Malaria Prevention and Use of Insecticide Treated Nets (ITNs) Among Pregnant Women in the Tamale Metropolis.

Abstract

Introduction: Insecticide-treated mosquito nets (ITNs) are a proven malaria prevention tools, particularly for pregnant women, who are at increased risk of malaria-related complications. In Ghana, malaria remains a leading cause of morbidity and mortality among pregnant women, making the use of ITNs critical in reducing malaria incidence. However, the extent of ITN utilization and the factors influencing usage among pregnant women in the Tamale Metropolis remain underexplored.

Aim: This study aimed to assess the knowledge, ownership, and utilization of ITNs among pregnant women in the Tamale Metropolis and identify factors influencing their usage.

Methods: Using a stratified sampling, a cross-sectional survey was conducted with 399 pregnant women in the Tamale Metropolis. A structured questionnaire was used to solicit the responses from the participants. Data was analyzed by Stata version 18 and p value less than 0.05 was considered statistically significant.

Results: The study found that 98.5% of participants were aware of ITNs, with the majority gaining knowledge through mass media (81.7%) and antenatal care centers (79.1%). Despite this high level of awareness, 92.5% of participants owned at least one ITN. Of those who owned ITNs, 32.8% owned one, 33.3% owned two, and 32.0% owned three or more. The main source of ITNs was free house-to-house distribution (79.7%) and ANC centers (78.6%). However, while 82.7% of participants used ITNs at home, only 22.6% reported consistent nightly use. The primary barriers to consistent ITN use included discomfort from heat (76.7%), difficulty using ITNs during hot weather (64.6%), and the absence of proper facilities to hang the nets (29.4%). In terms of education level, basic education (AOR=0.06, 95% CI: 0.02-0.18), secondary education (AOR=0.08, 95% CI: 0.03-0.23), and tertiary education (AOR=0.29, 95% CI: 0.09-0.95, p=0.042) had lower odds compared to those with no formal education. Respondents who were self-employed (AOR=0.04, 95% CI: 0.01-0.20) and unemployed (AOR=0.01, 95% CI: 0.005-0.32, p<0.001) had reduced odds compared to those who were employed. Additionally, household monthly income was significantly associated with those earning 500-999 (AOR=0.07, 95% CI: 0.02-0.21, p<0.001), 1000-1999 (AOR=0.10, 95% CI: 0.01-0.30, p<0.001), and ≥2000 (AOR=0.10, 95% CI: 0.03-0.21, p<0.001) had lower odds compared to the lowest income category (0-499).

Conclusions: While ownership of ITNs is high, consistent use among pregnant women remains low due to practical barriers such as discomfort and lack of proper facilities. Addressing these issues through education, infrastructural improvements, and increased access to ITNs, especially in remote areas, could enhance ITN usage.

Keywords: Insecticide-treated mosquito nets, malaria prevention, pregnant women, utilization, Tamale Metropolis, Ghana, barriers, socioeconomic factors.

Comment [BU1]: My Reviewer Recommendations

1. Some sections (e.g., the introduction and discussion) could be made more concise by eliminating repetitive statements or consolidating ideas.
2. Please perform a thorough statistical review to verify the accuracy of presented data and its interpretation.
3. Avoid over-explaining well-known concepts, such as the benefits of ITNs, which are repeated in multiple sections.

1. Some sections, like **Methods**, are overly detailed (e.g., geographical description of Tamale Metropolis) and could be trimmed to improve readability.
1. Ensure smooth transitions between sections to maintain flow, particularly between Results and Discussion.
2. Ensure all tables are self-explanatory with clear captions and include units where applicable (e.g., Ghana cedis in Table 1).
3. Some percentages in tables (e.g., "Better design to allow air circulation" showing 100.6% in Table 5) seem erroneous and should be rechecked.
4. Use graphs in some cases not all tables

Comment [BU2]: Specify the key statistical results, such as the adjusted odds ratios and their implications.

Introduction

In 2022, an estimated 249 million malaria cases and 608,000 malaria-related deaths were reported across 85 countries worldwide[1]. The WHO African Region bore tstudy he brunt of this burden, accounting for 94% (233 million) of global malaria cases and 95% (580,000) of malaria deaths. Alarmingly, children under the age of five represented approximately 80% of all malaria deaths in the Region, highlighting the severe impact of the disease on vulnerable populations[1]. Malaria is a primary contributor to morbidity, mortality, poverty, and diminished productivity among the majority of individuals residing in low- to middle-income countries (LMICs)[2]. Malaria elevates the risk of severe pregnancy problems for the mother, fetus, and neonate. Insecticide-treated bed nets (ITNs) are a kind of personal protection demonstrated to reduce malaria infection, severe illness, and mortality[3]. The efficient application of ITNs has diminished malaria morbidity by 50% in children under 5 years of age and decreased mortality by 17%[4, 5]. The WHO Roll Back Malaria (RBM) initiative, initiated in 1998, aimed to prevent and manage malaria in pregnant women through the utilization of insecticide-treated nets (ITNs) and additional strategies[6, 7].

