

Critical Gaps in Long-lasting Insecticide-treated Net Ownership and Usage Among University Students in Tanzania: An Outcome Evaluation Study to Unveil Key Determinants

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Received: March 29, 2025

Accepted: June 25, 2026

Published: October 10, 2026

Abstract

Introduction

Long-lasting insecticide-treated nets (LLINs) are recommended as an effective way to prevent malaria, especially in malaria-endemic areas such as Tanzania. Because of this, the Tanzania National Malaria Strategic Plan (NMSP) 2021-2025 aimed to ensure universal access to LLINs. This study evaluated ownership and use of LLINs, along with associated factors, among students at the Mzumbe University campus.

Methods

This cross-sectional quantitative evaluation included 414 on-campus students at Mzumbe University in Morogoro, Tanzania. Stepwise logistic regression was performed using STATA. Statistical association was assessed using the odds ratio; $P < 0.05$ was considered significant.

Results

LLINs were owned by less than one-third (28.9%) of participants. A quarter (25%) of net owners did not use them. Higher age (AOR = 1.06, $P = 0.023$); attending a boarding ordinary secondary school (AOR = 1.95, $p = 0.022$); being employed (OR = 1.97, $P = 0.035$); and hearing information on the use of LLINs in the past six months (AOR = 3.2, $p = 0.001$), were factors that were significantly associated with LLIN ownership. Significant predictors of LLIN utilisation included older age (AOR = 1.10, $p = 0.038$) and receiving information on malaria and LLIN use within the past six months (AOR = 3.58, $p = 0.014$). Reported reasons for not using LLINs included low mosquito density, discomfort sleeping under a net, and a lack of infrastructure to hang the net.

Conclusion

Ownership and utilisation of LLINs were very low, indicating failure to achieve universal access to LLINs in this population as desired by the NMSP 2021-2025. Context-specific interventions focusing on LLINs awareness creation, behaviour change and improving bed infrastructure should be prioritized.

Keywords: Outcome Evaluation study, Long-lasting insecticide-treated net, LLIN ownership, LLIN utilisation, Malaria

INTRODUCTION

Malaria remains a global public health problem, with the highest burden reported in Africa (WHO, 2023b). In 2022, Africa accounted for 94% of cases and 95% of deaths globally; 78.1% of these deaths were reported in children below 5 years of age (WHO, 2023b). In 2022, four countries, including Tanzania, accounted for over half of the global malaria deaths (Venkatesan, 2024; WHO, 2023b). While there are higher morbidity and mortality observed among under-five and pregnant women, the general population also remains at high risk of contracting malaria (Ezezika et al., 2022). Ninety per cent of the Tanzanian population is at risk of contracting the disease, and approximately 14–18 million malaria cases are reported yearly (Ezezika et al., 2022).

Although the burden of malaria has decreased significantly in Tanzania over the past decade, it remains a major public health issue with high rates of illness and death (Aikambe & Mnyone, 2020; MoH, 2020, 2023; Kija N. et al., 2022, WHO, 2023a). With about eight million reported cases and an incidence rate of 125.8 per 1,000 people, malaria caused 25,787 deaths in 2021 in Tanzania (WHO, 2023a). The incidence rate per 1,000 people has been steadily increasing since 2018, indicating the country is currently unlikely to meet the targets set by the Global Technical Strategy for Malaria (WHO, 2023a). Malaria continues to place a heavy burden on Tanzania and remains a major contributor to poverty and underdevelopment (Ezezika et al., 2022).

While larval source management and indoor residual spraying are recognised methods for controlling malaria mosquitoes, vector control using long-lasting insecticide-treated nets (LLINs) is considered an effective intervention for malaria prevention (MoH, 2020; Negasa et al., 2023; Ng'ang'a et al., 2021). LLINs create a physical barrier between the user and mosquito vectors and repel or kill mosquitoes upon contact with the insecticide (Kija et al., 2022; Negasa et al., 2023; Ng'ang'a et al., 2021; Scott et al., 2021; Tassew et al., 2017). It is estimated that 69% of the 663 million malaria cases averted in sub-Saharan Africa between 2000 and 2015 were due to LLINs (Bertozzi-Villa et al., 2021; Scott et al., 2021). In areas with stable malaria transmission, LLINs also have the potential to reduce severe malaria by up to 45% and malaria-related mortality in children under five by up to 55% (Bertozzi-Villa et al., 2021; Scott et al., 2021). Therefore, the use of LLINs is a recommended strategy for protecting individuals from infection and reducing transmission at the community level (Kija et al., 2022; Negasa et al., 2023; Ng'ang'a et al., 2021; Scott et al., 2021; Tassew et al., 2017; WHO, 2023b).

