	

***** END OF THE QUESTIONNAIRE *****

Please write whether there were any comments about the study or the nets / any messages from the households.

.....

Appendix 4: Net Care and Repair Project Research Tools

APPENDIX 1A PARTICIPANT INFORMATION SHEET AND INFORMED CONSENT FORM

FOCUS GROUP DISCUSSIONS (FGDs)

Name of project: Decoding perceptions, barriers and motivators of net care and repair in Tanzania

Part 1: Information sheet

Malaria continues to be a problem in Tanzania and we want to work with you to find ways to stop the disease. Malaria is transmitted by the bite of an infected mosquito that bites after sunset. A good way to stop malaria is to use a strong mosquito net that has insecticide to kill mosquitoes that try to bite while you are sleeping. The Government of Tanzania has been distributing nets to its citizens for years, particularly through the School Net Program in this region. However, over time nets degrade. We want to make sure mosquito nets protect you and your family from malaria and mosquito bites for as long as possible, and therefore want to hear your perspectives and to understand what encourages net care and repair as well as what the obstacles to net care and repair are, especially in your area.

We have discussed this project with the village leaders and they have agreed that we can work in this village. Your household is one of those that were chosen because you own at least one insecticide-treated net in your household. If you agree we would like to speak with you and ask you some questions about yourself, your mosquito net use and your net care and repair behaviours. You will be asked to participate in a group discussion. You will be with other people of the same age group and gender. After the group discussion you will also be asked to participate in an exercise where we will show you nets with different amount of holes and you will be asked what you would do with those nets. The group discussion will be audio-recorded and the research team may take some notes. Your responses will be anonymised and will not be able to be tracked back to you. All personal information taken will be stored safely away from the responses you give. You are asked to respect and maintain confidentiality of matters discussed by other members of the community.

Research Regulations

Your participation is voluntary. You can refuse to answer any questions you do not want to answer and you can choose to stop at any time. All of the responses will be anonymised because we will not put your full name on the recordings, we will use a number instead. If you decide that you do not want to continue with the group discussion, you are free to stop taking part at any time. The group discussion and activities will take about two and a half hours. This will help us understand more about the motivators and barriers to net care and repair in this area of Tanzania. You can talk to a friend or relative before you decide to take part in the study if you want to and you can ask the study team as many questions as you wish. Refreshments will be provided during the discussions. A flat rate of TSH 5,000 will be provided to you in compensation of your transport costs to get to the FGD venue.

Risks

There is no risk in participating in this study. Your name, location or voice will not be linked with any of the answers you have given. Please feel free to ask any questions you may have about the mosquito nets.

Benefits

You will get no direct benefits by taking part in this research. However, you will contribute to important research going on in Tanzania which will advise the government on malaria control strategies to provide its citizens with better healthcare. In addition, you may become more aware of the importance of net care and repair.

If you have any questions about this study at any time, contact Zawadi Mageni, the project leader at Ifakara Health Institute (Telephone: 0787- 428218), Beverly Msambichaka, Secretary of the Board of Ethics at IHI (Telephone: 022-2774714) or the National Health Research Ethics Committee at NIMR (Telephone: 022-121400).

Part 2: Informed Consent

Signing or putting your thumbprint on this form indicates that you have been told the nature of the study and your involvement in it.

I, _____, have read the information sheet concerning this study or have had the chance to discuss this information verbally. I have been told what will be required of me and what will happen to me if I take part in this study. My questions concerning this study have been answered. Specifically, I have read the Information Sheet describing the study, know the sponsoring institutions, and the terms of my participation. I have been given a copy of this information sheet for my reference.

I understand that

- 1) I will be asked some questions about my household.
- 2) I will participate in a group discussion and exercise with other members of this community about net care and repair.
- 3) I will respect and maintain confidentiality of matters discussed by other members in the community.
- 4) The discussion will be audio-recorded but none of my responses will be linked to me or my household.
- 5) The group discussion and exercise will take approximately 2.5 hours to complete.
- 6) I may withdraw from this study at any time without giving a reason.
- 7) Some of the things I say may be quoted in reports of this research, but this will be in a way that does not identify me.
- 8) I will be compensated TSH 5,000 towards my transport costs to get to the FGD venue.

I hereby consent to participate in the study.

Participant Name: _____ ID Number: |_|_|_|_|_|_|_|_|

Participant Signature: _____ Date _____

Witness Name: _____

Witness Signature: _____ Date _____

Interviewer Name: _____

Interviewer Signature: _____ Date _____

Investigators: Lena Lorenz; Karen Kramer; George Greer; Angel Dillip; Zawadi Mageni

Organizations: Ifakara Health Institute (IHI), London School of Hygiene & Tropical Medicine (LSHTM), USAID/PMI Tanzania

APPENDIX 1B PARTICIPANT INFORMATION SHEET AND INFORMED CONSENT FORM

IN-DEPTH INTERVIEWS (IDIs)

Name of project: Decoding perceptions, barriers and motivators of net care and repair in Tanzania

Part 1: Information sheet

Malaria continues to be a problem in Tanzania and we want to work with you to find ways to stop the disease. Malaria is transmitted by the bite of an infected mosquito that bites after sunset. A good way to stop malaria is to use a strong mosquito net that has insecticide to kill mosquitoes that try to bite while you are sleeping. The Government of Tanzania has been distributing nets to its citizens for years, particularly through the School Net Program in this region. However, over time nets degrade. We want to make sure mosquito nets protect you and your family from malaria and mosquito bites for as long as possible, and therefore want to hear your perspectives and to understand what encourages net care and repair as well as what the obstacles to net care and repair are, especially in your area.

We have discussed this project with the village leaders and they have agreed that we can work in this village. Your household is one of those that were chosen because you own at least one insecticide-treated net in your household. If you agree we would like to speak with you and ask you some questions about yourself, your mosquito net use and your net care and repair behaviours. After the interview you will also be asked to participate in an exercise where we will show you nets with different amount of holes and you will be asked what you would do with those nets. The whole interview will be audio-recorded and the research team may take some notes. Your responses will be anonymised and will not be able to be tracked back to you. All personal information taken will be stored safely away from the responses you give.

We will also ask to see the mosquito nets in your household to assess how many holes they have and whether they have been repaired or not. We might need to take your mosquito net outside of the house to look at the net and count the holes, but the net will be returned to you and hung up if you wish. Some of the things you say may be quoted in reports of this research, but this will be in a way that does not identify you.

Research Regulations

Your participation is voluntary. You can refuse to answer any questions you do not want to answer and you can choose to stop at any time. All of your responses will be anonymised because we will not put your full name on the recordings, we will use a number instead. If you decide that you do not want to continue with the interview then you are free to stop taking part at any time. The interview will take about one hour, the exercise a further 30 minutes and the assessment of nets will take approximately 10 minutes per net. This will help us understand more about the motivators and barriers to net care and repair in this area of Tanzania. You can talk to a friend or relative before you decide to take part in the study if you want to and you can ask the study team as many questions as you wish. You will be provided with refreshments during the interview.

Risks

There is no risk in participating in this study. Your name, location or voice will not be linked with any of the answers you have given. Please feel free to ask any questions you may have about the mosquito nets.

Benefits

You will get no direct benefits by taking part in this research. However, you will contribute to important research going on in Tanzania which will advise the government on malaria control strategies to provide its citizens with better healthcare. In addition, you may become more aware of the importance of net care and repair.

If you have any questions about this study at any time, contact Zawadi Mageni, the project leader at Ifakara Health Institute (Telephone: 0787- 428218), Beverly Msambichaka, Secretary of the Board of Ethics at IHI (Telephone: 022-2774714) or the National Health Research Ethics Committee at NIMR (Telephone: 022-121400).

Part 2: Informed Consent

Signing or putting your thumbprint on this form indicates that you have been told the nature of the study and your involvement in it.

I, _____, have read the information sheet concerning this study or have had the chance to discuss this information verbally. I have been told what will be required of me and what will happen to me if I take part in this study. My questions concerning this study have been answered. Specifically, I have read the Information Sheet describing the study, know the sponsoring institutions, and the terms of my participation. I have been given a copy of this information sheet for my reference.

I understand that

- 1) I will be asked some questions about my household,
- 2) I will discuss and participate in an activity about my net care and repair practices and beliefs,
- 3) I will be asked to present my nets to the researchers for further assessment
- 4) The interview will be audio-recorded but my full name will not be recorded and none of my responses will be linked to me or my household.
- 5) The interview will take approximately 2 hours to complete.
- 6) I may withdraw from this study at any time without giving a reason.
- 7) Some of the things I say may be quoted in reports of this research, but this will be in a way that does not identify me.
- 8) I will be provided with refreshments during the interview.

I hereby consent to participate in the study.

