**The Nelson Mandela AFrican Institution of Science and Technology**

**NM-AIST Repository** **https://dspace.mm-aist.ac.tz**

Life sciences and Bio-engineering Masters Theses and Dissertations [LISBE]

2022-08

# Mixed method study to evaluate factors associated with discarding of long-lasting insecticidal nets in Bagamoyo, Tanzania

Madumla, Edith

NM-AIST

https://doi.org/10.58694/20.500.12479/1514

*Provided with love from The Nelson Mandela African Institution of Science and Technology*

# MIXED METHOD STUDY TO EVALUATE FACTORS ASSOCIATED WITH DISCARDING OF LONG-LASTING INSECTICIDAL NETS IN BAGAMOYO, TANZANIA

**Edith P. Madumla**

**A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Public Health Research of the Nelson Mandela African Institution of Science and Technology**

**Arusha, Tanzania**

**August, 2022**

## ABSTRACT

Between 2000 and 2019, more than 1.8 billion long-lasting insecticidal nets (LLINs) were distributed in Africa. While the insecticidal durability of LLINs is around 3 years, nets are generally discarded 2 years post-distribution. This study investigated the factors associated with the decision of users to discard LLINs. A mixed-methods sequential explanatory approach using a structured questionnaire followed by focus group discussions (FGDs) was used to collect information on experiences, views, reasons, how and when LLINs are discarded as well as gather knowledge on net care and repair from the participants. Out of 6,526 households that responded to the questionnaire of LLINs durability trial, 160 households were randomly selected from the households in four villages in Bagamoyo Tanzania for FGDs but only 155 households participated in the FGDs. Five of the household representatives couldn't participate due to unexpected circumstances. A total of sixteen FGDs each comprising of 8-10 adults were conducted; older women (40–60 years), older men (40-60 years), younger women (18-39 years), and younger men (18-39 years). During the FGDs, participants visually inspected seven samples of LLINs that were "too-torn" based on the proportionate hole Index (PHI) recommended by the World Health Organization guidelines on LLIN testing, the nets were brought to the discussion, and participants had to determine if such LLINs were to be kept or discarded. The study assessed responses from the same participants that attended FGD and also responded to the structured questionnaire, 117 participants fulfilled the criteria, thus data from only 117 participants are analyzed in this study. In FGDs, the Physical condition of LLIN influenced the decision to discard or keep a net. Those of older age, women and householders with lower income were more likely to classify a WHO "too-torn" net as "good". The common methods used to discard LLINs were burning and burying. The findings were seen in the quantitative analysis. For every additional hole, the odds of discarding a WHO "too-torn" LLIN increased [OR=1.05 (95%CI (1.04 – 1.07)), $p<0.001$]. Younger age group [OR=4.97 (95%CI (3.25 – 7.32)), $p<0.001$], male-headed households [OR=6.85 (95%CI (4.44 –10.59)), $p<0.001$], and wealthy households [OR=3.88 (95%CI (2.33 – 6.46)), $p<0.001$] were more likely to discard LLINs: Physical condition of LLINs was the main determinant for discarding or keeping LLINs and the decision to discard the net is associated with the socioeconomic status of the household, and the age and gender of respondents. WHO "too torn" nets are encouraged to be used instead of none until replaced, and disposal of nets should be based on recommendation.

## DECLARATION

I, Edith P. Madumla, declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation is my original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

| Edith P. Madumla | | |
|---|---|---|
| **Name of the candidate** | **Signature** | **Date** |
| Sarah Moore, Ph.D. |  | 01st August, 2022 |
| **Supervisor 1** | **Signature** | **Date** |
| Zawadi Mageni Mboma, Ph.D. |  | 01st August, 2022 |
| **Supervisor 2** | **Signature** | **Date** |

## COPYRIGHT

This dissertation is copyright material protected under the Berne Convention, the Copyright Act of 1999, and other international and national enactments, non-hart behalf, of intellectual property. It must not be reproduced by any means, in full or in part, except for short extracts in fair dealing; for researcher private study, critical scholarly review, or course with an acknowledgment without the written permission of the office of Deputy Vice-Chancellor or for Academics, Research and Innovation on behalf of both the author and the Nelson Mandela African Institution of Scienceand Technology.

## CERTIFICATION

The undersigned certify that they have read and found to be in a form acceptable for examination by the Nelson Mandela African Institution of Science and Technology a dissertation entitled *Mixed Method study to evaluate factors associated with discarding of Long-lasting Insecticidal Nets (LLINs) in Bagamoyo, Tanzania.*

| Sarah Moore, Ph.D. | | 01st August, 2022 |
|---|---|---|
| **Supervisor 1** | **Signature** | **Date** |

| Zawadi Mageni Mboma, Ph.D. | | 01st August, 2022 |
|---|---|---|
| **Supervisor 2** | **Signature** | **Date** |

## ACKNOWLEDGEMENT

With truthful gratitude and deepest thanks, I would like to thank my almighty God for allowing me to pass triumph over this stage of the sincere appreciation onto the Nelson Mandela African Institution of Science and Technology for offering the admission and Ifakara Health Institute-Training unit department for sponsoring my study.

I would like to thank my supervisor, Dr. Sarah Moore, for her kindness, love, and caring. She has played a huge multi-role across all stages of report development, teaching counseling, and guidance. My career wouldn't have reached this stage without Dr. Sarah, may God bless you. Thankyou for your tireless support. I appreciate your mentorship Dr. Sarah I could not ask for a more inspiring mentor. I have learned a lot from you.

Also, thank you Dr. Zawadi Mageni Mboma. With your knowledge and tireless readiness efforts to supervise during my study. I would not reach this success without your support. May God bless you.

Further thanks go to Mr. Olukayode Odufuwa whose door was always opened for me. Without his guidance, effort, kindness, and high support during proposal writing, data management, and analysis as well as dissertation writing would not have been possible to persuade me to climb this high mountain.

I also would like to thank my project team million net and field workers who cooperated with me during the fieldwork and all Vector Control Product Testing Unit's members for their support, especially Mr. Jason Moore the Test facility manager for his support during the fieldwork and hissupport from study preparation to completion. Many thanks to my lectures, who have taught me and been part of my success.

I am forever thankful to my beloved sons Austin, Adrian, and Aiden especially my little son Aiden whom I left when he was five days only to start my coursework. Many thanks to my husband for his support during my studies and my beloved sister Melita Madumla, Dr. Siriana Madumla, and my parents for taking their love, care, and encouragement during the study period. I also appreciate my study coordinator Dr. Kafuruki Shubis for his good mentorship and guidance. I also appreciate Prof. Dickson Lweitojera and Cecilia Francis for their encouragement and support during my study period at NM-AIST. I would also like to thank my dear fellow studying Master of Science in Public Health research class cohort 2 for their

contribution, teamwork, and sharing of ideas throughout the study period. Lastly, I would like to thank Mr. Daniel Msellemu who take his time and read my work and support me during my final touch.

## DEDICATION

I am delighted to dedicate this work to my sons Austin, Adrian, and Aiden, especially my third son Aiden for being patient during my study period. May God bless them with good health and wisdom.

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| °C | Degree Centigrade |
| ANC | Antenatal Care Unit |
| BCC | Behavioural Change Communication |
| CI | Confidence Interval |
| FGD | Focus Group Discussion |
| HH | Head of Household |
| I-ACT | Ifakara Ambient Chambers test |
| IHI | Ifakara Health Institute |
| IRB | Institutional Review Board |
| IRS | Indoor Residual Spray |
| LLINs | Long-Lasting Insecticidal Nets |
| LN | Long-Lasting Insecticide-Treated Nets |
| NEMC | National Environment Management Council |
| NIMR | National Institute for Medical Research |
| NM-AIST | Nelson Mandela African Institute of Science and Technology |
| NMCP | National Malaria Control Program |
| PCA | Principal Component Analysis |
| PMI | U.S President's Malaria Initiative |
| SBCC | Social Behavioural Change Communication |
| SES | Socioeconomic Status |
| SNP | School Net Program |
| SOM | Supplementary Online Material |
| UCC | Universal Coverage Campaign |
| UK | United Kingdom |
| URC | Universal Replacement Campaign |
| USAID | United States Agency for International Development |
| VCPTU | Vector Control Product Testing Unit |
| WHO | World Health Organization |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the problem

Globally, it is estimated that 1.7 billion malaria cases and 10.6 million malaria occurred in the period 2000-2020 (WHO, 2020). Most of the cases (82%) and death (95%) occurred in the African Region because of disruptions to services during the COVID-19 pandemic (WHO, 2021). The malaria deaths in Tanzania 2020 were 4.1% (WHO, 2020). The prevalence of malaria was high in Bagamoyo District in 2000s was 20.3% (William *et al.,* 2013) due to the interventions of LLINs and Intermittent preventive treatment in pregnancy it is reduced until 2015 to 10% in village where by this study was conducted (Salim *et al.,* 2015). However, the study done by Sumari and colleagues, demonstrated that malaria prevalence in school children in Bagamoyo villages was higher in symptomatic (89%) compared to asymptomatic ones (57.5%) (Sumari *et al.,* 2017).

Furthermore, there has been largely attributable to the scale-up of vector control tools, particularly government-implemented universal coverage campaigns (LLINs) (Koenker *et al.,* 2018; Lim *et al.,* 2011; Steketee *et al.,* 2010). Globally from 2004-2020 manufactures data showed that almost 2.3 billion LLINs were distributed of which 2 billion (86%) LLINs were distributed in Africa (WHO, 2021). In Tanzania, various distribution programs such as The School Net Program, the Universal Coverage Campaign (UCC) and Antenatal Care Unit (ANC) distributed millions of nets (Koenker *et al.,* 2018; Yukich *et al.,* 2020). Unfortunately, evidence compiled in recent years on the durability studies of LLINs found a median survival of 2 years and only 50% of nets remain in use until the next campaign (Bertozzi-Villa *et al.,* 2021; Bhatt *et al.,* 2015).

Community trial Larger-scale field trials (Phase III) Candidate LLINs that pass phase I and phase II testing may receive an interim recommendation for use (WHO, 2013). For a full recommendation, however, a demonstration of durability are studies to assess LLIN durability are often Attrition; it refers to the LLIN lost in the household. Bioefficacy: Refers to the effect of insecticide on killing mosquitoes. Insecticide residual is meant by the retainment of insecticides on LLIN. Fabric integrity/net integrity which refers to the survivorship and ability of a bed net to maintain its physical condition for a longer time and acceptance after three years of field use (WHO, 2013; Sovi *et al.,* 2022). The damages of LLINs are determined based on

proportionate hole index (pHI), refers to the composite measure of the holes from four-hole size categories in centimeter: 0.5–2, 2–10, 10–25 and > 25, practically measured using smaller than a thumb, larger than a thumb but smaller than a fist, larger than a fist but smaller than a head and larger than a head, respectively. Based on these sizes of holes found on a net, the pHI value is estimated and then divided into three categories: with of a total hole surface area of <0.001 m2 (pHI<64) is considered as "good", a bed net of a total surface area of ≤ 0.1 m2 (pHI ≤ 642) is considered "damaged" and a torn bed net of a total surface area of > 0.1 m 2 (pHI >642) is considered as "too torn" to provide physical protection against mosquito bites (WHO, 2013; WHO, 2011). Based on these studies, WHO usually list or recommends LLINS that remain adequately insecticidal after three years of deployment, for this reason, mass campaigns of nets are implemented every 3 years, although most LLINs happen to be lost by the people once the nets are considered "too torn" – having many or large holes before 3 years.

The functional life of a LLIN is the amount of time that the bed net may be in service before it is rendered unusable due to changes in efficient requirements like failure to repel or kill mosquitoes. The gap between the median functional life of an LLIN and mass distribution of LLINs has contributed to low population access to LLINs. Other reasons that affect access to LLINs include a low quality of LLIN fabric that easily damage, limited funding, reduction in the supply of LLIN due to financial difficulties, poor socioeconomic status, unequal household access and poor infrastructures (Bhatt *et al.,* 2015; Manu *et al.,* 2017; Njau *et al.,* 2013). Thus, population access to LLINs in sub-Saharan Africa, including Tanzania remains around 50% despite substantial efforts to increase global access (WHO, 2020).

## 1.2 Statement of the problem

It has been documented in Tanzania, that about 84% of LLINs distributed from different campaigns are discarded before the next campaign (Bhatt *et al.,* 2015; Manu *et al.,* 2017), and campaigns happen at an interval of every 3-5 years. Individuals stop using mosquito nets (Ahorlu *et al*., 2019; Msellemu *et al.,* 2017; Pulford *et al.,* 2011), and discard them when they become extremely damaged as users no longer consider them to be protective (Briet *et al.,* 2020; Eisele *et al.,* 2011; García-Basteiro *et al.,* 2011; Kibe *et al.,* 2019; Koenker *et al.,* 2014; Loll *et al.,* 2013; Lorenz *et al.,* 2020; Lorenz *et al.,* 2014; Massue *et al.,* 2016; Mboma *et al.,* 2018). However, a study conducted on durability of LLINs in Tanzania demonstrated that damaged LLINs were still insecticidal durable that is, being able to repel and kill mosquitoes (Massue *et al.,* 2019). Therefore, it is of concern that there is widespread discarding of potentially protective

nets especially given the low population access to LLINs. Therefore, in this study, the discarding of LLINs states both samples presented to participants at the end of FGD and actual LLINs that were previously distributed to the study households. Also, the person who decide to discard LLIN/repurpose LLIN observed in this study was the Head of Household.