The utilization of insecticide-treated nets (ITNs) is an intervention demonstrated to diminish malaria infections and decrease malaria-related mortality in endemic areas[8]. A systematic review on ITNs use revealed that, ITNs reduce the prevalence of Plasmodium falciparum malaria by 17% [9]. In Ghana, access to ITNs in households resulted in a 7.1 percentage point decrease in self-reported malaria among women[10].

Several reasons contribute to disparities in the utilization of ITNs. A study conducted in Ghana by Bawuah and Ampaw[11] demonstrated that dwelling location and socioeconomic status are predictors of ownership and utilization of insecticide-treated nets (ITNs). Luukwa et al.[12] contended that children and secondary-educated pregnant women from impoverished rural families in a specific region of Ghana exhibited the highest utilization of ITNs compared to pregnant women with differing attributes[13]. In Malawi, the likelihood of utilizing ITNs was low among uneducated women, those with primary education, and impoverished individuals[14].

Ghana, ranked among the fifteen nations with the highest malaria infection rates globally, experienced a 5% rise in absolute case numbers from 2017 to 2018, resulting in almost 0.5 million additional cases[8]. The nation exhibits the highest prevalence of Intermittent Preventive Treatment in Pregnancy (IPTp) among pregnant women at 78%, with the proportion of those receiving the third dosage rising from 39%

Comment [BU3]: Highlight the novelty of this study more explicitly (if there is).
Please specify the specific gaps in the literature.
Does it fill regarding ITN use in Tamale Metropolis?

in 2016 to 60% in 2018, and reaching 61% in 2019[15]. IPTp entails administering a therapeutic dose of an efficacious antimalarial medication to all pregnant women without prior confirmation of malaria infection[16, 17].

In Ghana, the deliberate promotion and intervention about ITNs have led to an increase in household ownership of ITNs from 49% in 2011 to 68% in 2014[18, 19]. Nonetheless, the scarcity of access and knowledge on ITNs and malaria has been recognized as a substantial obstacle to ITN adoption in Africa. Over 40% of insecticide-treated nets (ITNs) in households remain unutilized[20]. Certain pregnant women forgo the use of bed nets owing to financial limitations, lost opportunities during complimentary distributions, discomfort from heat and odor, and challenges associated with suspending the net[13, 18].

Notwithstanding advancements in preventive and therapeutic strategies, malaria continues to be widespread in Ghana, constituting 38.1% of all outpatient department cases and over half of all hospital admissions for children under five years of age. Ghana is striving for universal ITN coverage, necessitating ongoing monitoring and evaluation of access to and utilization of treated bed nets to inform malaria control policies and practices, especially in high-risk regions of the country. In the Tamale Metropolis of northern Ghana, where malaria transmission is prevalent, comprehending the determinants affecting malaria prevention and the utilization of insecticide-treated nets (ITNs) among pregnant women is essential for enhancing mother and child health outcomes. Inadequate use of ITNs, together with insufficient understanding or misconceptions regarding malaria prevention, significantly endangers pregnant women and their unborn children, potentially resulting in issues such as anemia, low birth weight, and even maternal and fetal mortality. This study seeks to evaluate the extent of ITN utilization and determine the socio-demographic, cultural, and behavioral factors that affect malaria preventive practices among pregnant women in the Tamale Metropolis. The findings will elucidate deficiencies in existing interventions and assist in formulating more efficacious malaria preventive measures specifically designed for pregnant women in the Tamale Metropolis.

Comment [BU4]: While informative, the introduction is quite lengthy and includes general malaria statistics (e.g., global burden from WHO). This level of detail might be unnecessary for a study focused on a specific region (Tamale Metropolis). Consider summarizing global trends and narrowing focus earlier.

Methods

Study setting

The Tamale Metropolitan Assembly (TMA) is a part of the 261 Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana, located in the Northern Region. Elevated to the status of Metropolis in 2004, it is the capital of the Metropolis and is situated between latitude 9.16° and 9.34° North and longitudes 00.36° and 00.57. The topography is generally rolling with shallow valleys and isolated hills, but they do not hinder physical development. The Metropolis shares boundaries with Savelugu Municipality, Yendi Municipal Assembly, Tolon District, Central Gonja District, and East Ganja Municipal. The 2021 population and housing census recorded a population of 374,744.

Comment [BU5]: The geographical description of Tamale Metropolis (e.g., latitudes, boundaries, topography) is too detailed for the context of the study. Unless it directly impacts malaria transmission or ITN use, it should be condensed.

Study design

The study used cross sectional study with emphasis on the quantitative study. Cross-sectional studies observe factors without altering them and collect data from numerous people at once. Cross-sectional study designs allow researchers to concurrently examine several characteristics, including age, gender, income, and education level, in connection to the utilization of Insecticide treated mosquito nets.

Study population

The study population included pregnant women attending antenatal care (ANC) in the Tamale Metropolis.

Inclusion and exclusion criteria

Inclusion Criteria

The inclusion criteria included the following:

1. Pregnant women residing within the Tamale Metropolis.
2. Women who are currently attending antenatal care (ANC) clinics or are reachable within health facilities in the Tamale Metropolis.
3. Pregnant women who provide informed consent to participate in the study.
4. Women aged 18 years and above.