Participant Name: _____ ID Number: |_|_|_|_|_|_|_|_|

Participant Signature: _____ Date _____

Witness Name: _____

Witness Signature: _____ Date _____

Interviewer Name: _____

Interviewer Signature: _____ Date _____

Investigators: Lena Lorenz; Karen Kramer; Angel Dillip; Zawadi Mageni

Organizations: Ifakara Health Institute (IHI), London School of Hygiene & Tropical Medicine (LSHTM)

APPENDIX 2A QUESTIONNAIRE FOR USE BEFORE FOCUS GROUP DISCUSSIONS

<i>Interviewer use only – complete prior to interview</i>		
Questionnaire for FGD participants		
Interviewer ID: _____	Village Name: _____	Participant ID: _____
Date of Focus Group Discussion: _ _ _ _ _ _ _		

We invite you to answer the following questions that will tell us a little more about yourself and background with mosquito nets. This questionnaire is part of a study on decoding perceptions, barriers and motivators of net and repair in Tanzania funded by PMI Tanzania. Your privacy will be respected and you do not have to provide your name. When the study results are published or shared, no names or identifying information will be used.

Please tick and write the appropriate answers in shaded box.

Age:		_ _		
Sex:	Male			
	Female			
If female, currently pregnant?	Yes			
	No			
Child Nr	Age (years)	Currently living with you? Y/N	Currently going to school? Y/N	Current school grade
1				
2				
3				
4				
5				
6				
7				
8				
9				

Appendix 2A Questionnaire for FGD Participants

SOCIAL DETERMINANTS		
What is your current marital status? (please tick one box)	Married	
	Living together with partner	
	In a relationship but not living together	
	Widowed	
	Divorced or separated	
	Not in a relationship	
What is your highest level of education? (please tick one box)	No education	
	Primary Education	
	Secondary Education	
	Higher Education (college / university)	
What is the main source of income in your household? (please tick one box)	Salary	
	Business	
	Farming / livestock keeping	
	Skilled labour / entrepreneurship (fundi / tailor)	
	Casual labour (kibarua)	
	Fishing	
	Driver / taxi / bajaji / dalla dalla / lorry	
	Student	
	Pension	
	No source of income	
	Other, specify _____	
What is the main material of your roof? (please tick one box)	Grass /palm thatch	
	Iron sheets or tiles	
	Other metal, e.g. korie	
	Tembe house (roofed with soil)	
Is your house connected to electricity?	Yes	
	No	

Appendix 2A Questionnaire for FGD Participants

MOSQUITO NETS		
How many mosquito nets do you currently own?		_ _
Did your household receive any nets from the School-Net Programme?	Yes	
	No	
How many nets did you receive from the School-Net Programme?	2013	_ _
	2014	_ _
	2015	_ _
How many of the School-Net Programme nets are still in your household?	2013	_ _
	2014	_ _
	2015	_ _
BCC EXPOSURE		
In the past 6 months, have you heard or seen any messages or information about malaria?	Yes	
	No	
What was the content of the message(s)? (tick all that apply)	Hang your net	
	Sleep under the net	
	Use the net all year round	
	Make sure others in your community have nets	
	Go quickly for treatment if the child has fever	
	Pata Pata jingle	
	Pregnant women should get SP	
	Care for/repair your nets	
Where did you hear or see this/these messages? (tick all that apply)	Radio	
	Television	
	Health worker	
	Newspaper	
	Billboards	
	Soccer match	
	Concert	
	Social event	
	Road shows/mobile video	
	T-shirt/caps	

Appendix 2A Questionnaire for FGD Participants

	Friend/neighbour/family member	
	Tire cover	
	Calendar	
	Poster/sticker	
	Community outreach worker (VEO, community change agent,CBO staff etc)	

APPENDIX 2B QUESTIONNAIRE FOR USE BEFORE IN-DEPTH INTERVIEWS

<i>Interviewer use only – complete prior to interview</i>		
Questionnaire for IDI participants		
Interviewer ID: _____	Village Name: _____	Participant ID: _____
Date of Interview: _ _ _ _ _ _ _ _		

We invite you to answer the following questions that will tell us a little more about yourself and background with mosquito nets. This questionnaire is part of a study on decoding perceptions, barriers and motivators of net and repair in Tanzania funded by PMI Tanzania. Your privacy will be respected and you do not have to provide your name. When the study results are published or shared, no names or identifying information will be used.

Please tick and write the appropriate answers in shaded box.

Age:		_ _		
Sex:	Male			
	Female			
If female, currently pregnant?	Yes			
	No			
Child Nr	Age (years)	Currently living with you? Y/N	Currently going to school? Y/N	Current school grade
1				
2				
3				
4				
5				
6				
7				
8				
9				

Appendix 2A Questionnaire for IDI Participants

SOCIAL DETERMINANTS			
What is your current marital status? (please tick one box)	Married		
	Living together with partner		
	In a relationship but not living together		
	Widowed		
	Divorced or separated		
	Not in a relationship		
What is your highest level of education? (please tick one box)	No education		
	Primary Education		
	Secondary Education		
	Higher Education (college / university)		
What is the main source of income in your household? (please tick one box)	Salary		
	Business		
	Farming / livestock keeping		
	Skilled labour / entrepreneurship (fundi / tailor)		
	Casual labour (kibarua)		
	Fishing		
	Driver / taxi / bajaji / dalla dalla / lorry		
	Student		
	Pension		
	No source of income		
	Other, specify		_____
Is this house rented?	Yes		
	No		
	Other, specify		_____
What is the main material of your roof? (please tick one box)	Grass /palm thatch		
	Iron sheets or tiles		
	Other metal, e.g. korie		
	Tembe house (roofed with soil)		
What is the main material your walls? (please tick one box)	Mud and sticks		
	Burned bricks		

Appendix 2A Questionnaire for IDI Participants

	Cement bricks	
	Mud bricks (Matofali mabichi)	
Is your house connected to electricity?	Yes	
	No	
What is the principal type of toilet facility used by members of the household? (please tick one box)	Own flush toilet	
	Shared flush toilet	
	Own pit latrine	
	Shared pit latrine	
	Bush/forest/field	
What is the principal source of drinking-water in your household? (please tick one box)	Piped water in home or yard/bottled water	
	Rain water collection	
	Own well/pump	
	Shared well/pump	
	River/stream/pond/lake	
	Water truck/cart	
Does your household possess any of the following items? (Tick each item you possess)	Mobile phone	
	Radio	
	Refrigerator/freezer	
	Electric Fan	
	Television	
	Satellite Dish/Cable	
	Generator	
	Air conditioner	
	None of the above	
Does your household (any member) have any of the following means of transport? (Tick each item you possess)	Bicycle	
	Motorbike	
	Car/Truck	
	Bajaji	
	Animal/Cart	
	Boat/Canoe/Jahazi	
	None of the above	

Appendix 2A Questionnaire for IDI Participants

MOSQUITO NETS		
How many mosquito nets do you currently own?		_ _
Did your household receive any nets from the School-Net Programme?	Yes	
	No	
How many nets did you receive from the School-Net Programme?	2013	_ _
	2014	_ _
	2015	_ _
How many of the School-Net Programme nets are still in your household?	2013	_ _
	2014	_ _
	2015	_ _
BCC EXPOSURE		
In the past 6 months, have you heard or seen any messages or information about malaria?	Yes	
	No	
What was the content of the message(s)? (tick all that apply)	Hang your net	
	Sleep under the net	
	Use the net all year round	
	Make sure others in your community have nets	
	Go quickly for treatment if the child has fever	
	Pata Pata jingle	
	Pregnant women should get SP	
	Care for/repair your nets	
Where did you hear or see this/these messages? (tick all that apply)	Radio	
	Television	
	Health worker	
	Newspaper	
	Billboards	
	Soccer match	
	Concert	
	Social event	
	Road shows/mobile video	
	T-shirt/caps	

Appendix 2A Questionnaire for IDI Participants

	Friend/neighbour/family member	
	Tire cover	
	Calendar	
	Poster/sticker	
	Community outreach worker (VEO, community change agent,CBO staff etc)	



APPENDIX 3 TOPIC GUIDE FOR FOCUS GROUP DISCUSSION AND IN DEPTH INTERVIEWS

<i>Interviewer use only – complete prior to interview</i>		
Questionnaire for FGD participants		
Interviewer ID: _____	Phone number: _____	Village Name: _____
Date of Focus Group Discussion: _ _ _ _ _ _ _ _		
Group type (e.g. Male/Female; Young/Old): _____		
Number of participants: _ _		

Note to interviewer: Questions in italics are meant to be probes. They do not have to be asked as they appear here. Rather, phrase and order questions according to the flow of the discussion.