The LLIN is not beneficial to malaria when it can no longer protect the user from mosquito bites. Nonetheless they can be used by the owner for other none malaria activities like gardening, fishing, and rope. These are reproposing. However, currently there is a consensus statement that provides recommendations for beneficial repurposing once an LLIN is no longer useful is when an LLIN is old it can be used as a curtain, patch for holes in viable nets, eaves and constructing window or door screening for protecting against malaria infection (RBM, 2018). The recommendation provided by the WHO on discarding bed nets states that; LLIN should not be discarded in any water body because the residual insecticide on the net can be toxic to aquatic organism like fish (WHO, 2014). They also recommended that old LLINs should be collected and the best option for disposal is a higher temperature incineration (WHO, 2014. They should not be burned in an open-air if these options are not possible, the recommended method of disposal is burial and burial should be away from water sources and preferably in non-permeable soil (WHO, 2014).

However, these recommendations are often not followed by the communities, which results in careless handling and discarding of insecticidal nets in the environment including burning LLINs in the open-air. This may lead to the release of dioxins, which is harmful to human health. Improper burial on unspecified places can be toxic to aquatic organisms and a source of insecticide resistance. A recent study conducted in Kenya (Kibe *et al.,* 2019) described that insecticidal nets are washed in open water, repurpose for football posts, shopping bags ,and building in addition to being discarded either in the trash or burning. The behavior of improper discarding of LLINs exposes the environment to contamination. The factors associated with the discarding of insecticidal nets in Tanzania have not been extensively researched. Thus, this study was conducted to understand factors associated with discarding of LLINs that could still be beneficial from a public health perspective (Briet *et al.,* 2020).

### 1.3 Rationale of the study

This study was formulated to generate information on the reasons, time, how and where and processes followed in discarding of LLINs in Bagamoyo, Tanzania. Results from this study

will contribute to the body of information that will help net manufacturers,users and government bodies involved in net distribution understand the factors associated and what motivates individuals to discard nets. This in turn will help these stakeholders to devise means of increasing survivorship of nets within households by formulation of policies that encourage the production of more durable nets, create net care strategies that will minimize premature disposal of nets that may still be protective against mosquitoes as well as means to encourage environmentally sensitive means of net disposal or repurposing. Also, the information generated will inform the development of most appropriate messages during BCC which could facilitate change of behaviors, attitudes, beliefs associated with the discarding of LLINs in our communities. Not only these but also findings from the study will contribute knowledge to the existing literature regarding the factors associated with the discarding of LLINs.

## 1.4 Research objectives

### 1.4.1 General objective

To identify and explore social and cultural factors associated with the discarding of LLINs in Bagamoyo district, Tanzania.

### 1.4.2 Specific objectives

(i) To explore the timing and process of discarding LLIN after net distribution.

(ii) To identify factors that influence the discarding of LLINs.

## 1.5 Research questions

(i) Is the formation of holes in nets related to the discarding of nets?

(ii) Is there a difference in the timing of net discarding that is related to the location or size of holes in nets?

## 1.6 Significance of the study

The results of this study will be shared with the government, policymakers, and other stakeholders to procure good quality of LLINs that will stay for a long period in the community. However, this study will help to improve health, protect the environmental pollution and eliminate introduction of toxic in animals and plants by advising the government and National

Environmental Management Council to provide guidance about what to do on torn/old net or to reduce improper discarding of LLINs as well as to reduce insecticide resistance in the environment. Furthermore, this study already helped to improve health of the Bagamoyo villagers by distributing LLINs to 6526 households to cover all sleeping spaces and education on net care, repair and advising them not to discard LLINs until they are provided with new nets. Those distributed LLINs helped the community by protecting them from mosquito bites and dangerous diseases of malaria and other infectious diseases. Also, this study will help stakeholders and government to provide education through BCC regarding net care and repair which is the key element in the durability of LLINs where by this study found out that there was a gap on education during distribution of LLINs as most of community had low level of awareness and others didn't receive any education during distribution. Moreover, this study will be helpful to the researcher for purposes of fulfil the requirements of school to accomplish a master degree at Nelson Mandela Institute of Science and Technology.

## 1.7 Delineation of the study

The mixed-method sequential explanatory study design aimed to evaluate factors associated with the discarding of LLINs in Bagamoyo, Tanzania.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Malaria profile in Bagamoyo

The prevalence of malaria was high in Bagamoyo District in the 2000s was 20.3% (William *et al.,* 2013) due to the interventions of LLINs and Intermittent preventive treatment during in pregnancy the prevalence was reduced in the year 2015 10% in Bagamoyo where by this study was conducted (Salim *et al.,* 2015). However, the study done by Sumari *et al.* (2017) demonstrated that the malaria prevalence in school children in Bagamoyo villages was higher in symptomatic (89%) compared to asymptomatic ones (57.5%). Nevertheless, the population access to LLINs in Bagamoyo was estimated the proportion of one LLIN for two potential users that stayed in the house the previous night of the survey. The population access in Bagamoyo is lower than the least 80% coverage targets of the Tanzania National Malaria Operational Plan (Odufuwa *et al.,* 2020), this is associated with the discarding and re pure-purpose LLINs which given the lower access to LLINs in the community. Also, other factors which hinder coverage of LLINs in the community are a low quality of LLIN, limited funding, reduction in the supply of LLIN due to financial difficulties, poor socioeconomic status, unequal access as well as poor infrastructures (Bhatt *et al.,* 2015; Killeen *et al.,* 2007; Manu *et al.,* 2017; Njau *et al.,* 2013).

## 2.2 Distribution of nets in the community

The LLINs are a core intervention against malaria in the sub-Saharan Africa including Tanzania, and have successfully reduced the global burden of malaria (WHO, 2020). Over 1.8 billion LLINs have been distributed in Africa between 2000 and 2019 through mass distribution campaigns (WHO, 2020).

A total of 27 million LLINs were distributed in different campaigns (USAID, 2019) in Tanzania. This includes the school net program, the universal coverage campaign, and the antenatal care unit (ANC) program. Furthermore, these programs were provided free nets to pregnant women who attend their first antenatal care visit and children who have reached nine months old (USAID, 2019). However, in 2015-2016 a universal replacement campaign (URC) provided approximately 22 million nets to all households in Tanzania that are not covered by the school net program (SNP) (Massue *et al.,* 2016).

## 2.3 Problems with distribution

Even though free distribution of LLINs has contributed to the control of malaria in African countries,there are challenges in distribution facing providers in African countries including remoteness of areas, and poor transport infrastructure (Linn *et al.,* 2019). This has led to inefficient of bednets in some communities due to inadequate distribution (Bauch *et al.,* 2013; Birhanu *et al.,* 2015; Coalson *et al.,* 2020; Malede *et al.,* 2019; Mageni *et al.,* 2021).

## 2.4 Reason for reduction in the distribution

Despite the big impact of treated bednets in Sub-Saharan Africa, there have been reductions in the distribution of LLINs due to limited funds, budget constraints as well as lack of careful planning for the distribution of LLINs (de Brito *et al.,* 2020; Lorenz *et al.,* 2020).

## 2.5 Current programs that are distributing nets

The current programs that are distributing LLINs are SNP and ANC are continuous distribution campaigns. Although, only the UCC occurs every 3 years (Yukich *et al.,* 2020).

## 2.6 Discarding of nets among the community

Although in Tanzania, there are continuous mass distribution campaigns that occur in regular intervals, bednet coverage remains at <80% (Koenker *et al.,* 2018; Mboma *et al.,* 2021; Odufuwa *et al.,* 2020; Yukich *et al.,* 2020) with discarding and repurposing of nets being among the reasons for such low coverages. In a study that aimed to understand local barriers and motivators to net care and repair a community that received free (LLINs) in Southern Tanzania. Mboma *et al.* (2018) found out that, net discarding was associated with the number of holes (how torn it is) that is the more torn a net is the higher its likelihood of being discarded and used for other needs such as fencing the flower garden or as additional cushionunder the mattress led to repurposing of nets. This study shows that in the Southern part of Tanzania they discarded the net based on the number of holes (Mboma *et al.,* 2018).

A study conducted by Massue *et al.* (2016) in eight districts of Tanzania to assess the durability of Olyset-LLINs distributed during campaigns between 2009 and 2011, observed that about 84%of mosquito nets distributed in different campaigns were discarded and 2% of the LLNs were used for alternative purposes. Reasons for discarding or repurposing were the nets being torn 94% dirty 3% or they did not like them. Thus, it is evident that in many different parts of

Tanzania, users discard the LLINs and use them for other purposes. Additionally, other studies which reported the discarding of LLINs in Tanzania are (Massue *et al.*, 2016; Lorenz *et al.*, 2014; Bhatt *et al.*, 2015; Manu *et al.*, 2017*)* reported the discarding of LLINs in Tanzania.

Moreover, the study of Bertozz-Villa *et al.* (2021) did analysis from 40 countries analysis they found out that out of 40 countries including Tanzania 35 of their LLINs are not reached for 3 years they were discarded because they were perceived was too torn to provide physical protection against mosquitoes of public health important.

Not only the above but also, Loll *et al*. (2013) did a study on the determined end of net life in Senegal: A qualitative assessment of decision-making related to the retirement of expired nets. In this study, they found out that expired mosquito-treated nets are discarded. Although in this study the discarding net was associated with age, at least after three years of use it starts having holes which led to discarding or being given away.

Koenker *et al*. (2014) did a study investigating what happens to lost nets: a multi-country analysis of reasons for LLIN attrition (loss of nets from households) using 14 household surveys in four countries Ghana, Senegal, Nigeria, and Uganda. This study shows that 63% of mosquito nets are discarded in all countries included in the study. The nets were discarded because they were to **t**orn and old, after receiving new nets or after the family felt they had enough nets to protect all family members at the median of two years. In this study, discarding of the nets was primarily associated with the age and condition of the nets.

The above literature shows that LLINs are discarded after having many holes and some literature shows the time at the median of two years. Therefore, our study was important because it explored where, how and at what time after distribution LLINs are discarded.

## 2.7 Danger/concern associated with the discarding of nets

Furthermore, the improper discarding of LLINs is not recommended because it has a negative environmental impact. The LLINs improperly discarded may cause public health impact and dangers to the environment like environmental pollution, bioaccumulation of insecticides, and insecticide resistance (Kudom *et al.,* 2018).

Kudom *et al*. (2018) did a study in Ghana aimed at relating high insecticide residue in larval breeding habitats in urban residential areas to the selection of pyrethroids resistance in

*Anopheles gambiae* s.l. and found out that there are high levels of pyrethroids insecticides contamination. The study suspected improper discarding of the insecticide-treated net as the reason. It might also be as a result of domestic insecticides and the use of herbicides as source of contamination. Although in the study area there are no major agricultural activities. There is a need to improve behavior change campaigns (BCC) regarding the proper way of discarding LLINs to avoid environmental pollution and to improve health of people in the community.

The areas where agricultural activities involve intensive use of insecticides has observed resistance of pyrethroids to malaria vectors which are important to public health (Finda *et al.,* 2018; Hien *et al.,* 2017). In addition, improper discarding of insecticidal nets may lead to the killing of other organisms, bioaccumulation in vegetables, and the introduction of insecticides to the environments (Anyanwu *et al.,* 2006).

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Study area

The study was conducted in the Bagamoyo district (Fig. 1), 70 km north of Dar es Salaam, the economic hub of Tanzania. The population of Bagamoyo is approximately 311740 people: 154 198 males and 157 542 females according to the 2012 Tanzania national census with an average household size of 4.4 (Tanzania, 2013). More than 70% of the residents have primary education or higher. Annual temperature ranges from 22-33 °C with annual rainfall between 800 and 1200 mmper year means relative humidity of 73% Short rain (*vuli*) usually fall from October to December while long rain season (Masika) usually fall between March and May (Bagamoyo, 2013). The driest months are June to September. The main economic activities in the area are small-scale farming of pineapples, maize and cassava, fishing, livestock keeping, mariculture seaweed weed and prawn farming, salt production, trade and tourism (Bagamoyo, 2013). Also, most of the people living in Bagamoyo are Kwere and Zaramo tribes. Furthermore, the house characteristics of the participants were approximately 6% of the material used to make the roof were thatch/grass/banana and 94% were sheet. Also, 91% of the houses had no ceiling while approximately 9% of the house had ceiling. Likewise, more than 52% of the houses was made by mud. Also, more than 61% of the materials used to make the floor was cement. The material used to make window were more than 21% were designed wooden. Also, more than 26% of the participants have more than 3 sleeping places used by the household.

