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Improving Long-Lasting Insecticidal Nets use in Kayange community of North-Western Burundi: A Quality Improvement Study



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STUDENT NUMBER: 1496643

A research report submitted to the Faculty of Health Science in partial fulfillment of the requirements for the degree of *Master of Science (MSc)* in Epidemiology - Implementation Science

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A thesis submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfillment of the requirements for the Degree of Master of Science in Epidemiology, field of Implementation Science.

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SUPPORTED BY:
WHO TDR, the Special Programme for Research and Training in Tropical Diseases
University of the Witwatersrand
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DECLARATION

I, Desire Habonimana, hereby declare that this research work was carried out by me under the supervision of Dr. Gideon Nimako and Prof. Gabriel Ndayisaba. This thesis was entirely composed by myself and the work contained herein is my own except where explicitly stated otherwise in the text. It is being submitted for the degree of Master of Science in Epidemiology in the field of Implementation Science in the University of the Witwatersrand, Johannesburg. I have taken care in all respect to honor the intellectual property right and have acknowledged the contribution of others for using them in this work and further declare that the work reported in this project has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Parktown, Johannesburg, November, 2017



Desire Habonimana

DEDICATION

I humbly dedicate this degree to the Lord almighty who has made it possible for me to come this far in education. A special feeling of gratitude to my loving wife, Petronie Nyawenda, and my son Perry Dylann Habonimana. Sr. Chiarini Bruna, Desire Yamuremye sj, Tharcisse Manirakiza, Jean Baptiste Baribonekeza, Roger Ngendabanyikwa, Gaspard Sindayigaya, Richard Niragira, Jean-Bosco Ndihokubwayo, Yves-Richard Niyonkuru, and many others for their words of encouragement and support during my study and research periods. My Father, late Mother, late brother and sisters, brothers and sisters, you have never left my side and are very special to me. Through thick and thin, you have provided me all the support to make this level of my education come to pass.

I also dedicate this dissertation to my many friends who have supported me throughout the process. I will always appreciate all they have done.

ABSTRACT

Introduction

The World Health Organization (WHO) reported an estimated global 3.3 billion people still living at risk of malaria in 2015. In the world, only 15 countries bear approximately 80% of malaria related deaths. The Sub-Saharan Africa (SSA) alone accounts for 90% of malaria related deaths. The use of Long-Lasting Insecticidal Net (LLIN) for malaria prevention is a cost-effective intervention. WHO recommends LLIN universal coverage, defined as *at least one LLIN for every two people in the household*. In SSA and other Low and Middle Income Countries (LMICs), governments and multilateral partners have committed to fully subsidize and provide LLIN for free through mass distribution campaigns. However, LLIN mass distribution has not necessarily led to reduced malaria incidence and related deaths because of its non-use or missed. In Burundi, LLIN is provided free of charge through mass distribution at community level and to pregnant women coming for antenatal care or delivery and childhood immunization. Despite LLIN ownership, Burundi malaria report for 2014 says that only 49% of people sleep under LLIN and only 82% of LLIN are used for their purpose. This has impeded efforts to control malaria and also led to financial wastage. Our study sought to improve LLIN use in Kayange community of north-western Burundi by using the Model For Improvement (MFI).

Objective

This study assessed the level of LLIN ownership and use in Kayange community of north-western Burundi with an aim of building on drivers of LLIN non-use in order to identify and test improvement actions by using the MFI.

Methods

A one group pre-test post-test study design was conducted. LLIN ownership and use was assessed for four weeks before intervention and for another four weeks after intervention. The study was conducted on 96 households in Kayange community of north-western Burundi. The intervention consisted of testing four different weekly small change actions by using the MFI. The first change action consisted of the demonstration of how to mount LLIN and this was conducted at the community yard. The second change action consisted of selecting one *watchdog* in each household who was tasked of checking and reminding household members to mount LLIN before sleeping. The third change action consisted of conducting two community reminders every week. Reminders were done by a town-crier. The fourth change action consisted of a combination of the last two actions. Data was collected for each week. Descriptive analysis was performed on socio-demographic data and factors associated with LLIN non-use and misuse were summarized using frequency

tables. Each outcome indicator was calculated each week and plotted on a run chart.

Results

Of the 96 households, 83 (87%) households owned at least one LLIN. However, only 40 (42%) households owned *at least one LLIN for every two people*. After intervention, the number of LLIN used increased from 32 to 75% (134% increase) and the number of persons (general population) sleeping under LLIN from 35 to 73% (108% increase). The number of children under 5 years sleeping under LLIN increased from 31 to 76% (145% increase) and the number of pregnant women who slept under LLIN from 43 to 73% (69% increase). Also, the averages of the number of nights in each week that the general population slept under LLIN increased from 2.13 to 5.11 (140% increase), children under 5 years slept under LLIN from 1.68 to 4.78 (184% increase) and pregnant women slept under LLIN from 1.56 to 4.47 (186% increase).

Conclusion

In conclusion, our intervention led to significant increase of all outcome indicators. Drivers of success included community collaboration, an enabling context, and support from stakeholders. Small tests of change at community level have potential of achieving improved outcomes. It is essential to gain collaboration and support from stakeholders and also engage the community.

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ACRONYMS

ALUMA Action pour la Lutte contre la Malaria Burundi

CD4 Cluster of Differentiation 4 (immune cells)

CHW Community Health Worker

DMAIC Define, Measure, Analyse, Improve, and Control

DQIP Diabetes Quality Improvement Project

DHS Demographic and Health Survey

DRC Democratic Republic of Congo

ED Emergency Department

HREC Health Research Ethics Committee

ICF Informed Consent Form

IHI Institute for Healthcare Improvement

IPTi Intermittent Preventive Treatment in infants

IPTp Intermittent Preventive Treatment in pregnancy

IRS Indoor Residual Spraying

LLIN Long-Lasting Insecticidal Net

LMICs Low and Middle Income Countries

MCPMEs Massachusetts Coalition for the Prevention of Medical Errors

MDGs Millennium Development Goals

MFI Model For Improvement

NGOs Non-Governmental Organizations

MIS Malaria Indicators Survey

NIRN National Implementation Research Network

PCR olymerase Chain Reactiont

PDSA Plan-Do-Study-Act

PI Principal Investigator

PMTCT Prevention of Mother-To-Child Transmission of HIV

QI Quality Improvement

QIT Quality Improvement Team

RBMp Roll Back Malaria partnership

RDT Rapic Diagnostic Test

RSA Republic of South Africa

SES Socio-economic Status

SSA Sub-Saharan Africa

SYM Service Yezu Mwiza

TQM Total Quality Management

UNC University of North Carolina at Chapel Hill

USD United States dollar

USA United Sates of America

WHA World Health Assembly

WHO World Health Organization

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1

INTRODUCTION

Malaria is a mosquito-borne infectious disease that is prevalent in many countries around the world [51]. It is caused by protozoan parasites of the genus *Plasmodium* which are single-celled organisms that cannot survive outside of their hosts (mosquitos and humans). There are more than 100 species of *Plasmodium* capable to infect many animal species such as reptiles, birds, and various mammals. However, only four species of *Plasmodium* have long been recognized to infect humans in nature. Recently, another fifth species that naturally infects macaques has been recognized to be a cause of zoonotic malaria in humans. There are some additional species which can, exceptionally or under experimental conditions, infect humans [17, 49, 71]. The species infecting humans are:
P. falciparum, which is the first most significant species that is prevalent worldwide in tropical and subtropical areas, and especially in Africa where this species predominates. *P. falciparum* can cause severe malaria because it multiples rapidly in the blood, and can thus cause severe blood loss (anemia). It is responsible for the majority of malaria deaths globally. In addition, the infected parasites can clog small blood vessels and when this occurs in the brain, it results in cerebral malaria which bears a complication that can be fatal. The remaining species are not typically as life threatening as *P. falciparum*.
P. vivax, which is the second most significant species is mostly prevalent in Southeast Asia, Latin America, and in some parts of Africa. Because of the population densities especially in Southeast Asia, this species is probably the most prevalent human malaria parasite. *P. vivax* and *P. ovale*, have dormant liver stages ("hypnozoites") that can activate and invade the blood ("relapse") several months or years after the infecting mosquito bite.
P. ovale, which is found mostly in Africa (especially West Africa) and the islands of the western Pacific. It is biologically and morphologically very similar to *P. vivax*. However, differently from *P. vivax*, it can infect individuals who are negative for the Duffy blood group, which is the case for many residents of SSA. This explains the greater prevalence of *P. ovale* (rather than *P. vivax*) in most of Africa.

P. malariae found worldwide, is the only human malaria parasite species that has a quartan cycle (three-day cycle). The three other species have a tertian, two-day cycle. If untreated, *P. malariae* causes a long-lasting, chronic infection that in some cases can last a lifetime. In some chronically infected patients, *P. malariae* can cause serious complications such as the nephrotic syndrome. *P. ovale* and *P. malariae* represent only a small percentage of infections.

A fifth species, *P. knowlesi* – a species that infects primates – has led to human malaria, but the exact mode of transmission remains unclear. This species is found throughout Southeast Asia as a natural pathogen of long-tailed and pig-tailed macaques. It has recently been shown to be a significant cause of zoonotic malaria in that region, particularly in Malaysia. *P. knowlesi* has a 24-hour replication cycle and so can rapidly progress from an uncomplicated to a severe infection. Fatal cases of zoonotic malaria have been reported.

The species of malaria parasite are transmitted to humans by female mosquitoes of the genus *Anopheles*. Female mosquitoes take blood meals to carry out egg production, and such blood meals are the link between the human and the mosquito hosts in the parasite life cycle (see Appendix A.0.2). The successful development of malaria parasite in the mosquito (from the "gametocyte" stage to the "sporozoite" stage) depends on several factors. The most important is ambient temperature and humidity (higher temperatures accelerate the parasite growth in the mosquito) and whether the *Anopheles* survives long enough to allow the parasite to complete its cycle in the mosquito host ("sporogonic" or "extrinsic" cycle, duration 10 to 18 days). Differently from the human host, the mosquito host does not suffer noticeably from the presence of the parasites [17].

Anopheles are found worldwide except Antarctica. Malaria is transmitted by different *Anopheles* species, depending on the region and the environment. In many cases, two types of female *Anopheles*; *A. stephensi* which breeds in tin cans and confined spaces and *A. gambiae* which prefers small open sunlit pools transmit malaria in humans across many regions of the world [49].

P. falciparum and *P. vivax* constitute the main species across the world that cause malaria in humans [47]. The endemicity of this disease varies; while some countries are malaria holoendemic, hyperendemic, hypoendemic, and mesoendemic, others are epidemic, and malaria risk-free [5, 19, 30]. In Africa, many countries are holo and hyperendemic while South American and Asian countries are mainly hypoendemic [19]. The type of endemicity and species involved determine the risk of disease transmission [19].

Globally, 3.3 billion people (40% of the world's population) are at risk of malaria [78]. However, only 15 countries, mainly in Africa, shoulder the highest malaria burden with approximately 80% of deaths as a result of this disease [78]. In fact, across the Africa Region, only five countries, namely Botswana, Namibia, South Africa, Swaziland, and Zimbabwe are classified as "low malaria transmission" countries [78]. In this region, about 342 million people are at risk of malaria in west African countries, 313 million of people are at risk of malaria in eastern and southern African countries, and 158 million people are at risk of malaria in central African countries [78].

Significant efforts to prevent and control malaria have been jointly made by states and governments, Non-Governmental Organizations (NGOs), and private companies [77, 78]. For example, in 1998, the Roll Back Malaria partnership (RBMp) which is a global effort aiming at halving malaria-related deaths by 2010 and again by 2015 was launched [51, 77]. In 2000, the Millennium Development Goals (MDGs) were agreed upon with a bold malaria target to have halted and begun to reverse the incidence of malaria by 2015 [34, 73]. Furthermore, malaria global financing increased from an estimated United States dollar (USD) 960 million in 2005 to USD 2.5 billion in 2014 and almost 82% of international funds for malaria control and prevention were directed to Africa [78]. Adding to these existing efforts, in 2015, WHO developed the global Technical Strategy For Malaria 2016–2030, which was adopted in May 2015 by the World Health Assembly (WHA). Its target is to reduce global malaria burden by 90% by 2030 [57]. Though malaria interventions have been responsible for most decline of its morbidity and mortality, malaria control indicators still remain below international targets in many affected countries which still makes the disease a global infectious burden [10, 50, 56].

Despite efforts to control malaria, it remains the deadliest mosquito-borne disease in the world [52]. SSA alone accounts for 90% of malaria-related deaths [78]. For example, the Democratic Republic of Congo (DRC) reported the highest rate of malaria-related deaths across the world in 2014 (21601 deaths) [78]. Other African countries with high malaria-related deaths include Burkina Faso, Tanzania, Nigeria, Uganda, Angola, Malawi, Cameroon, Sierra Leone, Burundi, among many others [78]. Nevertheless, in many countries, malaria control programs are not effective [64].

Experience has shown that three main cost-effective interventions can help to achieve the bold malaria target 2030 as agreed upon through the WHO Technical Strategy for Malaria 2016–2030 [70, 80]. These interventions are; **vector control** by reducing malaria

parasites transmission LLIN and Indoor Residual Spraying (IRS), **chemoprevention** which comprises both malaria Intermittent Preventive Treatment in pregnancy (IPTp) and malaria Intermittent Preventive Treatment in infants (IPTi), and **management of malaria confirmed cases**.

To meet the bold 2030 malaria target, WHO recommends LLIN universal coverage, which is defined as *at least one LLIN for every two people in the household*, and effective use [26, 59].

1.1 PROBLEM STATEMENT

The effective use of LLIN is a well recognized cost-effective intervention in malaria control programs. Governments of malaria affected zones including Burundi provide LLIN for free of charge. But, LLIN misuse and non-use is reportedly high, which undermines efforts to control the disease. In Burundi, the distribution of LLIN is conducted at community level through regular mass distribution campaigns and also at clinic level to pregnant women attending antenatal care or during childhood immunization or paediatric healthcare visits.

However, LLIN use in households is not optimal. For instance, the Demographic and Health Survey (DHS) conducted in 2016 and 2017 found that only 40% of children under 5 years and 44% of pregnant women who belong to the households that have access to at least one LLIN reportedly slept under it the night before the survey [16, 63]. In some cases, LLIN are used for other activities, which results in a slow decline of malaria prevalence across the country. The primary consequence of LLIN non-use is the increase of disease burden and its mortality rates. For example, in 2016, 38% of children under 5 years who attended clinics and received malaria Rapic Diagnostic Test (RDT) had the disease [16]. In the same year, almost 3,800 malaria associated deaths were reported [60]. Recently, in April 2017, the government of Burundi declared a malaria epidemic in the country with 1,784,965 cases of malaria including almost 800 deaths in 3 months, which constituted a rise of 13% when compared with the same period in 2016. The secondary consequence of LLIN non-use is financial wastage. One LLIN costs approximates USD 3, therefore, its non-use or misuse constitutes considerable wastage of scarce resources on the side of the government which is already a fragile economy classified as *low income country* [23].