Questions/Themes	Probes
PART 1: Attitudes towards risk of malaria and value of nets	
What is your risk of getting ill from malaria?	<i>a) What are the consequences of malaria to you, your family and your community?</i>
Do mosquito nets protect you against malaria?	<i>a) What do you think of mosquito nets as an intervention against malaria? a. What is the value of mosquito nets to you, your household and your community? b) Willingness to invest (time, resources) in the care and repair of your mosquito net?</i>
How is a mosquito net used in your household?	<i>a) Protection against malaria b) Do you have alternative uses of nets (fishing, chicken coup, gardening, etc.) e.g. if it's old</i>
PART 2: Net possession and SNP	
Where do you get your mosquito nets from?	<i>a) Did you buy it? a. From where? b. How much? (Affordability, i.e. was the price acceptable to you?) c. Why? d. Does it have insecticide on the net? Is insecticide on the net important to you when buying a net? e. Who bought it?</i>

Appendix 3 – Topic Guide for FGDs and IDIs

	<p><i>b) Was it freely provided?</i></p> <p><i>a. By whom?</i></p> <p><i>b. Through what channels?</i></p> <p><i>c. How frequently?</i></p>
How long do you usually keep your nets?	<p><i>a) How have you maintained the net for the time you have owned it?</i></p> <p><i>b) In what condition is the net now? (holes; rips; dirtiness; usefulness etc.)</i></p>
When is a net no longer effective against mosquito bites / disease prevention?	<p><i>a) Why?</i></p>
If some participants report to have received nets from School Net Programme...	<p><i>a) Experience of SNP – positive, negative?</i></p> <p><i>b) Enough nets for household, community?</i></p> <p><i>c) Enough information about the programme?</i></p>
Have you been exposed to any messaging about net care and repair ?	<p><i>a) Source of messaging: radio, Community Change Agents, children etc</i></p> <p><i>b) Probe about <u>content</u> of messages / messaging</i></p>
PART 3 : Net care behaviours, attitudes and practices	
What is / counts as net care?	<p><i>a) Washing</i></p> <p><i>a. Frequency of washing; part of weekly clothes washing routine, only when visibly dirty or for special occasions?</i></p> <p><i>b. Type of soap</i></p> <p><i>c. Location</i></p> <p><i>d. Scrubbing/beating hard?</i></p> <p><i>e. Motions of washing – ask to demonstrate?</i></p> <p><i>b) Drying</i></p> <p><i>a. Location – sun or shade? Inside or outside? Why?</i></p> <p><i>c) Hanging up nets when net is first received or after the net has been washed</i></p> <p><i>a. Where?</i></p> <p><i>b. Using what?</i></p> <p><i>c. How quickly after washing?</i></p> <p><i>d. Whose responsibility?</i></p> <p><i>d) Daily storage routine; i.e. tying nets up and untucking nets</i></p> <p><i>a. During the day? Every day? All day?</i></p> <p><i>b. Who?</i></p> <p><i>c. Ease of tying up?</i></p> <p><i>d. Why tie up or not tie up the net?</i></p> <p><i>e) Storage</i></p> <p><i>a. Location; e.g. in bag etc.</i></p> <p><i>b. Check whether net still there; without holes</i></p> <p><i>c. Perceived danger of rats when storing nets.</i></p>

Appendix 3 – Topic Guide for FGDs and IDIs

Are you more likely to care for a net you received for free or one you bought yourself?	<p>a) <i>If yes, what is the difference?</i></p> <p>b) <i>Why is there a difference?</i></p>
Does the material of the net affect your net care?	<p>a) <i>More likely to care for nets made of one material than another?</i></p> <p>b) <i>Why?</i></p> <p>2 net types distributed by SNP: Olyset (polyethylene) and PermaNet (polyester).</p>
Gender and family roles in net care	
Who is responsible for net care in the household?	<p>a) <i>Why is he/she responsible for net care?</i></p> <p>b) <i>Specific responsibilities?</i></p> <p>c) <i>Gender-specific actions / roles.</i></p> <p>d) <i>What is the role of children in net care? Do school children advise their parents on the importance of net care? What has been the key message from children? Is age of children important in their roles of net care?</i></p> <p>e) <i>What things do women usually do that men could do relating to net care?</i></p> <p>f) <i>Does the gender of the main income earner affect responsibilities and choices in a household?</i></p>
How is this similar to or different from what other people in your community think?	<p>a) <i>Do you think that the division of labour/responsibility is the same in your neighbourhood as in your house, or is your household different?</i></p> <p>b) <i>What makes it different?</i></p> <p>c) <i>Why?</i></p>
Motivation for net care	
Why do you care for your nets? Do not prompt	<p>c) <i>Social norms on hygiene</i></p> <p style="padding-left: 20px;">a. <i>desire to be perceived as a clean and responsible person by neighbours, friends, community</i></p> <p style="padding-left: 20px;">b. <i>neat appearance</i></p> <p style="padding-left: 20px;">c. <i>What do you think if you visit a household with torn nets? How about if a household has repaired nets?</i></p> <p>d) <i>Increase lifespan / durability of nets</i></p> <p style="padding-left: 20px;">a. <i>prevent damage on nets</i></p> <p style="padding-left: 20px;">b. <i>recognized as good daily routine</i></p> <p>e) <i>Dirty nets causes disease</i></p> <p>f) <i>Daily household factors, e.g. bedwetting, dirty floors; smoke</i></p>
Barriers for net care	<i>Only ask in FGD or in IDIs that do not care for nets. E.g. if household says they wash nets with soap, then cost of soap cannot be a barrier etc.</i>

Appendix 3 – Topic Guide for FGDs and IDIs

<p>Why do you not care for your net?</p> <p>What makes it difficult for you to maintain a daily routine?</p>	<p>a) <i>Don't know how / Lack of proper instructions</i></p> <p>b) <i>Not part of daily routine</i></p> <p style="padding-left: 20px;">a. <i>Tiring to do daily</i></p> <p style="padding-left: 20px;">b. <i>Easy to forget</i></p> <p style="padding-left: 20px;">c. <i>Too busy in the morning rushing to work/fields</i></p> <p>c) <i>No point</i></p> <p style="padding-left: 20px;">a. <i>Children will mess it up anyway during the day</i></p> <p style="padding-left: 20px;">b. <i>Perceived little value in caring for nets or to one's health; doubtful that nets protect against malaria...</i></p> <p>d) <i>Frequent washing reduces effectiveness of the 'medicine' in the net</i></p> <p>e) <i>Cost of soap</i></p> <p>f) <i>Potential theft of the nets when on the washing line</i></p>
<p>How to overcome barriers to net care</p>	
<p>What do you think can be done to help a net last longer?</p>	<p>a) <i>Clearer instructions on packets from manufacturers / government</i></p> <p>b) <i>"Group cleaning"</i></p> <p>c) <i>Men taking more responsibility</i></p> <p>d) <i>Better information and demonstrations from Community Change Agents and health centres about importance of nets and their role in prevention of disease</i></p> <p>e) <i>Make it part of daily routine – how? What would help you do those things in your daily life?</i></p>
<p>PART 4: Net repair behaviours, attitudes and practice</p>	
<p>What is net repair?</p>	<p>a) <i>Methods of repair: sewing, patching and knotting</i></p> <p>b) <i>When and how often?</i></p> <p>c) <i>Completeness of repair:</i></p> <p style="padding-left: 20px;">a. <i>Is every single hole repaired completely?</i></p> <p style="padding-left: 20px;">b. <i>Are only the largest holes repaired and the smaller ones remain without repair?</i></p> <p style="padding-left: 20px;">c. <i>Is it enough to only repair large holes? WHY?</i></p> <p style="padding-left: 20px;">d. <i>Do some holes get partially repaired?</i></p> <p>d) <i>By whom? Do they do it themselves or take net to a tailor?</i></p> <p>e) <i>Perceived investment (money / time) in net repair</i></p>
<p>When is a net torn enough that it needs repair?</p>	<p><i>Number of holes, size, shape, location, source</i></p> <p><i>For each response ask the reason behind</i></p>
<p>Does the material of the net affect your net repair?</p>	<p>a) <i>More likely to repair for nets made of one material than another?</i></p> <p>b) <i>Why?</i></p> <p>2 net types distributed by SNP: Olyset (polyethylene) and PermaNet (polyester).</p>