Exclusion Criteria

1. Non-pregnant women or women who have already given birth and are in the postpartum period.
2. Pregnant women who do not reside within the Tamale Metropolis.
3. Women with serious medical conditions or complications that prevent them from participating in the study.
4. Pregnant women who decline to give consent for participation.

Sample size determination

$$n = \frac{z^2\sigma}{m_0 E^2}$$

- Sample size (n) =?
- Variance (σ) = P (1-P)
- A recent student study in Ghana estimated the utilization of ITNs is 62.0% [21]. Thus, p =62% (0.62)

Thus, Variance (σ) = P (1-P)

Variance (σ) = 0.62(1-0.62)

σ = 0.2356

- Margin of error (MOE)=0.05
- The critical value (Z) at 95% Confidence Interval = 1.96

The sample determination formula is stated as:

$$n = \frac{z^2\sigma}{m_0 E^2}$$

$$n = \frac{(1.96)^2 * 0.2356}{(0.05)^2}$$

$$n = \frac{3.8416 * 0.2356}{0.0025}$$

$$n = \frac{0.9051}{0.0025}$$

$$n = 362.04$$

$$n = 363$$

To account for noncompliance and response rate, 10.0% of the estimated was added. Thus, the sample size for this study was 399.

Comment [BU6]: Remove excessive derivation details. Including the final formula and calculated sample size suffices.
Not necessary for the journal

Sampling techniques

A stratified sampling technique was used to select research participants from four healthcare institutions in the Tamale Metropolis. Stratified sampling was selected to guarantee that the sample correctly reflected pregnant women from each institution, facilitating proportional representation and augmenting the dependability of the results. The research population was stratified according to the four healthcare institutions. Participants were thereafter chosen randomly from each stratum accordingto the number of pregnant women receiving prenatal care at each institution. This strategy guaranteed the capture of diversity within each institution, providing to a thorough knowledge of the determinants affecting postnatal care consumption in the Tamale Metropolis.

Comment [BU7]: Expand more on why the stratified sampling technique was chosen compared to other methods.

Data collection instruments

A structured questionnaire was used as the primary data collection instrument for this study. The questionnaire was designed to collect quantitative data and was developed by reviewing relevant literature and incorporating elements from existing validated instruments[8, 22–24]. The questionnaire was structured according to the study objectives and included the following sections: Section A consisted the

socio demographic characteristics, Section B included the knowledge of malaria prevention during pregnancy, Section C focused on accessibility and ownership of ITNs, Section D had questions on the utilization of the ITNs and Section E on the barriers to using the ITNs.

Data collection procedures

Data collection was executed by a team of five trained field enumerators. Before data collection, the enumerators received extensive training and participated in role-playing exercises to guarantee uniformity and standardization in giving the questionnaire. This preparation sought to improve the dependability and precision of the data obtained.

Authorization to do the research was secured from each of the four designated healthcare institutions within the Tamale Metropolis. Moreover, informed permission was obtained from all participants before their involvement. The enumerators performed in-person interviews with the participants, each lasting between 20 to 30 minutes.

Confidentiality was rigorously maintained throughout the data gathering procedure, safeguarding all participants' information. Ethical concerns were maintained by following the principles of voluntary participation, informed consent, and safeguarding the respondents' privacy and rights.

Data analysis and presentation

Data cleaning was performed using Microsoft Excel to ensure accuracy and completeness before being exported to STATA version 18 for analysis. Both descriptive and inferential statistics were conducted to address the specific objectives of the study. The results werepresented in tabular form for clarity.

The utilization of insecticide-treated nets (ITNs) was defined as respondents who reported consistent use of ITNs for malaria prevention. To assess the association between ITN utilization and demographic factors, as well as health accessibility characteristics, chi-square tests were conducted. Statistical significance was determined at a threshold of $p<0.05$.

Ethical consideration

The study was conducted in adherence to the ethical principles outlined in the Declaration of Helsinki. These included informed consent, confidentiality, non-discrimination, inclusivity, risk minimization, cultural sensitivity, and ethical training. Participants providedverbal informed consent, and personal data was kept secret. The recruiting procedure was fair, and the interviews were brief, polite, and unobtrusive. Cultural sensitivity was maintained, and data collectors received training in ethical practices. The study upheld the participants' rights, dignity, and safety.

Comment [BU8]: The extensive description of enumerator training and ethical considerations is commendable but can be summarized.
Just summarize as much as possible

Comment [BU9]: This section mentions verbal informed consent but doesn't specify why written consent was not used. Clarify whether this aligns with local ethical guidelines and justify this decision.

Results

Socio-demographic characteristics

Most participants are aged 20-29 (45.1%) and have no education (33.8%). Over half have fewer than three children (54.9%) and follow Islam (69.9%). Most are married (65.9%), with most respondents being unemployed (43.6%). Regarding health, more than half(52.4%) experienced more than one malaria episode during their pregnancy. Household income levels showed that 34.3% earn less than 500 Ghana cedis monthly (Table 1).