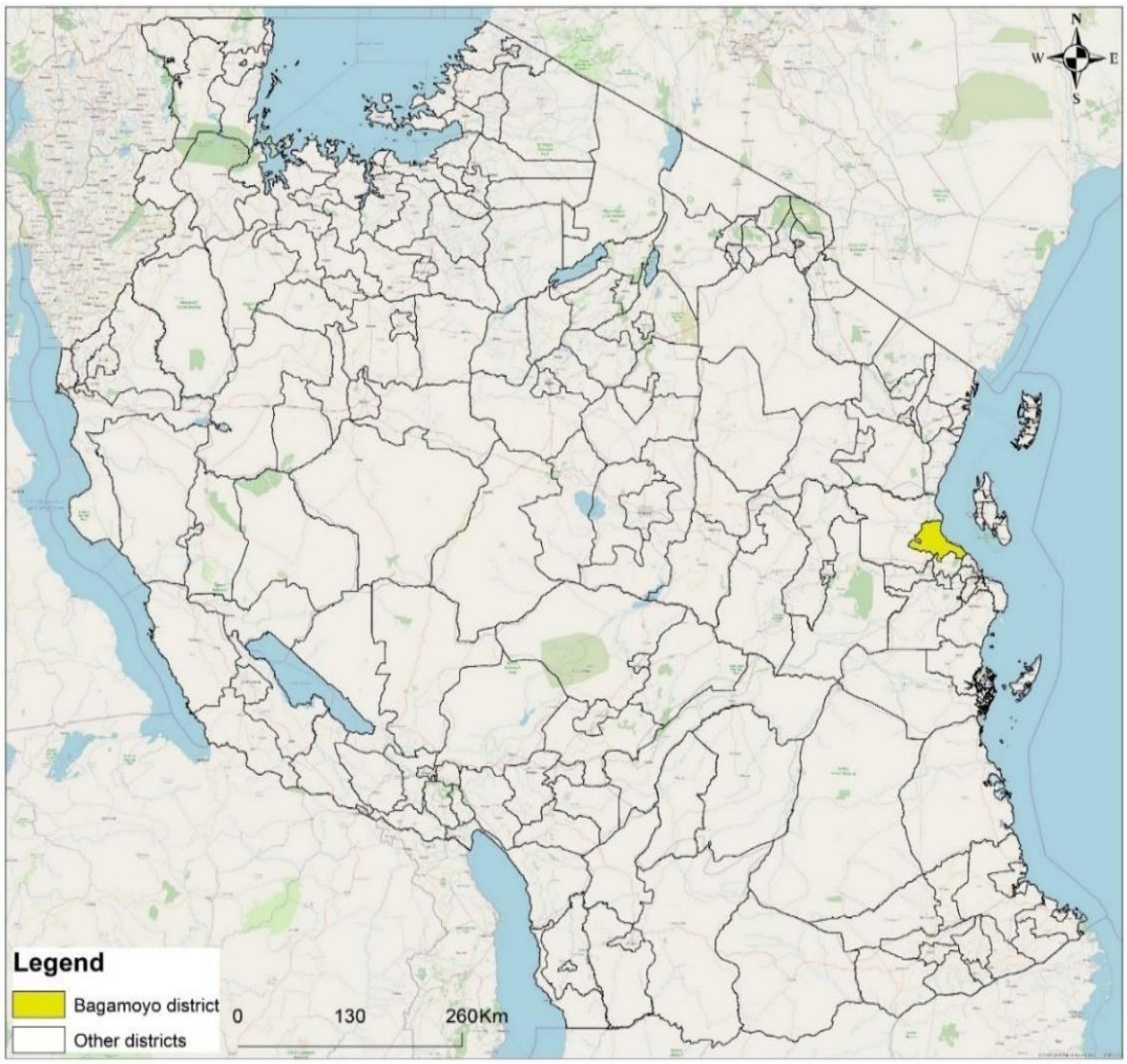


**Figure 1: Map showing the location of Bagamoyo district in Tanzania where the study was carriedout**

## 3.2 Study design

The study was a mixed-method sequential explanatory design (Ivankova *et al.*, 2016), embedded in a bed net durability trial of five brands of LLINs in six villages in Bagamoyo namely Kiwangwa, Bago, Mwavi, Msinune, Mwetemo and Masuguru. Quantitative analysis data led to the generation of themes for qualitative study. The FGD sessions captured information on participants experiences, opinions and views regarding the factors associated with the discarding of insecticidal nets, their perception of bed net use and net care; and the causes of damage to nets in their communities. Also, FGDs gathered knowledge on net care and repair from the participants.

The integration between quantitative and qualitative phases was connected during the middle stage of the research process. Participants who responded to the survey and reported to discard the nets were the ones who met the criteria to attend FGD and thus were selected to participate in the FGD. Data collected during the quantitative survey informed the topic guide which was used to collect qualitative data.

The participants were above 18 years of age and consented to participate in the study. These participants were put into four groups composed of similar characteristics which were age and gender. Each group had eight-to-ten participants seated in a circle with the moderator in the middle, while the note taker sat out of the circle but in a position where it was possible to see all the participants. The first group was of younger women aged 18-39, the second group was of older women aged 40-60, the third group made of younger men aged 18-39, and the last group was of older men aged 40-60 (Fig. 2). The groups were made such that participants could freely talk and discuss issues among their peers. This usually makes them comfortable when sharing their experiences.

A topic guide was used as an aid for smooth discussion including probing and rephrasing of words to elicit more information. A digital recorder was used to capture all the information communicated. Each discussion lasted for one hour. The discussions were conducted in Kiswahili, the locally spoken language (Fig. 3).

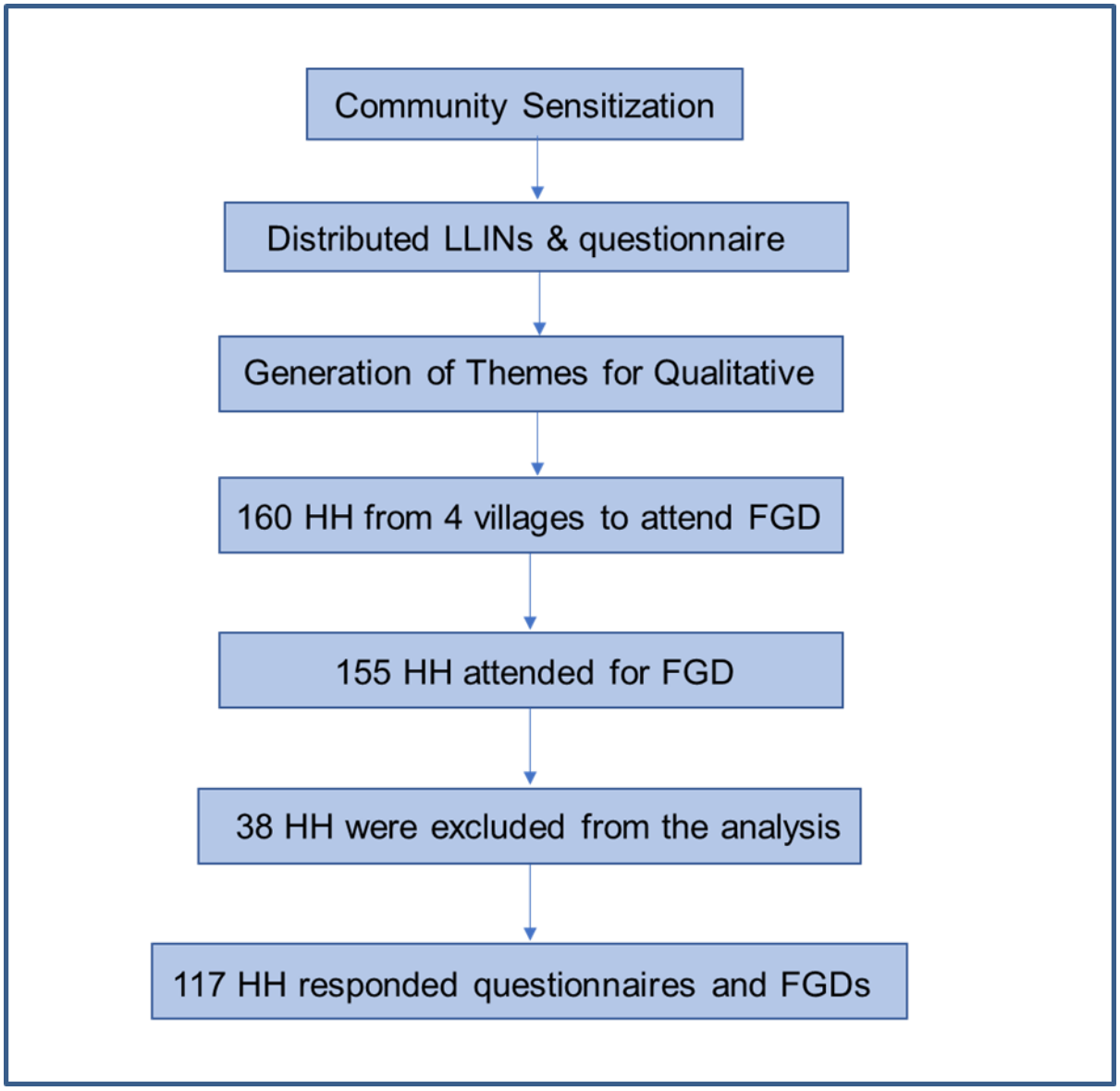


**Figure 2: Flow chart of the study design**

**Figure 3: One of the focus group discussion sessions with younger women**

### 3.3 Assessing why, how, and when nets are discarded in the FGDs

At the end of each FGD, seven 6x5 white LLINs from a previous LLIN durability trial (Massue *et al.,* 2016) representing "too torn" nets based on WHO pHI was brought and presented to the FGD participants to inspect and decide if they would discard or keep the LLINs based on their visual (Fig. 4). The characteristics of the LLINs assessed by the FGD participants are shown (Table 1). The characteristics of the net such as cleaning practices (dirty vs clean) and materials (rough vs smooth) were considered to assess if they are associated with discarding of WHO "too torn" nets in Bagamoyo villages. The participant wrote their responses with the intention of avoiding bias.


**Figure 4: Older men visually inspecting too torn nets to decide if they will keep the net or discardit**

**Table 1: Characteristics of the damaged nets assessed by the FGDs participants**

| Net ID | Net Material | Net cleanliness | Number of holes | Proportionate hole index | WHO size | No of holes | Hole location |
|---|---|---|---|---|---|---|---|
| 1 | Rough | Clean | 21 | 1620 | 1 | 5 | Mix |
| | | | | | 2 | 11 | |
| | | | | | 3 | 4 | |
| | | | | | 4 | 1 | |
| 2 | Rough | Clean | 27 | 1854 | 1 | 18 | Mix |
| | | | | | 2 | 4 | |
| | | | | | 3 | 3 | |
| | | | | | 4 | 2 | |
| 3 | Rough | Clean | 14 | 1632 | 1 | 5 | Mix |
| | | | | | 2 | 3 | |
| | | | | | 3 | 5 | |
| | | | | | 4 | 1 | |
| 4 | Rough | Clean | 41 | 2486 | 1 | 18 | Mix |
| | | | | | 2 | 14 | |
| | | | | | 3 | 8 | |
| | | | | | 4 | 1 | |
| 5 | Rough | Dirty | 22 | 816 | 1 | 19 | Mix |
| | | | | | 2 | 1 | |
| | | | | | 3 | 1 | |
| | | | | | 4 | 1 | |
| 6 | Smooth | Dirty | 79 | 6142 | 1 | 38 | Mix |
| | | | | | 2 | 20 | |
| | | | | | 3 | 17 | |
| | | | | | 4 | 4 | |
| 7 | Smooth | Dirty | 133 | 4987 | 1 | 87 | Mix |
| | | | | | 2 | 26 | |
| | | | | | 3 | 19 | |
| | | | | | 4 | 1 | |

**Note: 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**: largerthan a head (> 25 cm)

To quantitatively assess participants' perception of the nets, holes in the seven LLINs were categorized into four groups: 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), as per WHO recommendation (WHO, 2013). The proportionate hole index (pHI) of each net was calculated (WHO, 2011), and all were above 642, thus "too torn" nets, indicating that they provide little physical protection against

mosquito bites compared to intact ones. Therefore, the WHO "too torn" LLINs were the ones shown during the FGDs.

### 3.4 Factors associated with the discarding of LLINs using a structured questionnaire

Findings from the administering structured questionnaire may inform the development of additional themes/questions in the FGDs. Information was primarily collected from the head of households. The data extracted from the durability baseline questionnaire includes age, sex, level of education, number of occupants per household, house structure, livestock, assets owned, source of light and occupation. Other data extracted were availability of nets, their usage patterns, perception of bed nets, net care attitude questions around net care and repair as well as reasons for discarding nets, including how, when and where the LLINs are discarded. A net attitude score was also estimated to assess attitudes toward the net care and repair practices (RBM, 2014) using questions on perception of bed nets and net attitude provided as Supplementary Online Material 1 and 2, respectively.

