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Factors Influencing the Utilisation of Insecticide-Treated Nets to Prevent Malaria during Pregnancy: The Case of Rural Ekwendeni, Malawi

Chisomo Salangwa

csalangwa@gmail.com

The Copperbelt University

Reston Munthali

Synod of Livingstonia Health Department

Vegha Nyirenda

Synod of Livingstonia Health Department

Research Article

Keywords: ITN, ANC, Malaria, Malawi, Pregnant women, Ekwendeni

Posted Date: November 6th, 2025

DOI: https://doi.org/10.21203/rs.3.rs-7930704/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

The consistent use of an insecticide-treated net (ITN) throughout pregnancy is a proven method for preventing the adverse effects of malaria. Although access to this intervention has increased in sub-Saharan Africa, consistent use of ITNs during pregnancy remains uncommon.

Methods

Our objective was to identify factors that contribute to the utilisation of ITNs throughout pregnancy. To achieve this, we conducted a population-based random sampling of 700 women who had given birth in the past year in Ekwendeni.

Results

In a study of 700 pregnant women, 359 (51.2%) reported having an insecticide-treated net (ITN) at the beginning of their pregnancy, while 28 (4%) had an ITN after the first trimester. Of the 514 ITN owners, 73% reported sleeping under their nets during every trimester of pregnancy or after obtaining it. The possession of multiple nets was marginally associated with consistently sleeping under an ITN during pregnancy (relative risk (RR): 1.13; 95% confidence interval (CI): 1.00-1.28). Pregnant women who consistently slept under an ITN were more likely to be influenced by a radio or billboard advertisement than a free ITN (RR: 1.48; 95% CI: 1.24–1.76). Other sociodemographic characteristics, pregnancy history, antenatal care (ANC) use, and sociocultural factors did not differ significantly.

Conclusion

Pregnancy is a critical period during which women in Malawi must adhere to recommended guidelines for using insecticide-treated bed nets (ITNs). However, many women in Ekwendeni do not follow these guidelines consistently. Despite this, frequent self-reported ownership and use of ITNs have been observed throughout pregnancy. It is essential to gather additional information about each household's capacity for ITN installation, as this may be a critical factor in developing future interventions aimed at improving daily ITN usage and convenience.

Introduction

Malaria remains a significant public health challenge, particularly in endemic regions[1, 52]. Pregnant women with an elevated risk of adverse outcomes from malaria infection are those whose susceptibility is attributable to both immunological and physiological alterations during pregnancy[1–3, 52]. This vulnerability underscores the necessity for effective preventive measures, with insecticide-treated nets (ITNs) serving as the primary defence mechanism[1, 52]. ITNs function as a physical barrier against mosquitoes and provide insecticidal effects that substantially reduce the risk of malaria transmission. Consequently, ITNs have been widely endorsed by health organisations and national malaria control

programs as a cornerstone of malaria prevention, especially for vulnerable populations such as pregnant women[1, 52–53].

Despite robust evidence supporting the efficacy of ITNs, their use remains suboptimal across various settings. A range of factors influences both the uptake and consistent use of ITNs among pregnant women[1, 52]. These factors are multifaceted, encompassing not only awareness and access but also sociocultural beliefs, economic constraints, and behavioural practices. Understanding these influences is crucial in designing interventions to improve ITN coverage and adherence[1, 52]. This manuscript examines the barriers and facilitators of ITN use among pregnant women, highlighting critical gaps in current strategies and offering insights into potential pathways for enhancing ITN utilisation[1–3, 52]. By addressing these determinants, health programs can progress towards comprehensive malaria prevention in this high-risk group, thereby contributing to improved maternal and neonatal health outcomes.

Pregnancy-related malaria, characterised by parasitaemia, often presents without symptoms in regions with consistent malaria transmission is consistent[1, 52, 3]. However, the negative consequences of malaria can be severe in both symptomatic and asymptomatic women [2, 8–9]. As a result, controlling malaria during pregnancy requires the implementation of effective preventive measures and management of malaria illness[3, 6, 1]. A meta-analysis of the effectiveness of ITNs in preventing adverse maternal and foetal outcomes among pregnant women living in areas with endemic malaria in Africa found that using ITNs during pregnancy reduced placental malaria by 23%, foetal loss by 32%, and improved birth weight by 33 grams [4, 11, 5].