Despite the importance and recommendations, not everyone in many malaria-endemic countries in sub-Saharan Africa,

including Tanzania, manages to sleep under insecticide-treated nets (MoH, 2023a; Ng'ang'a et al., 2021; Scott et al., 2021). Additionally, Tanzania has not yet reached the 80% global target for universal coverage of LLINs (MoH, 2023a; Ng'ang'a et al., 2021; Scott et al., 2021). Several factors have been reported to contribute to low mosquito net utilisation in the Low- and Middle-Income Countries (LMICs), including limited access, inadequate awareness and misconceptions, heat-related discomfort, perceived low mosquito presence, and poor housing conditions (Kija et al., 2022; Negasa et al., 2023; Ng'ang'a et al., 2021; Scott et al., 2021). To promote universal ownership and utilisation of LLINs, the Tanzania Ministry of Health, through the National Malaria Control Programme (NMCP), established the National Malaria Strategic Plan (NMSP) 2021-2025, with one of its objectives to achieve universal ownership and utilisation of LLINs. As part of efforts to meet the WHO global strategy for malaria targets, the NMSP set mid-term (2023) and end-term (2025) targets for reaching 80% and 85% of Tanzanians owning and using LLINs, respectively (MoH, 2020; WHO, 2023b).

Better mechanisms must be continuously developed to improve access to and proper use of LLINs for effective malaria vector control. Such strategies may require further customisation to meet the specific needs of different populations. To do so, it is necessary to carefully assess the achievements and effectiveness of the NMSP 2021-2025 strategies in ensuring universal ownership and utilisation of LLINs across population groups. One key population with a distinctive trait is the community of students in higher learning institutions, who are expected to act positively by using LLINs because they have more training and should better understand malaria prevention and the proper use of mosquito nets. However, there is a lack of evaluation data to confirm such assumptions, which may differ in pattern and reality. Therefore, this evaluation aimed to assess the NMSP 2021-2025 in achieving universal ownership and use of LLINs, as well as related factors among students in higher learning institutions in Tanzania, specifically at Mzumbe University-Main Campus.

METHODS

Evaluation design

This evaluation employed an outcome evaluation approach aligned with the Tanzania National Malaria Strategic Plan 2021–2025, which prioritises universal access to and utilisation of LLINs as a core malaria prevention strategy. Specifically, the evaluation mapped study outcomes to NMSP outcome indicators related to LLIN ownership (access) and LLIN utilisation (use). LLIN ownership was operationalised as the proportion of students reporting possession of at least one LLIN, corresponding to the NMSP indicator on population access to LLINs. LLIN utilisation

was measured as self-reported sleeping under an LLIN, reflecting the NMSP indicator on effective use of LLINs. By assessing these indicators within a university setting, the evaluation examined whether intermediate programme outcomes envisioned by the NMSP, rather than long-term malaria impact - malaria morbidity or mortality, are being achieved among students in higher learning institutions, a population not routinely prioritised in malaria programme evaluations.

The evaluation employed a cross-sectional study design suitable for assessing both prevalence and risk factors simultaneously. The design enabled this evaluation to perform both descriptive and analytical analyses of LLIN ownership, usage, and associated factors. Cross-sectional study design has also been utilised in similar studies (Gichuki et al., 2022; Hunde et al., 2023; Negasa et al., 2023; Tassew et al., 2017). This evaluation employed a quantitative method. This approach was appropriate because it examined the proportion and related factors of LLIN access and utilisation. It was also ideal for generating generalisable information to guide decisions on LLIN ownership and use within the specified study population.

Evaluation setting

The evaluation was conducted at Mzumbe University's main campus in Morogoro. This is one of the public universities that offers higher education. The university offers certificate, diploma, undergraduate, and postgraduate degree programmes. For the 2023/2024 academic year, a total of 9,705 students were admitted, comprising 8,823 (91%) undergraduate students, 400 (5%) postgraduate students, and 482 (4%) non-degree students, according to data from the Mzumbe University Admissions Office. Student sponsorship is offered in two main forms: some students are privately sponsored by their families, while others receive financial support from the Higher Education Students' Loans Board and/or other sponsoring organizations.