Table 1: Socio-demographic characteristics

Variable	Category	Frequency	Percentage
Age			
	<20	43	10.8
	20-29	180	45.1
	30-39	129	32.3
	≥ 40	47	11.8
Highest level of education			
	No formal education	135	33.8
	basic education	83	20.8
	secondary	93	23.3
	tertiary	88	22.1
Parity			
	<3	219	54.9
	≥ 3	180	45.1
Religion			
	Islam	279	69.9
	Christian	113	28.3
	Traditional	7	1.8
Marital status			
	Single	102	25.6
	Married	263	65.9
	Divorced	30	7.5
	widowed	4	1.0
Occupation			
	Unemployed	174	43.6
	self-employed	102	25.6
	employed	123	30.8
Malaria episodes during current pregnancy			
	once	190	47.6
	More than once	209	52.4

Household monthly income(Ghana cedis)			
	0-499	137	34.3
	500-999	129	32.3
	1000-1999	56	14.0
	≥ 2000	77	19.3

Knowledge of Malaria Prevention During Pregnancy

Almost all participants (98.5%) wereaware of insecticide-treated nets (ITNs), with the primary sources of this knowledge being mass media (81.7%) and antenatal care (ANC) centers (79.1%). Most participants recognized the importance of ITNs for reducing contact with mosquitoes (90.6%) and preventing malaria infection (81.4%). Other common preventive methods reported include using insect repellents (72.9%), avoiding stagnant water (74.7%), and covering exposed skin at night (74.9%)(Table 2).

Table 2: Knowledge of Malaria Prevention During Pregnancy

Variable	Category	Frequency	Percentage
Knowledge on ITNs			
	Yes	393	98.5
	No	6	1.5
Source of knowledge			
	ANC centers	311	79.1
	Health education campaigns	249	63.4
	Mass media	321	81.7
	Friends and colleagues	138	35.1
	Family	174	44.3
	Neighbors	38	9.7
Opinion on importance of ITNsduring pregnancy			
	They reduce contact between pregnant women and mosquitoes	356	90.6
	They provide a shelter for mosquitoes	4	1.0
	They drive away mosquitoes from the room	94	23.9
	It is an instruction from the ANC clinic that must be followed	262	66.7
	They help prevent malaria infection	320	81.4
Other ways of preventing malaria in pregnancy			
	Use of insect repellents	291	72.9
	Indoor residual spraying	248	62.2
	Taking antimalaria drugs	47	11.8
	Avoiding stagnant water near the house	298	74.7
	Covering exposed skin at night	299	74.9
	Others(clearing bushes)	9	2.3

Accessibility and Ownership of ITNs

The study shows that 92.5% of participants own at least one ITN, with most obtaining them from free house-to-house distribution (79.7%) and ANC centers (78.6%). Among those who owned ITNs, ownership is relatively evenly distributed, with 32.8% owning one, 33.3% owning two, and 32.0% owning three or more. Most participants (76.2%) reported that ITNs were readily available when needed, though a substantial portion (39.6%) live 6-10 km from the nearest facility where they can obtain an ITN. Only 11% of participants expressed a specific preference for the type of ITN, with the most common preference being for a smooth texture (45.5%).

Table 3: Accessibility and Ownership of ITNs

Variable	Category	Frequency	Percentage
Own at least one ITN			
	Yes	369	92.5
	No	30	7.5
Number of ITNs owned currently			
	1	121	32.8
	2	123	33.3
	3 or more	118	32.0
source of ITN			
	ANC centers	290	78.6
	Market	33	8.9
	friends/relatives	35	9.5
	free house-house distribution	294	79.7
	pharmacy	45	12.2
ITNs were readily available when needed			
	Yes	304	76.2
	No	95	23.8
distance to the nearest facility where ITNs can be obtained			
	<1km	49	12.3
	1-5km	125	31.3
	6-10km	158	39.6
	>10km	67	16.8
Have a preference of ITN			
	Yes	44	11.0
	No	355	89.0

ITN preferences			
	smooth texture	20	45.5
	reusable ITN	16	36.4
	Low chemicals ITN	8	18.2

Utilization of ITNs

The study found that 82.7% of participants used an ITN at home, only 22.6% reported consistent nightly use, and 60.6% used it the previous night. Many participants (43.9%) began using ITNs before pregnancy, while others started during pregnancy (37.3% in the first trimester). The frequency of ITN use varies, with only 21.2% always using it. Most participants (70%) adequately placed the ITN by hanging it over the bed and tucking it under the mattress. However, consistent use is hindered by issues like discomfort due to heat (76.7%), inability to use it when it's hot (64.6%), and lack of proper facilities to hang the ITN (19.6%)(Table 4).