Appendix 3 – Topic Guide for FGDs and IDIs

Are you more likely to repair a net you received for free or one you bought yourself?	<ul style="list-style-type: none"> c) <i>If yes, what is the difference?</i> d) <i>Why is there a difference?</i>
Gender and family roles in net repair	<i>If this is the same as care, then no need to go through the same questions again, although the role of children should always be asked about.</i>
Who is responsible of net repair in the household?	<ul style="list-style-type: none"> a) <i>Why he/she is responsible for net repair?</i> b) <i>Specific responsibilities?</i> c) <i>Gender-specific actions / roles.</i> d) <i>What is the role of children in net repair? Do school children advise their parents on the importance of net repair? What has been the key message from children? Is age of children important in their roles of net repair?</i> e) <i>What things do women usually do that men could do relating to net repair?</i> f) <i>Does the gender of the main income earner affect responsibilities and choices made in a household?</i>
How is this similar to or different from what other people in your community think?	<ul style="list-style-type: none"> a) <i>Do you think that the division of labour/responsibility is the same in your neighbourhood as in your house, or is your household different?</i> b) <i>What makes it different?</i> c) <i>Why?</i>
Motivation for net repair	
Why do you repair your bed net?	<ul style="list-style-type: none"> a) <i>Increase protective potential of net</i> <ul style="list-style-type: none"> a. <i>Higher risk of malaria due to holes</i> b. <i>More mosquito bites due to holes (nuisance / disease)</i> c. <i>What size hole can mosquitoes enter through?</i> b) <i>Awareness that small holes can get bigger – earlier repair avoids nets becoming unusable.</i> c) <i>Cost savings</i> <ul style="list-style-type: none"> a. <i>from averting illness,</i> b. <i>not having enough money to obtain a new net</i> c. <i>The need to extend net life due to uncertainty of when one could expect a new net</i> d) <i>Social norm</i> <ul style="list-style-type: none"> a. <i>Having a net that looks good (strong dislike of nets with holes)</i> b. <i>Desire to be perceived as responsible and conscientious</i> e) <i>Quick and easy</i> <ul style="list-style-type: none"> a. <i>knotting and tying off holes,</i> b. <i>needle, thread, and patching materials easily available at low to no cost</i>

Appendix 3 – Topic Guide for FGDs and IDIs

Does the location of damage / holes to nets determine net repair?	<p>a) <i>Usually, where is most damage to nets? Bottom, middle, top of sides, roof? What causes this damage? (Only ask if it didn't come up during care questions)</i></p> <p>b) <i>Are nets more likely to be repaired when most damage is on the bottom of the net versus the top of the net?</i></p> <p>c) <i>Why?</i></p> <p>d) <i>Are different type of repairs associated with different hole locations?</i></p>
<p>Whose net are more likely to be repaired?</p> <p>Prompt all</p>	<p>a) <i>Are nets belonging to certain household members more likely to be repaired?</i></p> <p style="padding-left: 20px;">a. <i>Head of households; main income earner</i></p> <p style="padding-left: 20px;">b. <i>Pregnant women; infants</i></p> <p style="padding-left: 20px;">c. <i>Visitors</i></p> <p style="padding-left: 20px;">d. <i>Teenagers</i></p> <p style="padding-left: 20px;">e. <i>Children</i></p> <p style="padding-left: 20px;">f. <i>Children under 5 and babies</i></p> <p style="padding-left: 20px;">g. <i>Seniors etc.</i></p> <p>b) <i>Why?</i></p>
Barriers for net repair	
Why you do not repair your net?	<p>a) <i>Social desirability:</i></p> <p style="padding-left: 20px;">a. <i>Prefer to replace with new net if affordable</i></p> <p style="padding-left: 20px;">b. <i>Avoid to be perceived as poor</i></p> <p style="padding-left: 20px;">c. <i>Potential unattractiveness of repair (distortion due to knotting, neatness of sewing, colour of material and thread used)</i></p> <p style="padding-left: 20px;">d. <i>Nobody sees my nets so it doesn't matter whether they are dirty / full of holes.</i></p> <p>b) <i>Lack of</i></p> <p style="padding-left: 20px;">a. <i>Materials</i></p> <p style="padding-left: 20px;">b. <i>Ability to sew</i></p> <p style="padding-left: 20px;">c. <i>Knowledge of how to repair</i></p> <p style="padding-left: 20px;">d. <i>Time</i></p> <p style="padding-left: 20px;">e. <i>Motivation</i></p> <p>c) <i>Holes are too big or too many</i></p> <p>d) <i>Repairing holes creates more holes</i></p> <p>e) <i>Misconceptions, e.g. nets with holes still stop mosquitoes and malaria</i></p> <p>f) <i>Location of holes (bottom of net); e.g. not important as nets are tucked under mattress</i></p> <p>g) <i>location of holes – roof (repairs might change shape of the net)</i></p> <p>h) <i>Malaria is not a big problem for me / not susceptible to malaria</i></p> <p style="padding-left: 20px;">a. <i>Perceived little value in caring for nets or to one's health; doubtful that nets protect against malaria...</i></p>
How to overcome barriers to net repair	
What can be done to overcome barriers to net	<p>a) <i>Repair immediately after you have seen the first hole</i></p> <p>b) <i>Make sure you always keep the sewing kit in the household</i></p>

Appendix 3 – Topic Guide for FGDs and IDIs

repair?	<ul style="list-style-type: none">c) <i>“Repair kits”</i>d) <i>Repair / bring to tailor at the same time as clothes etc.</i>e) <i>Better information and demonstrations from Community Change Agents and health centres about importance of nets and their role in prevention of disease</i>
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APPENDIX 3A - TOPIC GUIDE FOR FOCUS GROUP DISCUSSION

<i>Interviewer use only – complete prior to interview</i>		
Topic Guide for FGD participants		
Interviewer ID: _____	Phone number: _____	Village Name: _____
Date of Focus Group Discussion: _ _ _ _ _ _ _		
Group type (e.g. Male/Female; Young/Old): _____		
Number of participants: _ _		

Note to interviewer: Questions in italics are meant to be probes. They do not have to be asked as they appear here. Rather, phrase and order questions according to the flow of the discussion.

Questions/Themes	Probes
PART 1: Attitudes towards risk of malaria and value of nets	
What is your risk of getting ill from malaria?	<i>a) What is the risk of malaria to you, your family and your community?</i>
Do mosquito nets protect you against malaria?	<i>a) What do you think of mosquito nets as an intervention against malaria? a. What is the value of mosquito nets to you, your household and your community? b) Willingness to invest (time, resources) in the care and repair of your mosquito net?</i>
How is a mosquito net used in your household?	<i>a) Protection against malaria b) Alternative use of nets (fishing, chicken coup, gardening, etc.)</i>
PART 2: Net possession and SNP	
Where do you get your mosquito nets from?	<i>a) Did you buy it? a. From where? b. How much? (Affordability) c. Why? b) Was it freely provided? a. By whom? b. Through what channels? c. How frequently?</i>

Appendix 3A – Topic Guide for FGDs

How long do you usually keep your nets?	For those with nets more than 2 years old: a) <i>How have you maintained the net for 2 years?</i> b) <i>In what condition is the net now? (holes; rips; dirtiness; usefulness etc.)</i>
When is a net no longer effective against mosquito bites / disease prevention?	a) <i>Time in months, years or duration of use – rationale behind timing</i> b) <i>Too much damage – define</i> c) <i>How long do you think you should use a net before it is no longer effective?</i> d) <i>How do you know a net is no longer effective?</i> e) <i>External cues; Do you have to keep a net until you obtain a new one? Is getting a new one for free the only time nets are usually replaced?</i>
If some participants report to have received nets from School Net Programme...	a) <i>Experience of SNP – positive, negative?</i> b) <i>Enough nets for household, community?</i> c) <i>Enough information about the programme?</i>
Have you been exposed to any messaging about net care and repair?	a) <i>Source of messaging: radio, Community Change Agents, children etc</i> b) <i>Probe about <u>content</u> of messages / messaging</i>
PART 3 : Net care behaviours, attitudes and practices	
What is / counts as net care?	a) <i>Hanging up nets</i> a. <i>Where?</i> b. <i>Using what?</i> c. <i>How quickly after washing?</i> d. <i>Whose responsibility?</i> b) <i>Daily storage routine; i.e. tying nets up</i> a. <i>During the day? Every day? All day?</i> b. <i>Who?</i> c. <i>Ease of tying up?</i> d. <i>Why tie up or not tie up the net?</i> c) <i>Washing</i> a. <i>Frequency of washing; part of weekly clothes washing routine, only when visibly dirty or for special occasions?</i> b. <i>Type of soap</i> c. <i>Location</i> d. <i>Scrubbing/beating hard?</i> e. <i>Motions of washing – ask to demonstrate?</i> d) <i>Drying</i> a. <i>Location – sun or shade? Inside or outside?</i> e) <i>Seasonal storage</i> a. <i>Location; e.g. in bag etc.</i> b. <i>Check whether net still there; without holes</i> c. <i>Perceived danger of rats when storing nets.</i>

