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FACTORS ASSOCIATED WITH OWNERSHIP AND UTILIZATION OF LONG-LASTING INSECTICIDAL NETS IN RWANDA: ANALYSIS FROM NATIONAL MALARIA INDICATOR SURVEY 2017

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Abstract:

Malaria remains a life-threatening disease, particularly in sub-Saharan Africa, including Rwanda. In Rwanda, Long-Lasting Insecticidal Nets (LLINs) are the primary method for malaria prevention and control. However, despite efforts to improve access, the use of LLINs remains inconsistent. In 2018, the World Health Organization reported that while 72% of households globally had at least one ITN, only 50% of at-risk individuals were using them. This study aims to assess the factors influencing the ownership and utilization of LLINs in Rwanda, using data from the 2017 Malaria Indicators Survey

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This study draws on data from Rwanda's 2017 Malaria Indicators Survey to examine the factors affecting the ownership and use of long-lasting insecticidal nets (LLINs) for malaria prevention. Data from 5,041 households were analyzed using SPSS, employing descriptive and bivariate methods to explore the relationship between socio-demographic variables and LLIN ownership and usage. Binary logistic regression was applied to identify the key factors influencing LLIN ownership and usage, with statistical significance set at $p < 0.05$, while adjusting for potential confounders.

The results show that LLIN ownership is common in Rwanda, with 86% of households reporting they own at least one. Of these, 83% use the nets for malaria prevention. Several factors significantly influence LLIN ownership, including age, marital status, household wealth, the presence of young children, awareness of malaria, and pregnancy. For example, older individuals are more likely to own LLINs (AOR=1.93), while married individuals are even more likely (AOR=4.76), suggesting that household structure plays an important role. Wealthier households are also more likely to own LLINs (AOR range: 2.13-3.22), highlighting the impact of financial resources. Additionally, households with children under five and those with greater malaria awareness show higher ownership rates.

LLIN utilization is also shaped by various factors such as marital status, wealth, rural residence, and access to information from Community Health Workers (CHWs). Married individuals are

twice as likely to use LLINs (AOR=2.04), and wealthier households report higher usage (AOR=2.15). However, rural households are less likely to use LLINs (AOR=0.56), possibly due to limited access or awareness. Malaria awareness (AOR=1.46) and information from CHWs (AOR=1.66) positively influence LLIN usage, highlighting the importance of health education and targeted interventions. These findings underscore the need for focused efforts to promote LLIN use, particularly in rural areas, through education and community health initiatives.

While LLIN ownership rates are relatively high, there remain disparities in utilization, highlighting the need for targeted interventions to enhance community awareness and address socio-demographic barriers.

Key words: *Long-Lasting Insecticidal Nets, Ownership, utilization, factors, National Malaria Indicator Survey 2017.*

1. Introduction

Malaria remains a significant global health issue, particularly in tropical regions, causing high levels of illness and death (Dhiman, 2019). The disease is transmitted to humans by female Anopheles mosquitoes, with Plasmodium falciparum and Plasmodium vivax being the most common strains in endemic areas (WHO, 2019). Despite being preventable and treatable, malaria continues to severely impact both health and livelihoods(WHO, 2018). In 2022, the World Health Organization (WHO) reported 249 million malaria cases worldwide, with the African region bearing the brunt of the burden, accounting for 94% of global cases (233 million) (WHO,202).

Moreover, between 2000 and 2019, malaria case incidence declined from 82 to 57 cases per 1,000 people at risk but rose to 59 in 2020, remaining stable in 2021. The increase from 2019 to 2021 was linked to disruptions in medical services during the COVID-19 pandemic (WHO, 2022). Various initiatives have been implemented to combat malaria, including the Roll Back Malaria (RBM) program, the Global Technical Strategy for Malaria 2016-2030 (GTSM), and the President's Malaria Initiative (PMI)(WHO, 2017, 2018). Efforts to control malaria vectors, such as Indoor Residual Spraying (IRS), distribution of insecticide-treated nets (ITNs), rapid diagnostic tests, and artemisinin-based combination therapies (ACTs), have also been strengthened (WHO, 2015a). Despite these strategies, 90.1% of people in Sub-Saharan Africa still live in malaria-endemic areas, falling short of the GTSM goal to reduce malaria incidence by 75% by 2015, with a target of 90% by 2030.

The Global Technical Strategy for Malaria (GTSM) aimed to eliminate malaria in 20 countries by 2025 and 30 by 2030(WHO, 2015. However, by 2022, only 49% of people at risk in Africa were sleeping under insecticide-treated nets (ITNs), with household ITN coverage at 40%, down from 45% in 2010. Challenges such as high malaria burden, insufficient funding, and drug resistance

hinder progress (WHO, 2018. Rwanda experienced significant success in malaria control between 2005 and 2011, with an 85% reduction in malaria incidence and notable drops in outpatient cases, inpatient deaths, and slide positivity rates. Despite an increase in malaria cases from 2012 to 2016, a decline was observed from July 2021 to June 2022, with incidence dropping from 114 to 76 per 1,000 people and the slide positivity rate decreasing from 27% to 22% (Karema et al., 2020; MoH, 2022).

According to the 2014-2015 Demographic and Health Survey (DHS), 81% of Rwandan households owned at least one long-lasting insecticidal net (LLIN), rising to 84% in the 2017 Rwanda Malaria Indicators Survey (RMIS) (NISR, 2015). However, only 55% of households had one LLIN per two people in 2017(MoH, 2017b). By 2019-2020, 67% of households owned at least one mosquito net, but only 48% reported using it, with 34% having an ITN for every two people. The survey also found that 78% of available ITNs were used the night before the survey.