1.2 MOTIVATION

Recently, there has been an increase in the use of Quality Improvement (QI) methods in healthcare and services provision across the world which led to better health outcomes [12, 35, 72]. For example, the Diabetes Quality Improvement Project (DQIP) which consisted of developing and implementing a comprehensive set of national measures for evaluation and QI of diabetes led to improved quality of life and clinical outcomes for diabetic patients and helped in controlling diabetes epidemic in the United Sates of America (USA) [25]. Many similar QI programmes implemented in the USA have also improved health outcomes in patients with chronic diseases [39, 66]. QI programmes have also been implemented in Africa. The Republic of South Africa (RSA) implemented a district-level Prevention of Mother-To-Child Transmission of HIV (PMTCT) QI programme in KwaZulu Natal that considerably improved health outcome indicators in one year following the intervention. The coverage of Cluster of Differentiation 4 (immune cells) (CD_4) testing increased from 40 to 97 (142,5% increase), uptake of maternal nevirapine from 57 to 96% (68,5% increase), uptake of infant nevirapine from 15 to 68% (353,3% increase) and olymerase Chain Reactiont (PCR) testing at six week in post-natal from 24 to 68% (183,3% increase) [21].

This study sought to fill this gap of using QI in malaria control by generating evidence-based improvement strategies that can improve LLIN use at community level. We took inspiration from existing evidence-based QI models implemented in healthcare and industry settings. Improvement models that have been used in healthcare and services include Six Sigma, Lean, and the MFI. Lean and Six Sigma are often used together in an integrated approach called Lean-Sigma [33]. Each QI method has a different philosophy but overall have common goals of improving delivery and support processes. Six Sigma is a systematic process that uses a 5-steps approach Define, Measure, Analyse, Improve, and Control (DMAIC) to collect data on process performance, identify the root causes for poor performance, and test and implement improvement ideas building on statistical analysis of the data. Lean is an improvement philosophy from Toyota that identifies *waste* in a system, where *waste* is defined as unnecessary activities that add to cost or affect the patient experience. The lean improvement model seeks to eliminate *waste* or *muda* while six sigma tries to eliminate *defects* [14, 31, 43]. The MFI is a simple framework for accelerating outcome improvement and it consists of two main parts which are a thinking and a

doing part [33]. The thinking part consists of three fundamental questions leading to improvement, while the doing part consists of the Plan-Do-Study-Act (PDSA) iterative cycles aimed at testing changes in real world settings (see Appendix A.0.3) . It is an iterative process of small tests of change of improvement actions. Each test cycle hypothesizes a change, implements it on a small scale, studies whether it works, and based on the results, decides what to try in the next cycle [1, 44].

In our study, we used the MFI to generate evidence-based improvement strategies aimed at maximizing LLIN use at community level in Kayange community of north-western Burundi. It was the first attempt to improve LLIN use in Kayange community which is a malaria holoendemic zone [4]. The study estimated the level of LLIN ownership and use in the community and elucidated strategies that can improve LLIN use at household level. Improving LLIN use in Kayange community enhanced community health by reducing malaria related child mortality, malaria in pregnancy, and even malaria incidence in the general population. Also, the effective use of LLIN reduced wastage of governmental scarce resources.

1.3 MAIN RESEARCH CONTRIBUTIONS

The major research contribution of this work is in the improvement of the use of long-lasting insecticidal nets in Kayange community using iterative small tests of change. The main results being reported here include:

1. The determination of the level of long-lasting insecticidal nets ownership in Kayange community
2. The identification of the drivers of long-lasting insecticidal nets non-use in Kayange community
3. The identification and testing of long-lasting insecticidal nets usage using improvement strategies in Kayange community using the model for improvement
4. The observation of the impact of improvement strategies on the level of long-lasting insecticidal nets use in Kayange community

1.4 ORGANIZATION OF THE RESEARCH REPORT

Our report continues with the chapter of background and related works. In this chapter, we focus on understanding why our research is important as compared to the existing related works. We explore what is already known and what has already been done related the use of LLIN in malaria prevention programmes. Firstly, we research instances of the positive impact of the use of LLIN in reducing malaria incidence and malaria-related deaths across the world and in Africa. Secondly, we search existing bottlenecks in the effective use of LLIN as well as the drivers of LLIN non-use.

After the chapter of background and related works, we describe the methods that were used in conducting the study. Next, we present the chapter of results which is divided into two main sections. The first section consists of the baseline findings and the second section consists of the findings of the improvement process. Mainly, our results are presented as summary tables and run charts with only a few graphs for categorical data. After the chapter of results, we discuss our findings, conclude and then formulate some key recommendations and future directions towards stakeholders involved in malaria control programmes.

2

BACKGROUND AND RELATED WORKS

Researchers have found that LLIN use is a very effective intervention to control malaria [1, 4, 44]. Lengeler et al. and Paintain et al. respectively reported that the use of LLIN resulted in 50% and 29% reduction of malaria cases and malaria-related deaths [44, 62]. In another study by Grabowsky et al., their findings concluded that clinic-based distribution ofLLIN to pregnant women and LLIN mass distribution compaigns ostensibly reduced malaria burden in Ghana [28]. Also, in Rwanda, Ethiopia, and Zanzibar, studies have found that widespread and countrywide LLIN distribution significantly reduced malaria cases and related deaths [11, 40, 61]. In addition, mass distribution of LLIN together with community education through awareness and sensitization campaigns have reduced the prevalence of *Plasmodium* among children in five high malaria prevalence villages of Toumodi district of central Côte d'Ivoire [41]. Similarly, improved LLIN use has led to improved health outcomes in Senegal, Togo, and Uganda [67, 70, 79, 80]. However, the cost of LLIN and the poverty rate of people from the most malaria affected zones challenged LLIN access in many countries [29, 54].

Efforts to control malaria by ensuring effective use of LLIN were slowed down by the poverty rates in most SSA countries because most of the people could not afford the cost of LLIN and sustain their provision for all household members [18, 54, 58]. In order to overcome this challenge, international organizations such as the WHO and the Global Fund to fight AIDS, TB, and Malaria together with governments and states initiated malaria financing programmes in subsidizing and providing LLIN for free of charge in Africa and other malaria affected zones in the world [42, 53, 81]. This has resulted in the mass distribution campaigns of LLIN at the community level and also at clinic level during antenatal care and childhood immunization visits [7, 69]. However, mass distribution of LLIN has not led to improved outcomes because of its non-use or misuse [8].

Expected impact of LLIN distribution in malaria prevention programmes cannot be achieved if the target populations misuse or do not regularly use the possessed LLIN [2, 3, 76]. In

a study that investigated the bed nets misuse in 7 fishing villages in rural western Kenya, findings revealed that 44.4% of sheets used to dry fish were bed nets, of which 84.5% were LLIN. In addition, 94.4% of the 72 bed nets used for fishing were LLIN. The common reasons for bed nets misuse included the fact that they are either freely distributed or cheap, and that fish dry faster when using a bed net than using the usual fish drying sheets [48]. Other factors such as Socio-economic Status (SES) largely affect the use of LLIN. In Uganda and Tanzania for instance, studies found a positive association between SES and the use of LLIN and recommended the need for interventions focusing on improving LLIN use among poorest and underprivileged communities [1, 45]. LLIN non-use and misuse has also been reported in Burundi which is a country with high malaria prevalence.

Burundi is a malaria holoendemic zone with 90% of severe malaria cases caused by *P. falciparum* [14, 22, 63]. Unlike global progress achieved in malaria prevention and control in the world [78], Burundi reported increased rates of malaria incidence and prevalence between 2010 and 2014 [22]. Soon before, in 2008, Burundi launched a bold malaria national strategic plan for 2008-2012. Among its targets, one was that *at least* 80% *of the population be regularly sleeping under LLIN by* 2010 [14]. However, until late 2012, the national Malaria Indicators Survey (MIS) found that only 63% of households possessed at least one LLIN and that only 49% of the population slept under LLIN the night before. This proportion was slightly high among children under 5 years and pregnant women with 54% and 56% respectively [15, 63]. According to the same source, the proportion of LLIN used at household level was 82% with variation between rural (80%) and urban (90%) settings [63]. The survey also concluded that LLIN possession and use increase with SES [63]. Another partial study conducted in 2012 to assess the knowledge of malaria among women in Kiremba district, a rural district located in northern Burundi, found that, though every woman reportedly confirmed to have been given free LLIN at least twice, only 33% of the surveyed women slept under LLIN the night before the survey [68].

Historically, health care has focused on *quality assurance*, a system for evaluating the delivery of services or the quality of products. They also focus on *quality control*, a system for verifying and maintaining a desired level of quality [75]. These methods, used alone, are not adequate to enhance outcomes. Checking for defects and recommending changes without recognizing the effects of these changes on other parts of the organization may improve one process but harm others. Consequently, the best organizations are now combining quality assurance with proactive and continuous QI using Lean, Six Sigma, and the

MFI which uses PDSA cycles [9].

PDSA cycles have mainly been used at clinical level. An instance is the Massachusetts Coalition for the Prevention of Medical Errors (MCPMEs) and the Institute for Healthcare Improvement (IHI) which used this model to reduce adverse drug events by identifying and testing 16 best practices or change ideas. As a result, the time to blood anticoagulation for heparinized patients reduced, the number of medical errors reduced, safety of patient-controlled analgesia improved, and coumadin incidents reduced as well [24]. Also, PDSA cycles improved clinical outcomes in a residency and fellowship curricula in medical intensive care in internal medicine at Harborview Medical Centre in the USA [13].

Lean thinking has also been used to improve healthcare in many settings [36]. The use of lean thinking in Emergency Department (ED) to improve problems with crowding, delays, cost containment, and patient safety resulted in improved patient care and in decrease of length of stay, waiting times, and proportion of patients leaving the ED without being seen. Additionally, only few negative patient care effects were reported after the implementation of lean model and indications of positive effects on employees and organizational culture were also reported [32, 38].

Six Sigma approach has proved efficacy in controlling healthcare cost increases, improving the quality of health process, and providing better healthcare [20, 74]. Six Sigma approach successfully reduced the rates of medication errors and was recommended to be integrated into all the Total Quality Management (TQM) efforts [65].

The above discussed improvement approaches all seek to attain the same objective – improving the quality of services and outcomes. They only differ in their concepts and theoretical thinking. Though most of the approaches were tested at clinic level, we believe that results be successful at community level as well. Hence, did we aim at using PDSA cycles to improve the use of LLIN in the community of Kayange.

3

RESEARCH METHODOLOGY

In this chapter, we describe the methods that were used in our study. The content of this chapter includes the study design, the study timeline, the study site and participants as well as the study procedures by focusing on the change actions and PDSA cycles that were conducted during our study. In the section of study procedures, we describe the process of development and testing different change actions. Outcomes variables, their operational definitions and measurement are also briefly described. We provide an overview on the selection of study participants, sampling techniques, and sample size. We continue this chapter with a brief description of the data management and analysis plan and conclude by an overview of ethical considerations.

3.1 STUDY DESCRIPTION

3.1.1 *Study Design*

This study was a one group pre-test and post-test design. It is a quasi-experimental design involving one intervention group with observations before and after intervention. LLIN use was assessed weekly at household level in Kayange community for a period of 4 weeks before intervention and for a period of another 4 weeks after intervention (see Box **Study Timeline**). The intervention consisted of a series of iterative tests of change using PDSA cycles.

Study Timeline

1. **Before Intervention**
   - First week: baseline survey
   - Second week: first datapoint
   - Third week: second datapoint
   - Fourth week: third datapoint
   - Fifth week: fourth datapoint
   - Sixth week: baseline data analysis
2. **Intervention**
   - Seventh week: PDSA cycle 1
   - Eighth week: fifth datapoint & PDSA cycle 2
   - Ninth week: sixth datapoint & PDSA cycle 3
   - Tenth week: seventh datapoint & PDSA cycle 4
3. **After Intervention**
   - Eleventh week: eighth datapoint
   - Twelfth week: ninth datapoint
   - Thirteenth week: tenth datapoint
   - Fourteenth week: Eleventh datapoint

3.1.2 *Study Site*

The study was conducted in Kayange community, Nyagatobe site, in north-western Burundi. In Burundi, administrative hierarchical levels are nation, province, commune, zone, and hill. Kayange is a hill located at $-3.2294°$ latitude and $29.4267°$ longitude in commune Rugazi, Province of Bubanza. Nyagatobe is a sub-community of Kayange composed of 96 households.

3.1.3 *Study Population*

The study participants consisted of a household woman or a female household head in each household in Kayange community between the period February and May 2017. Women were chosen to be our study population because they provide more reliable information on LLIN use and were likely to be found at home during our visits.

3.1.4 *Intervention*

Our study used the MFI as the intervention. It is a six-step model whereby the improvement specialist sets an aim, then creates a Quality Improvement Team (QIT) which establishes measures, identifies change actions, tests, and implements the identified change actions. In our study, the QIT was composed of six members and the Principal Investigator (PI) led that team. Before each test of change, a QIT meeting was held to learn from findings and identify a change action that was tested using a PDSA cycle.

3.1.5 *Variables and Operational Definition of Outcome Measures*

In our study, the following continuous and categorical data were collected;
Categorical variables: level of education, marital status and occupation.
Continuous variables: age of participants, number of persons in the household, number of children under 5 years in the household, number of pregnant women in the household, number of LLIN in the household, number of household members who slept under LLIN the previous week, number of children under 5 years who slept underLLIN the previous week, number of pregnant women who slept under LLIN the previous week, number of night of the previous week household members slept under LLIN, number of nights of the previous week children under 5 years who slept under LLIN, and number of nights of the previous week pregnant women slept under LLIN.
Outcome measures: LLIN ownership, LLIN used, persons who slept under LLIN, and the number of nights per week persons slept under LLIN (see Box **Outcome measures & indi-**

cators).

Outcome measures & indicators

1. **LLIN ownership**
   - Proportion of households with at least one LLIN
   - Proportion of households with at least one LLIN for every two people
   - Proportion of people with access to LLIN within their household
2. **People who slept under LLIN**
   - Proportion of household members sleeping under LLIN
   - Proportion of children under 5 years sleeping under LLIN
   - Proportion of pregnant women sleeping under LLIN
3. **Number of nights per week people slept under LLIN**
   - Number of nights per week household members slept under LLIN
   - Number of nights per week children under 5 years slept under LLIN
   - Number of nights per week pregnant women slept under LLIN

3.2 SELECTION OF STUDY POPULATION AND SAMPLING TECHNIQUES

Sampling was not done because our intervention targeted the entire community. All households in Kayange community ($n = 96$) were included in the study provided that they sign the Informed Consent Form (ICF).

3.3 STUDY PROCEDURES

3.3.1 *Data Collection*

Data were collected using an elaborated questionnaire to assess the level of LLIN ownership and use at household level (see Appendix A.0.4). It was translated in Kirundi for better comprehension and data were back-translated to English. The questionnaire

was semi-structured, paper-based, and administered by data collectors. Ten data collectors were identified from Kayange community and trained on data collection. All households in Kayange were assigned a unique identification number and were equally divided among interviewers. Each interviewer was assigned between 8 and 10 households ($n = 96$) and was required to collect data every week. Household visits were conducted on Saturdays during morning hours because in Burundi, people are more likely to be at home on weekends. During each day of data collection, the PI was present to oversee the data collection process. He visited each data collector for a period of 5 to 15 minutes during data collection.

3.3.2 *Baseline Assessment*

In the baseline assessment, socio-demographic data of participants comprising of age, level of education, marital status and occupation were collected. Household data such as the total number of people, the number of children under 5 years old and the number of pregnant women in each household were also collected. In addition, LLIN ownership was documented by asking the number of LLIN possessed in each household.

3.3.3 *Baseline Follow-Up*

Outcome indicators were tracked over a period of four weeks to observe the patterns of LLIN use in Kayange community. We started by summarizing weekly datasets in tabular formats. Secondly, each week's datapoint, which corresponds to each outcome indicator, was plotted on a run chart. For each week, drivers of LLIN non-use and other LLIN misuse were documented and summarized in tables and using histograms.