Appendix 3A – Topic Guide for FGDs

Are you more likely to repair a net you received for free or one you bought yourself?	<p>a) <i>If yes, what is the difference?</i></p> <p>b) <i>Why is there a difference?</i></p>
Does the material of the net affect your net care?	<p>a) <i>More likely to care for nets made of one material than another?</i></p> <p>b) <i>Why?</i></p> <p>2 net types distributed by SNP: Olyset (polyethylene) and PermaNet (polyester). Use net samples when asking question.</p>
Gender and family roles in net care	
Who is responsible for net care in the household?	<p>a) <i>Why is he/she responsible for net care?</i></p> <p>b) <i>Specific responsibilities?</i></p> <p>c) <i>Gender-specific actions / roles.</i></p> <p>d) <i>What is the role of children in net care? Do school children advise their parents on the importance of net care? What has been the key message from children?</i></p> <p>e) <i>What things do women usually do that men could do relating to net care?</i></p> <p>f) <i>Does the gender of the main income earner affect responsibilities and choices in a household?</i></p>
How is this similar to or different from what other people in your community think?	<p>a) <i>Do you think that the division of labour/responsibility is the same in your neighbourhood as in your house, or is your household different?</i></p> <p>b) <i>What makes it different?</i></p> <p>c) <i>Why?</i></p>
Motivation for net care	
Why do you care for your nets?	<p>c) <i>Social norms on hygiene</i></p> <p style="padding-left: 20px;">a. <i>desire to be perceived as a clean and responsible person by neighbours, friends, community</i></p> <p style="padding-left: 20px;">b. <i>neat appearance</i></p> <p style="padding-left: 20px;">c. <i>What do you think if you visit a household with torn nets? How about if a household has repaired nets?</i></p> <p>d) <i>Increase lifespan / durability of nets</i></p> <p style="padding-left: 20px;">a. <i>prevent damage on nets</i></p> <p style="padding-left: 20px;">b. <i>recognized as good daily routine</i></p> <p>e) <i>Dirty nets causes disease</i></p> <p>f) <i>Daily household factors, e.g. bedwetting, dirty floors; smoke</i></p>
Does the location of damage / holes to nets determine net care?	<p>a) <i>Usually, where is most damage to nets? Bottom, middle, top of sides, roof? What causes this damage?</i></p> <p>b) <i>Are nets more likely to be cared for when most damage is on the bottom of the net versus the top of the net?</i></p> <p>c) <i>Why?</i></p> <p>d) <i>Are different type of care behaviour associated with different hole locations?</i></p>

Appendix 3A – Topic Guide for FGDs

Barriers for net care	
<p>Why do you not care for your net?</p> <p>What makes it difficult for you to maintain a daily routine?</p>	<p>a) <i>Don't know how / Lack of proper instructions</i></p> <p>b) <i>Not part of daily routine</i></p> <p style="padding-left: 20px;">a. <i>Tiring to do daily</i></p> <p style="padding-left: 20px;">b. <i>Easy to forget</i></p> <p style="padding-left: 20px;">c. <i>Too busy in the morning rushing to work/fields</i></p> <p>c) <i>No point</i></p> <p style="padding-left: 20px;">a. <i>Children will mess it up anyway during the day</i></p> <p style="padding-left: 20px;">b. <i>Perceived little value in caring for nets or to one's health; doubtful that nets protect against malaria...</i></p> <p>d) <i>Frequent washing reduces effectiveness of the 'medicine' in the net</i></p> <p>e) <i>Cost of soap</i></p>
How to overcome barriers to net care	
<p>What do you think can be done to help a net last longer?</p>	<p>a) <i>Clearer instructions on packets from manufacturers / government</i></p> <p>b) <i>"Group cleaning"</i></p> <p>c) <i>Men taking more responsibility</i></p> <p>d) <i>Better information and demonstrations from Community Change Agents and health centres about importance of nets and their role in prevention of disease</i></p> <p>e) <i>Make it part of daily routine – how? What would help you do those things in your daily life?</i></p>
PART 4: Net repair behaviours, attitudes and practice	
<p>What is (net) repair?</p>	<p>Start the discussion on general "repair" and only move to "nets" later rather than immediately only focussing on net repair.</p> <p>a) <i>Are clothes (school uniforms, work clothes) or bedding repaired?</i></p> <p>b) <i>What about nets? Why is it the same / different?</i></p> <p>c) <i>Methods of repair: sewing, patching and knotting</i></p> <p>d) <i>When and how often?</i></p> <p>e) <i>Completeness of repair:</i></p> <p style="padding-left: 20px;">a. <i>Is every single hole repaired completely?</i></p> <p style="padding-left: 20px;">b. <i>Are only the largest holes repaired and the smaller ones remain without repair? Is it enough to only repair large holes?</i></p> <p style="padding-left: 20px;">c. <i>Do some holes get partially repaired?</i></p> <p>f) <i>By whom? Do they do it themselves or take net to a tailor?</i></p> <p>g) <i>Perceived investment (money / time) in net repair</i></p>

Appendix 3A – Topic Guide for FGDs

When / how frequently do you repair your nets?	<ul style="list-style-type: none"> a) <i>Weekly; monthly (i.e. fixed intervals)</i> b) <i>Immediately as a hole appears</i> c) <i>For special/ specific occasions, e.g. having visitors, during rainy seasons, during ngoma (puberty party) etc.</i> d) <i>When clothes are being repaired/ taken to the tailor</i> e) <i>When x number of holes are present (continue probing with next question)</i>
When is a net torn enough that it needs repair?	<p><i>Number of holes, size, shape, location, source</i></p> <p><i>For each response ask the reason behind</i></p>
Does the material of the net affect your net repair?	<ul style="list-style-type: none"> a) <i>More likely to care for nets made of one material than another?</i> b) <i>Why?</i> <p>2 net types distributed by SNP: Olyset (polyethylene) and PermaNet (polyester). Use net samples when asking question.</p>
Are you more likely to repair a net you received for free or one you bought yourself?	<ul style="list-style-type: none"> c) <i>If yes, what is the difference?</i> d) <i>Why is there a difference?</i>
Gender and family roles in net repair	
Who is responsible of net repair in the household?	<ul style="list-style-type: none"> a) <i>Why he/she is responsible for net repair?</i> b) <i>Specific responsibilities?</i> c) <i>Gender-specific actions / roles.</i> d) <i>What is the role of children in net repair? Do school children advise their parents on the importance of net repair? What has been the key message from children?</i> e) <i>What things do women usually do that men could do relating to net repair?</i> f) <i>Does the gender of the main income earner affect responsibilities and choices made in a household?</i>
How is this similar to or different from what other people in your community think?	<ul style="list-style-type: none"> a) <i>Do you think that the division of labour/responsibility is the same in your neighbourhood as in your house, or is your household different?</i> b) <i>What makes it different?</i> c) <i>Why?</i>
Motivation for net repair	
Why do you repair your bed net?	<ul style="list-style-type: none"> a) <i>Increase protective potential of net</i> <ul style="list-style-type: none"> a. <i>Higher risk of malaria due to holes</i> b. <i>More mosquito bites due to holes (nuisance / disease)</i> c. <i>What size hole can mosquitoes enter through?</i> b) <i>Awareness that small holes can get bigger – earlier repair avoids nets becoming unusable.</i> c) <i>Cost savings</i> <ul style="list-style-type: none"> a. <i>from averting illness,</i>

Appendix 3A – Topic Guide for FGDs

	<ul style="list-style-type: none"> <i>b. not having enough money to obtain a new net</i> <i>c. The need to extend net life due to uncertainty of when one could expect a new net</i> <i>d) Social norm</i> <ul style="list-style-type: none"> <i>a. Having a net that looks good (strong dislike of nets with holes)</i> <i>b. Desire to be perceived as responsible and conscientious</i> <i>e) Quick and easy</i> <ul style="list-style-type: none"> <i>a. knotting and tying off holes,</i> <i>b. needle, thread, and patching materials easily available at low to no cost</i>
Does the location of damage / holes to nets determine net care?	<ul style="list-style-type: none"> <i>a) Usually, where is most damage to nets? Bottom, middle, top of sides, roof? What causes this damage? (Only ask if it didn't come up during care questions)</i> <i>b) Are nets more likely to be repaired when most damage is on the bottom of the net versus the top of the net?</i> <i>c) Why?</i> <i>d) Are different type of repairs associated with different hole locations?</i>
Whose net are more likely to be repaired?	<ul style="list-style-type: none"> <i>a) Are nets belonging to certain household members more likely to be repaired?</i> <ul style="list-style-type: none"> <i>a. Head of households; main income earner</i> <i>b. Pregnant women; infants</i> <i>c. Visitors</i> <i>d. Children</i> <i>e. Seniors etc.</i> <i>b) Why?</i>
Barriers for net repair	
Why you do not repair your net?	<ul style="list-style-type: none"> <i>a) Social desirability:</i> <ul style="list-style-type: none"> <i>a. Prefer to replace with new net if affordable</i> <i>b. Avoid to be perceived as poor</i> <i>c. Potential unattractiveness of repair (distortion due to knotting, neatness of sewing, colour of material and thread used)</i> <i>d. Nobody sees my nets so it doesn't matter whether they are dirty / full of holes.</i> <i>b) Lack of</i> <ul style="list-style-type: none"> <i>a. Materials</i> <i>b. Ability to sew</i> <i>c. Knowledge of how to repair</i> <i>d. Time</i> <i>e. Motivation</i> <i>c) Holes are too big or too many</i> <i>d) Repairing holes creates more holes</i> <i>e) Misconceptions, e.g. nets with holes still stop mosquitoes and malaria</i> <i>f) Location of holes (bottom of net); e.g. not important as nets are tucked under mattress</i>

Appendix 3A – Topic Guide for FGDs

	<p>g) <i>Malaria is not a big problem for me / not susceptible to malaria</i></p> <p>a. <i>Perceived little value in caring for nets or to one's health; doubtful that nets protect against malaria...</i></p>
How to overcome barriers to net repair	
What can be done to overcome barriers to net repair?	<p>a) <i>Repair immediately after you have seen the first hole</i></p> <p>b) <i>Make sure you always keep the sewing kit in the household</i></p> <p>c) <i>“Repair kits”</i></p> <p>d) <i>Repair / bring to tailor at the same time as clothes etc.</i></p> <p>e) <i>Better information and demonstrations from Community Change Agents and health centres about importance of nets and their role in prevention of disease</i></p>

APPENDIX 3B - TOPIC GUIDE FOR IN-DEPTH INTERVIEWS

<i>Interviewer use only – complete prior to interview</i>		
Topic Guide for IDI participants		
Interviewer ID: _____	Phone number: _____	Village Name: _____
Date of In-Depth Interview: _ _ _ _ _ _ _ _		
Participant ID: _ _		

Note to interviewer: Questions in italics are meant to be probes. They do not have to be asked as they appear here. Rather, phrase and order questions according to the flow of the discussion.