**Table 2: SOM 1 - Bed net use questions**

| Number | Variables | Definitely could | Probably could | Probably could not | Definitely could not |
|---|---|---|---|---|---|
| Q1 | Obtain enough bed nets for all your children. | 1 | 2 | 3 | 4 |
| Q2 | Hang a bed net above your children's sleeping spaces. | 1 | 2 | 3 | 4 |
| Q3 | Protect yourself and your children from getting malaria. | 1 | 2 | 3 | 4 |
| Q4 | Save enough money to obtain bed nets for all your children. | 1 | 2 | 3 | 4 |
| Q5 | Sleep under a bed net every night of the year. | 1 | 2 | 3 | 4 |
| Q6 | Get all of your children to sleep under a net every night of the year. | 1 | 2 | 3 | 4 |

**Table 3: SOM 2 - Net attitude questions**

| Number | Variables | Strongly agree | Somewhat agree | Somewhat disagree | Strongly disagree |
|---|---|---|---|---|---|
| Q1 | Mosquito nets are valuable | 1 | 2 | 3 | 4 |
| Q2 | There are actions I can take to make my net last long | 1 | 2 | 3 | 4 |
| Q3 | It is not possible to repair holes in nets | 1 | 2 | 3 | 4 |
| Q4 | A repaired net can still be effective against mosquitoes | 1 | 2 | 3 | 4 |
| Q5 | Other people in this community fix holes in their mosquito nets | 1 | 2 | 3 | 4 |
| Q6 | I do not have time to repair a hole in my net | 1 | 2 | 3 | 4 |
| Q7 | I can help protect my family from malaria by taking care of my net | 1 | 2 | 3 | 4 |
| Q8 | I am confident I can repair holes immediately | 1 | 2 | 3 | 4 |

### 3.5 Sample size

The quantitative data from the LLIN durability trial was used to obtain qualitative members for FGD. A structured questionnaire from the trial collected demographic and socioeconomic information from 6526 households from six villages in Bagamoyo District. One hundred and sixty households among them who reported discarding of nets were selected randomly to participate in the FGDs from four villages, which were Kiwangwa, Bago, Mwavi and Msinune. Each village contributed 40 households and an individual represented each household in the FGD. A total number of four FGDs were held per village, thus sixteen FGDs were conducted in this study. Findings from the FGDs guided extraction of the information of 117 participants who also responded to the structured questionnaire during the baseline survey of the net durability trial.

### 3.6 Data analysis

Data collected during the quantitative LLIN durability trial informed the topic guide which was used to collect qualitative data (Ritchie *et al*., 1994). About 117 FGD households were found to match the quantitative data and were selected for qualitative analysis. The audiotapes from the FGD recording were transcribed verbatim independently by two researchers and checked

for completeness. Transcripts were then entered into the NVivo software (NVivo, 2018) and codes were developed thematically. Later selected quotes were translated into English. The thematic approach was used for analysis (Richie *et al.,* 1994). The analysis was conducted based into six stages which are: a) Familiarization of data, b) Coding, c) Searching for themes, d) Reviewing themes, e) Defining and naming themes and lastly f) writing up (Braun *et al.,* 2006; Clarke *et al.*, 2013; Terry *et al.*, 2017). After the initial coding of all transcripts, the next step was to look for similarities and differences between patterns and themes. Relationships and connections between themes were established and the final step was the interpretation of data. Furthermore, texts from transcripts on each theme were used to create the word cloud.

For quantitative data analysis, STATA 16 statistical package software was used (StataCorp, 2019). Variables; household socioeconomic status (SES) and positive net attitude were derived from a weighted score in a principal component analysis (PCA) (Vyas *et al.,* 2006). Variables used in the PCA analysis were categorized into binary. For SES, variables were categorized on having vs have not or modern vs traditional; For positive net attitude, variables were categorized based on definitely could and probably could versus definitely could not and probably could not for bed net use, and for net attitude, the variables were categorized as strongly agree and somewhat agree versus strongly disagree and somewhat disagree, except for the question on "*I do not have time to repair a hole in my net*". Socioeconomic status was categorized into three levels: lowest SES, middle SES and highest SES. Net care attitude was categorized into two levels: negative attitude and positive attitude. Net coverage indicators, namely: a) Net ownership (proportion of households that own at least one LLIN calculated as number of households surveyed with at least one LLIN divided by the total number of households surveyed), b) net use (proportion of households that slept under a LLIN the night before the survey, calculated as the number of people that slept under the net the previous night of the survey divided by the total number of people surveyed) and c) population access (proportion of the population with potential to be protected by an LLIN within their household, assuming each LLIN is used by two people, calculated the as number of net used multiplied by 2 divided by the number of people that slept in the household the previous night of the survey) were estimated.

A multivariable binary logistic regression analysis was performed to estimate factors associated with discarding of the LLIN assessed. The outcome variable was "bed net ending" which was binary with outcomes "kept" or "discard" as responses for each LLIN assessed. The outcome responses from the FGDs were matched with the respective data of the individual in structured

questionnaire. Primary explanatory factors such as age, sex, level of education, number of occupants per household and SES were considered in the models, in addition to factors that influenced the coefficient by 20% using backward elimination techniques (Bursac *et al.,* 2008) too-torn torn LLINs based on WHO pHI calculation, were visually assessed (Fig. 5).


**Figure 5: Pictures of all 7 "too torn" nets assessed by respondents**

### 3.7 Ethical considerations

Ethical approval for the work was obtained from Ifakara Health Institute (IRB) (IHI/IRB//No:34-2020). The Longitudinal field trial study was granted ethical clearance by Ifakara Health Institute-IRB (IHI/IRB/NO:030- 2018) and the Tanzania National Institute for Medical Research (NIMR/HQ/R.8A/VOL.X/2884). Only participants who were of age and consented in writing wererecruited to participate in the study.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 Results

### 4.1.1 Socio-demographic characteristics from the questionnaire

A total of one hundred and seventeen households participated in the FGDs and also responded to the baseline questionnaire of the LLIN durability trial. Sixty-nine of the participants were women, and sixty-four of the participants were people of 40-60 years old (55%). A majority (86%) of the participants reported having primary or higher education. The average size of a household was 4.8 people. Bed net ownership in the study area was 92%. Population access to LLIN was 63%, (95% CI: 56-70%) and 81% (95% CI: 74-87%) of the respondents reported sleeping under an LLIN the night before data collection (Table 4).

**Table 4: Socio-demographic characteristics of participants**

| **Variables** | **n (%)** |
|---|---|
| Bed net access | 63 (95% CI 56-70%) |
| Bed net use | 81 (95% CI 74-87%) |
| | |
| Age group | |
| 40-60 | 64 (55) |
| 18-39 | 53 (45) |
| | |
| Gender | |
| Men | 48 (41) |
| Women | 69 (59) |
| | |
| Education | |
| No formal education | 16 (14) |
| Formal education (Primary-higher) | 101 (86) |
| | |
| Household size | |
| 1-5 residents | 71 (61) |
| 6 & above residents | 46 (39) |
| | |
| Household Socioeconomic Status | |
| Lowest | 37 (33) |
| Middle | 37 (33) |
| Highest | 38 (34) |
| | |
| Study Villages | |
| Kiwangwa | 30 (26) |
| Bago | 30 (26) |
| Msinune | 32 (27) |
| Mwavi | 25 (21) |
| Total (N) | 117(100) |

### 4.1.2 Views, attitudes, behaviors, opinions, and experiences of participants on the factors associated with the discarding of long-lasting insecticidal nets in Bagamoyo in the FGDs

#### (i) Reasons for discarding nets in the FGDs

Most FGD respondents considered physical condition of the LLIN and how it continues to offer protection against mosquitoes as the deciding factor for discarding LLIN. A bed net with many holes or large holes is defined as "too torn" according to participants from the study where by bed net loses its functional life. Long-lasting insecticidal nets with poor the physical condition was discarded even if they were only one or two months old. Participants reported being happy to continue using older nets whose physical condition was good especially when they did not have a new net to replace (Fig. 6). The study found out that the position of the hole on the LLIN can determine whether the LLIN is still useful or should be discarded simply because a hole at the bottom of the LLIN can be tucked underneath the mattress. If holes are in other positions like above the mattress line, the LLIN is more likely to be discarded. However, LLINs with large holes are discarded because the chance that mosquitoes will pass and bite occupants is higher. Participants preferred to use a good LLIN even when it has small holes, they can repair, and continue to use.

*"When the net has large holes that even a person's head or limbs can pass through, I do not keep that net. But if the holes are small or normal size, I repair the net and keep it."* (Male, 60).

### 4.1.3 Causes of LLIN damage in the FGDs

Respondents were asked what were the causes of damages to the LLIN and how did they protect their LLIN from these damages. The participants answered that damages in LLINs occur due to the following reasons; friction from the mat and edges of the bed, bed bolts, children playing with the LLINs, low quality of LLINs, drying in pineapples/grass, rats, long finger and toenails, the small size of the LLINs compared to the sleeping space, and washing frequency (Fig. 6).

*"Damage to the nets is caused by rats, friction from the bed edge or children playing with a net. Children can cut holes in the net using a razor/knife"* (Female, 23)

### 4.1.4 Perceived duration of effectiveness in the FGDs

Most of the respondents said that LLINs are effective for about one year. The time in which LLINs remain effective depends on the materials used to make it and the care given to it (Fig. 6). In addition, the participants said that there is a relationship between care for the LLIN and functional life of the LLIN because if a new LLIN is left uncared for, it will not last for a year. When a LLIN is cared for, it can last for years. Furthermore, participants said LLIN obtained from malaria campaigns have to be replaced within a year because they often get old or torn easily after a year.

*"On average, a properly maintained net can last for one year. Even if maintenance is good, the mosquito net must be replaced within one year"* (Male, 45).


**Figure 6: Visual representation (word cloud) of factors associated with the discarding of LLINs and reasons for net damage in Bagamoyo, Tanzania**

### 4.1.5 Factors associated with durability in the FGD

Durability of a LLIN may be influenced by the quality of material used in making it, nature of the house in the net being used, frequency of washing, level of education of the head household and attitude on net care and repair. Additionally, it was noted from the dialogue that the quality

of the LLINs motivates people to care about the net. The participants from the FGDs said that the care for the LLIN can determine the durability of an LLIN. The participants indicated the importance of education regarding LLIN care and repair, as many people in the community don't know how to for care and repair a LLIN. Also, it was noted in the group discussions that some people in the communities don't know how to properly hang bed nets.

"*The issue here is many mosquito nets are of low quality. There was a time I bought a mosquito net and after one month it became too torn. Thus, I replaced it"* (Male, 29).

### 4.1.6 General knowledge of LLINs, their use, and treatment status in the FGDs

All participants valued LLINs and used them. Respondents knew that sleeping under an LLIN protected them against potentially infective mosquito bites. Also, LLINs offered protection to their family against pests like blackflies, cockroaches, spiders, rats as well as snakes. Participants mentioned that *"in starvation a bone can also be meat"*, it is better to sleep under an old or torn LLIN than without. Additionally, they get good night sleep (*Wanalala kwa raha*) with no disturbance from mosquitoes when under a LLIN. Yet, the majority of participants did not know how to identify insecticidal nets from non-insecticidal (untreated) or to identify when the insecticides are no longer effective. Others perceived the LLINs to be ineffective when mosquitoes could bite them through the LLINs or were able to enter their LLINs.

"*Yes, we are using mosquito nets because of many reasons, first is to protect ourselves from mosquitoes. Second, to prevent other vectors, rats, and snakes. Yes, it's like security*." (Male, 59)

### 4.1.7 Knowledge of net care and repair in the FGDs

Participants differed in opinions on caring and repairing the LLIN. Many female respondents said that they care for their LLINs. Some younger participants do not care for the LLINs and they do not have time to repair it when it is damaged. They believe that once an LLIN gets physically damaged, its effectiveness against mosquitoes is also lost and will not protect them as it is supposed to do. Therefore, they often replace it no matter how small the hole is. However, the majority of respondents said that caring for the LLINs is very important for LLIN's integrity. To maximize usage of LLIN, most participants prevented their LLINs from getting damage by controlling their children, folding or tying up the LLINs during the day and washing it gently.

While the majority of participants cared for the LLINs, only very few had access to information from radio, televisions, and the clinic regarding LLIN care, because the majority of the participants did not own a radio or have access to other media for information. Participants, especially the young women, had inherited the knowledge from their mothers. Therefore, when they grew up and started their family, they did what their mothers taught them about caring for and repairing of nets. From the discussions, the participants requested the ministry of health, or other stakeholders to provide education on how to care for the mosquito nets, as it will be very helpful to retain LLINs for a longer period.

*"My opinion is that the ministry of health should come to educate us on how to care for the net"* (Male, 28).


**Figure 7: Visual representation (word cloud) of knowledge on net care and repair**

### 4.1.8 Knowledge of LLIN disposal from the FGDs

The discussions revealed that community was also not informed on the proper ways of discarding the old LLINs. There was no communal plan or aware of any guidelines from the local government or instructions that guides on how to dispose the old or torn LLINs. Communities do not know what to do with the old /torn LLINs. Therefore, the lack of guidelines for discarding LLINs is a challenge raised during the discussions. Furthermore,

improper discarding of LLINs reported by the groups may lead to environmental hazards such as an introduction of insecticides to the environments cause pollution as well as insecticide resistance.