3.3.4 *Developing and Testing Change Ideas*

This phase started by setting an aim and creating a QIT. Each week's data informed a change action. Change actions were thought and developed by the entire QIT but mostly

tested by the PI who was assisted by one or two members of the team. In total, four change ideas were developed and tested using PDSA cycles.

- **Phase One: Setting an Aim**

The PDSA cycles started by setting an aim. The purpose of the aim was to provide the improvement team with clear and well defined end goals. Below is the overall aim statement agreed upon by the QIT which is specific to each outcome indicator, is measurable and time-bound (see Box **Aim Statement**) .

- **Phase Two: Creating a QIT**

Once the aim is agreed upon, we created a QIT composed of six members. The PI led the team . Two team members were selected from the community – that is one Community Health Worker (CHW) and one community leader. Another one team member was selected from the healthcare facility of Rugazi which is the nearest healthcare centre, while the remaining two members were selected from local NGOs working on malaria, namely Action pour la Lutte contre la Malaria Burundi (ALUMA) and Service Yezu Mwiza (SYM). The QIT received a half-day training on the MFI in order to build their skills. The team members accepted to volunteer for the project by showing up to scheduled meetings and responding to any solicitations that should arise during the study period.

Aim statement

During the next two months, the total number of LLIN possessed ($n = 210$) will be correctly used to reduce LLIN non-use rates. Improvement actions will be tested to increase the number of people (including children under 5 years and pregnant women) who sleep under LLIN by greater than 30% from baseline. All household members (including children under 5 years and pregnant women) will sleep under LLIN all nights of each week.

- *Guidance*

The community of Kayange ($n = 96$ households) will serve as the pilot population for this study. A QIT will be created to study baseline findings and spark creative thinking of improvement actions. Improvement actions will be tested using iterative PDSA cycles. Data will be regularly collected at weekly basis, summarized and data points plotted on run charts to observe patterns before and after each PDSA cycle.

- **Phase Three: Establishing Improvement Measures**

By establishing measures, we wanted to respond to the question; *how will we know that a change is resulting into an improvement?* In order to understand if tested change actions are leading to improvement, we used three different measures (see Box **Outcome, process, and balancing measures**) ;

1. **Outcome Measures** which defined the ultimate goal that the entire improvement process wanted to achieve.
2. **Process Measures** which were specific metrics that helped in assessing whether the process was positively or negatively leading to the outcome metric. Process measures were useful because they provided an opportunity for corrective and adaptive feedback before the failure of the process.
3. **Balancing Measures** which were specific metrics that aimed at tracking any side effects resulting from the actions for improvement. In fact, focusing on improving one or several aspects of a system, sometimes, may impact one or other several aspects of the same system or other interlinked systems.

- **Phase Four: Identifying Change Actions**

For each change action, the QIT had to critically analyze data on major factors affecting LLIN non-use. Findings informed each PDSA cycle. Four different change actions were identified and tested.

Outcome, process, and balancing measures

Outcome indicator number one: Proportion of LLIN used

1. *Outcome measures*
   - Proportion of LLIN used (100%)
2. *Process measures*
   - Number of LLIN used each week
3. *Balancing measures*
   - Number of LLIN torn out due to use

Outcome indicator number two: Proportion of people who slept under LLIN

1. *Outcome measures*
   - Proportion of household members who sleep under LLIN by April 2017 (30% increase)
   - Proportion of children under 5 years who sleep under LLIN by April 2017 (30% increase)
   - Proportion of pregnant women who sleep under LLIN by April 2017 (30% increase)

Outcome, process, and balancing measures

2. *Process measures*
   - Number of household members who sleep under LLIN each week
   - Number of children under 5 years who sleep under LLIN each week
   - Number of pregnant women who sleep under LLIN each week

3. *Balancing measures*
   - Number of people reporting LLIN side effects

Outcome indicator number three: Average number of nights in each week that the people slept under LLIN

1. *Outcome measures*
   - Average number of nights that all household members sleep under LLIN by April 2017
   - Average number of nights that children under 5 years sleep under LLIN by April 2017
   - Average number of nights that pregnant women sleep under LLIN by April 2017

2. *Process measures*
   - Number of nights in each week that all household members sleep under LLIN
   - Number of nights in each week that children under 5 years sleep under LLIN
   - Number of nights in each week that pregnant women sleep under LLIN

3. *Balancing measures*
   - Number of sleepless nights due to sleeping under LLIN

- **Phase Five: Testing Change Actions**

Four change actions were identified and tested using PDSA cycles.

First change action: LLIN hung-up demonstration

Baseline findings informed that *LLIN not hung-up* was the most leading factor associated with LLIN non-use in Kayange community. Therefore, the QIT decided to teach the community on how to hung LLIN up by demonstration and observe whether this action will lead to improvement.

Step One: Plan

During the *Plan* step, the QIT sought to answer a list of questions which later allowed us to compare predictions that we had before the test with what we actually observed during the test;

- What information is important to collect and why is it important?
- Who will collect and analyse the data prior to the next phase?
- When will data be collected and why?

The QIT decided that the teaching session on how to mount LLIN be done by demonstration at the community yard where all community members are invited to show up. The team decided to send the community invitation via usual communication channel which is house-to-house communication usually done by the community leaders or their delegates. The team agreed that the demonstration be done by the PI assisted by two members of the team namely the CHW and the community leader. After the session, it is essential that the community leader repeats the demonstration in front of the community in order to ensure appropriateness of the initiative, gain buy-in and more confidence. Also, it was decided that some community members be randomly chosen and given an opportunity to mount LLIN in presence of the community.

The QIT decided that data collection be done weekly. The team recommended that data on LLIN use and also data on drivers of LLIN non-use be collected using the data collection form that was used during the baseline phase. Data collectors remained the same. The PI, assisted by one member of the QIT, were tasked to clean weekly datasets, summarize and plot datapoints on the run charts. The team convened to meet right after data analysis in order to learn from the current findings.

Step Two: Do

The *Do* step started by engaging and communicating with all the community leaders about the planned LLIN mounting demonstration session. The PI asked the community leaders to invite and mobilize all community members for the demonstration session. The demonstration session was conducted in the morning hours on Saturday 18th of March 2017, from 9.30 a.m. to 11.15 a.m. Usually, this is the right moment when the vast majority of Burundians are at their homes after weeklong activities.

The demonstration was performed by the PI. He was assisted by the CHW and the community leader as planned. The CHW and the community leader brought one LLIN and one bed to simulate a real bedroom. The community lives in poor-condition as such houses with sometimes straw walls that may not be strong enough to maintain spike and hold LLIN for long, we used four pieces of wood of approximately 2 metres long each that we planted in each of the four corners of the bed. The PI hung the LLIN up by tying its four corners onto the four pieces of wood and smoothly and nicely scrolled the LLIN alongside the bed. All the steps of LLIN hunging up demonstration were accompanied by explanations. Community members were given the floor to ask questions, comment or express any concerns. Only one query about where to get the four *so-long* pieces of wood was raised. The PI replied by inviting the whole community to get the pieces of wood from the branches of forest or garden trees. Getting adequate branches was easy because the study community lives near the forest. The rest of the demonstration was perfectly clear, no further concerns were raised. Thereafter, the PI dismounted the LLIN. The CHW, two community leaders and five random volunteers repeated the demonstration by mounting and dismounting the LLIN.

Step Three: Study

During the *Study* step, weekly data on LLIN use and factors affecting its use were collected, summarized and plotted on run charts. The overall objective was to look at what happened, observe the new weekly pattern as compared to the trendline and learn from the findings. The QIT members met to learn from the findings and *act* by thinking about developing a new change action.

Step Four: Act

After the *Study* step, another QIT meeting was convened to refine the change action based on lessons learnt from the first PDSA cycle by critically thinking about another change action and also preparing for the second PDSA cycle.

Second change action: household-level watchdogs

After the first PDSA cycle, findings showed that still *LLIN not hung up* remained the leading cause of LLIN non-use in Kayange community. The QIT thought of an action that can remind household members of mounting LLIN before sleeping. Now that majority of community members know how to mount LLIN, a reminder to do so before sleeping was thought to lead to improvement. Hence, the QIT decided to use household-level *watchdogs*.

Step One: Plan

The plan was to select one person, regardless of gender, in each and every household across Kayange community. The person was named household *watchdog*. The PI, the CHW and the community leader were responsible for selecting *watchdogs* in each and every household in Kayange community. The agreement was that selection of *watchdogs* be done by simple convenience and that *watchdogs* accept to volunteer without expecting any financial or material reward. The role of *watchdogs* was to watch if any of the bedrooms at household level did not have a mounted LLIN before sleeping. If there was a bedroom without a mounted LLIN, *watchdogs* were asked to kindly remind the persons who sleep on the bed to mount the net. Also, *watchdogs* were allowed to write a notice that reads *muribuka kumanika umusegetera* which means *please, you are kindly reminded to mount LLIN* and hang it onto the walls inside each bedroom.

Step Two: Do

During the *Do* step, the PI and the CHW together with the community leader selected one *watchdog* in each household. *Watchdogs* were then called to the community yard to be given key recommendations pertaining to their responsibilities at household level. During the gathering, the PI reminded that *watchdogs* will be volunteering and added that there would be no expectations of reward. The PI informed them of their responsibilities; *"you will be watching if there is any of the bedrooms that does not have a mounted LLIN before sleeping hours. In case you find any, please, remind the persons who sleep onto the concerned bed that they need to mount LLIN first. Also, you are allowed to write a short notice in Kirundi that reads "muribuka kumanika umusegetera"* which means *'please, you are kindly reminded to mount LLIN" and hang it onto the walls inside each bedroom.*

Step Three: Study

During the *Study* step, weekly data were collected, summarized and datapoints plotted using run charts. Our overall aim was to look at what happened, observe the new patterns and compared with previous patterns.

Act

The QIT met again to learn from the new findings and *act* by linking the second PDSA cycle to the third PDSA cycle.

Third change action: two weekly community reminders done by a town-crier

In Burundi, rural community-level message is communicated by town-criers. At evening hours, when all or the majority of community members are in their houses, town-criers circulate throughout the houses announcing the message by passing. Town-criers use small drums to awake the attention of the community. Traditionally, when a small drum sounds during evening hours, the community pays attention to hear the message.

The QIT thought of building upon this existing traditional practice to remind the community of mounting LLIN during evening hours. The reminder was done only twice a week so as to avoid making the intervention burdensome. The town-crier was not given any incentives because it is the usual practice that is done country-wide. In each community, local administration is in charge of incentivizing town-criers.

Step One: Plan

During the *Plan* step, the QIT suggested that the town-crier communicates the message to the community between 7.00 p.m. and 9.00 p.m., that is after the vast majority of people has reached their houses and before the vast majority sleeps. The QIT drafted a clear and concise message that the town-crier had to communicate by producing it exactly as it is written.The message reads; *Dear community members of Kayange hill, Nyagatobe sub-hill, we are reminding you that malaria is a disease that is causing deaths to many people, especially pregnant women and children under 5 years. We therefore take the opportunity to remind you to sleep under LLIN.* The team decided that the message be communicated twice a week; on Saturday and on Tuesday evening hours. Also, the team reminded that data be collected

at weekly basis as usual and the PI, assisted by one member of the team, be tasked to clean, summarize and plot weekly datapoints using run charts. The team convened to meet right after data analysis in order to learn from the new findings.

Step Two: Do

During the *Do* step, the town-crier communicated the reminder message to the community on Saturday evening and again on Tuesday evening. The message was communicated as drafted and agreed upon by the QIT.

Step Three: Study

During the *Study* step, weekly data were collected, summarized and plotted using run charts. Once more, the QIT met to observe the new patterns, be informed by findings, and identify another change action.

Step Four: Act

The QIT realized that all the first three change actions resulted in continued improvement. However, the team was concerned about the improvement sustainability.

Fourth change action: household watchdogs and two weekly reminders done by the town-crier

Improvement sustainability came to be the major concern among the QIT members. Therefore, the team decided to combine the last two change actions and observe the results over the course of four weeks – endline follow-up.

Step One: Plan

During the *Plan* step, the QIT decided to maintain the same reminder message as for during the third test of change. The plan was that the reminder be conducted twice in a week as well; on Saturday and Tuesday at evening hours. In addition, it was agreed that *watchdogs* remind household members to mount LLIN before sleeping as it was done during the second PDSA cycle. The QIT suggested that the combination of two change actions be tested for one week and data be collected weekly for the following four weeks in order to

observe endline improvement patterns.

Step Two: Do

During the *Do* step, the PI and the community leader informed the town-crier to communicate the same reminder. The town-crier did so on Saturday and Tuesday between 7 : 00 p.m. and 9 : 00 p.m. In addition, the PI and the CHW together with the community leader informed the *watchdogs* to remind household members to hung LLIN for another one week.

3.3.5 *Endline Follow-Up*

Weekly data were collected over the course of four weeks. Weekly datasets were summarized in tables and each datapoint, which corresponds to each outcome indicator, was plotted on a run chart. These results are called *endline patterns*. After the fourth test of change, there was no further actions, the QIT did not meet again to think of another change action. All members of the QIT were informed about the improvements achieved during the endline phase.

3.4 DATA MANAGEMENT AND ANALYSIS

Weekly datasets were entered into an Excel Spreadsheet after collection. Data were double-checked for inconsistency and missing values. Any missing values were corrected immediately by checking with the questionnaire. Datasets were saved on a computer hard drive and only researchers (PI and Supervisors) had access to it. In the baseline assessment, descriptive analysis was performed on socio-demographic data. Age, level of education, occupation and marital status of study participants were summarized using frequency tables. Factors associated with LLIN non-use and misuse were also summarized using frequency tables. Each outcome indicator was calculated each week and plotted on a run chart (see Box **Outcome indicators and the analysis plan**).

3.5 ETHICAL CONSIDERATIONS

Ethical clearance and approval for the research was granted by the Medical Health Research Ethics Committee (HREC) of the University of the Witwatersrand before the commencement of the research (see Appendix A.0.5). Also, a local study authorization was obtained from The Ministry of Interior and the Communal Administrator of Rugazi (see Appendix A.0.6). Study participants were informed of the study and informed consent forms were signed (see Appendix A.0.7). Collected data were used strictly for the purposes of this study and were password-protected. Also, confidentiality and anonymity were ensured by using serial numbers during data collection. Names and identifiable data of participants were not documented. Only the researcher and the supervisors had access to the datasets.

Outcome indicators and the analysis plan

Objective 1. Determine the level of LLIN ownership in Kayange community

1.1. *Proportion of households with at least one LLIN*: number of households with at least one LLIN divided by the total number of households in Kayange community.

1.2. *Proportion of households with at least one LLIN for every two people*: number of households with at least one LLIN for every two people divided by the total number of households in Kayange community.

Objective 2. Assess the impact of improvement strategies on level of LLIN use in Kayange community

2.1. *Proportion of LLIN used*: number of LLIN used in each week divided by the total number of LLIN possessed by all households. Weekly proportions of LLIN used were plotted on a run chart over 11 weeks. The run chart had a target line at 100%. The trend line of weekly datapoints was observed to see when it touches the target line.

2.2. *Proportion of household members sleeping under LLIN*: number of household members in all households with LLIN who reportedly slept under LLIN divided by the total number of household members in all households with LLIN. Weekly proportions were plotted on a run chart over 11 weeks. The run chart had a target line at 44.82% (30% increase from 34.48 baseline). The trend line of weekly datapoints was observed to see when it touches the target line.