Questions/Themes	Probes
PART 1: Attitudes towards risk of malaria and value of nets	
What is your risk of getting ill from malaria?	a) <i>What is the risk of malaria to you, your family and your community?</i>
Do mosquito nets protect you against malaria?	a) <i>What do you think of mosquito nets as an intervention against malaria?</i> a. <i>What is the value of mosquito nets to you, your household and your community?</i> b) <i>Willingness to invest (time, resources) in the care and repair of your mosquito net?</i>
How is a mosquito net used in your household?	a) <i>Protection against malaria</i> b) <i>Alternative use of nets (fishing, chicken coup, gardening, etc.)</i>
PART 2: Net possession and SNP	
Where do you get your mosquito nets from?	a) <i>Did you buy it?</i> a. <i>From where?</i> b. <i>How much? (Affordability)</i> c. <i>Why?</i> b) <i>Was it freely provided?</i> a. <i>By whom?</i> b. <i>Through what channels?</i> c. <i>How frequently?</i>

Appendix 3B – Topic Guide for IDIs

How long do you usually keep your nets?	For those with nets more than 2 years old: a) <i>How have you maintained the net for 2 years?</i> b) <i>In what condition is the net now? (holes; rips; dirtiness; usefulness etc.)</i>
When is a net no longer effective against mosquito bites / disease prevention?	a) <i>Time in months, years or duration of use – rationale behind timing</i> b) <i>Too much damage – define</i> c) <i>How long do you think you should use a net before it is no longer effective?</i> d) <i>How do you know a net is no longer effective?</i> e) <i>External cues; Do you have to keep a net until you obtain a new one? Is getting a new one for free the only time nets are usually replaced?</i>
If the participant reports to have received nets from School Net Programme...	a) <i>Experience of SNP – positive, negative?</i> b) <i>Enough nets for household, community?</i> c) <i>Enough information about the programme?</i>
Have you been exposed to any messaging about net care and repair?	a) <i>Source of messaging: radio, Community Change Agents, children etc</i> b) <i>Probe about <u>content</u> of messages / messaging</i>
PART 3 : Net care behaviours, attitudes and practices	
What is / counts as net care?	a) <i>Hanging up nets</i> a. <i>Where?</i> b. <i>Using what?</i> c. <i>How quickly after washing?</i> d. <i>Whose responsibility?</i> b) <i>Daily storage routine; i.e. tying nets up</i> a. <i>During the day? Every day? All day?</i> b. <i>Who?</i> c. <i>Ease of tying up?</i> d. <i>Why tie up or not tie up the net?</i> c) <i>Washing</i> a. <i>Frequency of washing; part of weekly clothes washing routine, only when visibly dirty or for special occasions?</i> b. <i>Type of soap</i> c. <i>Location</i> d. <i>Scrubbing/beating hard?</i> e. <i>Motions of washing – ask to demonstrate?</i> d) <i>Drying</i> a. <i>Location – sun or shade? Inside or outside?</i> e) <i>Seasonal storage</i> a. <i>Location; e.g. in bag etc.</i> b. <i>Check whether net still there; without holes</i> c. <i>Perceived danger of rats when storing nets.</i>

Appendix 3B – Topic Guide for IDIs

Are you more likely to repair a net you received for free or one you bought yourself?	<ul style="list-style-type: none"> a) <i>If yes, what is the difference?</i> b) <i>Why is there a difference?</i>
Does the material of the net affect your net care?	<ul style="list-style-type: none"> a) <i>More likely to care for nets made of one material than another?</i> b) <i>Why?</i> <p>2 net types distributed by SNP: Olyset (polyethylene) and PermaNet (polyester). Use net samples when asking question.</p>
Gender and family roles in net care	
Who is responsible for net care in the household?	<ul style="list-style-type: none"> a) <i>Why is he/she responsible for net care?</i> b) <i>Specific responsibilities?</i> c) <i>Gender-specific actions / roles.</i> d) <i>What is the role of children in net care? Do school children advise their parents on the importance of net care? What has been the key message from children?</i> e) <i>What things do women usually do that men could do relating to net care?</i> f) <i>Does the gender of the main income earner affect responsibilities and choices in a household?</i>
How is this similar to or different from what other people in your community think?	<ul style="list-style-type: none"> a) <i>Do you think that the division of labour/responsibility is the same in your neighbourhood as in your house, or is your household different?</i> b) <i>What makes it different?</i> c) <i>Why?</i>
Motivation for net care	
Why do you care for your nets?	<ul style="list-style-type: none"> c) <i>Social norms on hygiene</i> <ul style="list-style-type: none"> a. <i>desire to be perceived as a clean and responsible person by neighbours, friends, community</i> b. <i>neat appearance</i> c. <i>What do you think if you visit a household with torn nets? How about if a household has repaired nets?</i> d) <i>Increase lifespan / durability of nets</i> <ul style="list-style-type: none"> a. <i>prevent damage on nets</i> b. <i>recognized as good daily routine</i> e) <i>Dirty nets causes disease</i> f) <i>Daily household factors, e.g. bedwetting, dirty floors; smoke</i>
Does the location of damage / holes to nets determine net care?	<ul style="list-style-type: none"> a) <i>Usually, where is most damage to nets? Bottom, middle, top of sides, roof? What causes this damage?</i> b) <i>Are nets more likely to be cared for when most damage is on the bottom of the net versus the top of the net?</i> c) <i>Why?</i> d) <i>Are different type of care behaviour associated with different hole locations?</i>

Appendix 3B – Topic Guide for IDIs

Barriers for net care	
<p>Why do you not care for your net?</p> <p>What makes it difficult for you to maintain a daily routine?</p>	<p>a) <i>Don't know how / Lack of proper instructions</i></p> <p>b) <i>Not part of daily routine</i></p> <p style="padding-left: 20px;">a. <i>Tiring to do daily</i></p> <p style="padding-left: 20px;">b. <i>Easy to forget</i></p> <p style="padding-left: 20px;">c. <i>Too busy in the morning rushing to work/fields</i></p> <p>c) <i>No point</i></p> <p style="padding-left: 20px;">a. <i>Children will mess it up anyway during the day</i></p> <p style="padding-left: 20px;">b. <i>Perceived little value in caring for nets or to one's health; doubtful that nets protect against malaria...</i></p> <p>d) <i>Frequent washing reduces effectiveness of the 'medicine' in the net</i></p> <p>e) <i>Cost of soap</i></p>
How to overcome barriers to net care	
<p>What do you think can be done to help a net last longer?</p>	<p>a) <i>Clearer instructions on packets from manufacturers / government</i></p> <p>b) <i>"Group cleaning"</i></p> <p>c) <i>Men taking more responsibility</i></p> <p>d) <i>Better information and demonstrations from Community Change Agents and health centres about importance of nets and their role in prevention of disease</i></p> <p>e) <i>Make it part of daily routine – how? What would help you do those things in your daily life?</i></p>
PART 4: Net repair behaviours, attitudes and practice	
<p>What is (net) repair?</p>	<p>Start the discussion on general "repair" and only move to "nets" later rather than immediately only focussing on net repair.</p> <p>a) <i>Are clothes (school uniforms, work clothes) or bedding repaired?</i></p> <p>b) <i>What about nets? Why is it the same / different?</i></p> <p>c) <i>Methods of repair: sewing, patching and knotting</i></p> <p>d) <i>When and how often?</i></p> <p>e) <i>Completeness of repair:</i></p> <p style="padding-left: 20px;">a. <i>Is every single hole repaired completely?</i></p> <p style="padding-left: 20px;">b. <i>Are only the largest holes repaired and the smaller ones remain without repair? Is it enough to only repair large holes?</i></p> <p style="padding-left: 20px;">c. <i>Do some holes get partially repaired?</i></p> <p>f) <i>By whom? Do they do it themselves or take net to a tailor?</i></p> <p>g) <i>Perceived investment (money / time) in net repair</i></p>