"*Because we have no education (on LLIN disposal), everyone uses his/her preferred approach. When mosquito nets become old or too torn, I do as I please to it. The mom using it to make a rope to seal charcoal bags to discarding it in the garbage pit*" (Female, 52)

### 4.1.9 Methods of discarding old/torn LLINs from the FGDs

Responses varied between younger and older participants. Younger participants (18-39 years old*)* often reported that they discarded old LLINs immediately when they received new ones even if the old LLIN had only one hole, while older participants (40-60 years old) stored old LLINs for visitors as well as for future use, and also used LLINs for other purposes when it was perceived to be too torn. Burning or throwing LLINs in a rubbish pit were the common disposal methods of old or torn LLINs (Fig. 8).

### 4.1.10 Alternative uses for old LLINs from FGDs

Bed nets were also said to be used for other purposes such as in farming by making garden screen against chickens, making ropes, chicken coops, soccer balls and bags. Others used them as charcoal bags because the material used to make LLIN (polyester and polyethylene) is perceived to be strong and cheap instead of buying charcoal bags from shops, which are considered to be expensive.

" *I usually give old LLINs to my friends who sell charcoal because buying rope from the shop which is strong to cover the bags of charcoal is quite expensive"* (Male, 59)."

### 4.1.11 Discarding visually inspected "too torn" nets using participatory data collection in the FGDs

Out of 117 participants of all FGDs, 59% were younger people 18-39 years old, 65% were male and 64% represented wealthy households. These three groups reported the WHO "too-torn" LLINs they inspected to be no longer useful (Table 5). The converse was true with older people, women and less wealthy who were more likely to classify the same nets as "good" instead of "too-torn". This demonstrated some group differences in how they classified the end

of useful life of an LLIN. More than half of respondents 55% suggested burning of LLINs as a means of disposal, repurposing was 3% versus discarded was 41% (Fig. 8).

In the multivariable analysis, male heads of households were approximately 7 times more likely to discard the WHO "too torn" LLINs than they were shown than their female counterparts [OR=6.85 (95% CI (4.44 – 10.59), p<0.001 with overall p=<0.001]. Household heads aged 18-39 years had higher odds of discarding "too torn" LLINs [OR=4.97(95% CI (3.25– 7.32), p<0.001 with overall p=<0.001] compared to older ones.

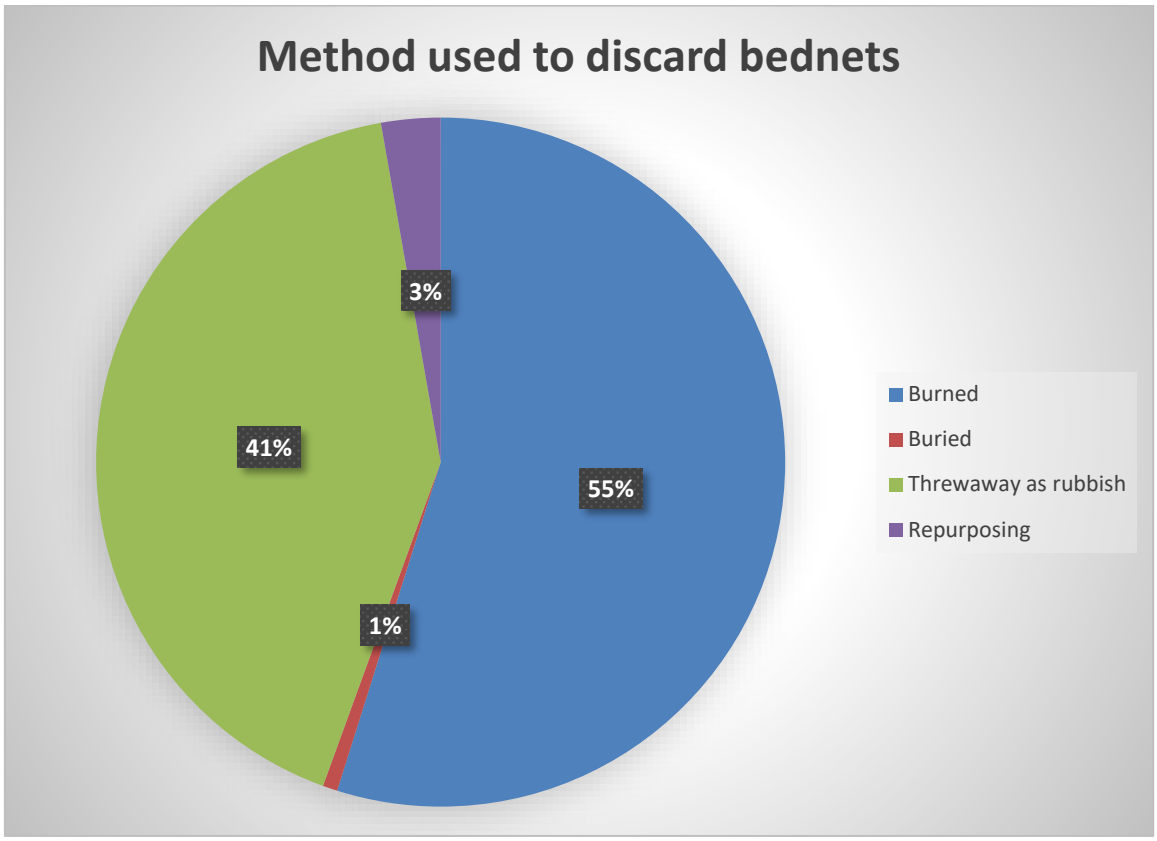


**Figure 8: Pie chart of methods used to discard LLINS %**

**Table 5: Percentage distribution of study participants that inspected WHO "too torn" nets and their decision to keep or discard the nets**

| **Variables** | **WHO too torn condition n (%)** | | | **Discard n (%)** | |
|---|---|---|---|---|---|
| Covariates | Good* | Damaged‡ | Too torn† | Yes | No |
| Age group | | | | | |
| 40-60 | 185 (41) | 72 (16) | 191 (43) | 192 (43) | 256 (57) |
| 18-39 | 123 (33) | 30 (8) | 218 (59) | 245 (66) | 126 (34) |
| Gender | | | | | |
| Men | 90 (27) | 26 (8) | 220 (65) | 240 (71) | 96 (29) |
| Women | 218 (45) | 76 (16) | 189 (39) | 197 (41) | 286 (59) |
| Household size | | | | | |
| 1-5 residents | 190 (38) | 67 (14) | 240 (48) | 250 (50) | 247 (50) |
| 6 & above residents | 118 (37) | 35 (11) | 169 (53) | 187 (58) | 135 (42) |
| Education | | | | | |
| No formal education | 64 (57) | 15 (13) | 33 (30) | 38 (34) | 74 (66) |
| Formal education | 244 (35) | 87 (12) | 376 (53) | 399 (56) | 308 (44) |
| Household SES | | | | | |
| Lowest | 115 (44) | 37 (14) | 107 (41) | 109 (42) | 150 (58) |
| Middle | 105 (41) | 36 (13) | 118 (46) | 125 (48) | 134 (52) |
| Highest | 71 (27) | 24 (9) | 171 (64) | 188 (71) | 78 (29) |
| Study Villages | | | | | |
| Kiwangwa | 57 (27) | 51 (24) | 102 (49) | 120 (57) | 90 (43) |
| Bago | 103 (49) | 21 (10) | 86 (41) | 92 (44) | 118 (56) |
| Msinune | 95 (43) | 12 (5) | 117 (52) | 121 (54) | 103 (46) |
| Mwavi | 53 (31) | 18 (10) | 104 (59) | 104 (59) | 71 (41) |
| **Total** | **308 (38)** | **102 (12)** | **409 (50)** | **437 (53)** | **382 (47)** |

***** Bed net of a total hole surface area of $<0.001m^2$ (pHI<64)
‡ Bed net of a total surface, $\leq 0.1m^2$ (pHI $\leq$ 642)
† Bed net of a total surface area of $>0.1m^2$ (pHI >642)

### 4.1.12 Socioeconomic factors associated with the discarding LLINs

In the multivariable analysis, socioeconomic status was also associated with discarding of WHO "too torn" LLINs. Households with the highest economic status were approximately 4 times more likely to discard "too-torn" LLINs than those from the lowest SES group [OR=3.88 (95% CI (2.33 – 6.46), p<0.001 with overall p=<0.001].

### 4.1.13 LLINs characteristics associated with the discarding of LLIN

Materials used in making the LLINs were found to be associated with discarding, where "too-torn "LLINs with a rougher texture (polyethylene) were 11 times more likely to be discarded compared to "too-torn" smoother textured (polyester) LLINs [OR=11.29 (95% CI (3.39-37.58), p<0.001 with overall p=<0.001]. Dirty "too-torn" LLINs were 4 times more likely to be discarded compared to clean "too-torn" LLINs [OR=4.13 (95% CI (2.43-7.01), p<0.001 with overall p=<0.001]. For every one-unit increase in the number of holes, the odds of discarding WHO "too torn" LLINs increased [OR=1.05 (95% CI (1.04-1.07), p<0.001 with overall p=<0.001] (Table 6).

**Table 6: Logistic regression of the factors associated with the discarding of "too-torn" LLINs"from the participatory activity data reported in Bagamoyo, Tanzania (N=117)**

| Models | Univariable | | P-Value | Multivariable | | P-Value | Overall P-value |
|---|---|---|---|---|---|---|---|
| Co-variates | OR | 95% CI | | OR | 95% CI | | |
| Gender | | | | | | | <0.001 |
| Women | 1 | | | 1 | | | |
| Men | 3.63 | 2.69- 4.89 | <0.001 | 6.85 | 4.44- 10.59 | <0.001 | |
| Age group | | | | | | | <0.001 |
| 40-60 | 1 | | | 1 | | | |
| 18-39 | 2.69 | 1.95- 3.45 | <0.001 | 4.97 | 3.25-7.32 | <0.001 | |
| Education | | | | | | | 0.509 |
| No formal education | 1 | | | 1 | | | |
| Formal education | 2.52 | 1.66- 3.83 | <0.001 | 1.24 | 0.65-2.34 | 0.511 | |
| Household size | | | | | | | 0.815 |
| 1-5 residents | 1 | | | 1 | | | |
| 6 & above residents | 1.37 | 1.03-1.82 | 0.030 | 1.05 | 0.70-1.57 | 0.815 | |
| Household SES | | | | | | | <0.001 |
| Lowest | 1 | | | 1 | | | |
| Middle | 1.28 | 0.91-1.81 | 0.158 | 1.62 | 1.01-2.61 | 0.047 | |
| Highest | 3.32 | 2.31-4.76 | <0.001 | 3.88 | 2.33-6.46 | <0.001 | |
| Study Village | | | | | | | <0.001 |
| Kiwangwa | 1 | | | 1 | | | |
| Bago | 0.58 | 0.39- 0.86 | 0.006 | 0.26 | 0.15-0.47 | <0.001 | |
| Msinune | 0.88 | 0.60- 1.29 | 0.513 | 0.75 | 0.45-1.26 | 0.278 | |
| Mwavi | 1.09 | 0.73- 1.65 | 0.651 | 0.87 | 0.50-1.50 | 0.616 | |
| LLIN Material | | | | | | | <0.001 |
| Smooth | 1 | | | 1 | | | |
| Rough | 0.15 | 0.10- 0.22 | <0.001 | 11.29 | 3.39-37.58 | <0.001 | |
| LLIN cleanliness | | | | | | | <0.001 |
| Clean | 1 | | | 1 | | | |
| Dirty | 4.81 | 3.55- 6.52 | <0.001 | 4.13 | 2.43-7.01 | <0.001 | |
| LLIN number of holes | 1.03 | 1.02-1.03 | <0.001 | 1.05 | 1.04-1.07 | <0.001 | <0.001 |

### 4.1.14 Multivariable analyses of the factors associated with the discarding of LLINs from the structured questionnaire data

As was observed in the participatory analysis of FGD responses, the multivariable analysis of questionnaire data also showed that male heads of households were more likely to discard "too torn" LLIN [OR=8.20 (95% CI (2.48 – 27.14), p=0.001, with overall p=0.001] compared to female as well as younger heads of households compared to the older ones [OR= 7.51 (95% CI (2.36 – 23.84), p=0.001, overall p<0.001]. Socioeconomic status influenced discarding of LLINs; households with the highest SES were ten times more likely to discard LLINs than those in the lowest SES [OR=9.66 (95% CI (2.18 – 42.86), p=0.003, overall p=0.002]. Having recently repaired their LLINs, having received information on LLIN care and repair, or recalling a family discussion on LLIN care and repair was not associated with a reduction in the likelihood of discarding a LLIN (Table 5). A positive net attitude score was associated with a lower likelihood of discarding nets in the univariate analysis but this was no longer significant in the multivariable analysis [OR=0.38 95% CI (0.15 – 0.97), p=0.044, overall p=0.122] (Table 7).