Among admitted students, some came from work in the public and private sectors, while others had just completed their previous level of studies and came directly from school. The university is located in the moderate malaria-stratified district, Mvomero district council, in the Morogoro Region, with an estimated malaria prevalence of 6% (MoH, 2020). Malaria transmission in Morogoro Region is primarily driven by *Anopheles arabiensis*, with *Anopheles funestus* also contributing significantly as a secondary vector (MoH, 2020). Mzumbe University offers a suitable environment for assessing the NMSP 2021-2025 outcomes in ensuring universal access to LLINs among students in higher education institutions.

Target population

The study involved continuing non-degree, undergraduate, and postgraduate students enrolled at Mzumbe University's Main Campus. This group represented the primary focus of the evaluation, as they are directly affected by the malaria prevention initiatives implemented within the university

environment. Our concentration on this specific demographic, the evaluation aimed to offer insights into the effectiveness of the strategic plan in ensuring universal access to LLINs among students in higher education institutions, particularly within the context of Mzumbe University's main campus.

Sample Size

The sample size was calculated mathematically using Cochran's formula, as applied in other similar studies (Negasa et al., 2023), with a proportion ($P = 62\%$) derived from baseline data on the proportion of people using LLINs in moderate malaria transmission strata (MoH, 2020). A Z value of 1.96 and a margin of error of 0.05 were used, with a 95% confidence interval, consistent with another comparable study (Negasa et al., 2023). A non-response rate of 10% was accounted for, resulting in a final sample size of 401; however, data were collected from 414 participants.

Sampling technique

A multi-stage cluster sampling method was applied. Initially, *restricted simple random sampling* was performed using Microsoft Excel 2010 to select five hostels for the study. After determining the number of residents from the warden's office, a *probability-proportionate-to-size sampling strategy* was employed to allocate the sample size to each selected hostel in proportion to the resident count. Following this, the sample was divided equally among the floors of each hostel to ensure fair representation. Subsequently, *systematic sampling* was used to select rooms, starting with the first room on the right as the initial point. A pattern of skipping one room was then followed to select additional rooms for the study. In each room, a simple random sampling method using paper numbers was used to select one respondent, and face-to-face interviews were conducted to complete the questionnaires. If a room was unoccupied, the next room was chosen as a replacement.

Data Collection

Data were gathered through face-to-face interviews and observations using a questionnaire. The researchers developed the questionnaire after a thorough literature review. The researchers piloted the tool with 36 participants at a non-study hostel on campus/in the study area, similar to other studies (Ng'ang'a et al., 2021). We refined the questions based on the pilot study. The Kiswahili version of the questionnaire was created in RedCap, and data were collected via the RedCap Android application on Android smartphones. Each participant took approximately ten minutes to complete the questionnaire.

Data Analysis

The questionnaire was created in a password-protected RedCap system, where all completed questionnaires were stored. During data collection, we checked all questionnaires for completeness. The final data file was uploaded as a password-protected CSV and stored on a secure computer. Data cleaning and analysis were conducted using STATA Version 17. All data were coded into a machine-readable

format in STATA; new dummy variables were generated, and values were replaced and recorded using appropriate STATA commands. For regression analysis, all data were encoded as dichotomous variables, and dummy variables were created for variables with more than 2 responses. Three variables – level of education, floor of residence, and malaria strata category in the region of origin – were coded as dummy variables for analysis. For education level, ‘non-degree’ served as the reference; for floor, ‘ground floor’ served as the reference; and for region, the area with very low malaria prevalence served as the reference. Entries with missing values and typos were omitted. Variables with skip patterns were analysed as subsets to include individuals who met the specific criteria for each variable.

Both descriptive and inferential/analytical statistics were purposively utilised to describe study participants and address evaluation objectives. Descriptive statistics involved using summary statistics for continuous variables (such as age) and tabulation for categorical variables to present key demographic characteristics of participants and to determine the proportions of ownership and utilisation of LLINs. A chi-square test was conducted to assess the statistical significance of the distribution of key demographic variables in relation to the proportion of ownership and utilisation of LLINs among study participants.