Appendix 3B – Topic Guide for IDIs

When / how frequently do you repair your nets?	<ul style="list-style-type: none"> a) <i>Weekly; monthly (i.e. fixed intervals)</i> b) <i>Immediately as a hole appears</i> c) <i>For special/ specific occasions, e.g. having visitors, during rainy seasons, during ngoma (puberty party) etc.</i> d) <i>When clothes are being repaired/ taken to the tailor</i> e) <i>When x number of holes are present (continue probing with next question)</i>
When is a net torn enough that it needs repair?	<p><i>Number of holes, size, shape, location, source</i></p> <p><i>For each response ask the reason behind</i></p>
Does the material of the net affect your net repair?	<ul style="list-style-type: none"> a) <i>More likely to care for nets made of one material than another?</i> b) <i>Why?</i> <p>2 net types distributed by SNP: Olyset (polyethylene) and PermaNet (polyester). Use net samples when asking question.</p>
Are you more likely to repair a net you received for free or one you bought yourself?	<ul style="list-style-type: none"> c) <i>If yes, what is the difference?</i> d) <i>Why is there a difference?</i>
Gender and family roles in net repair	
Who is responsible of net repair in the household?	<ul style="list-style-type: none"> a) <i>Why he/she is responsible for net repair?</i> b) <i>Specific responsibilities?</i> c) <i>Gender-specific actions / roles.</i> d) <i>What is the role of children in net repair? Do school children advise their parents on the importance of net repair? What has been the key message from children?</i> e) <i>What things do women usually do that men could do relating to net repair?</i> f) <i>Does the gender of the main income earner affect responsibilities and choices made in a household?</i>
How is this similar to or different from what other people in your community think?	<ul style="list-style-type: none"> a) <i>Do you think that the division of labour/responsibility is the same in your neighbourhood as in your house, or is your household different?</i> b) <i>What makes it different?</i> c) <i>Why?</i>
Motivation for net repair	
Why do you repair your bed net?	<ul style="list-style-type: none"> a) <i>Increase protective potential of net</i> <ul style="list-style-type: none"> a. <i>Higher risk of malaria due to holes</i> b. <i>More mosquito bites due to holes (nuisance / disease)</i> c. <i>What size hole can mosquitoes enter through?</i> b) <i>Awareness that small holes can get bigger – earlier repair avoids nets becoming unusable.</i> c) <i>Cost savings</i> <ul style="list-style-type: none"> a. <i>from averting illness,</i>

Appendix 3B – Topic Guide for IDIs

	<ul style="list-style-type: none"> <i>b. not having enough money to obtain a new net</i> <i>c. The need to extend net life due to uncertainty of when one could expect a new net</i> <i>d) Social norm</i> <ul style="list-style-type: none"> <i>a. Having a net that looks good (strong dislike of nets with holes)</i> <i>b. Desire to be perceived as responsible and conscientious</i> <i>e) Quick and easy</i> <ul style="list-style-type: none"> <i>a. knotting and tying off holes,</i> <i>b. needle, thread, and patching materials easily available at low to no cost</i>
Does the location of damage / holes to nets determine net care?	<ul style="list-style-type: none"> <i>a) Usually, where is most damage to nets? Bottom, middle, top of sides, roof? What causes this damage? (Only ask if it didn't come up during care questions)</i> <i>b) Are nets more likely to be repaired when most damage is on the bottom of the net versus the top of the net?</i> <i>c) Why?</i> <i>d) Are different type of repairs associated with different hole locations?</i>
Whose net are more likely to be repaired?	<ul style="list-style-type: none"> <i>a) Are nets belonging to certain household members more likely to be repaired?</i> <ul style="list-style-type: none"> <i>a. Head of households; main income earner</i> <i>b. Pregnant women; infants</i> <i>c. Visitors</i> <i>d. Children</i> <i>e. Seniors etc.</i> <i>b) Why?</i>
Barriers for net repair	
Why you do not repair your net?	<ul style="list-style-type: none"> <i>a) Social desirability:</i> <ul style="list-style-type: none"> <i>a. Prefer to replace with new net if affordable</i> <i>b. Avoid to be perceived as poor</i> <i>c. Potential unattractiveness of repair (distortion due to knotting, neatness of sewing, colour of material and thread used)</i> <i>d. Nobody sees my nets so it doesn't matter whether they are dirty / full of holes.</i> <i>b) Lack of</i> <ul style="list-style-type: none"> <i>a. Materials</i> <i>b. Ability to sew</i> <i>c. Knowledge of how to repair</i> <i>d. Time</i> <i>e. Motivation</i> <i>c) Holes are too big or too many</i> <i>d) Repairing holes creates more holes</i> <i>e) Misconceptions, e.g. nets with holes still stop mosquitoes and malaria</i> <i>f) Location of holes (bottom of net); e.g. not important as nets are tucked under mattress</i>

Appendix 3B – Topic Guide for IDIs

	<p>g) <i>Malaria is not a big problem for me / not susceptible to malaria</i></p> <p>a. <i>Perceived little value in caring for nets or to one's health; doubtful that nets protect against malaria...</i></p>
How to overcome barriers to net repair	
What can be done to overcome barriers to net repair?	<p>a) <i>Repair immediately after you have seen the first hole</i></p> <p>b) <i>Make sure you always keep the sewing kit in the household</i></p> <p>c) <i>"Repair kits"</i></p> <p>d) <i>Repair / bring to tailor at the same time as clothes etc.</i></p> <p>e) <i>Better information and demonstrations from Community Change Agents and health centres about importance of nets and their role in prevention of disease</i></p>

APPENDIX 4A - PARTICIPATORY ACTIVITY GUIDE FOR FGDS

A participatory activity (PA) will be taking place after each FGD. The purpose of the participatory activity is to examine net use and repair decisions associated with different net damage and repair attributes. The discussion will be audio-recorded and the activity will take 60 minutes.

PA guide:

1. Facilitator explains the purpose of the activity to participants.
2. Distribute PA decision sheet (Appendix 4C) and pen to each study participant.
3. Facilitator shows uniquely labelled nets with different levels of damage and repair (Table 1).
4. Facilitator asks to make decision on future of net (Table 2):
 - a. first what they *would* do;
 - b. second what they *think they should* do.
5. Each participant writes their answers on the PA decision sheet (Appendix 4C).
6. After all nets have been shown and decided on, the facilitator collects the PA decision sheets and conducts a quick assessment of choices for the different nets.
7. Facilitator leads a discussion on the choices around each net, identifying each net by its unique ID number. Questions will include:
 - a. Why was the choice made?
 - b. Was there a difference between *would* and *should*, and why?
 - c. If choice was to use the net for something else in household, what would it be used for? Why?
 - d. If choice was to discard the net, where would it be discarded?
8. Facilitator should encourage discussions among FGD members.

The nets with different levels of damage and repair (Table 1) have been designed to address the following four hypotheses:

1. Large holes more likely to get repaired.
2. Holes in roof more likely to be repaired.
3. Small holes are not repaired.
4. If there are large holes and smaller holes, all holes will be repaired.

Table 1 – Net with different damage and repair attributes for PA exercise.

Net ID	Number of holes	Hole sizes (Table 3)	Hole location ¹	Repair? ²
7	2	Size 1	1 bottom, 1 top	N
8	9	Size 1	1 roof, mix bottom/top	N
9	1	Size 2	Top	N
15	1	Size 2	Bottom	N
5	1	Size 2	Roof	N
1	1	Size 3	Bottom	N
2	1	Size 3	Bottom	Y (Partially repaired)
6	18	15 Size 1, 3 Size 2	Mix	N
12	18	15 Size 1, 3 Size 2	Mix	Partial (2 Size 2)
3	9	8 Size 1, 1 Size 3	Size 1 top, Size 3 bottom	N
4	9	8 Size 1, 1 Size 3	Size 1 top, Size 3 bottom	Partial (Size 3)
14	2	1 Size 2, 1 Size 4	Size 4 roof, Size 2 bottom	N
13	2	1 Size 2, 1 Size 4	Size 4 roof, Size 2 bottom	Partial (Size 4)
11	25	22 Size 1, 1 Size 2, 2 Size 3	Mix	N
10	25	22 Size 1, 1 Size 2, 2 Size 3	Mix	Partial (Size 2, 1 Size 3)

¹Each side panel split in top half and bottom half.