This implies that there is still big gap between possession and usage of ITNs in the households regardless the observed substantial decline in malaria morbidity and mortality. Hence, the ownership and usage of LLINs might have be affected by intra-household factors like usage of nets for other purpose, family sleeping arrangements, family size, level of education, selection of the people to sleep under LLINs among others (De Sousa et al., 2019; Nuwamanya et al., 2018; Raghavendra et al., 2017; Solomon et al., 2019; Tassew, Hopkins, & Deressa, 2017).

Environmental factors also including heat embarrassment, status of the weather and type of housing were found to influence the usage of LLINs (Aberese-Ako et al., 2019; Fokam et al., 2017). Therefore, there is currently a lack of comprehensive information regarding the factors that influence LLIN ownership and usage in Rwanda, as the 2017 RMIS report did not delve deeply into these issues. Thus, this study aims to address this gap by providing evidence on the determinants of LLIN ownership and usage, which is essential for informing policymakers, guiding program implementation, and developing more tailored interventions. The main goal of this study is to evaluate the factors related to the ownership and usage of bed nets for malaria prevention in Rwanda, utilizing data from the 2017 Malaria Indicators Survey. The study will focus on the following specific aims:

- To evaluate the extent of LLIN ownership among households in Rwanda.
- To analyze the rate of LLIN utilization within households in Rwanda.
- To investigate the factors that influence LLIN ownership among Rwandan households.
- To examine the factors that impact the utilization of LLINs among households in Rwanda.

2. Research Methodology

2.1. Research design

This study is based on the analysis of secondary data of some variables of the Rwanda Malaria Indicator Survey (RMIS) conducted in 2017 with aim to assess factors associated with ownership and utilization of LLINs in Rwanda. Using secondary data of some variables of RMIS 2017 has been chosen because it was observed a big discrepancy between the ownership and utilization of LLINs/ITNs within household and many studies (including RMIS 2017) confirmed this difference. The RMIS 2017 collected various related data to factors which might contribute to identified situation, but these factors were not explored while they could provide evidences for country representative.

The 2017 RMIS was a cross-sectional household survey designed to update demographic and health indicators related to malaria. It collected data on household ownership of LLINs, healthcare-seeking behaviors among adults, and the management of fever in children. Additionally, it assessed knowledge of malaria prevention and control among women of reproductive age (15-49 years).

The primary focus of this study was on heads of households, while knowledge regarding malaria prevention and control was specifically evaluated among women aged 15 to 49. Participants included residents of the household or any individual present in the household the night before the RMIS 2017.

2.2. Sampling techniques

The RMIS 2017 was used to assess the key factors influencing the LLINs ownership and utilization at national level in both rural and urban through two-stage sample design. Firstly, the clusters were selected from the sampling frame, this involved enumeration areas (EAs) with reference to data from Rwandan Population and Housing Census of 2012. A total of 170 clusters using probability proportional size were selected from those EAs. Secondary, the households were selected using systematic sampling. The households were listed from all selected EAs, and the 30 households from this list were randomly selected making a total sample size of 5,100 households. For the analysis of knowledge related to malaria prevention and control, a subset of 5,022 women interviewed in the RMIS 2017 was included.

2.3. Data collection analysis methods

The data utilized in this study were extracted from the RMIS 2017 and are stored in SPSS file format within the DHS Program Database. This data is publicly accessible online at DHS Program. Access to the data was obtained by completing an online request form, detailing the study's title and objectives, which allowed for retrieval of various related datasets.

During the RMIS 2017, three questionnaires were employed to collect nationally representative data pertinent to population and health issues in each region. These included the household questionnaire, the women's questionnaire, and the biomarker questionnaire. For this study, the data extracted were specifically from the Household and Women's questionnaires to identify factors associated with the ownership and utilization of Insecticide-Treated Bed Nets in Rwanda.

Before importing the dataset into SPSS, the file format was verified, and the relevant variables of interest were confirmed. Appropriate statistical analysis methods that matched the dataset structure and the intended outcomes were also reviewed prior to the actual data analysis.

3. Research findings and Discussion

3.1. Demographic Characteristics of Respondents

This section analyzes the demographic characteristics of respondents from the National Malaria Indicator Survey 2017 in Rwanda, focusing on factors such as age, gender, and education level. Understanding this demographic profile is essential for identifying disparities in bed net ownership and utilization, as well as for informing targeted interventions to enhance coverage rates. The examination aims to uncover patterns and associations that can help improve malaria prevention efforts.

Table 1: Demographic characteristics of respondents

Characteristics	Frequency (N=5041)	Percent (%)
Household Head Age		
<21	67	1.3
21-30	924	18.3
31-40	1,382	27.4
41-50	990	19.6
51-60	853	17.0
60 and above	825	16.3
Household Head Sex		
Male	3146	62.4
Female	1895	37.6
Marital status		
Never married	392	7.8
Married	2365	46.9
Living together	1067	21.2
Widowed	940	18.7
Divorced	206	4.1
Not living with partner	71	1.4
Residence		

Urban	1024	20.3
Rural	4017	79.7
Under five children		
None	2508	49.8
Only One	1638	32.5
More than one	895	17.8
Household Members		
Only 1	516	10.2
2-5	3457	68.6
6-9	1052	20.9
10 and above	17	0.3

Source: Analysis of Rwanda Malaria indicators survey 2017

A demographic analysis of 5,041 household heads shows a significant concentration in the middle-aged groups, particularly those aged 31 to 40 (27.4%) and 41 to 50 (19.6%), together making up nearly half of the sample. The youngest group, under 21, comprises only 1.3%, while older categories (51-60 and 60+) account for 33.3%, indicating many are nearing retirement. In terms of gender, 62.4% of household heads are male, reflecting traditional roles in decision-making. Marital status reveals that 46.9% are married and 21.2% live with a partner, suggesting stable family structures that may influence resource distribution and health behaviors.