2.3. *Proportion of children under 5 years sleeping under LLIN*: number of children under 5 years in all households with LLIN who reportedly slept under LLIN divided by the total number of children under 5 years in all households with LLIN. Weekly proportions were plotted on a run chart over 11 weeks. The run chart had a target line at 40.78% (30% increase from 31.37 baseline). The trend line of weekly datapoints was observed to see when it touches the target line.

Outcome Indicators and the Analysis Plan

2.4. *Proportion of pregnant women sleeping under LLIN*: number of pregnant women in all households with LLIN who reportedly slept under LLIN divided by the total number of pregnant women in all households with LLIN. Weekly proportions were plotted on a run chart over 11 weeks. The run chart had a target line at 56.52% (30% increase from 43.48 baseline). The trend line of weekly datapoints was observed to see when it touches the target line.

2.5. *Average number of nights per week all household members slept under LLIN*: total number of nights per week that all household members with access to LLIN slept under it divided by the total number of households in Kayange community with access to LLIN. Weekly averages were plotted on a run chart over 11 weeks. The run chart had a target line at 7 (227% increase from 2.14 baseline) and the trend line of weekly datapoints was observed to see when it touches the target line.

2.6. *Average number of nights per week children under* 5 *years slept under LLIN*: total number of nights per week children under 5 years in all households with access to LLIN slept under it divided by the total number of households with both children under 5 years and access to LLIN in Kayange community. Weekly averages were plotted on a run chart over 11 weeks. The run chart had a target line at 7 (317% increase from 1.68 baseline) and the trend line of weekly datapoints was observed to see when it touches the target line.

2.7. *Average number of nights per week pregnant women slept under LLIN*: total number of nights per week pregnant women in households with access to LLIN slept under it divided by the total number of households with both pregnant women and access to LLIN in Kayange community. Weekly averages were plotted on a run chart over 11 weeks. The run chart had a target line at 7 (346% increase from 1.57 baseline) and the trend line of weekly datapoints was observed to see when it touches the target line.

4

LLIN PDSA RESULTS IN KAYANGE COMMUNITY

The results of this study are presented into two sections; the baseline assessment and the improvement process. In the baseline, we describe the study participants and present demographics in terms of children under 5 years and pregnant women. We also report proportions of LLIN ownership and its use over the course of four weeks. Results are presented as summary tables and graphs were plotted on run charts.

In the second section, we report weekly proportions of LLIN used, the number of people including children under 5 years and pregnant women who slept under LLIN, and the number of nights in each week that people slept under LLIN before, during and after intervention. Results are mainly presented using run charts with only few summary tables and graphs.

4.1 BASELINE ASSESSMENT

4.1.1 *Socio-demographic Characteristics of the Study Participants*

Our study was conducted on a total number of 96 participants, representing each household in Kayange community. The age of participants ranged from 15 to 81 years. Approximately 66% of the participants were aged between 20 and 40 years. Only 3% and 8% of the study participants were aged below 20 years and above 60 years respectively. Majority of the study participants had no formal education. Less than 4% of the participants had reached secondary school while none of the participants reached the university level. Of 96 participants, approximately 70% and 14% were married and widowed respectively, 4% were household heads and 3% divorced. In terms of occupation, majority of participants were full-time household wives and they represented more than 65% (see Table 1).

4.1.2 *LLIN Ownership in Kayange Community*

Of 96 households, 83 (87%) households possessed at least one LLIN. However, only 40 households (42%) possessed at least one LLIN for every two people (see Table 2).

4.1.3 *Pregnant Women and Children under 5 years in Kayange Community*

The community of Kayange has a population of 482 people. Of the 482 population, 110 (23%) were children under 5 years and 23 (5%) were pregnant women (see Table 2).

4.1.4 *Baseline Follow-ups*

The baseline follow-up was conducted over four weeks and data were recorded each week. These follow-ups datasets included the number of LLIN that were used, the number of people who slept under LLIN, the number of children under 5 years who slept under LLIN and the number of pregnant women who slept under LLIN. We analyzed weekly datasets as proportions (see Table 3). Weekly proportions were plotted on run charts to observe the baseline patterns (see Figure 1). The average number of nights in each week that all members in the households, children under five years, and pregnant women slept under LLIN were recorded and plotted on run charts (see Figure 2).

LLIN use before intervention

1. **Percent of LLIN used before Intervention**. Nearly one third of the total number of LLIN possessed in Kayange community ($n = 210$) were used before intervention. There was a slight increase of LLIN used during the third week, but the overall trend remained horizontal (see Figure 1).
2. **Percent of household members who slept under LLIN before intervention**. Approximately 35% of persons in Kayange slept under LLIN. Similar to the number of LLIN that were used before intervention, we noticed a slight increase of persons who slept under LLIN during the third week (see Figure 1).

3. **Percent of children under 5 years who slept under LLIN before intervention**. The number of children under 5 years who slept under LLIN before intervention varied between 28 and 34%. There was a slight downwards trend during the second week with no significant modification of the overall horizontal trend (see Figure 1).

4. **Percent of pregnant women who slept under LLIN before intervention**. The number of pregnant women who slept under LLIN in Kayange significantly increased during the first three weeks and fell down to the bottom during the fourth week. Our investigation did not find any special events or clear explanation that could justify this sudden increase and decrease (see Figure 1).

5. **Average number of nights in each week that all household members slept under LLIN before intervention**. Overall, the weekly averages of the number of nights that the general population slept under LLIN in Kayange did not increase. The general population slept under LLIN only 2 nights in each week before intervention (see Figure 2).

6. **Average number of nights in each week that children under 5 years slept under LLIN before intervention**. There was not significant change in the trend of the weekly average number of nights that children under 5 years slept under LLIN in Kayange before intervention. On the average, children under 5 years slept under LLIN less than 2 nights in each week before intervention (see Figure 2).

7. **Average number of nights in each week that pregnant women slept under LLIN before intervention**. Weekly averages of the number of nights that pregnant women slept under LLIN in Kayange slightly increased during the first three weeks and fell below the initial value during the fourth week. Overall, pregnant women slept under LLIN less than 2 nights in each week before intervention (see Figure 2).

4.1.5 *Baseline Drivers of LLIN non-use in Kayange Community*

In this section, we sought to understand drivers of LLIN non-use in Kayange community. Our baseline findings suggested that most of the factors affecting LLIN use in Kayange community were related to challenges in *hanging up the nets (46%)* (see Table 4).
In addition to drivers of LLIN non-use, we also sought to understand other usage of nets in

the study community by asking participants what else LLIN were used for. Though most of the participants did not disclose what else LLIN were used for (61%), activities such as fishing (20%), night covering (5%) and screens for windows (3%) were noted (see Table 5).

4.2 IMPROVEMENT PROCESS

During our study, none of the participating households ($n = 96$) dropped out. The number of LLIN remained constant all through the study period ($n = 210$). Four women became pregnant ($n = 27$ versus $n = 23$ at the baseline) and among those who were pregnant at baseline ($n = 23$), 7 gave birth over the course of our study period. Also, there was in-migration and out-migration of few people over the course of our study period. We did not consider all the minor demographic variations occurring during each week of the study in our analysis.

4.2.1 *Process and Outcome Measures*

For each outcome indicator, a baseline value was documented (during the baseline assessment) and a target value agreed upon (i.e., the aim statement). Of 7 outcome indicators, the target value was achieved for 3 indicators with significant differences. Target value was not achieved for the rest 4 indicators though significant increase was achieved (see Table 6).

4.2.2 *Effects of the Intervention*

Outcome indicators were monitored weekly before intervention ($\mathtt{total} = 4$ weeks), during intervention ($\mathtt{total} = 3$ weeks) and after intervention ($\mathtt{total} = 4$ weeks). Improvements were noted in all outcome indicators (see Figures 3, 4, 5, 6, 7, 8, 9).
The proportion of LLIN used increased from 32.35% before intervention to 55.72% during intervention and to 75.24% after intervention. The proportion of persons who slept under LLIN increased from 34.48% before intervention to 54.70% during intervention and

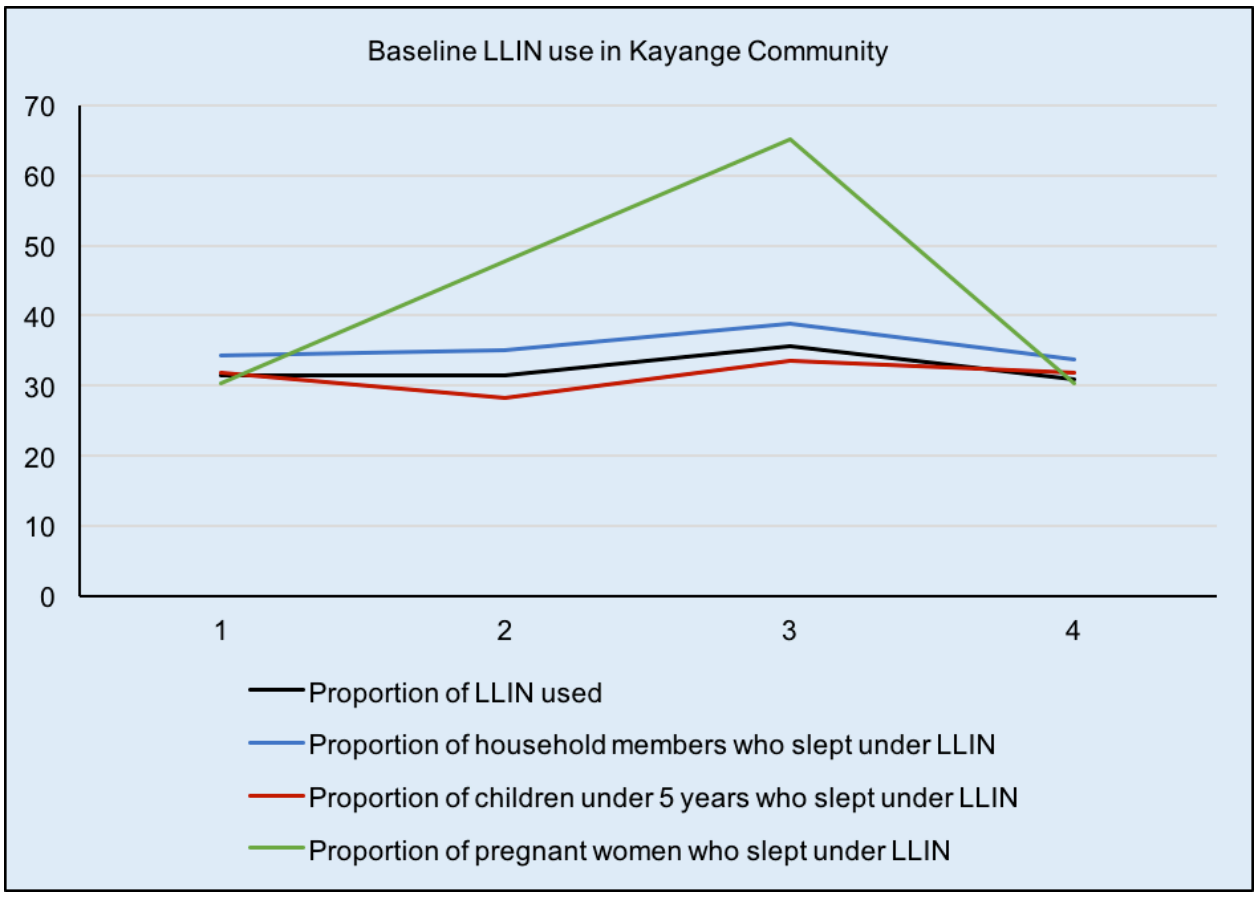


Figure 1: Baseline LLIN use in Kayange community

to 73.14% after intervention. The proportion of children under 5 years who slept under LLIN also increased from 31.37% before intervention to 57.57% during intervention and to 76.59% after intervention. The proportion of pregnant women increased from 43.48% before intervention to 55.07% during intervention and to 73.92% after intervention.

A significant increase in the number of nights that persons slept under LLIN each week was also observed. The average number of nights that the general population slept under LLIN 2.14 increased from intervention, then 3.46 nights during intervention, and 5.11 nights after intervention. For children under 5 years, the number of nights per week increased from 1.68 before intervention to 3.16 during intervention and to 4.78 after intervention. For pregnant women, figures increased from 1.57 before intervention to 2.83 during intervention and to 4.47 after intervention.

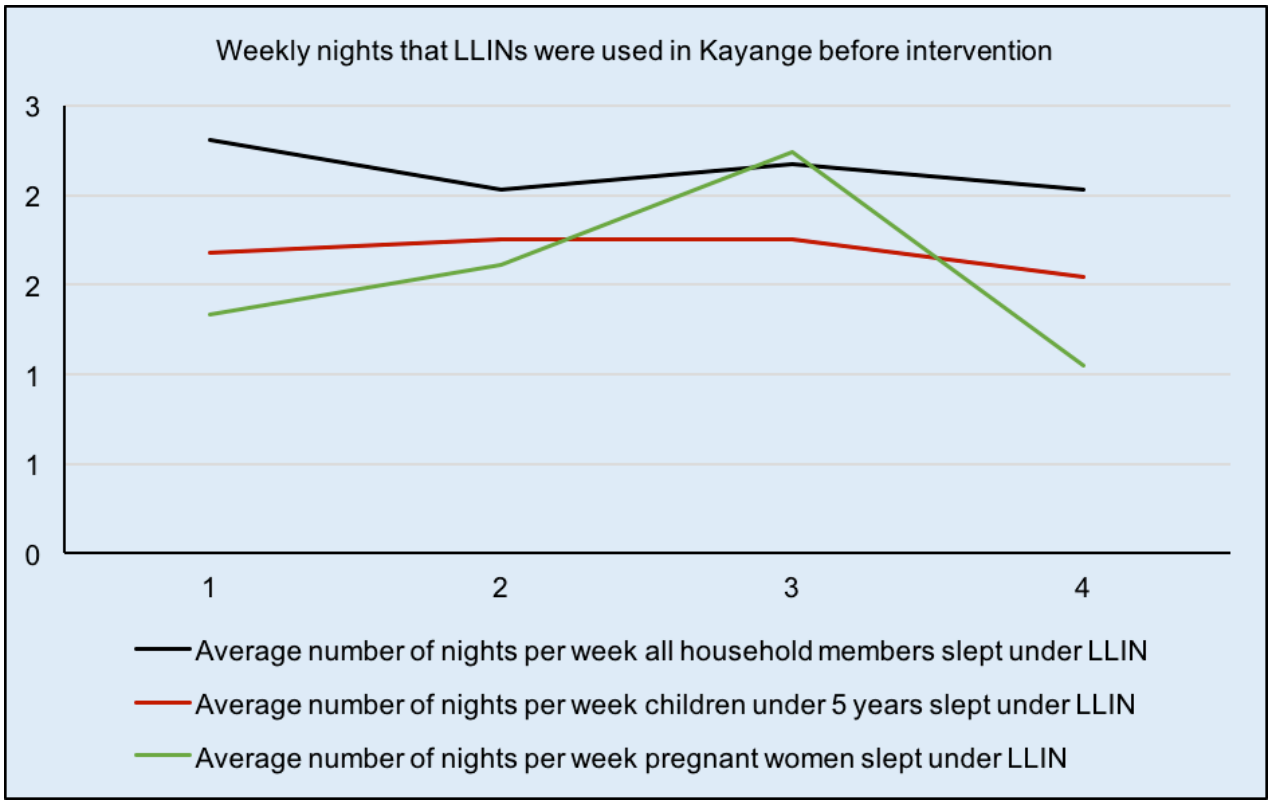


Figure 2: Weekly nights that LLINs were used in Kayange before intervention

Table 1: Socio-demographic characteristics of participants

SOCIO-DEMOGRAPHIC CHARACTERISTIC	NUMBER (N)	PERCENT
Age category		
10-19	3	3.13
20-29	41	42.71
30-39	23	23.96
40-49	7	7.29
50-59	14	14.58
60-69	5	5.21
70-79	2	2.08
80-89	1	1.04
Level of education		
No formal education	62	64.58
Primary	31	32.29
Secondary	3	3.13
Tertiary	0	0.00
Marital status		
Divorced	3	3.13
Married	67	69.79
Separated	9	9.38
Single	4	4.17
Widowed	13	13.54
Occupation		
Farmer	19	19.79
Housewife	62	64.58
Other	62	15.63