²Type of repair: Sewing with needle and thread (as per School Net Programme Behavioural Change Communication messaging)

Table 2 – Decisions on net actions

1	Do nothing and continue to use
2	Repair and continue to use
3	No longer use net and use for something else in household
4	No longer use the net and discard the net

Table 3 – Different hole size categories as per WHO

Hole Category	Hole Size Description	Hole Size (cm)	Hole Diameter (cm)	Weighta
Size 1	Smaller than a thumb (finger)	0.5-2	1.25	1
Size 2	Larger than a thumb but smaller than fist (fist)	2-10	6	23
Size 3	Larger than a fist but smaller than a head (head)	10-25	17.5	196
Size 4	Larger than a head	>25	30 (assumed)	578

APPENDIX 4B - PARTICIPATORY ACTIVITY GUIDE FOR IDIS

A participatory activity (PA) will be taking place after each IDI. The purpose of the participatory activity is to examine net use and repair decisions associated with different net damage and repair attributes. The discussion will be audio-recorded and the activity will take 30 minutes.

PA guide:

1. Interviewer explains the purpose of the activity to participants.
2. Interviewer shows uniquely labelled nets with different levels of damage and repair (Table 1).
3. Interviewer asks to make decision on future of net (Table 2):
 - a. first what they *would* do;
 - b. second what they *think they should* do.
4. The participant makes their choice and tells the interviewer.
5. Interviewer probes on reasons behind the choices around each net, identifying each net by its unique ID number. Questions will include:
 - a. Why was the choice made?
 - b. Was there a difference between *would* and *should*, and why?
 - c. If choice was to use the net for something else in household, what would it be used for? Why?
 - d. If choice was to discard the net, where would it be discarded?

The nets with different levels of damage and repair (Table 1) have been designed to address the following four hypotheses:

1. Large holes more likely to get repaired.
2. Holes in roof more likely to be repaired.
3. Small holes are not repaired.
4. If there are large holes and smaller holes, all holes will be repaired.

Table 1 – Net with different damage and repair attributes for PA exercise.

Net ID	Number of holes	Hole sizes (Table 3)	Hole location ¹	Repair? ²
7	2	Size 1	1 bottom, 1 top	N
8	9	Size 1	1 roof, mix bottom/top	N
9	1	Size 2	Top	N
15	1	Size 2	Bottom	N
5	1	Size 2	Roof	N
1	1	Size 3	Bottom	N
2	1	Size 3	Bottom	Y (Partially repaired)
6	18	15 Size 1, 3 Size 2	Mix	N
12	18	15 Size 1, 3 Size 2	Mix	Partial (2 Size 2)
3	9	8 Size 1, 1 Size 3	Size 1 top, Size 3 bottom	N
4	9	8 Size 1, 1 Size 3	Size 1 top, Size 3 bottom	Partial (Size 3)
14	2	1 Size 2, 1 Size 4	Size 4 roof, Size 2 bottom	N
13	2	1 Size 2, 1 Size 4	Size 4 roof, Size 2 bottom	Partial (Size 4)
11	25	22 Size 1, 1 Size 2, 2 Size 3	Mix	N
10	25	22 Size 1, 1 Size 2, 2 Size 3	Mix	Partial (Size 2, 1 Size 3)

¹Each side panel split in top half and bottom half.

²Type of repair: Sewing with needle and thread (as per School Net Programme Behavioural Change Communication messaging)

Table 2 – Decisions on net actions

1	Do nothing and continue to use
2	Repair and continue to use
3	No longer use net and use for something else in household
4	No longer use the net and discard the net

Table 3 – Different hole size categories as per WHO

Hole Category	Hole Size Description	Hole Size (cm)	Hole Diameter (cm)	Weight
Size 1	Smaller than a thumb (finger)	0.5-2	1.25	1
Size 2	Larger than a thumb but smaller than fist (fist)	2-10	6	23
Size 3	Larger than a fist but smaller than a head (head)	10-25	17.5	196
Size 4	Larger than a head	>25	30 (assumed)	578

APPENDIX 5A MOSQUITO NET ASSESSMENT

<i>Interviewer use only – complete prior to interview</i>		
HOUSEHOLD MOSQUITO NET ASSESSMENT		
Interviewer ID: _____	Village Name: _____	Participant ID: _____
Date: _ _ _ _ _ _ _ _		

The following assessment will tell us a little more about current status of your mosquito nets. This mosquito net assessment tool is part of a study on decoding perceptions, barriers and motivators of net and repair in Tanzania funded by PMI Tanzania. We will have a look at your nets and count the number of holes. We request to mount your nets on a frame in order to better find and count all the holes. The net will be returned to you and hung up again if you wish.

Research assistant to mount the net on net frame for hole counting. Make sure that only one net is assessed at a time and enter data directly from the tally sheet (Appendix 5C).

Net number: _____				
Who slept under this mosquito net the previous night?				
No.	Age (years)	Sex (M or F)	Relationship with the head of Household (enter code)	<u>Codes for relationship to head of household</u>
1			_ _	01...Head of household
2			_ _	02...Spouse
3			_ _	03...Son or daughter
4			_ _	04... Adopted/foster/stepchild
5			_ _	05...Son-in-law or daughter-in-law
6			_ _	06...Grandchild
7			_ _	07...Parent
8			_ _	08...Parent-in-law
				09...Brother or sister
				10...Niece or nephew
				11...Other/Not related

Appendix 5A – Household Mosquito Net Assessment

Question	Coding Category		Response
Which of these statements does best describe your net?	01... This net is still in a good condition and can be used as it is 02... This net is beginning to fall apart and should be repaired soon and then continue to be used 03... This net is no longer usable to sleep under but can be used for other alternative uses in the household 04... This net is no longer usable and definitely needs to be replaced		_ _
Does this net have any holes? <i>Observe</i>	01...Yes 00...No		_ _
What type of holes are observed? <i>Answer every category</i>	01... Yes 00...No	Horizontal tears at bottom Holes at hanging points Open seams Burn holes Holes from rodents Whole section missing	_ _ _ _ _ _ _ _ _ _ _ _
Is there any evidence of repair on this net? <i>Observe</i>	01...Yes 00...No		_ _
How many of these repairs are observed? <i>Enter number; if none, write '00'</i>	01...Stitched 02...Knotted/tied 03...Patched 04...Other way, specify _____		_ _ _ _ _ _ _ _
Has the net been modified? <i>Observe</i>	01...Yes 00...No		_ _
How was the net modified?	01...Shape was changed		_ _

Appendix 5A – Household Mosquito Net Assessment

<i>Observe</i>	02...Material was added to lengthen 03...Material was added to reinforce 04...Other, specify	_____
Number of holes in top	Size 1 (finger) Size 2 (fist) Size 3 (head) Size 4 (larger than head)	
Number of holes repaired in top	Size 1 (finger) Size 2 (fist) Size 3 (head) Size 4 (larger than head)	
Number of holes in middle	Size 1 (finger) Size 2 (fist) Size 3 (head) Size 4 (larger than head)	
Number of holes repaired in middle	Size 1 (finger) Size 2 (fist) Size 3 (head) Size 4 (larger than head)	
Number of holes in bottom	Size 1 (finger) Size 2 (fist) Size 3 (head) Size 4 (larger than head)	
Number of holes repaired in bottom	Size 1 (finger) Size 2 (fist) Size 3 (head)	

Appendix 5A – Household Mosquito Net Assessment

	Size 4 (larger than head)	_ _
Number of holes in roof	Size 1 (finger)	_ _
	Size 2 (fist)	_ _
	Size 3 (head)	_ _
	Size 4 (larger than head)	_ _
Number of holes repaired in roof	Size 1 (finger)	_ _
	Size 2 (fist)	_ _
	Size 3 (head)	_ _
	Size 4 (larger than head)	_ _



APPENDIX 5C HOLE ASSESSMENT TALLY SHEET

Participant ID

Net ID

					TOTAL			
ZONE 1								
HOLES	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○		■		
Size 3	○○○○○	○○○○○	○○○○○	○○○○○			■	
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				■
REPAIRS	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○		■		
Size 3	○○○○○	○○○○○	○○○○○	○○○○○			■	
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				■
ZONE 2								
HOLES	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○		■		
Size 3	○○○○○	○○○○○	○○○○○	○○○○○			■	
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				■
REPAIRS	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○		■		
Size 3	○○○○○	○○○○○	○○○○○	○○○○○			■	
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				■

Appendix 5C - Hole Assessment Tally Sheet

					TOTAL			
ZONE 3								
HOLES	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○				
Size 3	○○○○○	○○○○○	○○○○○	○○○○○				
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				
REPAIRS	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○				
Size 3	○○○○○	○○○○○	○○○○○	○○○○○				
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				
ROOF								
HOLES	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○				
Size 3	○○○○○	○○○○○	○○○○○	○○○○○				
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				
REPAIRS	5	10	15	20	Size 1	Size 2	Size 3	Size 4
Size 1	○○○○○	○○○○○	○○○○○	○○○○○				
Size 2	○○○○○	○○○○○	○○○○○	○○○○○				
Size 3	○○○○○	○○○○○	○○○○○	○○○○○				
Size 4	○○○○○	○○○○○	○○○○○	○○○○○				