Table 4: Utilization of ITNs

Variable	Category	Frequency	Percentage
Utilize ITN at home.			
	Yes	330	82.7
	No	69	17.3
Consistently utilize ITN every Night			
	Yes	90	22.6
	No	309	77.4
Utilized ITN last night			
	Yes	200	60.6
	No	130	39.4
Started using ITNs			
	Before pregnancy	145	43.9
	During 1st trimester	123	37.3
	During 2nd trimester	26	7.9
	During 3rd trimester	36	10.9
Frequency of ITN utilization			
	Always	70	21.2
	Often	69	20.9
	Sometimes	110	33.3
	Rarely	81	24.5
How do you usually place ITNs			
	Hanging it over the bed and tucking it under the mattress to prevent contact with the body	231	70.0
	Hanging it at one corner of the room	7	2.1
	Hanging it over the bed but the net has contact	42	12.7

	with the skin while sleeping under it		
	Hanging over the windows and doors to prevent mosquitoes from entering	57	17.3
Sleep under ITNs even when it is hot.			
	Yes	122	37.0
	No	208	63.0
Reason for inconsistent use of ITNs			
	It is uncomfortable	113	47.1
	It causes excessive heat and discomfort	184	76.7
	I don'tknow how to hang it properly	42	17.5
	No facility to hang it in my room	47	19.6
	Can't use it when the weather is hot	155	64.6
	Traps mosquitoes inside when tucked in	4	1.7
	Heard it harms the baby in the womb	46	19.2
	Others(contains chemicals)	5	2.1

Barriers to Using ITNs

The primary barriers to using ITNs among pregnant women were excessive heat and discomfort (97.0%), with additional challenges such as difficulty using ITNs during hot weather (70.3%) and lack of knowledge on how to hang them properly (37.6%). Structural issues like the absence of facilities to hang ITNs (29.4%) and the discouraging routine of raising the net each morning (34.2%) also contributed to inconsistent use. Affordability was a concern for 20.9% of participants, and 26.7% reported not receiving an ITN when they were distributed for free. Suggested improvements to encourage ITN usage included making them readily available (80.6%), designing them for better air circulation (100.6%), providing adequate information on proper use (76.7%), and enhancing education on their benefits and safety for pregnant women (Table 5).

Table 5: Barriers to Using ITNs

Variable	Category	Frequency	Percentage
Challenges faced when using ITNs			
	Too costly, I cannot afford it	69	20.9
	Causes excessive heat and discomfort	320	97.0
	I don'tknow how to hang it properly	124	37.6
	No facility to hang it in my room	97	29.4
	I can't use it when the weather is hot	232	70.3
	The routine of raising it every morning after use is discouraging	113	34.2
	I heardit hurts the baby in the womb	78	23.6
	Did not get one when it was freely distributed	88	26.7
	Traps mosquitoes inside when tucked in	13	3.9
	Others(contains chemicals)	5	1.5
Measuresto make ITN usage easy and correctly			
	Adequate information on how to hang ITNs should be provided	253	76.7
	They should be made readily available	266	80.6

	They should be given free of charge	235	71.2
	The price should be reduced	53	16.1
	Better design to allow air circulation	332	100.6
	Improved education on the benefits and safety of ITNs for pregnant women	228	69.1

Comment [BU10]: Resolve discrepancies like the "100.6%" under "Better design to allow air circulation" Just like in this part because it might suggest that there is a calculation or data aggregation error

Association between socio-demographic characterize and consistent usage of ITNs

Several key variables showed significant associations in the study on consistent usage of insecticide-treated nets (ITNs). Age had a p-value of less than 0.001, indicating younger individuals were less likely to use ITNs. Parity ($p = 0.012$) suggested that women with fewer than three children had higher usage rates. Educational level was highly significant ($p < 0.001$), with those holding tertiary degrees more likely to use ITNs. Marital status ($p = 0.012$) and occupation ($p = 0.004$) also correlated with ITN usage, as married and employed individuals reported higher usage. Furthermore, the number of malaria episodes ($p < 0.001$) and household income ($p = 0.013$) were significant, with multiple malaria episodes and lower-income households linked to more consistent ITN use (table 6).

Table 6: Association between socio-demographiccharacterize and consistent usage of ITNs

Comment [BU11]: This particular table on sociodemographic characteristics and ITN usage could benefit from better grouping or visual aids (like graphs) to emphasize trends. (Reason) Long tables with numerous categories are hard to interpret at a glance.

Variable	*Category*	*Consistently usage of ITNs*		*P-value*
		Yes	No	
Age				P<0.001
	<20	4(9.3%)	39(90.7%)	
	20-29	33(18.3%)	147(81.7%)	
	30-39	48(37.2%)	81(62.8%)	
	≥ 40	5(10.6%)	42(89.4%)	
Parity				P=0.012
	<3	39(17.8%)	180(82.2%)	
	≥ 3	51(18.3%)	129(71.7%)	
Highest education level				P<0.001
	Tertiary	28(31.8%)	60(68.2%)	
	Secondary	11(11.8%)	82(88.2%)	
	Basic education	7(8.4%)	76(91.6%)	
	No formal education	44(32.6%)	91(67.4%)	
Religion				P=0.260
	Islam	67(24.0%)	212(76.0%)	
	Christianity	23(20.4%)	90(79.6%)	
	Others	0(0.0%)	7(100.0%)	
Marital status				P=0.012
	Married	64(24.3%)	199(75.7%)	
	Single	26(25.5%)	76(74.5%)	
	Divorced	0(0.0%)	30(100.0%)	
	Widowed	0(0.0%)	4(100.0%)	
Occupation				P=0.004
	Employed	28(22.8%)	95(77.2%)	