In 38 African countries, ITNs are provided free of charge to all age groups, whereas most other countries have systems in place to sell ITNs at reduced prices [5, 3, 8]. Despite the success of large-scale, free ITN distribution campaigns and subsidised voucher programs for ITNs targeting pregnant women and children in raising the percentage of households that own and use an ITN, ITN use among pregnant women remains low in many intervention areas [6, 5]. According to a recent compilation of coverage data, 23 million births in sub-Saharan Africa in 2007 were not covered by the ITNs [7, 9, 3]. In Malawi's 2000–2010 Malaria Indicator Surveys (MIS) and DHS/MICS surveys, 43.7% of expectant mothers slept under a mosquito net the night before the interview, up from 34% in 1999, and 43.7% slept under an ITN, up from 10% in 1999 [8, 33]. Additionally, 77% of the pregnant women who owned an ITN reported using it the night before the survey [8, 33, 16].

Despite the documented disparity between ITN ownership and usage prevalence [9, 23], little is known about the personal characteristics linked to bed net use during pregnancy among net-owning households. Previous studies reported inconsistent demographic relationships [10, 30]. Qualitative studies have found that low awareness of malaria during pregnancy, scepticism about the effectiveness of ITNs, and concerns about the safety of insecticides during pregnancy are common reasons for not using bed nets[11, 18, 7]. Other barriers to bed net use include high ambient temperatures, lack of bed net hanging hardware, and high costs [12, 38]. Therefore, it is essential to understand the factors that

influence a woman's decision to use an ITN during pregnancy, considering the persistent disparity between ITN ownership and usage and the most recent modifications to national policy to distribute ITNs at no cost[13, 20–23]. To support the National Malaria Strategic Plan-2023-2030 (NMSP) goal of requiring all pregnant women to sleep under an ITN during their pregnancy, we conducted a population-based study in Ekwendeni, Malawi, to determine the factors that influence the use of ITNs during pregnancy[14, 8].

Materials and Methods

Selection of study participants

A stratified random sample of 700 female residents aged 15 to 40 years from T/A Mtwalo within Ekwendeni catchment area under Mzimba North District, Malawi, was interviewed at home between November 2023 and January 2024. The purpose of the survey was to investigate the ownership, acquisition, and usage of ITNs as well as the use of antimalarial medication during pregnancy and any associated factors. To qualify for the study, participants had to have given birth within the previous 12 months and have had a pregnancy that continued until at least the third trimester, regardless of the pregnancy outcome. The study population and methods have been described above.

Study setting:

The Malawian Malaria Surveillance Project conducted a census in November 2000–2010, from which a population-based sample was derived. A total of 191,108 individuals resided in 16 villages distributed across T/A Mtwalo and Ekwendeni (Baluba Chirwa, Chibisa Mtonga), which constitute the study area[15, 7]. Among 4,654 women aged 15–49 years, 867 reported having given birth within the preceding 12 months.

Data collection:

A standardised questionnaire that had been pre-tested by interviewers was used to collect data. This questionnaire was based on a conceptual framework modified by Ribera et al. [16, 7] and was designed to gather information on sociodemographic characteristics, sociocultural elements, obstetric history, malaria knowledge and attitudes, utilisation of prenatal clinics, and ownership and usage of ITNs. Where possible, questions from large international surveys, such as the Malaria Indicator Survey and Malawian Demographic and Health Survey, were incorporated into the survey [15, 7]. The survey was translated into Chichewa, the official language in Malawi, and then back into English for easy data entry, transcription, and analysis.

Women were instructed to maintain a pregnancy history calendar, on which they recorded any instances of self-reported malaria, the use of antimalarial medication during pregnancy, and ANC visits.

Additionally, the women were asked to indicate how frequently they slept under a mosquito net during the first, second, and third trimesters of their index pregnancy to assess the frequency of bed net usage. The women were shown the corresponding months on the calendar for each menstrual cycle, after which they were asked to respond. The calendar also includes national holidays and culturally significant dates to aid memory.