**Table 7: Logistic regression of factors associated with the discarding of LLINs from participant questionnaire data, in Bagamoyo Tanzania (N=117)**

| | Discard nets | Univariate | | | P-Value | Multivariable | | Overall | |
|---|---|---|---|---|---|---|---|---|---|
| | n/N | % | OR | 95% CI | | OR | 95% CI | P-Value | P-value |
| Gender | | | | | | | | | <0.001 |
| Women | 19/69 | 39 | 1 | | | 1 | | 0.001 | |
| Men | 30/48 | 61 | 4.39 | 1.99- 9.64 | <0.001 | 8.20 | 2.48-27.14 | | |
| Age group | | | | | | | | | <0.001 |
| 40-60 | 18/64 | 37 | 1 | | | 1 | | | |
| 18-39 | 31/53 | 63 | 3.60 | 1.76- 7.89 | 0.001 | 7.51 | 2.36-23.84 | 0.001 | |
| Education | | | | | | | | | 0.357 |
| No formal education | 2/16 | 4 | 1 | | | 1 | | | |
| Formal education | 47/101 | 96 | 6.09 | 1.32-28.20 | 0.021 | 2.56 | 0.32-20.19 | 0.372 | |
| Household size | | | | | | | | | 0.251 |
| 1-5 residents | 29/71 | 59 | 1 | | | 1 | | | |
| 6 & above residents | 20/46 | 41 | 1.11 | 0.53-2.36 | 0.778 | 0.50 | 0.15-1.66 | 0.259 | |
| Study village | | | | | | | | | 0.068 |
| Kiwangwa | 14/30 | 29 | 1 | | | 1 | | | |
| Bago | 13/30 | 26 | 0.87 | 0.32-2.42 | 0.795 | 0.61 | 0.14-2.59 | 0.506 | |
| Msinune | 7/32 | 14 | 0.32 | 0.11-0.96 | 0.043 | 0.23 | 0.05-1.17 | 0.076 | |
| Mwavi | 15/25 | 31 | 1.71 | 0.59-5.02 | 0.326 | 2.22 | 0.44-11.13 | 0.333 | |
| Net attitude score | | | | | | | | | 0.122 |
| Negative | 14/23 | 29 | 1 | | | 1 | | | |
| Positive | 35/94 | 71 | 0.38 | 0.15-0.97 | 0.044 | 0.36 | 0.09-1.35 | 0.130 | |
| Household SES | | | | | | | | | 0.002 |
| Lowest | 10/37 | 21 | 1 | | | 1 | | | |

| | Discard nets | Univariate | | | P-Value | Multivariable | | Overall | |
|---|---|---|---|---|---|---|---|---|---|
| | n/N | % | OR | 95% CI | | OR | 95% CI | P-Value | P-value |
| Middle | 11/37 | 23 | 1.14 | 0.42-3.14 | 0.797 | 1.44 | 0.36-5.79 | 0.606 | |
| Highest | 27/38 | 56 | 6.63 | 2.42-18.18 | <0.001 | 9.66 | 2.18-42.86 | 0.003 | |
| | **Repaired nets in the last 6 months** | | | | | | | | |
| No | 7/14 | 50 | 1 | | | | | | |
| Yes | 35/90 | 83 | 0.64 | 0.21-1.97 | 0.433 | | | | |
| | **Received information on the net use, care & repair** | | | | | | | | |
| No | 22/56 | 45 | 1 | | | | | | |
| Yes | 27/61 | 55 | 1.23 | 0.59-2.56 | 0.586 | | | | |
| | **Family discussion on net care & repair** | | | | | | | | |
| No | 19/49 | 39 | 1 | | | | | | |
| Yes | 30/68 | 61 | 1.25 | 0.59-2.63 | 0.564 | | | | |

## 4.2 Discussion

There was a clear association between net damage and the probability of the nets being thrown away. Households reported that they would often use a net until they perceived it to be irreparably damaged. The net was determined expired due to the presence of holes in the net or the presence of mosquitoes inside the net. This is consistent with other research which found that the physical condition of the net and its perceived efficacy is often associated whether the net remains in use or is thrown away (Loll *et al.,* 2013; Mutuku *et al.,* 2013; Solomon *et al.,* 2018; Tan *et al.,* 2016).

The community perceived nets to last around 1 year and that this could be less if there is the presence of holes within 2-3 months of use. Durability studies done in Tanzania, Rwanda, Madagascar, Benin and Ethiopia have also reported less than 3 years of functional life of LLINs (Gnanguenon *et al.,* 2014; Hakizimana *et al.,* 2014; Lorenz *et al.,* 2020; Massue *et al.,* 2016; Randriamaherijaona *et al.,* 2017; Solomon *et al.,* 2018). A recent study from forty high malaria burden African countries estimated LLIN durability is around 2 years in Tanzania and even lower in many of the other sub-Saharan countries (Bertozzi-Villa *et al.,* 2021).

Furthermore, heads of households did not perceive campaign nets to have been of sufficient quality and said that the nets were quick to damage after regular use and washing. Therefore, more durable materials may enhance the longevity of nets, and stakeholders such as National Malaria Control Programmes (NMCP), U.S President's Malaria Initiative (PMI), Global Fund and manufacturers should consider the resistance to damage (Kilian *et al.,* 2021) of nets procured to maximize their longevity and reward the manufacture of good quality products. This finding is consistent with a cross-sectional study in Ghana that showed that householders were willing to pay for better LLINs (Alfonso *et al.,* 2020). Household's 'perceptions of nets were clearly related to the physical characteristics of the nets with dirty nets and rough (polyester nets) were more likely to be discarded when damaged in this setting. User preference for polyester LLINs has been seen in other studies as they are softer to the touch: Tanzania (Tami *et al.,* 2004), India and Nepal (Das *et al.,* 2007), Madagascar (Mattern *et al.,* 2016) and Vietnam (Canavati *et al.,* 2021).

Assessing the tolerance community members had for net damage, older people and women were more likely to keep damaged nets. They kept damaged nets for future use or use by visitors. Additional education should be provided to the other user groups that it is better to

sleep under a damaged net than without a mosquito net (Briet *et al.,* 2020; Randriamaherijaona *et al.,* 2015). Net retention is also important as when coverage is incomplete, school children are often left without an LLIN (Olapeju *et al.,* 2018) due to within-household prioritization and allocation of sleeping spaces (Mboma *et al.,* 2021). These children bear a great burden of malaria at a critical life stage and have long been reported to be the group that contributes much of the ongoing malaria transmission (Coalson *et al.,* 2016; Cohee *et al.,* 2021; Gonçalves *et al.,* 2017; Nankabirwa *et al.,* 2014; Stone *et al.,* 2015; Zhou *et al.,* 2016).

Those who have more income were less tolerant of damaged nets. Households with more income can afford to buy nets and hence replace their program nets (Mboma *et al.,* 2021; Mboma *et al.,* 2018). The association between the poorest wealth quantile and determinants of damages was due to poor house structure, crowding, and absence of adequate sleeping places (Ahogni *et al.,* 2020; Kilian *et al.,* 2015; Mutuku *et al.,* 2013). Therefore, those in the poorest group were most likely to have damaged nets, but more likely to hold on to them in the absence of a replacement unless their sleep is disturbed (Mboma *et al.,* 2018).

### 4.2.1 Alternative use of old nets

This study found that most nets were thrown away or burned and a minority of too-torn nets are used for other purposes once they are perceived to be non-functional against mosquitoes. Alternative purposes of LLINs found in this study are also reported in Kenya, Malawi, Ghana, Senegal, Nigeria, and Uganda (Berthe *et al.,* 2019; Koenker *et al.,* 2014; Opoku *et al.,* 2021; Santos *et al.,* 2019). In addition, due to the perceived strength of the material used to make LLINs, they are sold as ropes or bags thereby an alternative source to generate income. The participants pointed out that they used nets for the aforementioned alternative purpose, because the standard materials such as sisal ropes were more expensive to purchase directly from the shops. Long-lasting insecticidal nets made of stronger fibers (polyester and polyethylene) are offered as a cheaper alternative. Previous study was done by Randriamaherijaona *et al.* (2013, 2027) and Allan *et al.* (2009, 2012) found that polyethylene (Olyset nets) was more durable and accumulated less damage than polyester nets (PermaNet). More recent research has found that polyethylene (Olyset) LLINs are more prone to damage than polyester (PermaNet) LLINs (Haji *et al.,* 2020; Lorenz *et al.,* 2020; Morgan *et al.,* 2015). No one repurposed old nets for continued malaria control such as house screening or to close eave gaps through which mosquitoes enter even though this can be easily done and may offer substantial relief from mosquito bites (Kampango *et al.,* 2013). This could be due to lack of information/education

that these methods could offer continued protection against malaria mosquitoes. Screening windows and eaves with netting have been observed to decrease mosquito entry in multiple studies (Knols *et al.,* 2016; Njoroge *et al.,* 2020; Ogoma *et al.,* 2010; Sternberg *et al.,* 2016). The consensus statement on the repurposing of LLINs which provides recommendations for beneficial repurposing when an LLIN is no longer useful, LLIN when is old can be used for beneficial repurposing like curtains, patches for holes in viable nets, eaves and constructing window or door screening for protecting against malaria infection (RBM, 2018). Not only this but also the recommendation provided by the WHO on discarding bed nets acclaims that; LLIN should not be discarded in any water body because the residual insecticide on the net can be toxic to organism, especially fish (WHO, 2014). They also recommended that old LLINs should be collected and the best option for disposal is a high-temperature incineration (WHO, 2014). Therefore, LLINs should not be buried in an open-air Also, WHO suggested that if the above options are not possible, the recommended method of disposal is burial and burial should be away from water sources and preferably in non-permeable soil (WHO, 2014). Unfortunately, these recommendations are not followed by the communities, they were discarding insecticidal nets in the environment including burning LLINs in the open-air this may lead to the release of dioxins, which is harmful to human health. Improper burial on unspecified places can be toxic to aquatic organisms and a source of insecticide resistance.

### 4.2.2 Premature discarding of nets

This study observed that young people prematurely discarded LLINs because of small holes that could have been repaired as noted by the older people. The older people repaired holes in nets by sewing, tying, stitching, or tacking. Net repair extends LLIN lifespan, which is crucial for protection. Therefore, it is necessary to emphasize and improve Behavior Change Communication (BCC) to promote net retention. Behavior Change Communication refers to the strategic use of communication approaches to promote changes in knowledge, attitudes, norms, beliefs, and behavior (RBM, 2014). Therefore, BCC can be used among young people to encourage net care to prevent quick deterioration and promote retainment especially if the net was acquired recently. While malaria prevention is taught as part of the curriculum in all Tanzanian schools, net care and repair are not. Extending the curriculum to include net care could be an important means of encouraging young people to value and care for their nets.

### 4.2.3 Methods used for discarding of nets

Although majority of the respondents reported improper discarding of LLINs such as discarding in the public rubbish pit and burning, however, this is not recommended because it has a negative environmental impact. Research done by Kudom *et al.* (2018) in Ghana reported high level of pyrethroid resistance of *Anopheles* species in an urban setting without urban agriculture which was postulated to be due to improper discarding of old insecticides such as LLINs, domestic insecticides as well as the use of herbicides. Agricultural areas where they intensively use insecticides have observed resistance of pyrethroids of vectors which are important to public health (Finda *et al.,* 2018; Hien *et al.,* 2017). In addition, burning of LLINs is very damaging to the environment and human health (Weise *et al.,* 2020), also disposal should be buried away from water bodies. Respondents felt that they did not have enough information on the correct disposal of nets and this could be overcome by adding this information to the LLIN label or packaging.

### 4.2.4 Care for the nets

Study participants reported that they care for their LLINs by washing, repairing when it gets holes by sewing, stitching, and tying, although nets in other studies in Tanzania were not often found to be repaired (Ahogni *et al.,* 2020; Mansiangi *et al.,* 2020), which suggests that users gave responses that were perceived as desirable to the moderator, or other members of the focus group. Consistent care for the net was also reported by other studies done in Senegal (Loll *et al.,* 2014), Nigeria (Koenker *et al.,* 2015), Ethiopia (Batisso *et al.,* 2012) and, Kenya (Santos *et al.,* 2019). In practice, LLINs are cared for by washing, folding during the day, sometimes drying in the shade but are rarely repaired. Participants mentioned a desire to receive messages on the importance of care and repair which could motivate repair and increase LLINs lifespans. Older male respondents said that the cost of getting treatment from the health facility when their child is sick for malaria are usually high, so it's better to care for their nets to protect them from regular sickness and can enable to reduce associated costs of attending the health facility.This study observed that younger people were not readily caring for their nets because they did not have time with their busy schedules and work. Although in the study area few respondents reported to have received information on net care and repair from the radio and/or television because they lack devices about 48% owned radios and 23% owned television. This was also seen in Ethiopia where <25% of respondents own radio which led few people to receive the intended messages (Choi *et al.,* 2017). Interestingly, in this study women reported to getting

knowledge from their mothers. Women are primarily the ones who take care and of repair nets in households (Dillip *et al.*, 2018). While there was low level of knowledge on net care and repair participants are interested in learning how to care for their nets to make them longer lasting. Targeting this kind of information to younger age groups could be useful to ensure continuity across generations as was observed by the younger women who credit their mothers for information.