	Self employed	34(33.3%)	68(66.7%)	
	Unemployed	28(16.1%)	146(83.9%)	
Malaria episodes during current pregnancy				P<0.001
	Once	43(22.6%)	147(77.4%)	
	More than once	47(22.5%)	162(77.5%)	
Aware of ITN				P=0.183
	Yes	90(22.9%)	303(77.1%)	
	No	0(0.0%)	6(100.0%)	
Household monthly income				P=0.013
	0-499	42(30.7%)	95(69.3%)	
	500-999	21(16.3%)	108(83.7%)	
	1000-1999	15(26.8%)	41(73.2%)	
	≥ 2000	12(15.6%)	65(84.4%)	

Determinant of ITNs among pregnant women

Several factors showed notable associations with the outcome. In terms of education level, individuals with basic education (AOR=0.06, 95% CI: 0.02-0.18, p<0.001), secondary education (AOR=0.08, 95% CI: 0.03-0.23, p<0.001), and tertiary education (AOR=0.29, 95% CI: 0.09-0.95, p=0.042) had lower odds compared to those with no formal education. Employment status also demonstrated significance, where self-employed individuals (AOR=0.04, 95% CI: 0.01-0.20, p<0.001) and unemployed individuals (AOR=0.01, 95% CI: 0.005-0.32, p<0.001) had reduced odds compared to those who were employed. Additionally, household monthly income was significantly associated; those earning 500-999 (AOR=0.07, 95% CI: 0.02-0.21, p<0.001), 1000-1999 (AOR=0.10, 95% CI: 0.01-0.30, p<0.001), and ≥2000 (AOR=0.10, 95% CI: 0.03-0.21, p<0.001) had lower odds compared to the lowest income category (0-499) (Table 7).

Table 7: Determinant of ITNs among pregnant women

Variable	Category	AOR (95% CI)	p-value
Age			
	<20	Ref*	
	20-29	0.58(0.14-2.38)	0.448
	30-39	2.93(0.49-17.65)	0.24
	≥ 40	0.31(0.04-2.61)	0.284
Highest level of education			
	No formal education	Ref*	
	Basic education	0.06(0.02-0.18)	p<0.001
	Secondary	0.08(0.03-0.23)	p<0.001
	Tertiary	0.29(0.09-0.95)	0.042
Marital status			
	Married	Ref*	
	Single/divorced/separated	1.32(0.59-2.94)	0.496
Parity			
	< 3	Ref*	
	≥ 3	2.16(0.65-7.22)	0.209
Occupation			

Comment [BU12]: This variable "Aware of ITN" show non-significant associations but remain included in the analysis. Non-informative variables should either be excluded or noted explicitly as non-significant findings.

Comment [BU13]: Check the comment on the table

Comment [BU14]: Check whether "AOR" values are correctly calculated, as some appear unusually low, such as for employment categories.

Comment [BU15]: Please clarify why education levels with "reduced odds" might correlate inversely with ITN use. This contradicts global trends and warrants deeper discussion.
For instance: The finding that higher education levels (e.g., tertiary education) are associated with lower odds of ITN usage contradicts global and regional trends, which typically show higher education correlates with better health behavior adherence. This should be examined further and adequately discussed.

Employed	Ref*	
Self-employed	0.04(0.01-0.20)	p<0.001
Unemployed	0.01(0.005-0.32)	p<0.001
Malaria episodes during current pregnancy		
Once	Ref*	
More than once	1.60(0.78-3.27)	0.199
Household monthly income		
0-499	Ref*	
500-999	0.07(0.02-0.21)	p<0.001
1000-1999	0.10(0.01-0.30)	p<0.001
≥ 2000	0.10(0.03-0.21)	p<0.001

Ref*= Reference, AOR-Adjusted Odds Ratio

Comment [BU16]: The AOR values for some categories are extremely low (e.g., unemployed women: AOR=0.01, CI: 0.005–0.32). Such extreme values warrant double-checking for errors in model specification or sample size issues.

Comment [BU17]: While the negative association between income and ITN usage might reflect access issues among lower-income households, it's unclear why this relationship persists across all income levels. It might indicate confounding variables or issues with data interpretation.

Discussions

Comment [BU18]: Would you mind streamlining the discussion by focusing on key findings and contextualizing them within global literature.

The study assessed the utilization of ITNs among pregnant women in the Tamale Metropolis.

Comment [BU19]: Elaborate on any unexpected findings, such as the inverse relationship between education and ITN usage, and provide possible explanations.

The study showed that majority of the respondents were aware of ITNs. Similar levels of ITN awareness have been reported in studies conducted in sub-Saharan Africa. For instance, a study by Asumah et al., [8]indicated that over 90% of households in regions targeted by malaria control programs were aware of ITNs. The widespread dissemination of malaria prevention messages via mass media and health centers supports such high awareness levels. The role of mass media and ANC clinics as key information sources is consistent with findings in the literature. A study by Saha et al. [25] demonstrated that radio campaigns and health facility visits during pregnancy significantly increased ITN awareness among pregnant women. ANC visits are particularly effective because they target women during a crucial stage when they are more likely to prioritize preventive health measures for themselves and their unborn children[26].