Definitions:

In this community, two types of pretreatment nets are available: long-lasting insecticide-treated nets (LLINs), which require no retreatment for up to five years, and regular insecticide-treated nets (ITNs), which are advertised as effective for up to one year[17, 52]. Families in the study area may have received a net for free through a community-based subsidised net distribution program, a mass distribution program aimed at pregnant women and children under five years, or they may have purchased a net from a nearby vendor. It is important to note that ANC clinics in the study area did not offer free or subsidised ITN distribution. To accurately identify the type of net used, the women were shown pictures of the nets found in the most commonly available packets in their communities. The use of ITNs was determined independently for each trimester of pregnancy. A woman consistently used an ITN if she reported always sleeping under one during the trimester in which her home had a net. The matching months on the calendar are shown for each trimester.

Statistical analysis

SPSS version 26 was employed to conduct the analyses. The primary analyses focused on women who had been pregnant within the previous 12 months and revealed the correlations between self-reported consistent ITN use and age, marital status, education, religion, parity, pregnancy history, knowledge of malaria, and sociocultural factors. A composite variable was created using seven questions on the prevention, consequences of infection, and transmission of malaria during pregnancy to summarise a woman's knowledge of the disease. This variable had a maximum score of 9.5, which was obtained by respondents who answered all the questions correctly. Subsequently, the distribution of scores was dichotomised at the mean.

The household wealth index, a standardised composite measure that combines a household's cumulative living standards, was computed using principal components analysis [18, 7]. This measure is based on a household's ownership of specific assets, such as televisions and bicycles, building materials, and different types of water access and sanitation facilities.

Relative risk regression was used to assess the relationship between these variables and the use of an ITN during pregnancy [19, 7]. Multivariate models were created to evaluate the independent impacts of the different correlates. A priori, covariates believed to be connected to the outcome and the exposure of interest were identified. Unadjusted and adjusted risk estimates did not differ from one another,

suggesting that confounding by the measured variables is unlikely to skew the results. Consequently, updated estimates were not provided.

Results

Characteristics of the study population

To identify the 700 eligible women, 867 households were visited between November 2023 and January 2024. All eligible women participated in this study. The eligibility, participation, and study subject characteristics have been previously published [20]. Many of the women in this group were married, with a mean age of 26 years (range: 15–49 years) (90 per cent). Most women resided in small rural settlements (74 per cent).

Table 1
Sociodemographic Factors Associated with Consistent Insecticide-Treated Net (ITN) Use.

Characteristic	Always ITN use n = 279	Did not always use ITN n = 212	RR (95% CI)
Age (years)			
≤ 18 years	20 (61)	13 (39)	0.82 (0.61, 1.10)
19–24 years	115 (74)	41 (26)	Reference
25–34 years	108 (73)	41 (28)	0.98 (0.85, 1.12)
≥ 35 years	38 (78)	11 (22)	1.05 (0.88, 1.26)
Marital status			
Single	19 (66)	10 (35)	0.89 (0.68, 1.17)
Married	262 (73)	96 (27)	Reference
Education			
None	13 (65)	7 (35)	0.87 (0.63, 1.21)
Primary	204 (75)	69 (25)	Reference
Secondary/Postsecondary	64 (68)	30 (32)	0.91 (0.78, 1.06)
Religion			
Christian	187 (78)	54 (22)	Reference
Muslim	94 (64)	52 (36)	0.83 (0.72, 0.95)
Ekwendeni			
Baluba Chirwa	129 (70)	55 (30)	Reference
Chibisa Mtonga	152 (75)	51 (25)	1.07 (0.94, 1.21)
Village type			
Rural	217 (75)	74 (25)	1.12 (0.96, 1.31)
Peri-Urban	64 (67)	32 (33)	Reference
Household wealth index			

Characteristic	Always ITN use n = 279	Did not always use ITN n = 212	RR (95% CI)
1 (Most poor)	53 (79)	14 (21)	Reference
5 (Least poor)	37 (61)	24 (39)	0.77 (0.60, 0.97)
2	58 (75)	19 (25)	0.95 (0.80, 1.14)
3	68 (78)	19 (22)	0.99 (0.84, 1.17)
4	60 (71)	25 (29)	0.89 (0.74, 1.07)