Concern was raised about receiving information via radio. The younger population rarely listen to radios and when they do, they often listen to the music and ignore other programs. Therefore, BCC should reach out to music artists for the promotion of net care and disposal educational information as well as through schools and health facilities. Government and other stakeholders should consider providing training during LLINs distribution to improve life span of LLINs and to reduce misuse of LLINs and premature discarding of LLINs. National Environment Management Council (NEMC) of Tanzania may provide a guidance on the disposal of old/torn nets, or other acceptable alternative uses like curtains for doors and windows as a means of forming a barrier against mosquitoes and vectors of other infectious diseases, to eliminate improper discarding of LLINs and protect environmental pollution. Bundling information on all the areas where participants expressed interest in learning more i.e., proper use, care and disposal of nets may be best bundled with nets at distribution either on packaging, on the label or with the net on a leaflet.

### 4.3 Limitations of the study

The study has several limitations. The FGDs were conducted among a group of people that had already taken part in a LLIN durability study. Therefore, they had been recently sensitized on to the use and importance of LLINs and thus, may have a higher average knowledge of LLINs' use. The color of LLINs distributed by the durability study was white which is not preferred by the study participants and may have affected their decision to discard the nets. In addition, the LLINs shown to participants were not of a wide range of damage levels, all LLINs were too torn based on WHO pHI, and it would have been better if a wider range of LLIN damage levels that could be considered "good" and "serviceable" were made available. It is also likely that the participants' responses were biased to a certain extent by peer pressure as many reported repairing their LLINs.

The study interviewed only those who discarded bed nets, this may have introduced some bias in the data therefore, opinions gathered may be one-sided despite intensive probing on discarding and retaining bed nets practices in the communities.

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

This study demonstrated that factors associated with the discarding of LLINs were physical condition, age, gender, Socioeconomic status and perceived efficacy of the LLINs to kill mosquitoes. Also, the LLINs characteristics associated with the discarding of LLINs are material used to make the LLIN, cleanliness and number of holes in the LLIN. More robust nets with strong fibers and quality will help the community in cost saving and improve health because current campaign nets do not reach 3-years of use as recommended by WHO.

With the behavioral component that influences when to discard nets, Behavior Change Communication could help to appropriately inform community members on best practices of alternative nets use or disposal to ensure continued protection without negative environmental impact.

Moreover, Behavior Change Communication programs should also use music artists in promotion and provision of education in net use, netcare and disposal. This education should also be provided in schools and during ANC program when pregnant women and children attend.

Government and other stakeholders should consider providing training during LLINs distribution to improve the life span of LLINs and to reduce misuse of LLINs and premature discarding of LLINs. National Environment Management Council (NEMC) of Tanzania may provide a guidance on the disposal of old/torn nets, or other acceptable alternative uses like curtains for doors and windows as a means of forming a barrier against mosquitoes and vectors of other infectious diseases, to eliminate improper discarding of LLINs and protect environment pollution.

## 5.2 Recommendations

The following recommendations are made to the PMI, NMCP, NEMC, and other partners who implementing vector control interventions to improve community health:

(i) The LLINs become too damaged for use and will need to be replaced within three years.

Therefore, the mass distribution campaigns should not exceed 3 years. Additionally, education should be provided to community members on how long nets are expected to last, how best to care for them, importance of repairing nets, and at what point the net is no longer protecting them from malaria and other infectious diseases.

(ii) Manufactures, PMI, and other stakeholders in the design and making of bednets should consider user preference in terms of fabric texture which is preferred by the community to reduce misuse and premature discarding of LLINs.

(iii) NMCP should ensure that Behavior Change Campaigns (BCC) go hand in hand with mass distribution of LLINs. This will ensure that the communities are well informed on bednet care and repair. The BCC messages should emphasize proper washing techniques, proper storage of the nets to prevent damage when the net is not in use as well as regular checking and repair of bednets holes to minimize further damage.

(iv) To reduce improper use and disposal of LLINs, the NEMC of Tanzania should provide guidelines on retainment and acceptable repurposes of old/torn nets like curtains for doors and windows as a means of forming a barrier against mosquitoes and vectors of other infectious diseases. This in turn will help protect non-targeted animals and plants from coming into contact with the insecticides (toxins) bednets improperly discarded or misused.

## REFERENCES


Ahorlu, C. S., Adongo, P., Koenker, H., Zigirumugabe, S., Sika-Bright, S., Koka, E., Tabong, P. T., Piccinini, D., Segbaya, S., Olapeju, B., & Monroe, A. (2019). Understanding the gap between access and use: A qualitative study on barriers and facilitators to insecticide-treated net use in Ghana. *Malaria Journal, 18*(1), 1-13. https://doi.org/10.1186/s12936-019-3051-0

Bhatt, S., Weiss, D. J., Mappin, B., Dalrymple, U., Cameron, E., Bisanzio, D., Smith, D. L., Moyes, C. L., Tatem, A. J., Lynch, M., Fergus, C. A., Yukich, J., Bennett, A., Eisele, T. P., Kolaczinski, J., Cibulskis, R. E., Hay, S. I., & Gething, P. W. (2015). Coverage and system efficiencies of insecticide-treated nets in Africa from 2000 to 2017. *Elife, 4*, 1-37. https://doi.org/10.7554/eLife.09672

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Briet, O., Koenker, H., Norris, L., Wiegand, R., Eng, J. V., Thackeray, A., Williamson, J., Gimnig, J. E., Fortes, F., & Akogbeto, M. (2020). Attrition, physical integrity and insecticidal activity of long-lasting insecticidal nets in sub-Saharan Africa and modelling of their impact on vectorial capacity. *Malaria Journal, 19*(1), 1-15.

Bursac, Z., Gauss, C. H., Williams, D. K., & Hosmer, D. W. (2008). Purposeful selection of variables in logistic regression. *Source Code for Biology and Medicine, 3*(1), 1-8. https://doi.org/10.1186/1751-0473-3-17

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist, 26*(2), 1-13.

Eisele, T. P., Thwing, J., & Keating, J. (2011). Claims about the misuse of insecticide-treated mosquito nets: are these evidence-based? *PLoS Medice, 8*(4), 1-3. https://doi.org/10.1371/journal.pmed.1001019

García-Basteiro, A. L., Schwabe, C., Aragon, C., Baltazar, G., Rehman, A. M., Matias, A., Nseng, G., & Kleinschmidt, I. (2011). Determinants of bed net use in children under five and household bed net ownership on Bioko Island, Equatorial Guinea. *Malaria Journal, 10*(1), 1-11.

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2016). Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. *Field Methods*, *18*(1), 3-20. https://doi.org/10.1177/1525822x05282260

Kibe, L. W., Kamau, A. W., Gachigi, J. K., Habluetzel, A., & Mbogo, C. M. (2019, Jul 3). A formative study of disposal and re-use of old mosquito nets by communities in Malindi, Kenya. *Malariaworld Journal*, *6*, 1-18. https://www.ncbi.nlm.nih.gov/pubmed/31293898

Killeen, G. F., Tami, A., Kihonda, J., Okumu, F. O., Kotas, M. E., Grundmann, H., Kasigudi, N., Ngonyani, H., Mayagaya, V., Nathan, R., Abdulla, S., Charlwood, J. D., Smith, T. A., & Lengeler, C. (2007). Cost-sharing strategies combining targeted public subsidies with private-sector delivery achieve high bednet coverage and reduced malaria transmission in Kilombero Valley, southern Tanzania. *BMC Infectious Diseases*, *7*(1), 1-20. https://doi.org/10.1186/1471-2334-7-121

Koenker, H., Arnold, F., Ba, F., Cisse, M., Diouf, L., Eckert, E., Erskine, M., Florey, L., Fotheringham, M., Gerberg, L., Lengeler, C., Lynch, M., Mnzava, A., Nasr, S., Ndiop, M., Poyer, S., Renshaw, M., Shargie, E., Taylor, C., Thwing, J., Van Hulle, S., Ye, Y., Yukich, J., & Kilian, A. (2018). Assessing whether universal coverage with insecticide-treated nets has been achieved: Is the right indicator being used? *Malar Journal*, *17*(1), 1-11. https://doi.org/10.1186/s12936-018-2505-0

Koenker, H., Kilian, A., de Beyl, C. Z., Onyefunafoa, E. O., Selby, R. A., Abeku, T., Fotheringham, M., & Lynch, M. (2014). What happens to lost nets: A multi-country analysis of reasons for LLIN attrition using 14 household surveys in four countries. *Malaria Journal*, *13*(1), 1-10.

Lim, S. S., Fullman, N., Stokes, A., Ravishankar, N., Masiye, F., Murray, C. J., & Gakidou, E. (2011). Net benefits: A multicountry analysis of observational data examining associations between insecticide-treated mosquito nets and health outcomes. *PLoS Medicine*, *8*(9), 1-13. https://doi.org/10.1371/journal.pmed.1001091PMEDICINE-D-11-00174 [pii]

Loll, D. K., Berthe, S., Faye, S. L., Wone, I., Koenker, H., Arnold, B., & Weber, R. (2013). User-determined end of net life in Senegal: A qualitative assessment of decision-making related to the retirement of expired nets. *Malaria Journal, 12*(1), 1-9. https://doi.org/10.1186/1475-2875-12-337

Lorenz, L. M., Bradley, J., Yukich, J., Massue, D. J., Mageni Mboma, Z., Pigeon, O., Moore, J., Kilian, A., Lines, J., Kisinza, W., Overgaard, H. J., & Moore, S. J. (2020). Comparative functional survival and equivalent annual cost of 3 long-lasting insecticidal net (LLIN) products in Tanzania: A randomised trial with 3-year follow up. *PLoS Medicine, 17*(9), 1-18. https://doi.org/10.1371/journal.pmed.1003248

Lorenz, L. M., Overgaard, H. J., Massue, D. J., Mageni, Z. D., Bradley, J., Moore, J. D., Mandike, R., Kramer, K., Kisinza, W., & Moore, S. J. (2014). Investigating mosquito net durability for malaria control in Tanzania-attrition, bioefficacy, chemistry, degradation and insecticide resistance (ABCDR): Study protocol. *BMC Public Health, 14*(1), 1-11.

Manu, G., Boamah-Kaali, E. A., Febir, L. G., Ayipah, E., Owusu-Agyei, S., & Asante, K. P. (2017). Low Utilization of Insecticide-Treated Bed Net among Pregnant Women in the Middle Belt of Ghana. *Malar Research Treatment, 2017*, 1-7. https://doi.org/10.1155/2017/7481210

Massue, D. J., Lorenz, L. M., Moore, J. D., Ntabaliba, W. S., Ackerman, S., Mboma, Z. M., Kisinza, W. N., Mbuba, E., Mmbaga, S., Bradley, J., Overgaard, H. J., & Moore, S. J. (2019). Comparing the new Ifakara Ambient Chamber Test with WHO cone and tunnel tests for bioefficacy and non-inferiority testing of insecticide-treated nets. *Malaria Journal, 18*(1), 1-15. https://doi.org/10.1186/s12936-019-2741-y

Massue, D. J., Moore, S. J., Mageni, Z. D., Moore, J. D., Bradley, J., Pigeon, O., Maziba, E. J., Mandike, R., Kramer, K., Kisinza, W. N., Overgaard, H. J., & Lorenz, L. M. (2016). Durability of Olyset campaign nets distributed between 2009 and 2011 in eight districts of Tanzania. *Malaria Journal, 15*(1), 1-11. https://doi.org/10.1186/s12936-016-1225-6

Mboma, Z. M., Dillip, A., Kramer, K., Koenker, H., Greer, G., & Lorenz, L. M. (2018). 'For the poor, sleep is leisure': Understanding perceptions, barriers and motivators to mosquito net care and repair in southern Tanzania. *Malaria Journal, 17*(1), 1-13. https://doi.org/10.1186/s12936-018-2528-6

Msellemu, D., Shemdoe, A., Makungu, C., Mlacha, Y., Kannady, K., Dongus, S., Killeen, G. F., & Dillip, A. (2017). The underlying reasons for very high levels of bed net use, and higher malaria infection prevalence among bed net users than non-users in the Tanzanian city of Dar es Salaam: A qualitative study. *Malaria Journal, 16*(1), 1-10. https://doi.org/10.1186/s12936-017-2067-6

Njau, J. D., Stephenson, R., Menon, M., Kachur, S. P., & McFarland, D. A. (2013). Exploring the impact of targeted distribution of free bed nets on households bed net ownership, socio-economic disparities and childhood malaria infection rates: Analysis of national malaria survey data from three sub-Saharan Africa countries. *Malaria Journal, 12*(1), 1-15. https://doi.org/10.1186/1475-2875-12-245

NVivo. (2018). *QSR International Pty Ltd.* https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home

Odufuwa, O. G., Ross, A., Mlacha, Y. P., Juma, O., Mmbaga, S., Msellemu, D., & Moore, S. (2020). Household factors associated with access to insecticide-treated nets and house modification in Bagamoyo and Ulanga districts, Tanzania. *Malaria Journal, 19*(1), 1-13. https://doi.org/10.1186/s12936-020-03303-8

Pulford, J., Hetzel, M. W., Bryant, M., Siba, P. M., & Mueller, I. (2011). Reported reasons for not using a mosquito net when one is available: A review of the published literature. *Malaria Journal, 10*(1), 1-10.