A notable urban-rural divide exists, with 79.7% of household heads residing in rural areas, affecting access to healthcare and malaria prevention resources. Nearly half of the households (49.8%) do not have young children, while 32.5% have one, and 17.8% have more than one, highlighting a need for targeted malaria prevention strategies for households with children. These demographic insights emphasize the importance of tailored interventions and communication strategies, particularly in rural areas, to enhance malaria prevention efforts in Rwanda. Household size exhibited variability, with the majority consisting of 2-5 members (68.6%), potentially influencing bed net distribution and utilization practices. The socioeconomic characteristics of households surveyed in the National Malaria Indicator Survey 2017 in Rwanda offer valuable insights into factors potentially influencing bed net ownership and utilization.

Table 2: Socioeconomic characteristics of respondents

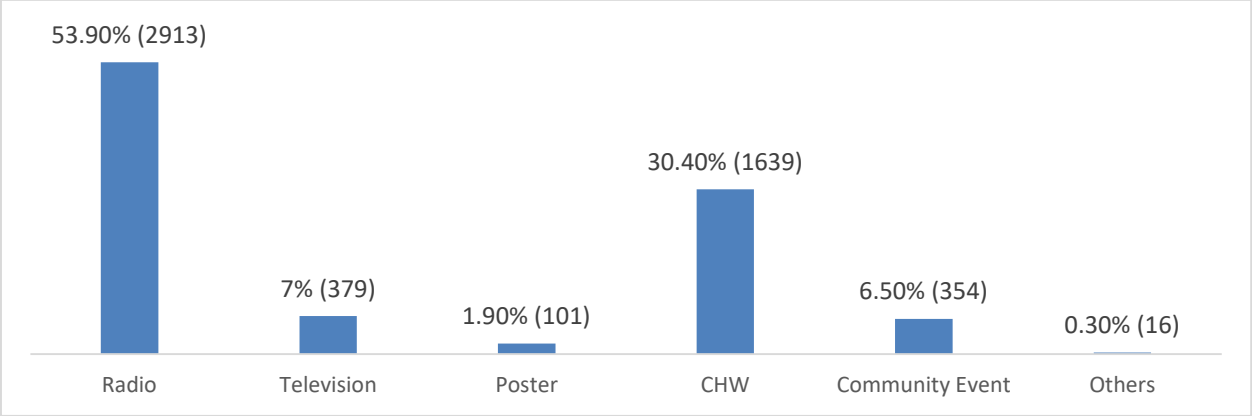
Characteristics	**Frequency (N=5041)**	**Percent (%)**
Wealth		
Poorer	1129	22
Middle	1034	21
Richer	943	19
Richest	916	18

Roof Material		
No roof	3	0.1
Sod	13	0.3
Metal	3356	66.6
Wood	14	0.3
Ceramic	1599	31.7
Cement	37	0.7
Roofing	20	0.4
Children sleeping under NET		
None	360	7.2
All children	1574	31.2
Some children	130	2.6
No net	248	4.9
Not sure	2728	54.1
House Floor material		
Earth/sand	3564	70.7
Dung	52	1.0
Ceramic tiles	62	1.2
Cement	1311	26.0
Carpet	13	0.3
Bricks	27	0.5
Other	11	0.2

Source: Analysis of Rwanda Malaria indicators survey 2017

A survey of 5,041 respondents reveals a diverse range of socioeconomic conditions, with 22% classified as poorer and a fairly balanced distribution among the middle (21%), richer (19%), and richest (18%) wealth categories. The quality of housing is reflected in the types of roofing materials used, with 66.6% of households having metal roofs and 31.7% using ceramic. However, it is concerning that 54.1% of respondents were unsure whether their children utilized bed nets, and only 31.2% reported that all their children slept under one, highlighting a significant gap in prevention efforts. Additionally, 70.7% of households have earth or sand floors, which may negatively affect hygiene and health. These findings underscore the pressing need for targeted interventions to raise awareness and improve access to bed nets for children. Additionally, the survey also investigated sources of information about malaria in Rwanda to assess the level of awareness among citizens, with the results illustrated in the figure below.

Figure 1: Sources of information about Malaria



Source: Analysis of Rwanda Malaria indicators survey 2017

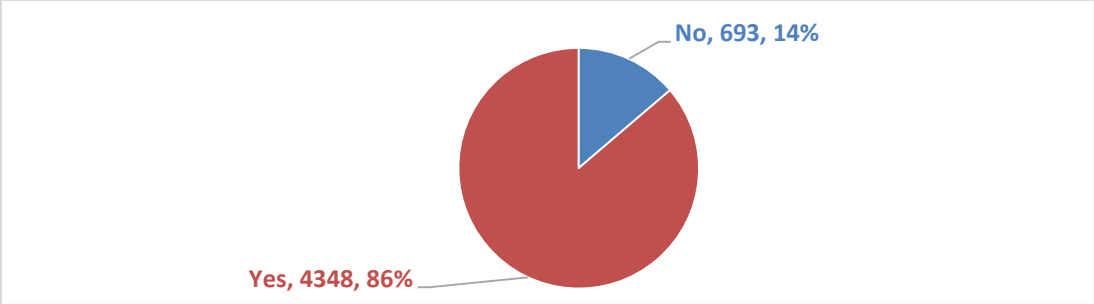
The information presented in the figure 1, indicates that radio is the primary source of information about malaria in Rwanda, used by 53.9% of respondents, particularly effective in rural areas. Community Health Workers (CHWs) also contribute significantly, informing 30.4% of the population, underscoring the value of localized health education. In contrast, television (7.0%), posters (1.9%), and community events (6.5%) are less effective, indicating they may not adequately engage the community. The low usage of other sources (0.3%) highlights the need for targeted communication strategies that capitalize on the popularity of radio and CHWs to effectively disseminate crucial malaria-related information.