Inferential statistics were conducted using binary logistic regression to identify factors associated with LLINs ownership and utilisation. We used both bivariate and multivariate logistic regression models. The bivariate model assessed the association between each individual predictor and the outcome. The multivariable model included all predictors initially, then iteratively removed those without significant associations, leaving only significant predictors, as also used in other studies (Anasel M.G & Swai I.L., 2023; Anasel M.G & Swai I.L., 2024; Muya, M., Ilembo, B. and Anasel, M.G., 2024). Although not statistically significant, the variable ‘employment status’ was retained in the model due to the recognised importance of income in influencing LLIN purchasing and ownership among students. The logistic regression model is represented by the following logit function.

$$\text{Logit}(y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots \beta_p X_p$$

Whereas;

Y is a dichotomous dependent variable called logit, defined as;

y = (1 = having a LLIN; 0 = not having a LLIN); (1 = Using the LLIN; 0 = not using the LLIN)

β_0 = Is the intercept

$\beta_1, \beta_2, \beta_p$ = Logistic regression coefficient of X_1, X_2, X_3 respectively

X_1, X_2, X_3 = Independent variables.

The odds ratio was used to measure associations. Statistical significance was determined at a 95% confidence level with a P-value less than 0.05.

Ethical Approval

We meticulously followed ethical guidelines for the research of human subjects to ensure the credibility and reliability of the findings. Approval for data collection was initially obtained from Mzumbe University (MU), ensuring compliance with institutional ethical standards. This approval was then submitted to wardens, who granted permission to conduct research within specific hostels. These steps ensured that the research was carried out with the full knowledge and consent of relevant administrative bodies, in accordance with ethical research practices.

Informed consent was carefully obtained from each study participant, ensuring they were fully aware of the study's purpose and the confidentiality of their information. Participants were reassured that their data would be handled with the highest level of confidentiality, with all personal details and data files securely stored on password-protected computers accessible only to the research team. This commitment to data security and participant confidentiality maintained the ethical standards of the study, fostering trust and integrity in the research process.

RESULTS

Socio-demographic characteristics of respondents

The mean age in the study population was 23 years (SD 4.5). The majority (90.5%) of study participants were single, over three-quarters (86.9%) were not employed, 85.2% joined the university directly from school, and 63.5% had ever heard information about malaria and LLIN use in the past six months. Over half (52.9%) studied at an ordinary boarding school, and 85.9% studied at an advanced boarding secondary school. The majority (82.6%) were undergraduate students, and more than half (56%) were sponsored through the Higher Education Students' Loans Board. There was almost an equal distribution of residence floors in the hostels. Compared to other strata, most participants lived in regions with moderate malaria prevalence (39.4%) and very low prevalence (27%) (Table 1).

Table 1: Demographic characteristics of students recruited (N 414)

Variables	Sex	
	Male (n; %)	Female (n; %)
	186 (44.9%)	228 (55.1%)
Marital status		
Single	163 (87.6%)	212 (92.8%)
Married	23 (12.4%)	16 (7.0%)
Participant occupation		
Not employed	154 (82.8%)	206 (90.3%)
Employed	32 (17.2%)	22 (9.6%)
Heard information on LLIN in the past six months		
Yes	129 (69.4%)	134 (58.8%)
No	57 (30.6%)	94 (41.2%)

Where were you before joining the university?

From work/home	33 (17.7%)	28 (12.3%)
Direct from school	153 (82.3%)	200 (87.7%)
O-Level school type		
Boarding	95 (51.0%)	124 (54.4%)
Day school	91 (49.0%)	104 (45.6%)
A-Level school type		
Boarding	154 (82.8%)	202 (88.6%)
Day school	32 (17.2%)	26 (11.4%)
Degree Program		
Non-degree	11 (5.9%)	15 (6.6%)
Postgraduate	26 (14.0%)	20 (8.8%)
Sponsor of studies		
Undergraduate	149 (80.1%)	193 (84.6%)
HESLB/Other sponsors	99 (53.2%)	133 (58.3%)
Parents/oneself	87 (46.8%)	95 (41.7%)
Floor of residence		
Ground floor	46 (24.7%)	67 (29.4%)
First floor	56 (30.1%)	54 (23.7%)
Second floor	48 (25.8%)	62 (27.2%)
Third floor	36 (19.4%)	45 (19.7%)
Malaria prevalence in the region of origin		
Very low	41 (22.0%)	71 (31.2%)
Low	35 (18.8%)	44 (19.4%)
Moderate	77 (41.4%)	86 (37.8%)
High	33 (17.8%)	27 (11.8%)

Ownership and utilisation of LLINs among students

Less than one-third (28.9%) of participants in this study owned LLINs. A quarter (25%) of students who owned LLINs did not use them. The difference in LLIN ownership and utilisation between males and females was not statistically significant ($p > 0.05$) (Table 2).