Ritchie J., & Spencer, L. (1994). *In Analyzing qualitative data.* (A. Bryman & R. G. Burgess, Eds.). https://www.taylorfrancis.com/ chapters/edit/10.4324/ 9780203413081-14/ qualitative-data-analysis-applied-policy-research-jane-ritchie-liz-spencer

Salim, N., Knopp, S., Lweno, O., Abdul, U., Mohamed, A., Schindler, T., Rothen, J., Masimba, J., Kwaba, D., & Mohammed, A. S. (2015). Distribution and risk factors for Plasmodium and helminth co-infections: A cross-sectional survey among children in Bagamoyo district, coastal region of Tanzania. *PLoS Neglected Tropical Diseases, 9*(4), 1-20.

StataCorp. (2019). *Stata Statistical Software: Release 16.* In StataCorp LLC. https://www.stata.com/

Steketee, R. W., & Campbell, C. C. (2010). Impact of national malaria control scale-up programmes in Africa: Magnitude and attribution of effects. *Malaria Journal, 9*(1), 1-15. https://doi.org/1475-2875-9-299 [pii]10.1186/1475-2875-9-299

Sumari, D., Mwingira, F., Selemani, M., Mugasa, J., Mugittu, K., & Gwakisa, P. (2017). Malaria prevalence in asymptomatic and symptomatic children in Kiwangwa, Bagamoyo district, Tanzania. *Malaria Journal, 16*(1), 1-7.

Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. *The SAGE Handbook of Qualitative Research in Psychology, 2*, 17-37.

Vyas, S., & Kumaranayake, L. (2006). Constructing socio-economic status indices: how to use principal components analysis. *Health Policy and Planning, 21*(6), 459-468.

WHO. (2021). World malaria report 2021. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021

WHO. (2014). *WHO recommendations on the sound management of old long-lasting insecticidal nets*. https://apps.who.int/iris/bitstream/handle/10665/338356/WHO-HTM-GMP-MPAC-2014.1-eng.pdf

WHO. (2020). World malaria report 2020: 20 years of global progress and challenges. In *World malaria report 2020: 20 years of global progress and challenges*. https://www.who.int/publications/i/item/9789240015791

William, J., Dillip, A., Smithson, P., & Hildon, Z. (2013). *Comparing changes in morbidity and mortality in under-five year olds in Kilombero and Bagamoyo district hospitals*. Ifakara Health Institute. https://core.ac.uk/download/pdf/16666681.pdf

# APPENDICES

## Appendix 1: Participatory activity guide for FGD

A participatory activity (PA) will be taking place after each FGD. The purpose of the participatory activity is to examine net discard and decisions of nets with different damage and how it is discarded.

PA guide:

1. Facilitator explains the purpose of the activity to participants.
2. Facilitator shows uniquely labelled nets with different levels of damage
3. Facilitator asks to make decision on future of net (Table 2):
    a. First what they think if it is good, serviceable and too torn;
    b. Second what they *think they would* do. (use / repair / repurpose/ throw away, sell)
4. Each participant would answer the decisions with different level of damage of nets.
5. After all nets have been shown and decided on, the facilitator will conduct a quick assessment of choices for the different nets.
6. Facilitator leads a discussion on the choices around each net, identifying each net by its unique ID number. Questions will include:
    a. What is the condition of the net?
    b. If the answer will be too torn, will ask if they will continue to use and is it tucked or untucked?
    c. If choice were to use the net for something else in household, what would it be used for? Why?
    d. If choice were to discard the net, where would it be discarded?
7. Facilitator should encourage discussions among FGD members.

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

1. Which net will be discarded and which will not be discarded
2. Where will the net be discarded?

**Table 1 – Net with different damage and discarded decisions**

| Net ID | Number of holes | Hole sizes (Table 3) | Hole location | Action | Perception of damage |
|---|---|---|---|---|---|
| 1 | 21 | 5 size 1, 11 size 2, 4 size 3, 1 size 4 | Mix | | |
| 2 | 27 | 18 Size 1, 4 size 2, 3 size 3, 2 size 4 | Mix | | |
| 3 | 14 | 5 size 1, 3 size 2, 5 size 3, 1 size 4 | Mix | | |
| 4 | 41 | 18 size 1, 14 size 2, 8 size 3, 1 size 4 | Mix | | |
| 5 | 22 | 19 size 1, 1 size 2, 1 size 3, 1 size 4 | Mix | | |
| 6 | 79 | 38 size 1, 20 size 2, 17 size 3, 4 size 4 | Mix | | |
| 7 | 133 | 87 size 1, 26 size 2, 19 size 3, 1 size 4 | Mix | | |

**Table 2 – Decisions on net actions**

| | | | |
|---|---|---|---|
| 1 | Good | | |
| 2 | Serviceable | | |
| 3 | Too torn | Tucked | Untucked |
| 4 | No longer use the net and use for something else in the household | | |
| 5 | Discard the net | | |
| 6 | Where will be discarded | | |
| 7 | Sell | | |

## Appendix 2: Topic guide for focus group discussion/Muongozo kwa ajili ya majadiliano ya vikundiApp

*Interviewer use only – complete prior to interview*

**Muongozo kwa ajili ya majadiliano ya vikundi**

| **Utambulisho wa Mhojaji:** | **Namba ya simu:** | **Jina la kijiji:** |
|---|---|---|
| | | |

**Tarehe ya mahojiano:** |__|__|__|__|__|__|__|__|

**Idadi ya washiriki:** |__|__|

| **Sl. No.** | **v0.1 Jina la kwanza la watu wote wanaoshiriki mahojiano**<br>**First name of people participating in the discussion** | **V0.3 Umri**<br>**Age** | **V0.4 Jinsia**<br>**Sex** | **V0.5 Elimu ya yake**<br><br>**Highest education level** |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**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/ Maswali/Mandhari** | **Probes/ Uchunguzi** |
|---|---|
| PART 1: SEHEMU 1 | Perception of Bed net uses/ Matumizi ya vyandarua |
| What is the good thing about mosquito net? / *Je ni kitu gani kizuri kuhususiana na chandarua cha mbu?* | Why do you use a bednet? / *Kwanini unatumia chandarua?*<br>Is it important to use the net?/ *Je kuna umuhimu wa kutumia chandarua?*<br>What do you like in your net?/ *Unapenda nini kutoka kwenye chandarua chako?*<br>How are nets damaged /*Neti inapataje matobo?*<br>Are your kids make damage in your net? *Je watoto wako wameshawahi kuharibu chandarua?*<br>How do you stop them getting damaged? / *Mnazuiaje vyandarua visiharibike au visipate matobo?* |
| Do you use insecticide treated nets in your households? / *Je unatumia chandarua chenye dawa kwenye kaya yako?* | Do you use insecticide treated nets against malaria, in your family? /*Je kwenye familia yako mnatumia chandarua chenye dawa?*<br>Does everyone sleep under bed net? / *Je kila mtu analala kwenye chandarua?* If no who are those that do not sleep under bed net, in terms age and sex? /*Kama sio, nani halali kwenye chandarua, umri gani na jinsia gani?*<br>Why don't they sleep under net? *Kwanini hawalali kwenye chandarua?* |

| **SEHEMU YA PILI/** PART TWO | **NET CARE ATTITUDE/** UTUNZAJI WA VYANDARUA |
|---|---|
| **How does your family or community care for bed nets?** Kwenye familia yako au jamii yako huwa mnatunzaje vyandarua? | **Washing?/** *Kufua*<br><br>**Repairing?** *Kurekebisha?*<br><br>**How do you care for your net? /** *Je unatunzaje chandarua chako?* |
| **Where do you get your information on Net care?** Mmepata wapi elimu ya utunzwaji wa vyandarua? | ***Are you aware of any information on how to take care of nets to last longer?*** *Je umeshawahi kupata taarifa yeyote kuhususiana na jinsi ya kutunza chandarua ili kiweze kukaa muda mrefu?*<br><br>***How did you know about it. From which source radio, tv?*** *Ulipatia wapi taarifa hizo?*<br><br>***Has net caring ever been a debate among family and friends?*** *Je, utunzaji chandarua ni swala la majadiliano kati ya familia au marafiki zako?*<br><br>**What is your opinion about net care?/** *Una maoni gani kuhusu utunzwaji wa vyandarua* |
| **PART 3:** SEHEMU 3 | **Net damage /** Uharibifu wa vyandarua |
| **When is a net no longer effective** / Ni baada ya muda gani chandarua hakifanyi kazi tena? | ***Time in months, years or duration of use – rationale behind timing/*** *Muda kwa miezi kadhaa, au miaka – kabla ya wakati*<br>***Too much damage – define*** */ Kikishaharibika sana-elezea*<br>***How long do you think you should use a net before it is no longer effective?*** */ Kwa muda gani unafikiri unaweza ukatumia chandarua kabla ya nguvu ya dawa kupungua?*<br>***How do you know a net is no longer effective?*** */ Unajuaje kama nguvu ya dawa imeisha au imepungua kwenye chandarua?*<br>***External cues****/ Sababu zinazopelekea;*<br>***Do you have to keep a net until you obtain a new one****/ Je huwa unahifadhi chandarua hadi unapopata chandarua kipya?*<br>***Is getting a new one free the only time nets are usually replaced?*** */ Je mnapopata chandarua kipya bure ndio kinakua mbadala wa kile?* |

| | |
|---|---|
| | ***Immediately after receiving or after how many months or years do your family, your community discard the mosquito treated nets given during the last campaign?****/ Ni muda huohuo mkishapokea au ni baada ya miezi mingapi au miaka mingapi kwenye familia yako au jamii yako ndio mnatupa hivi vyandarua?* |
| **When you receive the new the new net what do you do to the old one.?/** Pale unavyopata chandarua kipya huwa cha zamani unakifanyia nini? | ***In your family or community when you receive the new net, what do you do to the old one?*** *Kwenye familia yako au jamii pale mnavyopata chandarua kipya huwa mnakifanyia nini kile cha zamani?* |
| **At what stage of the damage of the net you decided to discard it?** Chandarua kikiharibika | *a)* ***In your family and community at what stage of the damage of the net you decided to discard it?*** *Kwenye familia yako na jamii yako chandarua kikiharibika kiasi gani ndipo mnapoamua kukitupa?* |
| Kiasi gani ndipo mnapoamua kukitupa? | |
| **Does the location of damage / holes to nets determine net discarded?** Je uharibifu wa chandarua na chandarua kinapotoboka, uwepo wa mashimo na sehemu ya hayo matobo yalipo inapelekea kuamua kutupa vyandarua? | ***Do you think the location of holes/ damage to the nets determine net discarded in your family?*** *Unafikiri sehemu mashimo yalipo kwenye chandarua ndio inasababisha utupwaji wa vyandarua?* |
| **Position of net damage** Kwa kawaida ni sehemu gani ya chandarua inayoharibika sana? Mbele, katikati, pembeni au juu? Nini sababu ya chandarua kuharibika ivyo? | **Usually, where is most damage to nets? Bottom, middle, top of sides, roof**? **What causes this damage? /** Kwa kawaida ni sehemu gani huwa inaharibika zaidi kwenye chandarua? Mbele, katikati, pembeni au juu? |

| **PART 4:** SEHEMU YA NNE | **Discarded of nets/ Utupwaji wa vyandarua** |
|---|---|
| **What do you do to the net which has finished its use in your family?** / Huwa unafanyia nini | **Do you use the nets for other purposes?** Je, huwa mnamatumizi mengine ya vyandarua hivyo? |
| Na vile vyandarua vilivyokwisha matumizi yake kwenye familia yako? | **The nets that are perceived as not good to sleep under, where are they discarded? /** Kwa vyandarua ambavyo unaona havifai tena kutumika sio vizuri huwa unavitupa wapi?<br><br>***What reasons influence where the nets are discarded?*** *Unafikiri ni sababu gani inayochangia maamuzi ya wapi kutupa vyandarua ambavyo havifai kutumika?* |
| **Why do you throw away your net/** Kwanini mnatupa vyandarua? | ***Is it no longer effective (mosquito bites)****/ Hakifanyi kazi tena (mbu wanawang'ata)*<br>***Looks bad (big holes / dirty)****/ Kikiwa kinaonekana vibaya (kikiwa na matobo makubwa/ kikiwa kichafu)*<br><br>***Get a new net****/ Mkishapata neti mpya*<br>***When people get rid of the net, does this cause any problem in your house or environment? /*** *Je kuna shida yeyote inayotokea katika mazingira au kwenye kaya yako iwapo mtu atatupa/kuondoa neti?* |

## RESEARCH OUTPUTS

### Publication paper

Madumla, E. P., Moore, S. J., Moore, J., Mbuba, E., Mbeyela, E. M., Kibondo, U. A., Kobe, D., Baraka, J., Msellemu, D., Swai, J. K., & Mboma, Z. M., 2022. "In starvation, a bone can also be meat": A mixed methods evaluation of factors associated with discarding of long-lasting insecticidal nets in Bagamoyo, Tanzania. *Malaria Journal*, *21*(1), 1-19. https://doi.org/10.1186/s12936-022- 04126-5

### Poster presentation

Mixed method study to evaluate factors associated with discarding of Long-lasting insecticidal nets in Bagamoyo, Tanzania.