3.2 Presentation of findings

This section details the results of analysis which focus on four specific objectives regarding the ownership and utilization of Long-Lasting Insecticidal Nets (LLINs) among households in Rwanda. Firstly, we determine the level of LLIN ownership, providing insights into the prevalence and distribution of these essential malaria prevention tools across the country. Secondly, we assess the level of LLIN utilization among households, examining the extent to which these nets are being effectively utilized for malaria prevention. Thirdly, we analyze the factors associated with LLIN ownership, aiming to identify key determinants influencing the adoption of these interventions. Lastly, we investigate the factors associated with LLIN utilization, seeking to understand the factors influencing the proper use of LLINs among households in Rwanda. Through these analyses, we contribute valuable insights to malaria control efforts in Rwanda, informing the development of targeted strategies to enhance LLIN coverage and maximize their impact on public health outcomes.

The descriptive analysis was carried out to find the ownership level of LLINs among households surveyed. The following figure, indicate the results from the analysis.

Figure 2: LLIN ownership by Rwanda's households



Source: Analysis of Rwanda Malaria indicators survey 2017

The descriptive analysis indicates that a large majority of households in Rwanda (86%) possess Long-Lasting Insecticidal Nets (LLINs), while a smaller portion (14%) do not, as shown in Figure 2. The main sources of these LLINs are shown in the table below.

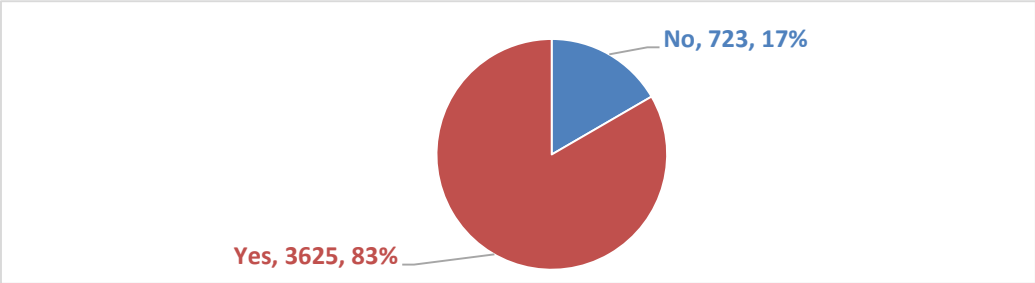
Table 3: The source of LLINs among respondents

Source of NET	Frequency (N = 4348)	Percent (%)
Pharmacy	726	16.7
Government health facility	548	12.6
Shop/market	391	9.0
CHW	235	5.4
Religious institution	48	1.1
School	35	0.8
Other	2217	51.0
Don't know	148	3.4

Source: Analysis of Rwanda Malaria indicators survey 2017

The sources of bed nets among households in Rwanda display a diverse distribution, with "Other" sources comprising the majority (51.0%), likely including community distributions and NGO initiatives. Pharmacies are another significant source (16.7%), while government health facilities (12.6%) play a critical role in formal distribution programs. Shops and markets (9.1%) and Community Health Workers (5.4%) also help ensure access to bed nets, underscoring the importance of a multi-sectoral approach. Further analysis shows that 92.7% of households received LLINs through mass campaigns, 6.2% through antenatal care services, and 1.1% via immunization programs. The utilization of LLINs was also examined, with the findings illustrated in the figure below.

Figure 3: The utilization proportion of LLINs among respondents



Source: Analysis of Rwanda Malaria indicators survey 2017

The results on LLIN utilization among respondents show that out of 4,348 households that own LLINs, a significant majority (3,625 households, or 83%) report using Long-Lasting Insecticidal Nets, while a smaller proportion of 723 households (17%) do not utilize them. This high level of LLIN usage indicates strong adherence to malaria prevention practices among Rwandan households. Additionally, exploring the reasons for non-utilization proved valuable, with the findings presented in the table below.

Table 4: : Reasons for not utilizing the LLINs

Reason for not utilization	Frequency (N=723)	Percent (%)
Too hot	37	5.1
Too cold	2	0.3
Net used for other purposes	22	3.1
Net not hanged	327	45.2
Bugs in net	44	6.0
Other	205	28.4
Net too old	72	10.0
Don't know	13	1.8

Source: Analysis of Rwanda Malaria indicators survey 2017

The study also explored the reasons for not using LLINs, with the majority (45.2%, or 327 respondents) citing the nets were not hung as the primary reason. Additionally, 10% (72 respondents) mentioned that their LLINs were too old, while 28.4% (205 respondents) gave various other reasons.

A bivariate analysis of factors associated with LLIN ownership among households in Rwanda was conducted using the chi-square test. This analysis examines the relationships between

demographic, economic, and awareness-related factors and LLIN ownership, identifying key determinants that influence the likelihood of owning LLINs. The results are discussed in the following paragraphs.