Table 2: Proportion of LLIN ownership and utilisation

Variables	Male	Female	P-value
Ownership of LLINs			
<i>Not owning LLINs</i>	137 (73.6%)	157 (68.8%)	0.285
<i>Owning LLINs</i>	49 (26.4)	71 (31.2%)	
Utilisation of LLINs among owners			
<i>Own a LLIN but have not used it</i>	13 (26.5%)	17 (23.9%)	0.747
<i>Own a LLIN and use it</i>	36 (73.5%)	54 (76.1%)	

When asked why they did not own LLINs, the most commonly cited reasons were: considering that there were no mosquitoes around (35%); the claim that it's too hot, so that one feels

uncomfortable sleeping under a net (32%); and the absence of infrastructure to hang the net in the room (17%) (Figure 1).

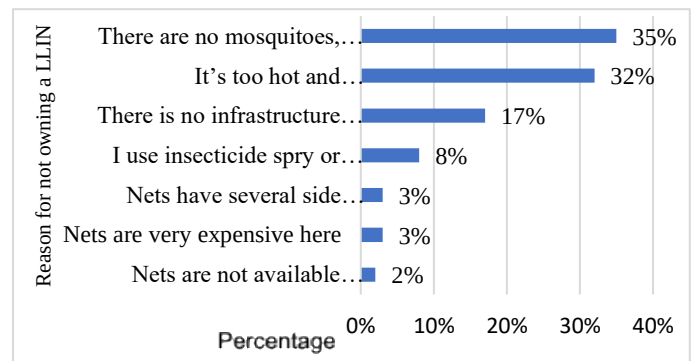


Figure 1: Mentioned reasons for not owning LLINs (N 327)

Factors associated with ownership of LLINs

Every one-year increase in a person's age was marginally associated with 5% higher odds of owning LLINs [Adjusted Odds Ratio (AOR) = 1.06, 95% CI = 0.96 – 1.19, $P = 0.023$]. Married individuals were more likely to own LLINs than unmarried individuals (OR = 2.04, 95% CI = 1.04 – 3.99, $P = 0.038$). Individuals who reported hearing information about malaria and using LLINs in the past six months had higher odds of owning LLINs compared to those who had not heard the information (AOR = 3.2, 95% CI = 1.73 – 5.99, $P = 0.001$). Students attending boarding ordinary secondary schools were more likely to own LLINs compared to those attending day schools (AOR = 1.95, 95% CI = 1.10 – 3.44, $P = 0.022$). Additionally, employed participants had higher odds of owning LLINs (OR = 1.97, 95% CI = 1.05 – 3.71, $P = 0.035$); however, this association did not reach statistical significance at the multivariable stage ($P > 0.05$) (Table 3 and Table 4).

Table 3: Bivariable logistic regression of factors associated with ownership of LLINs

Variable	Bivariable logistic regression		
	OR	95% CI (OR)	P
Age of the participant			
Age (years)	1.05	1.01 – 1.10	0.04
Sex of participant			
Female	1.0		
Male	0.83	0.51 – 1.34	0.436
Marital status			
Single	1.0		
Married	2.04	1.04 – 3.99	0.038
Heard Information about Malaria and LLINs uses in the past six months			
No	1.0		
Yes	3.0	1.67 – 5.40	0.001
O – Level school			

Day school	1.0		
Boarding	1.65	1.07 – 2.55	0.023
A – Level school			
Boarding	1.0		
Day school	0.89	0.44 – 1.80	0.750
Where the person was before joining university			
Home/at work	1.0		
Direct from school	0.56	0.30 – 1.03	0.063
Program			
Non degree	1.0		
Undergraduate	1.1	0.4 – 3.0	0.853
Postgraduate	1.0	0.3 – 3.5	0.973
Employment status			
Un employed	1.0		
Employed	1.97	1.05 – 3.71	0.035
Sponsorship			
HESLB	1.0		
Parents/self	0.87	0.53 – 1.41	0.562
Floor of residence in the hostel			
Ground	1.0		
First floor	0.69	0.35 – 1.33	0.269
Second floor	0.95	0.50 – 1.79	0.871
Third floor	0.9	0.45 – 1.81	0.774
Malaria prevalence in the region of origin			
Very Low	1.0		
Low	1.17	0.56 – 2.43	0.677
Moderate	1.26	0.68 – 2.32	0.462
High	1.4	0.65 – 3.02	0.391