Recognition of ITNs for reducing mosquito contact and preventing malaria (90.6% and 81.4%, respectively) is comparable to findings in studies where ITNs are often considered the gold standard for malaria prevention[9, 27, 28].The emphasis on the multiple advantages of ITNs corresponds with community-wide educational initiatives that present ITNs as both protective and economically viable. The application of repellents, the avoidance of stagnant water, and the covering of exposed skin at night conform to WHO-recommended malaria prevention strategies. Research has seen analogous tendencies, emphasizing the significance of multimodal preventative strategies, especially in regions where access to ITNs may be restricted or behavioral patterns affect compliance[29, 30].

While the findings broadly agree with existing research, there are nuanced areas of convergence and divergence. Near-universal awareness (98.5%) among participants is consistent with reports from regions with robust malaria control programs. This demonstrates the success of campaigns and ANC integration, similar to results from programs in Africa [31]. The prominence of ANC as a source reflects the increasing focus on maternal health as a critical entry point for malaria prevention efforts, as seen in programs by Roll Back Malaria (RBM). However, the literature often highlights gaps between ITN awareness and actual usage. Some studies indicate that factors such as affordability, accessibility, and cultural perceptions limit ITN use despite widespread awareness[32, 33]. Despite participants' general comprehension of the advantages of ITNs, the marginally reduced awareness of malaria prevention

(81.4%) relative to mosquito contact reduction (90.6%) may indicate insufficient messaging. Previous research emphasizes comprehensive malaria education's significance in strengthening the connection between mosquito bites and malaria transmission[34]. Targeted campaigns, such as mass media and ANC programs, effectively reach vulnerable populations, particularly pregnant women and children. Recognizing ITNs and other preventive methods is influenced by culturally appropriate messaging and community engagement. However, socioeconomic factors, cultural norms, and healthcare access variations can explain differences in awareness and perceived importance of ITNs. Economic barriers, misconceptions about safety, and discomfort in hot climates can also contribute to discrepancies[35].

The study's finding that 92.5% of participants own at least one ITN is in line with other research that has found widespread ITN distribution efforts have been successful in increasing ownership. For example, research in sub-Saharan Africa has shown that ITN ownership rates often exceed 90% in areas with large-scale distribution programs [30]. The high rate of ITN ownership observed in this study is likely the result of effective interventions, such as free house-to-house distribution and ANC center distributions, which have been documented as effective strategies to increase access to ITNs [8]. However, the finding that 39.6% of participants live 6-10 km from the nearest ITN distribution facility highlights access barriers that may still exist, especially in rural or hard-to-reach areas. This is consistent with the literature, which suggests that even when ITNs are distributed freely, geographic barriers or poor infrastructure may hinder their accessibility for certain populations#8.

The study’s finding that 82.7% of participants use ITNs at home but only 22.6% use them consistently every night is also consistent with previous studies, which have shown a gap between ITN ownership and consistent usage. For example, researches[8, 36] found that while a high percentage of households owned ITNs, consistent nightly use often fell short, primarily due to discomfort, heat, and inadequate knowledge on proper usage. The study's finding that 76.7% of participants reported discomfort due to heat, and 64.6% had difficulty using ITNs when it was hot, supports these reports, suggesting that environmental factors significantly impact ITN use, especially in hot climates. Studies have consistently pointed out that discomfort during warm weather is a primary barrier to ITN use, particularly in tropical areas where temperatures can make sleeping under a net challenging[37–39].

Comment [BU20]: To me, a stark contrast exists between high ownership (92.5%) and low consistent usage (22.6%). While barriers such as heat and discomfort are acknowledged, there is no clear explanation why ownership doesn’t translate into higher usage beyond anecdotal reasons. Would you mind elaborating hence this is a discussion section

The finding that 70% of participants adequately hung their ITNs over the bed and tucked them under the mattress is in line with other studies that highlight the importance of correct installation and usage for effective protection. However, the 19.6% who lacked proper facilities to hang the ITNs is concerning, as previous literature has emphasized that the absence of proper infrastructure can lead to improper use, diminishing the net's effectiveness[40].

The study identified several barriers to consistent ITN use, including discomfort, heat, and structural challenges such as the inability to properly hang the nets. These are well-documented in the literature. According Manu et al., [18] found that in many settings, the physical discomfort of using ITNs, especially during hot weather, was one of the most common reasons for non-use. The report by Doe et al., [33]also highlighted the challenges of ITN usage in hot climates, where individuals are reluctant to use the nets due to perceived discomfort. This finding aligns with the 76.7% of participants in this study who cited discomfort due to heat.

Additionally, the study found that 29.4% of participants reported the absence of proper facilities to hang ITNs, and 34.2% found the daily routine of raising the net each morning discouraging. These logistical

barriers are common in the literature and have been shown to hinder regular use[18]. The findings on structural issues—such as inadequate space to hang the ITN or the routine of moving the net—are particularly important, as they highlight the need for more than just the provision of ITNs. They also emphasize the necessity of improving living conditions and providing education on how to use ITNs effectively.