Table 5: Bivariate Analysis of factors associated with ownership of LLINs among households in Rwanda

Association of factors with ownership of LLINs				
Characteristics	**No, N(%)**	**Yes, N(%)**	**Chi-square**	**P-Value**
Household Head Age			**4.781**	**<0.01**
<21	32 (48.5)	35 (51.5)		
21-30	176 (19.0)	748 (81.0)		
31-40	153 (11.1)	1229 (88.9)		
41-50	124 (12.5)	866 (87.5)		
51-60	98 (11.5)	755 (88.5)		
60 and Above	105 (12.7)	720 (87.3)		
Household Head Sex			47.123	0.273
Male	415 (13.2)	2731 (86.8)		
Female	271 (14.3)	1624 (85.7)		
Marital status			1.827	**<0.01**
Never married	138 (35.2)	254 (64.8)		
Married	187 (7.9)	2178 (92.1)		
Living together	182 (17.1)	885 (82.9)		
Widowed	118 (12.6)	822 (87.4)		
Divorced	45 (21.8)	161 (78.2)		
Not living with partner	18 (24.7)	53 (75.3)		
Wealth			31.932	**0.002**
Poorer	164 (14.5)	965 (85.5)		
Middle	111 (10.7)	923 (89.3)		
Richer	94 (10.1)	849 (90.0)		
Richest	107 (11.7)	809 (88.3)		
Residence			252.5	0.582
Urban	139 (13.6)	885 (86.4)		
Rural	550 (13.7)	3471 (79.7)		
Under five children			11.823	**<0.01**
None	411 (16.4)	2097 (83.6)		
Only One	188 (11.5)	1450 (88.5)		
More than one	88 (9.8)	807 (90.2)		
Pregnancy status			4.821	**<0.01**

No or unsure	675 (13.6)	86 (86.4)		
Yes	11 (14.0)	86 (86.0)		
Roof Material			261.8	0.826
No roof	1 (29.3)	2 (70.7)		
Sod	5 (36.5)	8 (63.5)		
Metal	483 (14.4)	2873 (85.6)		
Wood	3 (21.4)	11 (78.6)		
Ceramic	182 (11.4)	1417 (88.6)		
Cement	8 (21.3)	29 (78.7)		
Roofing	5 (23.2)	15 (76.8)		
Heard about Malaria			4.813	**0.027**
No	45 (17.2)	215 (82.8)		
Yes	637 (13.6)	4047 (86.4)		
Don't know	5 (5.6)	93 (94.4)		
Household Members			71.62	**0.031**
Only 1	140 (27.1)	376 (72.9)		
2-5	453 (13.1)	3004 (86.9)		
6-9	92 (8.8)	960 (91.3)		
10 and Above	1 (8.5)	16 (91.5)		
Source of information			42.715	0.391
Radio	431 (14.8)	2482 (85.2)		
Television	52 (13.6)	327 (86.4)		
Poster	5 (4.7)	96 (95.3)		
CHW	198 (12.1)	1441 (87.9)		
Community Event	50 (14.1)	304 (85.9)		
Else	1 (6.2)	15 (93.8)		

Source: Analysis of Rwanda Malaria indicators survey 2017

The bivariate analysis highlights several significant factors related to LLIN ownership among households in Rwanda. Households led by younger heads (<21 years) have notably lower ownership rates (51.5%) compared to those led by older heads, particularly those aged 31-40, where ownership reaches 88.9% (Chi-square = 4.781, $p < 0.01$). Married households also demonstrate higher ownership (92.1%) compared to never-married households (64.8%) (Chi-square = 1.827, $p < 0.01$). Wealth status plays a significant role, with wealthier households exhibiting higher ownership rates (90.0%) compared to poorer households (85.5%) (Chi-square = 31.932, $p = 0.002$). Households with children under five years old show greater ownership (88.5% and 90.2% for households with one or more children, respectively) compared to those without children (83.6%) (Chi-square = 11.823, $p < 0.01$).

Malaria awareness also correlates with higher LLIN ownership, with 86.4% ownership among those aware of malaria, compared to 82.8% among those unaware (Chi-square = 4.813, p = 0.027). Additionally, larger households (6-9 members) report higher ownership rates (91.3%) compared to single-member households (72.9%) (Chi-square = 71.62, p = 0.031). These findings underscore the critical role of demographic, economic, and awareness-related factors in LLIN ownership. Furthermore, a multivariate analysis was conducted to explore the demographic and socioeconomic determinants influencing LLIN ownership, using odds ratios (ORs) and 95% confidence intervals (CIs) to quantify the strength of these associations. Furthermore, the assessment of factors associated with ownership of LLINs was investigated and findings were presented in the table below.

Table 6: Multivariate analysis of factors associated with ownership of LLINs among respondents

Factors associated with ownership of LLINs			
Characteristics	**AOR**	**95% CI**	**P-value**
Household Head Age			
<21			
21-30	1.93	[1.08 - 3.42]	**0.03**
31-40	2.49	[1.39 - 4.44]	**<0.01**
41-50	2.18	[1.22 - 3.90]	**<0.01**
51-60	2.42	[1.27 - 4.54]	**<0.01**
60 and Above	2.46	[1.26 - 4.58]	**<0.01**
Marital status			
Never married			
Married	4.76	[3.08 - 7.37]	**<0.01**
Living together	2.38	[1.56 - 3.63]	**<0.01**
Widowed	3.38	[2.24 - 5.12]	0.09
Divorced	1.85	[1.10 - 3.11]	0.12
Not living with partner	1.48	[0.73 - 3.00]	0.27
Wealth			
Poorer	1.55	[1.21 - 1.98]	**<0.01**
Middle	2.13	[1.54 - 2.95]	**<0.01**
Richer	2.41	[1.70 - 3.42]	**<0.01**
Richest	3.22	[2.08 - 4.98]	**<0.01**
Under five children			
None			
Only One	1.24	[1.05 - 1.55]	**0.01**
More than one	1.39	[1.00 - 1.94]	**0.04**
Pregnancy status			
No or unsure			

Yes	3.44	[1.42 - 6.07]	**0.03**
Heard about Malaria			
No			
Yes	4.34	[1.83 - 10.29]	**<0.01**
Don't know	1.24	[0.79 - 1.93]	0.35
Household Members			
Only 1			
2-5	1.37	[1.01 - 1.84]	**0.04**
6-9	1.38	[0.94 - 2.03]	0.10
10 and above	1.19	[0.23 - 6.25]	0.84

Source: Analysis of Rwanda Malaria indicators survey 2017

The logistic regression analysis demonstrated that households with older heads are more likely to own LLINs, with the likelihood increasing as the household head's age rises. For instance, households led by individuals aged 31-40 years have 2.5 times higher odds of owning LLINs compared to those with younger heads (AOR: 2.49, 95% CI: 1.39-4.44, $p < 0.01$). Marital status is another important factor, with married individuals having nearly five times higher odds of owning LLINs compared to those who have never married (AOR: 4.76, 95% CI: 3.08-7.37, $p < 0.01$).