Table 4: Multivariable logistic regression of factors associated with ownership of LLINs

Variable	Multivariable logistic regression		
	AOR	95% CI (AOR)	P
Age of the participant			
Age (years)	1.06	0.96 – 1.19	0.023
Heard Information about Malaria and LLINs uses in the past six months			
No	1.0		
Yes	3.2	1.73 – 5.99	0.001
O – Level school			
Day school	1.0		
Boarding	1.95	1.10 – 3.44	0.022
Employment status			
Un employed	1.0		

Employed	1.03	0.21 – 5.07	0.071
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Factors associated with utilization of LLINs

A one-year increase in participants' age was slightly linked to a 10% higher LLIN use (AOR = 1.10, 95% CI: 0.91–1.33, $p = 0.038$). Additionally, individuals who reported receiving information about malaria and LLIN use within the past six months were significantly more likely to use LLINs compared to those who had not received such information (AOR = 3.58, 95% CI: 1.29–9.88, $p = 0.014$) (Table 5 & 6).

Table 5: Bivariable logistic regression of factors associated with utilisation of LLINs

Variable	Bivariable logistic regression		
	OR	95% CI (OR)	P
Age of the participant			
Age (years)	1.17	1.0 – 1.34	0.022
Sex of participant			
Female	1.0		
Male	0.87	0.38 – 2.01	0.748
Where the person was before joining university			
Home/work	1.0		
Direct from school	0.12	0.02 – 0.94	0.064
O – Level school			
Boarding	1.0		
Day school	0.63	0.27 – 1.46	0.280
A – Level school			
Boarding	1.0		
Day school	0.41	0.14 – 1.19	0.104
Employment status			
Un employed	1.0		
Employed	7.76	0.99 – 60.7	0.051
Sponsorship			
HESLB	1.0		
Parents/self	0.95	0.42 – 2.20	0.915
Floor of residence			
Ground	1.0		
First floor	1.04	0.35 – 3.05	0.943
Second floor	3.24	0.62 – 16.8	0.162
Malaria prevalence in the region of origin			
Very Low	1.0		
Low	1.85	0.56 – 6.28	0.321
Moderate	2.18	0.79 – 6.01	0.132
High	2.05	0.55 – 7.57	0.284

Heard Information about Malaria and LLINs uses in the past six months

No	1.0		
Yes	3.82	1.53 – 9.50	0.004

Table 6: Multivariable logistic regression of factors associated with utilization of LLINs

Variable	Multivariable logistic regression		
	AOR	95% CI (AOR)	P
Age of the participant			
Age (years)	1.10	0.91 – 1.33	0.038
Heard Information about Malaria and LLINs uses in the past six months			
No	1.0		
Yes	3.58	1.29 – 9.88	0.014

DISCUSSION

In this study, the proportion of ownership and utilisation of LLINs among students was below the national average (53%) (MoH, 2023). This was well below the NMSP 2021-2025 mid-term target (80%) intended to be achieved by 2023 for the moderate malaria strata (MoH, 2020). Therefore, for this particular student population at one campus, the NMSP 2021-2025 failed to meet the mid-term target of ensuring universal access to LLINs, and the NMCP falls behind in achieving the Global Technical Strategy for Malaria 2016-2030 (WHO, 2021).

Our findings support Singh M. et al. (2013) observation that LLIN coverage remains well below the targets in most malaria-endemic areas of LMICS. Our results also align with those reported in another study of school-age children in Ethiopia (Zerdo et al., 2020). However, the proportion of LLIN ownership in our study was much lower than what has been recently reported in other similar studies of the general population in Ethiopia, where an average of 85% to 99% of the surveyed population owned mosquito nets (Hunde et al., 2023; Tassew et al., 2017). Our findings were also significantly lower than the 95% LLIN ownership recently reported in a population survey in Kenya (Gichuki et al., 2022), and less than the 64.1% reported in another survey conducted six months after a free LLIN distribution campaign in Kenya (Ng'ang'a et al., 2021), as well as lower than the 58.3% reported in a community cross-sectional survey in Mozambique (Scott et al., 2021).