Table 2: LLIN ownership in Kayange community

LLIN OWNERSHIP IN KAYANGE COMMUNITY	COUNT	PERCENT
Total number of households	96	
Total number of households with at least one LLIN	83	86.46
Total number of LLIN in the entire community	210	
Households with at least one LLIN for every two people	40	41.67
PREGNANT WOMEN AND CHILDREN UNDER 5 YEARS		
Total number of persons in the entire community	482	
Total number of children under 5 years in the entire community	110	22.82
Total number of pregnant women in the entire community	23	4.77
Total number of households with at least 1 child under 5 years	65	67.71
Total number of households with at least 1 pregnant women	22	22.92

Table 3: Baseline Follow-up: outcome indicators

Outcome indicator	**Week1**	**Week2**	**Week3**	**Week4**
LLIN used (%)	31.43	31.43	35.71	30.82
People using LLIN (%)	34.23	35.06	38.80	33.82
Children under 5 years using LLIN (%)	31.82	28.18	33.64	31.82
Pregnant women using LLIN (%)	30.43	47.83	65.22	30.43
Nights that people use LLIN (weekly average)	2.31	2.03	2.17	2.03
Nights that children under 5 use LLIN (weekly average)	1.68	1.75	1.75	1.54
Nights that pregnant women use LLIN (weekly average)	1.33	1.61	2.24	1.05

Table 4: Drivers of LLIN non-use in Kayange community

Variable (reason of LLIN on-use)	**Total Count (4 Weeks)**	**Percentage**
LLIN Not hung up	175	45.57
Do not know	92	23.96
Too hot	57	14.84
Do not have LLIN	20	5.21
LLIN is bad for health	18	4.69
Other	12	3.13
Not enough LLIN	7	1.82
LLIN in poor condition	2	0.52
Non response	1	0.26
Grand Total	384	100

Table 5: Other usage of LLIN in Kayange community

Variable (Other usage of LLIN)	**Total Count (4 Weeks)**	**Percentage**
Do not know	233	60.68
Fishing	76	19.79
Night covering	21	5.47
Do not have LLIN	20	5.21
Other	18	4.69
Screens for windows	12	3.13
Clothing	2	0.52
Non response	2	0.52
Grand Total	384	100

Table 6: Process and outcome measures of LLIN use in Kayange

Measure	**n**	**BV**	**TV***	**AV**	**Ai**
Proportion of LLIN used	210	32.35	100 *(209% increase)*	75.24	134%
Proportion of persons who slept under LLIN	482	34.48	44.82 *(30% increase)*	73.14	108%
Proportion of children under 5 years who slept under LLIN	110	31.37	40.78 *(30% increase)*	76.59	145%
Proportion of pregnant women who slept under LLIN	23	43.48	56.52 *(30% increase)*	73.92	69%
Number of nights per week persons slept under LLIN	7	2.14	7 *(227% increase)*	5.11	140%
Number of nights per week children under 5 years slept under LLIN	7	1.68	7 *(317% increase)*	4.78	184%
Number of nights per week pregnant women slept under LLIN	7	1.57	7 *(346% increase)*	4.47	186%

n = Sample

BV = Baseline Value

TV* = Target Value (Baseline Value + percent increase)

AV = Achieved Value

Ai = Achieved increase

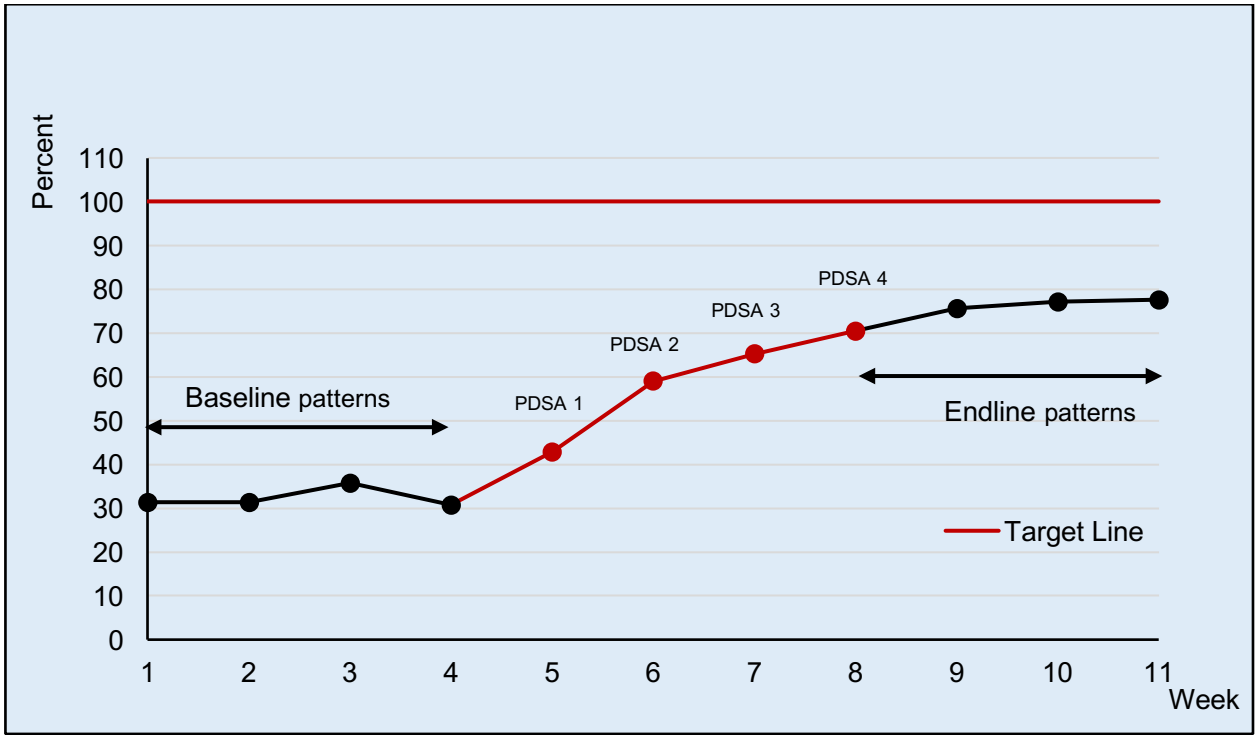


Figure 3: Percent of long-lasting insecticidal nets used in Kayange community

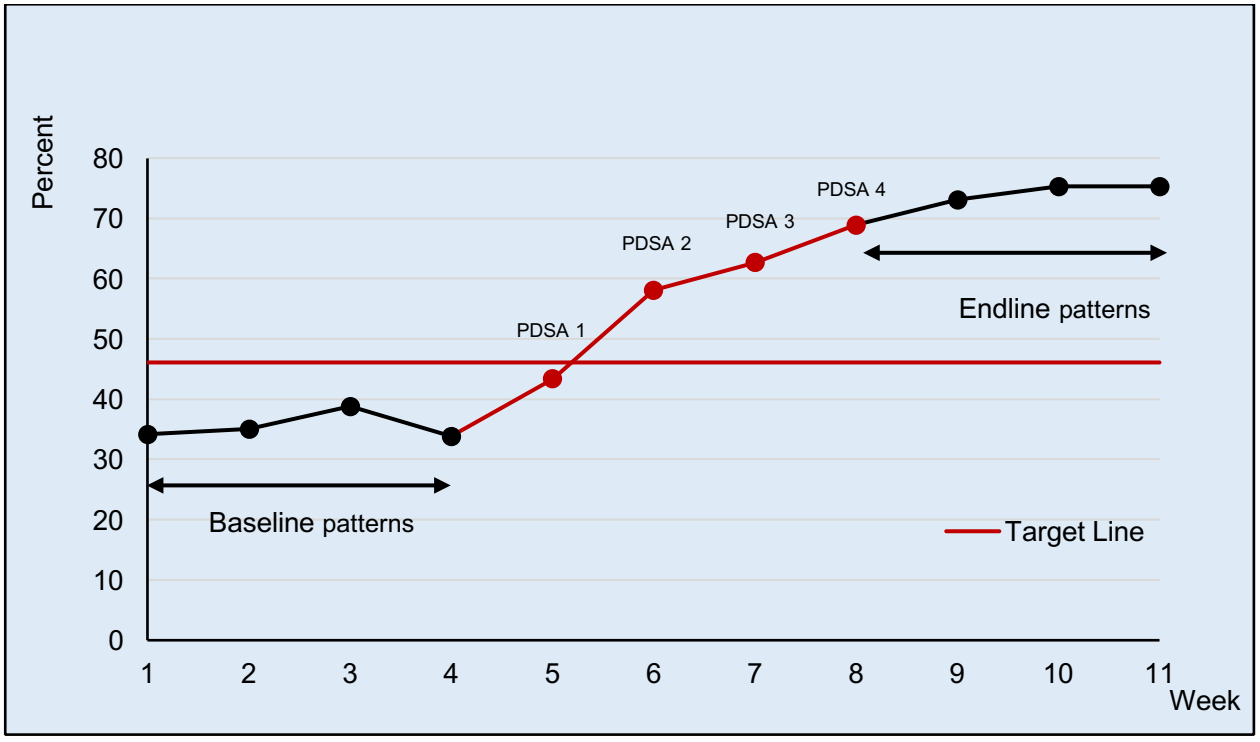


Figure 4: Percent of household members who slept under long-lasting insecticidal nets in Kayange community

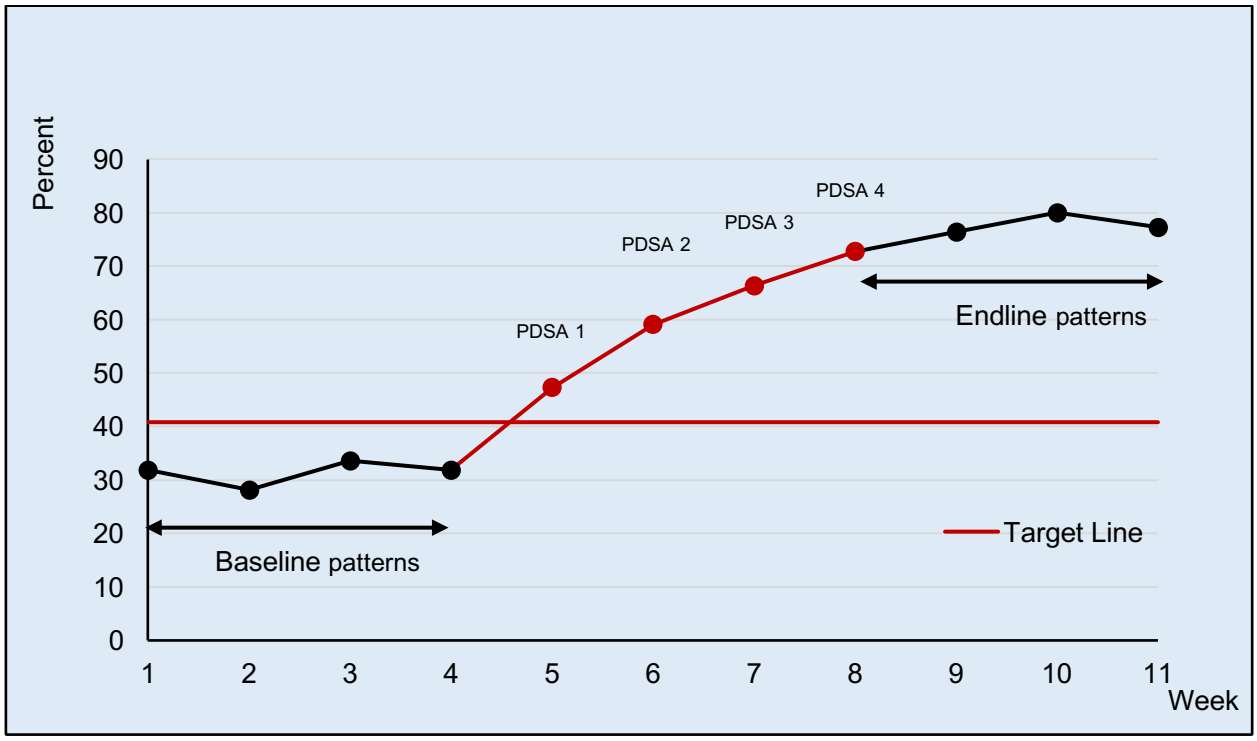


Figure 5: Percent of children under 5 years who slept under long-lasting insecticidal nets in Kayange community

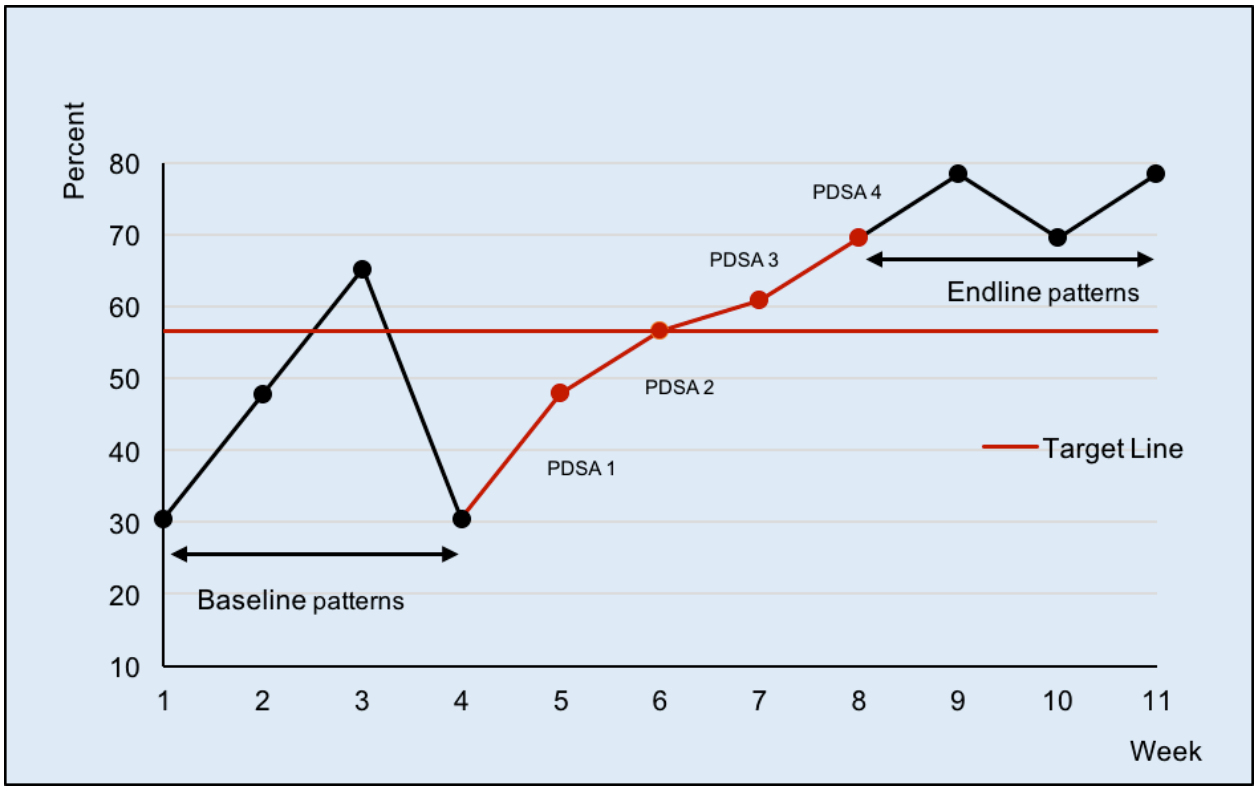


Figure 6: Percent of pregnant women who slept under long-lasting insecticidal nets in Kayange community