Economic status strongly influences LLIN ownership, as wealthier households are significantly more likely to own LLINs. The richest households have over three times the odds of owning LLINs compared to the poorest (AOR: 3.22, 95% CI: 2.08-4.98, $p < 0.01$). Additionally, households with young children under five years old are 1.4 times more likely to own LLINs if they have more than one child (AOR: 1.39, 95% CI: 1.00-1.94, $p = 0.04$). Similarly, households with a pregnant member are 3.4 times more likely to own LLINs compared to those without a pregnant member (AOR: 3.44, 95% CI: 1.42-6.07, $p = 0.03$). Awareness of malaria also significantly increases ownership, with informed households having over four times higher odds of owning LLINs (AOR: 4.34, 95% CI: 1.83-10.29, $p < 0.01$). Additionally, household size plays a role, with households of 2-5 members having higher odds of ownership compared to single-member households (AOR: 1.37, 95% CI: 1.01-1.84, $p = 0.04$). The bivariate analysis explores the connections between various demographic, economic, and household characteristics and the use of Long-Lasting Insecticidal Nets (LLINs) among Rwandan households. Chi-square tests reveal significant relationships between these factors and LLIN utilization, pinpointing areas where disparities in net use are evident.

Table 7: Bivariate analysis of factors associated with utilization of LLINs

Characteristics	Factors associated with utilization of LLINs			
	No N (%)	Yes N (%)	Chi-Square	P-Value
Household Head Age			11.452	0.271
<21	9 (24.0)	29 (76.0)		
21-30	107 (13.5)	680 (86.4)		
31-40	179 (14.7)	1041 (85.3)		
41-50	147 (17.5)	691 (82.5)		
51-60	139 (18.5)	610 (81.5)		
60 and Above	140 (19.6)	575 (80.4)		
Household Head Sex			4.12	<0.01
Male	416 (15.6)	2256 (84.4)		
Female	308 (18.4)	1367 (81.6)		
Marital status			12.73	0.072
Never married	55 (18.4)	245 (81.6)		
Married	301 (14.2)	1820 (85.8)		
Living t	154 (17.4)	732 (82.6)		
Widowed	168 (20.6)	649 (79.4)		
Divorced	35 (21.1)	132 (78.9)		
Not living together	9 (17.2)	45 (82.8)		
Wealth			28.09	0.03
Poorest	179 (20.2)	703 (79.8)		
Poorer	181 (21.2)	672 (78.8)		
Middle	131 (16.3)	674 (83.7)		
Richer	118 (14.6)	686 (85.4)		
Richest	106 (10.6)	898 (89.4)		
Residence			1.823	<0.01
Urban	117 (11.4)	907 (88.6)		
Rural	597 (18.0)	2727 (82.0)		
Under five children			30.251	0.04
None	375 (17.8)	1733 (82.2)		
Only One	222 (15.3)	1227 (84.7)		
More than one	126 (15.9)	665 (84.1)		
Pregnancy status			21.96	0.528
No or unsure	717 (16.7)	3561 (83.3)		
Yes	6 (8.6)	70 (91.4)		
Roof Material			47.92	0.082
No roof	1 (60.8)	1 (39.2)		
Sod	2 (21.0)	7 (79.0)		

Metal	490 (17.3)	2345 (82.7)		
Wood	3 (24.6)	10 (75.4)		
Ceramic	220 (15.3)	1221 (84.7)		
Cement	3 (10.9)	26 (89.1)		
Roofing	3 (15.2)	16 (84.8)		
Heard about Malaria			22.84	0.07
No	58 (25.1)	173 (74.9)		
Yes	649 (16.2)	3356 (83.8)		
Don't know	17 (14.9)	94 (85.1)		
Household Members			17.83	0.46
Only 1	70 (17.9)	319 (82.1)		
2-5	492 (16.4)	2508 (83.6)		
6-9	159 (16.9)	784 (83.1)		
10 and Above	2 (11.3)	14 (88.7)		
Source of info			13.26	0.043
Radio	445 (19.1)	1883 (80.9)		
Television	49 (15.8)	263 (84.2)		
Poster	3 (3.4)	87 (96.6)		
CHW	167 (12.6)	1162 (87.4)		
Event	56 (20.2)	221 (79.8)		
Else	3 (21.5)	9 (78.5)		
Floor material			1.94	0.027
Earth/sand	536 (18.3)	2394 (81.7)		
Dung	11 (21.8)	39 (78.2)		
Ceramic	14 (21.9)	52 (78.1)		
Cement	147 (12.2)	1057 (87.8)		
Carpet	1 (6.8)	17 (93.2)		
Bricks	0 (0.0)	71 (100.0)		
Other	5 (54.5)	5 (45.5)		

Source: Analysis of Rwanda Malaria indicators survey 2017

Additionally, the Logistic regression analysis of factors associated with utilization of LLINs was also done in this study. This logistic regression analysis focuses on identifying the factors significantly associated with the utilization of Long-Lasting Insecticidal Nets (LLINs) among households in Rwanda. The variables included in this analysis were those that emerged as significant in the preceding bivariate analysis.