The study showed that education level, employment status, and household income were significant determinants of the insecticide-treated mosquito net (ITN) usage among pregnant women. The study showed that education consistently emerges as a determinant of ITN utilization in several studies. Higher education levels are often associated with increased health literacy, awareness of malaria prevention strategies, and better adoption of ITNs. For instance, studies by Hill et al.[41]in Sub-Saharan Africa emphasize that educated women are more likely to understand the importance of ITNs and adhere to their use. The findings that basic, secondary, and tertiary education levels are associated with reduced odds of non-usage compared to no formal education align with these patterns[42, 43]. However, the observation of a less pronounced protective effect for tertiary education compared to lower levels diverges slightly from global trends. This could indicate that foundational education levels are sufficient to instill malaria prevention knowledge, with higher education providing diminishing returns in awareness specific to ITNs.

Employment status also plays a complex role. The reduced odds of non-usage among self-employed and unemployed women compared to formally employed individuals diverge from the conventional assumption that employment facilitates health resource access. This divergence may reflect the time flexibility of self-employed women, who may prioritize household health measures, including ITN use, over work commitments. Similarly, unemployed women may have more opportunities to engage with community health campaigns or receive ITNs through targeted programs. These findings echo patterns reported in regions where formal employment is associated with time constraints, reducing the likelihood of engaging in preventive health behaviors.

Household income shows a consistent relationship with ITN usage, as higher-income households generally have better access to health resources. Higher income reduces financial barriers to purchasing ITNs when they are not freely distributed and supports better living conditions, which may reduce exposure to malaria. However, the significant reduction in non-usage odds observed across all higher-income brackets suggests that even modest increases in income can make a substantial difference in ITN accessibility and utilization. This pattern is consistent with findings from Polec et al., [44], who observed that small increases in household income improved malaria prevention practices in resource-limited settings.

This study's strengths include its high participation rate, robust sample size, and thorough quantitative analysis of factors influencing ITN utilization among pregnant women in Tamale Metropolis. The focus on socio-demographic determinants provides valuable insights into how education, employment, and income levels affect ITN usage. The study also benefits from clear data collection methods and statistical analysis that allow for meaningful comparisons between different socio-economic groups. However, the study has limitations, such as its reliance on self-reported data, which may introduce biases regarding ITN use and awareness. The cross-sectional design limits the ability to establish causal relationships, and the findings may not be generalizable to other regions outside Tamale Metropolis due to cultural and geographical differences. Additionally, the study does not assess the long-term impact of ITN usage on

malaria prevention outcomes, restricting its scope in evaluating the broader effectiveness of malaria control programs.

Conclusion

Comment [BU21]: Emphasize actionable takeaways and the broader implications of the findings for policy and public health programs.

This study highlights the significant role of education, employment status, and household income in determining the utilization of insecticide-treated mosquito nets (ITNs) among pregnant women in the Tamale Metropolis. Despite high awareness and ownership of ITNs, consistent usage remains low due to discomfort from heat, lack of proper hanging facilities, and logistical challenges. These barriers, alongside socio-economic disparities, emphasize the need for targeted interventions to improve the accessibility and usability of ITNs. Efforts should focus on enhancing educational campaigns, addressing environmental discomfort, and ensuring the provision of adequate infrastructure for ITN installation. The study underscores the importance of a multifaceted approach, combining awareness, resources, and community engagement, to increase the effectiveness of malaria prevention strategies in the region.

Recommendations

Pregnant women should be encouraged to use ITNs consistently by overcoming barriers like discomfort, Education on proper ITN usage and managing heat discomfort can improve adherence. Women should be urged to access free ITNs through ANC services and other distribution programs to ensure continuous protection against malaria.

The Ministry of Health should ensure better access to ITNs, particularly in rural areas, and focus on overcoming infrastructural challenges. Enhanced educational campaigns should target pregnant women, emphasizing the importance of ITNs and their proper use. Special attention should be given to addressing discomfort issues, such as designing more breathable nets or providing guidelines to manage heat during sleep.

Midwives should be trained to educate pregnant women on the importance of ITN use, proper installation, and maintenance. They should actively advocate for using ITNs consistently during ANC visits and help overcome challenges related to heat discomfort and installation.

Future research should explore socio-cultural factors that influence ITN use and identify strategies to overcome barriers related to discomfort and infrastructure. Longitudinal studies assessing the impact of ITN usage on maternal and child health outcomes would provide valuable data, while investigating alternative malaria prevention methods for pregnant women could offer additional insights.

Consent for publication

Not applicable

Data Availability

Data used to support this study are available from the corresponding author upon request.

Disclaimer (Artificial intelligence)

Authors at this moment declare that generative AI (ChatGPT) has been used during manuscript editing(grammar).

Funding Statement
The authors did not receive specific funding for this work.

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Comment [BU22]: Ensure all references are formatted consistently per journal requirements. A

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