The lower proportions of LLIN ownership reported in this study might be due to the absence of free mass-distributed LLINs in this population. Students have to buy nets from the market with their own money or obtain them from other sources. This could affect their ability to own a mosquito net, despite the existence of cheaper options. This is because ownership of purchased nets depends on individuals' wealth

quintiles (Olapaju et al., 2019). In the analysis of malaria demographic health survey data among LMICs, households in higher wealth quintiles had greater odds of owning a purchased net than poorer households in all countries, and the odds of owning a purchased net increased significantly with each rising wealth quintile (Olapaju et al., 2019). The proportion of people owning purchased nets in LMICs is very low, ranging from 1.0% to 23.4% (Olapaju et al., 2019). Thus, as most students have low incomes and depend on the HESLB sponsorship for meals and accommodation, they may be less likely to prioritise purchasing LLINs over other urgent school and personal needs. Authorities may focus on mass distribution and the provision of subsidised LLINs to ensure universal ownership and utilisation among students on campus, as recommended by the NMSP.

The lower proportion of LLIN ownership and utilisation in this study might also be due to limited knowledge of malaria and LLIN use. In our study, nearly four in ten individuals had not heard any information about malaria in the past six months. This aligns with a recent survey that assessed knowledge and malaria treatment-seeking behaviours among students at higher learning institutions in Morogoro, where students at Mzumbe University were reported to have lower levels of knowledge about malaria transmission than others (Mbogo N. Kija, 2022). This may reduce their ability to own and use LLINs, as individuals with less knowledge about the risks of malaria and the effectiveness of LLINs as a preventive measure are less likely to own one.

Ownership of LLINs does not guarantee their use among owners. In our study, a quarter of LLIN owners were not using them. Previous studies have reported higher rates of LLIN utilisation among owners (Gichuki et al., 2022; Ng'ang'a et al., 2021). In a household cross-sectional survey in Kenya, 99.5% of LLIN owners had their nets hung at the sleeping area (Gichuki et al., 2022). In another community survey in Kenya, among those who owned LLINs, 98.1% reported using them the previous night (Ng'ang'a et al., 2021).

In our study, common reasons cited by participants for not owning or using nets included perceptions of low mosquito density and low malaria risk in the area, the belief that there were no mosquitoes forcing one to sleep under a mosquito net, and the absence of proper infrastructure for hanging the net on the bed, which makes it difficult for individuals to hang the net even if they own one. Additionally, some participants argued that it is too hot and uncomfortable to sleep under a net, while others used alternative malaria prevention methods such as insect repellent. Similar reasons are also reported at high density in previous studies (Olapaju et al., 2019; Pulford et al., 2011; Shannon et al., 2024; Singh et al., 2013; Negasa et al., 2023). Discomfort, mainly due to heat, difficulties with hanging nets, lack of space, and perceived (low) mosquito density were the most common reasons for the non-use of LLINs in systematic reviews of published articles (Pulford et al., 2011; Singh et al., 2013).

In our study, older participants were more likely to own and use LLINs. This confirms findings reported in similar previous studies (Hunde et al., 2023; Olapeju et al., 2019; Scott et al., 2021). In the analysis of malaria demographic health survey data (2011-2016) among malaria endemic LMICs, Olapeju et al. (2019) observed that households headed by individuals aged 35 to 59 years had 40% higher odds of owning a purchased net compared to households headed by those younger than 35 years. Higher odds of LLINs utilisation were also observed among older age groups in Mozambique (Scott et al., 2021). In another cross-sectional study in Ethiopia, households aged 40 to 49 years were 1.82 times more likely to use LLINs than households aged 30 or younger (Hunde et al., 2023). An increase in age might be associated with greater wealth and a higher likelihood of employment, which are known factors for LLIN ownership and utilisation in LMICs (Hunde et al., 2023; Olapeju et al., 2019; Zerdo et al., 2020).

Participants who attended boarding school at the ordinary level had significantly higher odds of owning LLINs than those who attended day school in this study. This might be because students spend a longer duration (four years) at the ordinary education level, where one is required to have a mosquito net upon reporting to boarding school. Furthermore, compared to day schools, boarding schools may benefit from free LLINs mass distribution campaigns, increasing students' chances of using mosquito nets and developing a habit of net use, unlike those who rent private rooms during day school. Similarly, other studies have shown that the presence of school-aged children in the household was associated with 30–40% higher odds of using purchased nets in Tanzania, Uganda, and Zimbabwe (Olapeju et al., 2019).