Table 8: Multivariable Analysis: Logistic regression analysis of factors associated with utilization of LLINs

Characteristics	Factors associated with Utilization of LLINs		
	AOR	95% CI	P-value
Household Head Sex			
Male	1*		
Female	0.82	[0.69 - 0.97]	**0.02**
Wealth			
Poorest	1*		
Poorer	0.94	[0.73 - 1.22]	0.65
Middle	1.3	[1.03 - 1.64]	**0.03**
Richer	1.48	[1.12 - 1.97]	**0.01**
Richest	2.15	[1.49 - 3.08]	**<0.01**
Residence			
Urban	1*		
Rural	0.59	[0.41 - 0.84]	**<0.01**
Under five children			
None	1*		
Only One	1.2	[0.99 - 1.45]	0.06
More than one	1.15	[0.89 - 1.49]	0.3
Source of info			
Radio	1*		
Television	1.26	[0.89 - 1.80]	0.20
Poster	6.68	[2.33 - 19.13]	<0.01
CHW	1.64	[1.31 - 2.06]	<0.01
Event	0.94	[0.66 - 1.33]	0.71
Else	0.87	[0.17 - 4.30]	0.86
Floor material			
Earth/sand	1*		
Dung	0.8	[0.43 - 1.51]	0.43
Ceramic	0.8	[0.38 - 1.68]	0.38
Cement	1.61	[1.25 - 2.09]	<0.01
Carpet	3.1	[0.46 - 21.07]	0.25
Bricks	1	-	-
Other	0.19	[0.04 - 0.99]	0.05

Source: Analysis of Rwanda Malaria indicators survey 2017

Female-headed households are 18% less likely to use LLINs compared to male-headed households (AOR: 0.82, 95% CI: 0.69-0.97, p = 0.02). Wealthier households show higher rates of LLIN utilization, with middle-income households being 30% more likely to use LLINs than the poorest

households (AOR: 1.3, 95% CI: 1.03-1.64, p = 0.03). This likelihood increases for richer households, who are 48% more likely to use LLINs (AOR: 1.48, 95% CI: 1.12-1.97, p = 0.01), while the wealthiest households are more than twice as likely to use LLINs compared to the poorest (AOR: 2.15, 95% CI: 1.49-3.08, p < 0.01).

Households in rural areas are 41% less likely to use LLINs compared to those in urban areas (AOR: 0.59, 95% CI: 0.41-0.84, p < 0.01), highlighting a notable disparity between urban and rural households in LLIN utilization. The source of malaria-related information significantly influences LLIN use. Households that received information from posters are over six times more likely to use LLINs (AOR: 6.68, 95% CI: 2.33-19.13, p < 0.01), while those informed by community health workers are 64% more likely to use LLINs (AOR: 1.64, 95% CI: 1.31-2.06, p < 0.01). Household infrastructure also plays a crucial role; households with cement floors are 61% more likely to use LLINs compared to those with earth or sand floors (AOR: 1.61, 95% CI: 1.25-2.09, p < 0.01). Conversely, households with other types of flooring are 81% less likely to use LLINs compared to those with earth or sand floors (AOR: 0.19, 95% CI: 0.04-0.99, p = 0.05).

5.3 Discussion

This study revealed that 4348 households corresponding with 86% among a total of surveyed 5041 households own at least one LLIN while 693 households (14%) do not possess any LLIN. Moreover, only 3625 representing 83% declared its usage. This percentage is lower than 96% of households owning at least one LLIN in Western Kenya as declared in the study conducted by Ng'ang'a et al. (2021). Overall, while both studies underscore the importance of LLINs in malaria prevention, they provide context-specific findings that can inform tailored approaches to enhance LLIN ownership and utilization in their respective regions.

The longitudinal analysis conducted by Clark et al. (2016) among the Indigenous Batwa population in Uganda reveals important insights into the sustainability of LLIN ownership and utilization following a targeted distribution. Both studies emphasize the importance of scaling up LLIN ownership and use for malaria prevention, particularly in marginalized populations. However, while the study in Uganda focused specifically on the Indigenous Batwa population, the current study in Rwanda examined LLIN ownership and utilization among households across the country. Despite the free distribution of LLINs to Batwa households, the longitudinal analysis found that sustainable increases in LLIN ownership and use were not achieved. Three months post-distribution, only 73% of households owned at least one LLIN, and this prevalence further decreased over time, with only a third of households retaining LLINs after 18 months.

In contrast, the Rwandan study reported higher levels of LLIN ownership (86%) and utilization (83%) among households owned at least one LLIN. Additionally, while socioeconomic determinants, particularly household wealth, were significant predictors of LLIN retention among the Batwa population, the Rwandan study identified factors such as marital status, wealth, rural

residence, and sources of information as predictors of LLIN ownership and utilization. The cross-sectional study conducted by Fru et al. (2021) in the Tiko Health District (THD) of Cameroon sheds light on the ownership and utilization rates of long-lasting insecticidal nets (LLINs) in different contexts. While the study in the THD reported high ownership rates of at least one LLIN per household (89%), the utilization rates were comparatively lower, with only 24.9% of respondents reporting sleeping under LLINs the previous night and 14.1% indicating universal utilization. In contrast, the current study in Rwanda found higher levels of LLIN ownership (86%) and utilization (83%) among households, suggesting potential variations in LLIN uptake and adherence to malaria prevention measures across different regions. Factors significantly associated with LLIN ownership in the THD included respondent's age and gender, highlighting demographic influences on LLIN access.