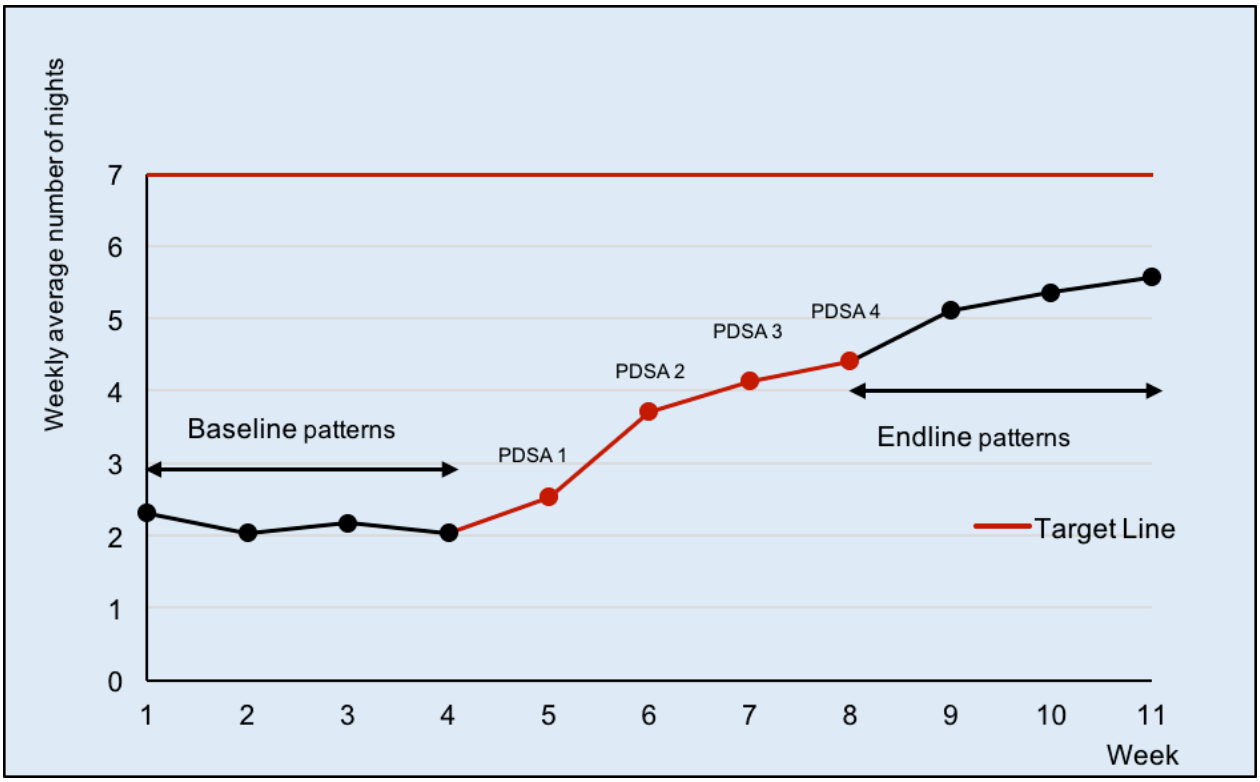


Figure 7: Weekly average number of nights that all household members slept under long-lasting insecticidal nets in Kayange community

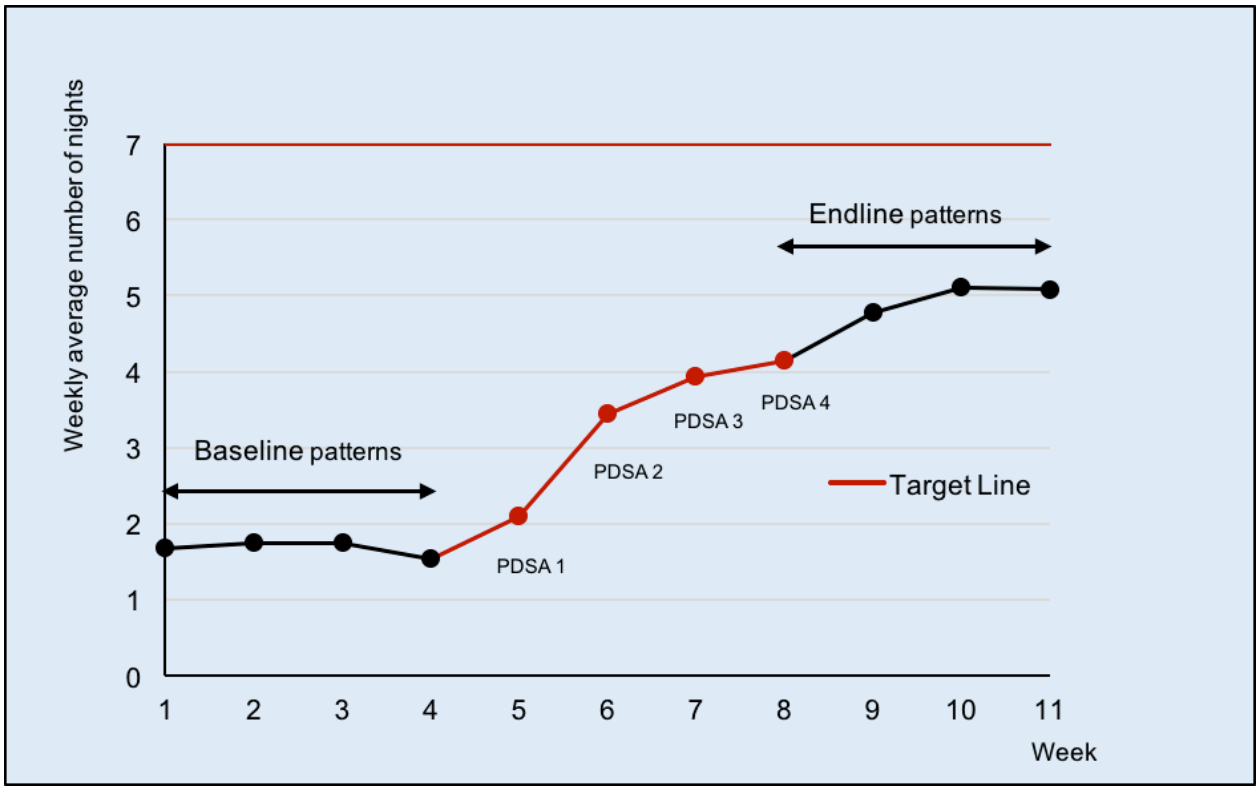


Figure 8: Weekly average number of nights that children under 5 years slept under long-lasting insecticidal nets in Kayange communty

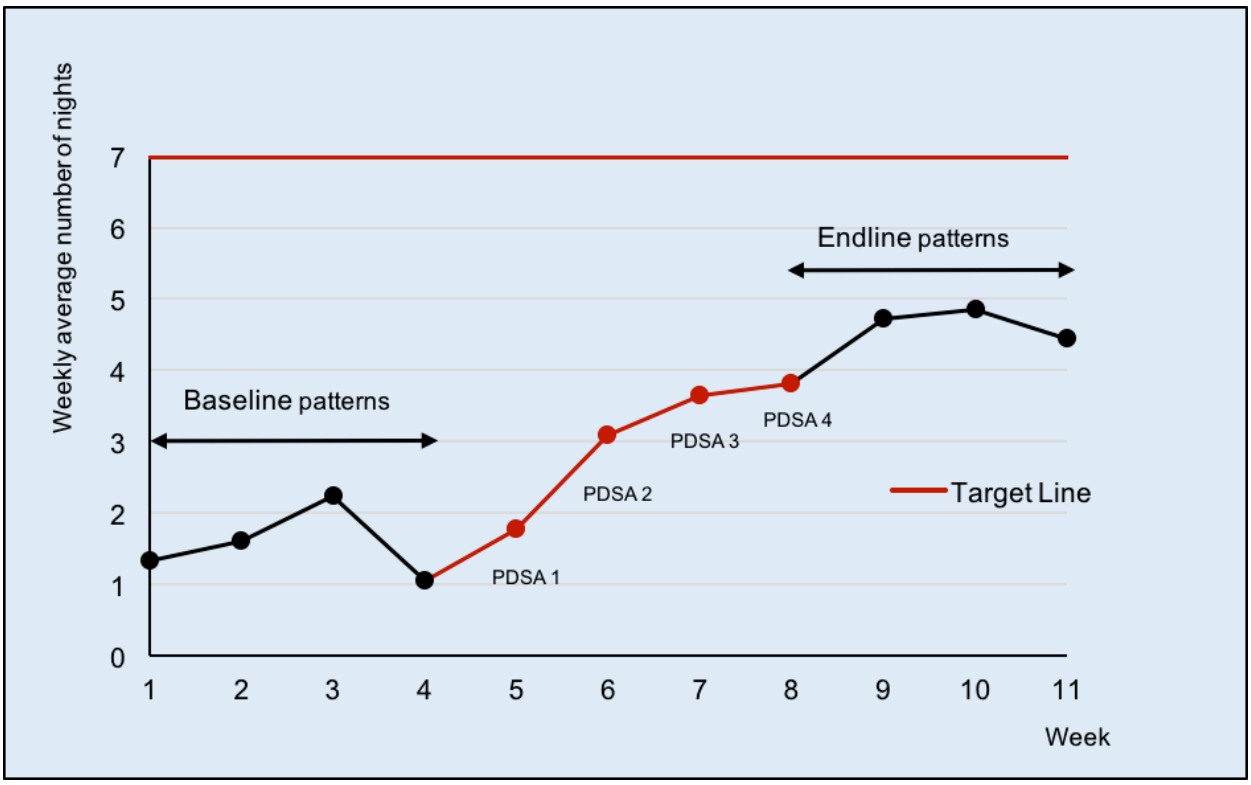


Figure 9: Weekly average number of nights pregnant women slept under long-lasting insecticidal nest in Kayange community

5

DISCUSSIONS OF LLIN PDSA RESULTS IN KAYANGE COMMUNITY

The aim of this study was to assess the level of LLIN ownership and use in Kayange community of north-western Burundi, determine main factors affecting LLIN use in that community and build on that information to identify and test improvement change actions using the MFI. Despite considerable rate of LLIN ownership in Kayange community, baseline findings revealed that its use was low. Our interevention, which used small tests of change, improved the use of LLIN for the entire community and also for pregnant women and children under 5 years.

This chapter presents discussion of the study findings. We discuss the level of LLIN ownership and use in Kayange community by comparing them with other recent findings. We also discussed the factors associated with LLIN use in that community as well as the process for improvement by sharing our real-field experiences. The chapter ends with some implementation science considerations and an overview of the study limitations.

5.1 BASELINE DISCUSSIONS

5.1.1 *LLIN Ownership in Kayange Community*

Proportion of households with at least one LLIN. In our study, 83 households ($n = 96$), that is 87%, possessed at least one LLIN. Our baseline findings were higher than the national average of LLIN possession in Burundi which was 63% in 2012 [15]. Baseline findings were also higher than that of Ahmed S.M. et al. in Uganda in 2010 ($41 - 59\%$) [1]. On the other hand, LLIN possession in Kayange community was lower than that in Ghana after the LLIN mass distribution in 2007 (95.6%) [28]. Our results are comparable to the findings of Esayas K. et al. in Ethiopia who found that 86.4% (95% CI : $85.3 - 87.9$) of households owned at least one bed net in 2016 [37].

Proportion of households with at least one LLIN for every two people. The total number

of LLIN in the community was 210, which means that, at community level, 420 persons (87.5%) had access to at least one LLIN. However, the distribution of LLIN at household level was imbalanced. We observed that, of 96 households, only 40 (42%) possessed at least one LLIN per every two people. In DRC, Ntuku H. M. et al. found that 41.1% of households had at least one LLIN for every two people in 2017, which is very comparable to our findings [55]. However, our baseline results were higher than those of Ayalew S. et al. in Ethiopia which was only 26.1% ($CI : 21.7 - 30.5\%$) of households with at least one LLIN for every two people in 2016 [6].

The level of LLIN ownership in Kayange community was good when compared to national data for previous years and also when compared to data from other countries in SSA. This is due to the bold agenda of the National Malaria Programme to attain LLIN universal coverage – at least one LLIN for every two people in the household – and also the commitment of the government and donors in subsidizing LLIN market.

5.1.2 *LLIN use in Kayange Community*

Proportion of LLIN used. The number of LLIN used compared to the total number of LLIN possessed ($n = 210$), was low (32.35%). This rate is below that of the national survey conducted in 2012 which was 82% [15]. It is also low when compared to the findings from other countries such as DRC (68.3%), Kenya (85%) and Ethiopia (73.5%) [27, 37, 55]. We did not find comparable lower rates of LLIN use from other SSA countries.

Proportion of household members who slept under LLIN. Of the 482 people, 35.48% slept under LLIN before intervention. Our findings are below the national estimates of 2012 which was 47% in rural areas and 63% in urban settings [15]. Likewise, this value is low when compared to DRC (68.3%), Ethiopia (76.1%, 95%$CI : 71.9 - 80.4\%$), Uganda (80.1%) and Kenya (59%) [55, 79]. Our results were however similar to the findings of Thwing J. in Senegal (34.7%) [70].

Proportion of children under 5 years who slept under LLIN. In households with at least one LLIN, our study found that only 31.37% of children under 5 years slept under LLIN during February 2017. This rate was high when compared to the rates of children under 5 years who slept under LLIN in Uganda ($17 - 19\%$) in 2010 [1] but was lower than 60% of

children who slept under LLIN in Rwanda [61]. The proportions of children under 5 years who slept under LLIN were higher in DRC (73.7%), Ethiopia (78.7%), Uganda (83.12%) and Senegal (45.6%) [6, 55, 70, 79].

Proportion of pregnant women who slept under LLIN. At baseline, 43.48% of pregnant women in households owning LLIN slept under it. In Uganda, findings were lower ($25-27\%$) while they were significantly higher in DRC; (74% CI: $63.9-82.2\%$) and in Ethiopia; (71.4% CI: 64.4–78.5%) [1, 6, 55]. Our findings were comparable to that in Senegal (49,2%) in 2011 [70]. The average number of nights per week that the community members slept under LLIN was 2.14 nights for the general population against only 1.68 nights and 1.56 nights for children under 5 years and pregnant women respectively.