In our study, participants who were employed in the formal sector had higher odds of using LLINs. Similar findings were also reported in previous studies (Hunde et al., 2023; Olapeju et al., 2019; Zerdo et al., 2020). Employed individuals may have a better income and are therefore more likely to belong to a higher wealth quantile compared to those who were merely students with no employment in the study. Higher wealth quantiles are associated with increased odds of owning purchased LLINs (Olapeju et al., 2019). Additionally, employed people are presumed to be more educated in this case. Higher education levels are a known factor influencing ownership and utilisation of LLINs, as more educated people may have a greater understanding of the threats of malaria (Olapeju et al., 2019).

Increased odds of owning LLINs were observed among students who reported having heard information about malaria and used LLINs in the previous six months. Several previous studies also reported similar findings (Hunde et al., 2023; Scott et al., 2021; Singh et al., 2013). Higher odds of using LLINs were reported among respondents who had proper malaria knowledge in a cross-sectional study in Ethiopia (Hunde et al., 2023). In a community-based cross-sectional survey in Mozambique, lack of knowledge of malaria, community beliefs, and misconceptions about malaria and its

prevention contribute to the non-use of nets (Scott et al., 2021). Access to information on malaria is supposed to improve awareness of the risk of malaria, which may positively influence ownership and utilisation of LLINs among individuals.

In our study, married individuals had significantly higher odds of owning LLINs than unmarried individuals. Married individuals might be accustomed to sleeping under nets because they live with partners and children under five, a known factor associated with positive LLIN use (Olapeju et al., 2019). The presence of children under five in a household increased the odds of owning a purchased net in the Malaria Demographic and Health Survey data in SSA (Olapeju et al., 2019). Married individuals are also more likely to be in higher age groups and employed, factors that have been shown to increase the likelihood of owning LLINs among participants in this study. Previous studies have also confirmed the association between marital status and LLIN ownership, noting increased odds of LLIN use among married persons (Ng'ang'a et al., 2021; Scott et al., 2021).

Limitations of the Study and Mitigation Procedures

This study has some limitations that should be considered when interpreting the findings. Although multivariable logistic regression was employed, residual confounding from unmeasured variables such as socioeconomic status, previous malaria episodes, or housing characteristics may have affected the observed associations between participant characteristics and LLIN ownership and utilisation. To reduce the impact of confounding, adjusted odds ratios were reported, which statistically control for measured covariates included in the models, thereby enhancing the validity of the observed associations.

Furthermore, the use of a cross-sectional design and a single-site focus limits the ability to draw causal inferences and fully assess the implementation of the NMSP at the national level. Since the results reflect LLIN ownership and utilisation at one point in time within a specific university setting, the findings may not be generalisable to all higher learning institutions or to the broader population in Tanzania. To address this limitation, the Methods section clearly states that the evaluation specifically targeted on-campus students at Mzumbe University, aligning the study scope with its objectives. Additionally, cross-sectional assessments are recognised in the NMSP as an appropriate and recommended method for measuring outcome indicators related to LLIN ownership and utilisation in populations, supporting the methodological suitability of the study for these outcomes.

Conclusion

The proportion of LLIN ownership and utilisation in this study was far lower than the NMSP 2021-2015 mid-term target, indicating failure to achieve the desired goal in this specific higher-education student population at one campus. Reasons given for not using LLINs included low mosquito density,

discomfort while sleeping under a net, and the lack of infrastructure to hang the net. Older age, being married, attending a boarding school, being employed, and having access to information about malaria were significantly associated with LLIN ownership. Interventions focused on raising awareness, changing behaviour, improving bed infrastructure, and ensuring the availability of subsidised LLINs should be prioritised to achieve universal ownership and use of LLINs in this population, as aimed by the NMSP 2021-2025.

Acknowledgment

We would like to thank the Mzumbe University authorities and the warden's offices for granting us permission to conduct the study. We also appreciate Ngereja John, Bernadetha Mwakikuti, Bushi Lugoba, Agatha Mwinyipembe, Leons Maliyaheze, Mwahija Hamis, Nathara Mruma, Festus Tandoo, Edwin Aron, and Julius Massaba for their technical advice on conceptualising the research idea and for their valuable support during data collection. Our sincere gratitude goes to all study respondents for their time.

Conflicts of interest

The authors declare that they have no competing interests

Authors' contributions

MGA: Supervisor of the research team, reviewed the research proposal, analysed the data, and worked on the manuscript. LLS, AI, BC, GN, SK: Conceived the idea, designed the study, analysed the data, interpreted the results, and drafted the manuscript.

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