Compared to the findings from the study in Rwanda, where 86% of households owned Long-Lasting Insecticidal Nets (LLINs), the study assessing ITN ownership and utilization among pregnant women in Ghana showed a higher ownership rate of ITNs (93.5%) among pregnant women.
This indicates a widespread adoption of malaria prevention measures. However, despite high ownership levels, the utilization rate of ITNs was substantially lower in Ghana, with only 6.0% of pregnant women reported to have slept under an ITN the night before the survey. In Rwanda, 83% of households reported utilizing LLINs, reflecting a strong adherence to malaria prevention practices. Nevertheless, 15% of households reported not hanging their bed nets, citing various reasons such as having many nets, using the nets for other purposes, or citing the nets being too old.

Additionally, factors influencing ITN ownership and utilization differed between the two studies. While age, marital status, household wealth, presence of young children, awareness of malaria, and household composition were significant determinants of bed net ownership in Rwanda, marital status, household wealth, rural-urban residence, awareness of malaria, and information sources such as Community Health Workers and posters were associated with ITN utilization in Ghana. These findings underscore the importance of tailored interventions addressing both access to and utilization of ITNs, taking into account contextual factors specific to each setting, to effectively combat malaria and reduce disease burden among vulnerable populations (Diebieri & Antwi, 2023).

Compared to the findings from the study on insecticide-treated net (ITN) use among children and pregnant women in Nigeria, several similarities and differences can be observed. In both studies, demographic factors were identified as significant determinants of ITN use. However, in the Nigerian study, 49.8% of children and 44% of pregnant women slept under ITNs, whereas in this study in Rwanda, 83% of households reported utilizing Long-Lasting Insecticidal Nets (LLINs).

This suggests a higher level of ITN/LLIN utilization in Rwanda compared to Nigeria. Additionally, factors associated with ITN/LLIN use differed between the two studies.

In Nigeria, children's ITN use was associated with age, geopolitical zone, and wealth quintile, while pregnant women's ITN use was associated with household education level and wealth quintile. In contrast, the study in Rwanda found associations between bed net ownership or LLIN utilization and factors such as age, marital status, household wealth, presence of young children, awareness of malaria, and household composition. These differences highlight the importance of considering contextual factors specific to each setting when designing interventions to promote ITN/LLIN use and combat malaria effectively (Auta, 2012).

4. Conclusion and Recommendations

4.1 Conclusion

The study showcases Rwanda's significant strides in promoting the ownership and use of Long-Lasting Insecticidal Nets (LLINs) as a crucial strategy for malaria prevention. A large majority of households possess LLINs, and many actively use them, demonstrating the effectiveness of national malaria prevention efforts. However, a gap remains between ownership and consistent usage, revealing that merely having a bed net does not necessarily translate into regular use.
The research also highlights demographic and socioeconomic disparities in LLIN ownership and utilization. Younger household heads, those with lower income, and rural residents are less likely to own and use LLINs. These findings underscore the need for targeted interventions to address the unique challenges faced by these vulnerable groups, ensuring broader and more equitable malaria prevention coverage. The study further emphasizes the critical role of awareness, noting that households informed by community health workers or posters are more likely to use LLINs, underscoring the importance of ongoing education campaigns. Additionally, environmental factors, such as housing conditions, influence LLIN utilization, suggesting that improving living conditions should be part of a comprehensive malaria prevention approach.

The study highlights Rwanda's substantial progress in increasing the ownership and use of Long-Lasting Insecticidal Nets (LLINs) as a key measure for malaria prevention. With 86% of households owning at least one LLIN and 83% of those actively utilizing them, the overall rates of ownership and usage are commendable. This achievement makes a call for the effectiveness of Rwanda's national malaria prevention strategies. The findings suggest that while Rwanda has achieved commendable success in distributing and utilizing LLINs, disparities in usage among specific groups, particularly in rural and less wealthy households, indicate the need for more targeted interventions. Simply providing LLINs is insufficient; additional measures must be implemented to ensure consistent use, especially among vulnerable populations.

To enhance the effectiveness and equity of malaria prevention efforts, the study recommends focusing on increasing public awareness, improving access to LLINs, and addressing socio-

demographic barriers that hinder their use. Tailored interventions that address the specific needs of younger, poorer, and rural households are essential for closing the gap between LLIN ownership and utilization. These efforts will ensure that all individuals at risk of malaria are adequately protected, highlighting the multifaceted nature of malaria prevention and the importance of continued, targeted strategies.

4.2 Recommendations

Recommendations to the Ministry of Health:

i. Develop and implement nationwide awareness campaigns that focus on the importance of consistent LLIN use, particularly targeting rural and low-income households.
ii. Enhance the monitoring and evaluation of LLIN distribution and usage to identify gaps in coverage and utilization, ensuring that all parts of the country, especially rural areas, are adequately covered.
iii. Work with other governmental institutions to improve housing conditions, which will support better LLIN utilization, especially in areas with poor infrastructure.
iv. Allocate more resources to malaria prevention programs, ensuring that sufficient funds are available to maintain high levels of LLIN ownership and usage.

Recommendations for Researchers:

v. Conduct research to better understand the behavioral factors that prevent consistent LLIN usage, particularly in rural and low-income communities.
vi. Evaluate the effectiveness of current malaria awareness campaigns to identify best practices and areas for improvement.
vii. Study the impact of environmental factors, such as housing conditions, on LLIN utilization to develop more comprehensive prevention strategies.
viii. Prioritize research on the specific challenges faced by vulnerable populations, such as young, poor, and rural households, in accessing and using LLINs.
ix. Track long-term trends in LLIN ownership and usage to assess the sustainability of malaria prevention efforts and inform future policy.

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