Summary of LLIN Use in Kayange Community

In conclusion, our baseline findings proved that LLIN use was low when compared to LLIN ownership in Kayange community. Also, when compared to WHO recommendations and targets, LLIN universal coverage and regular use, LLIN ownership and use were below the targets. The lower rates of LLIN use in the general population can be attributed to factors such as lower level of education (64.58% of residents have no formal education and none of the residents has reached tertiary education) and poverty (64.58% housewives and 19.79% cultivators) (see Table 1). Other factors such as the lack of decent infrastructures may explain the lower rates of LLIN use in this indigenous community of Kayange.

Instead of distributing LLIN to the communities and conducting general sensitization campaigns on LLIN use, the government should focus on identifying context-specific factors related to LLIN non-use in particular settings such as indigenous communities and instruct QI programmes to increase LLIN usage rates.

5.1.3 *Factors Affecting LLIN Use in Kayange Community*

Our findings revealed that most of LLIN were not used because of challenges related to the process of hanging it up (45.57%). Non-disclosed factors accounted for 23.96% while other major factors consisted of hot weather (14.84%) and the lack of LLIN (5.21%). LLIN was used for fishing (19.79%) or night covering (5.47%). Majority of respondents did not reveal what else they used the net for (60.68%). In a study that was conducted in Kenya in

2008, 94.4% ($n = 68$) of LLIN and 84.5% ($n = 239$) bed nets were used for fishing and drying fish respectively [48]. Also, LLIN misuse has been reported in Tanzania where 97.4% of bed nets were used for fishing [46].

Summary of Factors Affecting LLIN Use in Kayange Community

The low level of instruction, lack of knowledge about malaria prevention, lack of knowledge on hanging LLIN up, the unwillingness to sleep under LLIN, ignorance and poor infrastructures can be thought to be among causes of failing to mount LLIN among residents of Kayange.

5.2 THE PROCESS FOR IMPROVEMENT

5.2.1 *Developing The Process for Improvement*

The aim of increasing by greater than 30% from baseline the number of persons (general population), pregnant women, and children under 5 years who sleep under LLIN was more likely achievable. However, the aim of attaining 7 nights every week that all persons (including children under 5 years and pregnant women) sleep under LLIN, which means achieving an increase of at least 227 from baseline was less likely to be achieved especially in a period of three months and with only four PDSA cycles. Also, the aim of attaining 100% of LLIN being used (209% increase) was less likely achievable.

Creating a QIT composed of persons with diverse expertise and background related to malaria control programmes, community health, and monitoring and evaluation was of paramount contribution to the success of the project. The QIT training linked existing skills to the process of improvement using the MFI. Monitoring process and outcome measurement every week was paramount to the success of the project. It was very essential that the change process be supported by measurable data collected over time.

5.2.2 *Testing Change Actions*

After the first PDSA cycle, the proportion of LLIN used increased from 32.35 to 42.86% (32.49% increase), the proportion of persons who slept under LLIN from 35.48 to 43.36% (22, 21% increase), the proportion of children under 5 years who slept under LLIN from 31.37 to 47.27% (50.69% increase) and the proportion of pregnant women who slept under LLIN from 43.48 to 47, 83% (10% increase). The averages of the number of nights in a week that household members slept under LLIN increased from 2.14 to 2.23 (4.20% increase) and from 1.68 to 2.09 (24.40% increase) and 1.56 to 1.77 (13.46% increase) for the general population, children under 5 years and pregnant women respectively.

The second change action increased proportions of LLIN used from 42.86 to 59.05% (37.77% increase), household members who slept under LLIN from 43.36 to 58.09% (33.97% increase), children under 5 years who slept under LLIN from 47.27 to 59.09% (25% increase) and pregnant women who slept under LLIN from 47.83 to 56.52% (18.17% increase). The averages of the number of nights in a week that people slept under LLIN increased from 2.23 to 3.71 (66.37% increase) and from 2.09 to 3.45 (65.07% increase) and 1.77 to 3.09 (74.57% increase) for children under 5 years and pregnant women.

After the third change action, proportions of LLIN used increased from 59.05 to 65.24% (10.48% increase), persons who slept under LLIN from 58.09 to 62.66% (7.87% increase), children under 5 years who slept under LLIN from 59.09 to 66.36% (12.30% increase) and pregnant women who slept under LLIN from 56.52 to 60.87% (7.70% increase). The averages of the number of nights in a week that persons slept under LLIN increased from 3.71 to 4.13 (11.32% increase) and from 3.45 to 3.94 (14.20% increase) and 3.09 to 3.64 (17.80% increase) for children under 5 years and pregnant women.

When we combined the reminders done by household *watchdogs* and the town-crier, proportions of LLIN used increased from 65.24 to 70.48% (8.03% increase), persons who slept under LLIN from 62.66 to 68.88% (9.06% increase), children under 5 years who slept under LLIN from 66.36 to 72.73% (9.60% increase) and pregnant women who slept under LLIN from 60.87 to 69.57% (14.29% increase). The averages of the number of nights in a week that persons slept under LLIN increased from 4.13 to 4.41 (6.78% increase) and from 3.94 to 4.15 (5.33% increase) and 3.64 to 3.38 (4.95% increase) for children under 5 years and pregnant women.

Summary of Test of Change Actions

In conclusion, all the four change actions led to improved results. The improvement was more significant after the two first change actions than it was after the two last actions. After the first change action, the increase in the number of LLIN used and in the number of persons (including children under 5 years and pregnant women) who slept under LLIN was higher than the increase in the number of nights that people slept under LLIN. In order words, many people slept under LLIN but for only a few nights in a week. Hence the need for another change action that aimed at reminding household members to mount LLIN before sleeping.

The second change action, reminding people to mount LLIN, led to a considerable increase in the numbers of persons who slept under LLIN and also a significant increase in the number of nights that people slept under LLIN.

The increase achieved after the two reminders conducted by a town-crier was not considerable when compared to the increase obtained after the reminders done by *watchdogs*.

Of the 7 outcome indicators, the aim was met for 3 indicators which are the number of persons (including children under 5 years and pregnant women) who slept under LLIN. For the rest 4 indicators, we got improvements but did not attain the overall aim.

5.2.3 *Contextual Enablers and Barriers*

Three factors contributed to the significant outcomes of our intervention (see Figure 10) as described by National Implementation Research Network (NIRN) and University of North Carolina at Chapel Hill (UNC).

1. **Effective Intervention.** The Science for Improvement recognizes the MFI as an effective QI evidence-based intervention and recommends its use for QI programmes in healthcare settings.
2. **Effective Implementation.** Contextualized change actions were tested and all steps of the MFI were followed as recommended by evidence-based researches.

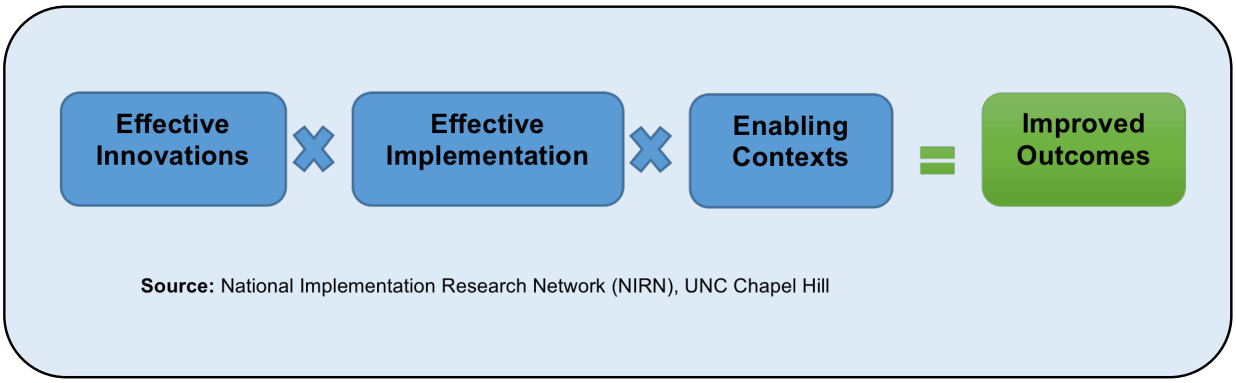


Figure 10: Factors contributing to better intervention outcomes

3. **Enabling Context.** During our study, we gained buy-in from stakeholders, community leaders and the community itself. Also, national and global policies on malaria contributed to the success of our project because LLIN is provided free of charge and improving its use aligns with the overall national and global aim.

Lower level of education, poverty as well low health literacy levels were the main barriers that deserved most attention during our field experience. Engaging and collaborating with stakeholders, community leaders and the community members were key strategies used to overcome barriers to the project success.

5.2.4 *Study Limitations and Strengths*

Our study did not assess the impact of improving LLIN use on malaria outcome in the general population, pregnant women and children under 5 years old. Also, time and financial constraints did not allow us to collect more data in order to observe if the small tests of change have yielded a sustainable LLIN improved use. In addition, our study did not assess implementation outcomes such as *consumer acceptability* and *implementation fidelity* in testing different change actions. Sampling has not been done and hence findings cannot be generalised. Among the strengths of the study include accuracy and completeness of primary data.

6

CONCLUSION, RECOMMENDATIONS & FUTURE DIRECTIONS

6.1 CONCLUSION

The small tests of change have improved the use of LLIN in Kayange community. The number of LLIN used increased from 32 to 75% (134% increase), the number of persons (general population) sleeping under LLIN from 35 to 73% (108% increase), the number of children under 5 years sleeping under LLIN from 31 to 76% (145% increase) and the number of pregnant women who sleep under LLIN from 43 to 73% (69% increase). The averages of the number of nights in a week that household members slept under LLIN increased from 2.13 to 5.11 (140% increase), from 1.68 to 4.78 (184%) and from 1.56 to 4.47 (186% increase) for the general population, children under 5 years and pregnant women.

In conclusion, there has been considerable increase for all the outcome indicators except that the aim was not successfully achieved for all of them. The significant increase of outcome indicators is a result of a combination of an enabling context and an effective implementation of an evidence-based QI intervention (MFI). Time constraint did not allow us to observe impact for extended period of time. If endline data were collected for an extended period, our belief is that achieved outcomes would either stabilize or decrease. The reason is that community improvement projects are not "once-off" interventions, but rather iterative interventions.

6.2 RECOMMENDATIONS

With only four PDSA cycles and within a period of three months, an ascending trend in LLIN use was observed in Kayange community. This serves as a positive token of the possibility of improving LLIN use and better health outcomes. Therefore, we highlight the

need for the following actions:

The government of Burundi and other stakeholders engaged in malaria control programs:

- Identify and implement community-level strategies such as LLIN mounting demonstration associated with community and household level reminders which are easy-to-implement interventions with potential of high impact on malaria prevention. This can be achieved through the engagement of QI experts in collaboration with local administration, community leaders and members.
- Increase the frequency of community mass distribution campaigns of LLIN to meet the WHO recommendation on LLIN coverage.
- Conduct improvement projects on extended periods using time series designs to observe sustainability of impact.

Recommendations from this study have implications to other similar rural and malaria endemic settings in Burundi and potentially, in other LMICs of the SSA and beyond.

6.3 FUTURE DIRECTIONS

Small tests of change at community level have potential of achieving improved outcomes. Beforehand, it is essential to gain collaboration and support from stakeholders and also engage the community. The change package used in our study can be implemented as it is at larger scales but for only similar contexts – rural and poor settings and for a community that is living together and also sharing social norms. However, we are skeptical about scaling our intervention package to different contexts such as middle and high income settings, urban or complex mix of communities. In this case, it is therefore essential that change actions that were used in our study be adapted first and tested before moving to the scale-up phase. Such scalability study has been earmarked to future work.

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APPENDIXES

A.0.1 *Plagiarism Declaration*

A.0.2 *Malaria Lifecycle*

A.0.3 *Model for Improvement*

A.0.4 *Data Collection Form*

A.0.5 *Ethics Clearance*

A.0.6 *Research Authorization*

A.0.7 *Informed Consent Form*

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APPENDIX ONE: PLAGIARISM DECLARATION

I, **Desire Habonimana**, (Student number: **1496643**) am a student

registered for the degree of **MSc in Epidemiology (Implementation Science**) in the academic year 2017.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission

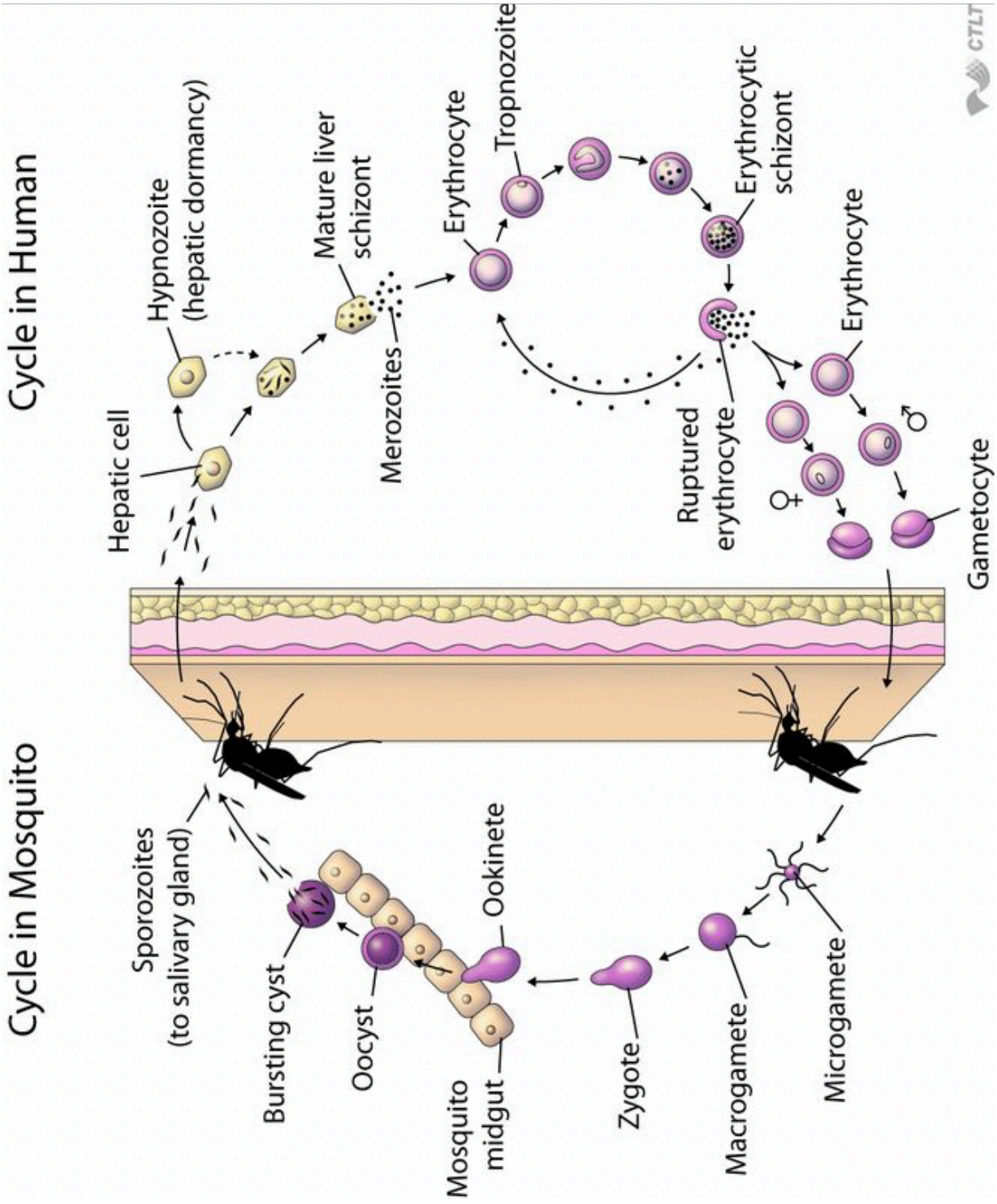
  and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided

  work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against

  me if there is a belief that this is not my own unaided work or that I have failed to

  acknowledge the source of the ideas or words in my writing.

Signature:  Date: June 29, 2017



APPENDIX TWO: MALARIA LIFECYCLE

Source: open public health courses and materials.

APPENDIX 3. THE MODEL FOR IMPROVEMENT

Part 1: Three fundamental questions leading to improvement

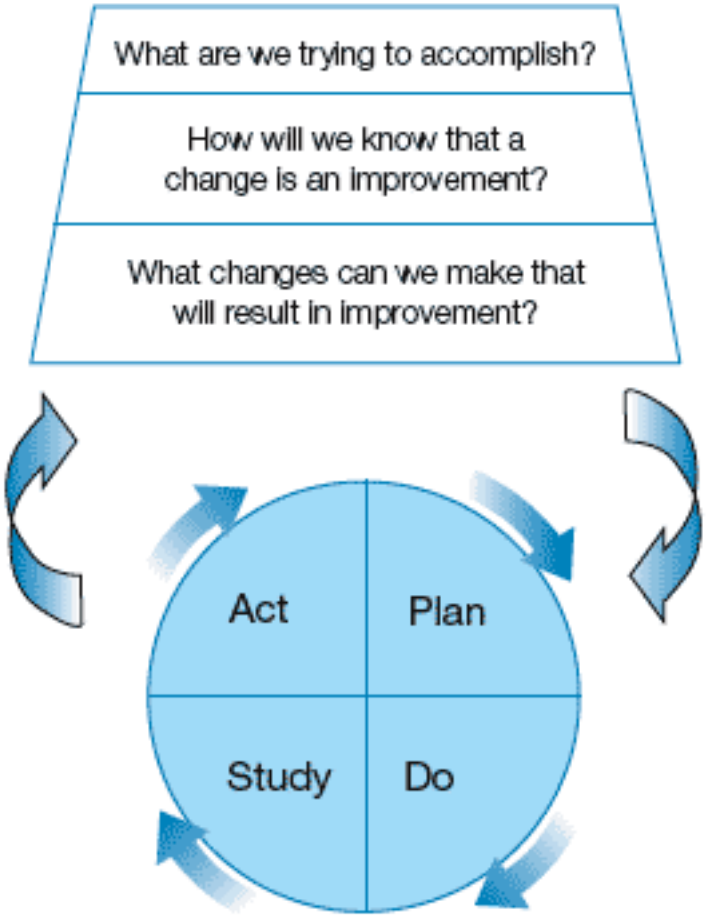
1. **Setting an aim**: What are we trying to accomplish? The aim must be time-specific and measurable and must define the specific population that will be affected by the change.
2. **Establishing measures**: How will we know a change is an improvement? The quality improvement team sets quantitative measures that will help to determine whether a specific change leads to improvement.
3. **Selecting changes**: What change can we make that will result in improvement? Change ideas are clearly identified by the quality improvement team, inspired by those who already work in the system or by experience from other successful improvements.

Part 2: The PDSA Cycles (Plan, Do, Study, Act)

The PDSA cycle is a shorthand for testing a change in the real work setting by planning it, trying it, observing the results, and acting on what is learned.

1. Plan: in this step, the quality improvement team sets specific, measurable, attainable, realistic and timely objectives. The team clearly plan to carry out the change by responding to key questions such as “who?”, “what?”, “where?”, and “when?” The team elaborates the plan for data collection.
2. Do: during this step, the quality improvement team carries out the plan, monitor the process, and record data.
3. Study: this is an analysis step whereby the quality improvement team analyses data, compares results to predictions (objectives), and summarizes learned lessons (what did work? What did not work and why?)
4. Act: building on the learned lessons of the “study” step, the quality improvement team identifies what changes can improve better and the next PDSA cycles start with new improvement strategies.

The PDSA are “iterative”, which means that the quality improvement team tries several strategies, each PDSA cycle testing one set of strategies.



SIX STEPS OF THE MODEL FOR IMPROVEMENT

The six steps that an improvement team must go through when applying the Model for Improvement in a healthcare setting:

1. Set an aim. This is a general statement. The **aim statement** should be time-specific and measurable, stating exactly: “How good?” “By when?” and “For whom?”

2. Form a team. Including the right people is critical when you are changing a complex system. The team should include representatives of all processes affected

by the aim of the improvement team. For example, the group might include a senior leader, multi-disciplinary frontline staff members, and even a patient or two.

3. Establish measures. You need feedback to know if a specific change actually leads to an improvement, and quantitative measures can often provide the best feedback.

4. Identify changes. So, how are you going to achieve your aim? Where do new ideas come from? You can spark creative thinking in various ways, and there are tools that can help.

5. Test changes. This is where the **PDSA cycle** portion of the Model for Improvement comes in. By planning a test of change, trying the plan, observing the results, and acting on what you learn, you will progressively move toward your aim.

6. Implement changes. After you have a change that results in improvement under many conditions, the logical next step is to implement it – meaning, make the change the new standard process in one defined setting.



APPENDIX 4. QUESTIONNAIRE

IMPROVING LONG-LASTING INSECTICIDAL NEST USE IN KAYANGE COMMUNITY OF NORTH-WESTERN BURUNDI: A QUALITY IMPROVEMENT STUDY

INDIVIDUAL QUESTIONNAIRE

Country: Burundi
Province : Bubanza
Commune : Rugazi
Hill : Kayange – Nyagatobe

Household serial number _____

Dear Participant,
Ndi umuganga yiga muri Afrika yepfo, ndiko ndanonosora inyigisho zijanye n'ubushakashatsi mu vy'amagara y'abantu. Iki cigwa turiko turakora kigamije tuteza imbere amagara y'abarundi bifatiye kukugwanya indwara ya Malariya. Twifuza kwiga ukuntu twogwanya malariya mukuryama mumusegetera urimwo umuti wica imibu iminsi yose. Tuzokoresha ubuhinga twize kugira ngo ivyo tubishikeko. Mwebwe rero muri uyu muhana, muri mubantu mwatowe ngo mwunganire muri iki cirwa kibaye irya mbere mu Burundi. Intererano yanyu mukwishura ivyo tuzobabaza irahambaye cane kuko bizotuma tumenya ukuntu tubigenza kugirango dushike kunyishu yo kurwanya malariya. Ntagahato kariwmo, umuntu wese yishura kukibazo yumvise ko kimutomokeye. Tubamenyesheje ko inyishu mutanga tutazozararaza, ni ibanga riri hagati yacu namwe gusa, kandi inyishu mutanga tuzozikoresha muri iki cigwa gusa.
MURAKOZE!

I am a post-graduate student studying towards my MSc in Epidemiology in the field of implementation Science at the University of the Witwatersrand, Johannesburg South Africa. The aim of my study is to improve long-lasting insecticidal nets usage in Muyange community using small tests of change. Your household was selected for the survey that will be conducted by my research team. I believe that my study would make a contribution to improving long-lasting insecticidal nets service by the government and overall plan for addressing the scourge of mosquito's infestation and malaria transmission in Muyange community and Burundi at large.
As one of the selected respondents, your views are invaluable to the success of this study. Your responses to the questions are highly appreciated and it should not take more than twenty minutes of your time and we want to thank you in advance for your co-operation. We guarantee that all information will be handled with the utmost CONFIDENTIALITY. Thank you very much.

Dr. Desire Habonimana & Research Team Members.

Section 1: Socio-demographic characteristics of respondents		
No	**IKIBAZO/***Question*	**Inyishu/**Response
101	Wavutse ryari? *What is your age?*	
102	Wize gushika mumwaka wakangahe? *What is your level of education?*	1. Primary _____ 2. Secondary _____ 3. Tertiary _____ 4. No formal education _____
103	Urubatse? *What is your marital status?*	1. Single _____ 2. Married _____ 3. Divorced _____ 4. Separated _____ 5. Windowed _____ 6. No answer _____
104	Ukazi usanzwe ukora ni akahe? *What is your occupation?*	1. Full-time housewife_____ 2. Civil servant _____ 2. Trader _____ 3. Farmer _____ 4. Other (specify)_____

Section 2: Household data		
No	**IKIBAZO/***Question*	**Inyishu/**Response
201	Muri bangahe muri iyi nzu? *How many people are there in this house?*	
202	Ni bangahe bansangira kunkoko imwe? *How many people in this house eat from the sate pot?*	
203	Muhise abana bangahe baru munsi y'imyaka 5? *How many children under 5 are in this household?*	
204	Mufise abagore bibungze bangahe muriyi nzu? *How many pregnant women are in this household?*	

Section 3: LLIN ownership		
No	**IKIBAZO/***Question*	**Inyishu/**Response
301	Murafise umusegetera muri iyi nzu? *Do you have any LLIN in your household?*	1. Yes ____ 2. No_____
302	Mufise imisegereta ingahe muri iyi nzu? *How many LLIN do you have in your household?*	

Section 4: Reasons for LLIN non-use		
401	Imvo nyamukuru ituma mutaryama mumusegetera ni iyihe? *What is the main reason that you prefer not to sleep under LLIN?* **Record one answer**	1. Too hot _____ 2. Too cold _____ 3. Not enough nets _____ 4. Net not hung up _____ 5. Net used by someone else _____ 6. Net worn out or poor condition ___ 7. Net bad for health _____ 8. Other (specify) _____ 9. Don't know _____
402	Mwarigeze gukoresha umusegetera muri kimwe canke vyinshi bijanye no … *Have you ever used LLIN for any of the following?* **Multiple responses possible**	1. Fishing _____ 2. Covering or protection _____ 3. Screens for windows _____ 4. Clothing _____ 5. Other (specify) _____ 6. Don't know _____

Section 5: LLIN weekly use
Household serial number _____

No	IKIBAZO/*Question*	W1	W2	W3	W4	W5	W6	W7	W8
501	Mwakoresheje imisegetera ingahe mundwi iheze? How many LLIN were used in this household last week?								
502	Nibangahe baryamye mumusegetera mundwi iheze? How many household members slept under LLIN last week?								
503	Abana bari munsi y'imyaka 5 baryamye mumusegetera ni bangahe mundwi iheze? How many children under 5 years slept under LLIN last week?								
504	Abagore bibungenze baryamye mumusegetera ni bangahe mundwi iheze? How many pregnant women slept under LLIN last week?								
505	Abantu bose hamwe muri iyi nzu baryamye mumusegetera amajoro angahe mundwi iheze? How many nights in the last week did all household members sleep under LLIN?								
506	Abana bari munsi y'imyaka 5 baryamye mumusegetera amajoro angahe mundwi iheze? How many nights in the last week did children under 5 sleep under LLIN?								
507	Abagore bibungenze baryamye mumusegetera amajoro angahe mundwi iheze? How many nights in the last week did pregnant women sleep under LLIN?								

R14/49 Dr Desire Habonimana

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M1611101

NAME: (Principal Investigator)	Dr Desire Habonimana
DEPARTMENT:	Epidemiology and Biostatistics School of Public Health Kayange Community, Nyagatobe Site, Bubanza Province, Burundi
PROJECT TITLE:	Improving Long-Lasting Insecticidal Nets use in Kayange Community of North-Western Burundi: A Quality Improvement Study
DATE CONSIDERED:	25/11/2016
DECISION:	Approved unconditionally
CONDITIONS:	Phase One
SUPERVISOR:	Dr Gideon Nimako and Prof Gabriel Ndayisaba
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	25/01/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in November and will therefore be due in the month of November each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date 27/01/2017

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

REPUBLIC OF BURUNDI
MINISTRY OF INTERIOR
PROVINCE OF BUBANZA
COMMUNE RUGAZI

Re: Letter of research authorization

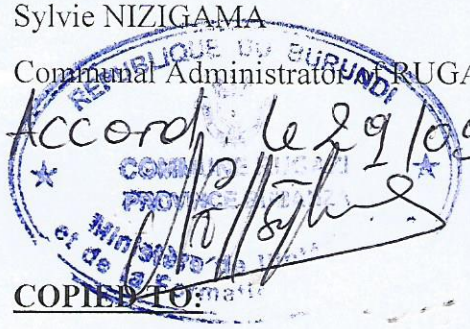
Dear Dr. Desire Habonimana
Post-graduate student 1496643
University of the Witwatersrand, Johannesburg.

We are writing to inform you that you have been authorized to carry the research "**Improving long lasting insecticidal nets use in Kayange community of North-Western Burundi: a quality improvement project**" in the populations and households of the community of Kayange, Commune Rugazi of the Province of Bubanza, Republic of Burundi.

The present authorization is valid for the period going from October 2016 to December 2018.

We look forward to your collaboration.

Yours sincerely,
Sylvie NIZIGAMA
Communal Administrator of RUGAZI



Accord le 29/09/2016

COPIED TO:

- The Minister of Interior and Patriotic Training
- The Governor of Bubanza Province

The Republic of Burundi

APPENDIX 7: PARTICIPANTS' INFORMATION SHEET AND CONSENT FORM

Good Day.

My name is Desire Habonimana. I am a Masters student in the Division of Epidemiology and Biostatistics, School of Public Health at the University of the Witwatersrand, Johannesburg, South Africa. I am conducting a study in order to assess the ownership of long-lasting insecticidal nets and try to improve their use in the community of Kayange. The use of long-lasting insecticidal nets in this community will enhance primarily child and maternal health, and also the population health as a community.

The reason why I am conducting this study is because malaria incidence has not decreased despite the government's policy to distribute long-lasting insecticidal nets free of charge to pregnant women attending ante-natal care settings, mothers attending clinics for childhood immunization, and also through regular community mass distribution campaigns. That implies that possession of long-lasting insecticidal nets does not necessarily mean the use of long-lasting insecticidal nets, hence the need to implement some community level strategies aimed at improving the use long-lasting insecticidal nets.

As a community member and also a household woman who nurses children and oversees household activities, I would like to invite you to participate in this study because your response is important. Before you decide to take part, you need to understand why the research is being conducted and what would be required of you. Therefore, take your time to read this information sheet carefully. Please ask any question if anything you have read is not clear or would like further information.

The entire survey will take about 15 to 20 minutes. The survey is confidential and anonymous. This is guaranteed by not needing to indicate your name while being interviewed. If you decide to take part in this study, be assured that your participation is voluntary and you are free to withdraw at any time without giving any reason. There is no risk, penalty or loss of benefits whether you participate or not.

The information from this study will elucidate questions about ownership and use of long-lasting insecticidal nets in community. Data collected will be compiled in a thesis report, and may be shared in publications or presentations. However, your identity will not be shared whatever the reason.

If you have any concerns or questions regarding any aspect of this study or wish to obtain a summary of the results of the survey, please kindly contact me on the following details:

Name: Desire Habonimana
Tel: +257 79 573 694
Email: 1496643@students.wits.ac.za | habonimanadesirefr@gmail.com

University of Witwatersrand | WITS
Human Research Ethics Committee (Medical)

1. Chairperson: peter.cleaton-jones1@wits.ac.za
2. Administrators:
   - Ms. ZaneleNdlovu
   - Mr. RhulaniMkansi
   - Mr. Lebo Moeng

   Tel : 011 717 2700/2656/1234/1252
   Email : HREC-Medical.ResearchOffice@wits.ac.za

University of Burundi, Faculty of Medicine
Prof. Gabriel Ndayisaba
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E-mail: gndayisaba@yahoo.fr