Perception of malaria risk among the study participants

These populations perceived a high risk of malaria; seventy per cent of the women who responded indicated that they were particularly concerned about contracting the disease during their most recent pregnancy. Pregnant women's primary concerns regarding malaria include the risk of miscarriage/stillbirth (50 per cent), maternal death (16 per cent), and adverse effects on the unborn child (12 per cent). Sixty-seven per cent of the women self-reported having malaria during their most recent pregnancy, and thirty-seven per cent of them reported having the disease more than once. In terms of knowledge of malaria, 58 per cent of the women scored highly.

Table 2
Factors Associated with Consistent Insecticide-Treated Net (ITN) Use Among Pregnant Women.

Characteristic	Always ITN use n = 279	Did not always use ITN n = 212	RR (95% CI)
Belief ITN is safe during pregnancy; n (%)			
Yes	253 (71.3)	102 (28.7)	Reference
No	28 (87.5)	4 (12.5)	1.23 (1.06, 1.42)
The most important influence to use ITN; n (%)			
Given free ITN	60 (64.5)	33 (35.5)	Reference
Told by a doctor or nurse	137 (72.9)	51 (27.1)	1.13 (0.95, 1.34)
Advertisement on the radio or a poster	22 (95.6)	1 (4.4)	1.48 (1.24, 1.76)
Hearing from other pregnant women	27 (71.0)	11 (29.0)	1.10 (0.86, 1.42)
Having an extra net for kids	35 (77.8)	10 (22.2)	1.21 (0.97, 1.50)

ITN ownership and acquisition during pregnancy

At the outset of their most recent pregnancy, 72% of the women reported having an ITN (n = 359). Among the 141 women who did not have an ITN at the start of their index pregnancy, 28 acquired one during their pregnancy. Most women reported obtaining an ITN during the second (57%) or third (43%) trimester of pregnancy. All the pregnant women who purchased the net stated that they slept under it constantly throughout their pregnancy.

Table 3
Antenatal Care Utilisation by Insecticide-Treated Net (ITN) Use Among Pregnant Women.

Characteristic	Always ITN use n = 279	Did not always use ITN n = 212	RR (95% CI)
Use of ANC			
# ANC visits (mean (sd))	3.2 (1.2)	3.2 (1.2)	0.99 (0.94, 1.04)
ANC initiation; n (%)			
1st trimester	53 (19.1)	23 (22.1)	0.95 (0.81, 1.12)
2nd trimester	183 (65.8)	67 (64.4)	Reference
3rd trimester	42 (15.1)	14 (13.5)	1.02 (0.87, 1.21)

ITN use during pregnancy.

According to a study conducted on 387 women who owned ITNs, 73% reported that they consistently slept beneath the net during every trimester of pregnancy or after acquiring one. The primary reason for not always sleeping under the net was the presence of heat (49%). Additional reasons are listed in Fig. 1.

The study found that Muslim women were less likely than women of Christian religions to consistently use a net during pregnancy (RR: 0.83; 95% CI: 0.72, 0.95). Furthermore, compared to women in the poorest households, those in the wealthiest families were less likely to consistently use a net during pregnancy (RR: 0.77; 95% CI: 0.60, 0.97). Participants were asked to select the factor with the greatest impact on their decision to sleep under an ITN during pregnancy.

Table 4
Association Between Pregnancy History and Consistent Use of Insecticide-Treated Nets (ITNs) Among Study Participants.

Characteristic	Always ITN use n = 279	Did not always use ITN n = 212	RR (95% CI)
Pregnancy history			
Number of births			
1 birth	56 (70.9)	23 (29.1)	0.98 (0.83, 1.15)
> 1 birth	225 (73.0)	83 (27.0)	Reference
Prior miscarriage			
Yes	48 (68.6)	22 (31.4)	0.93 (0.79, 1.11)
No	233 (73.5)	84 (26.5)	Reference
Prior stillbirth			
Yes	16 (84.2)	3 (15.8)	1.17 (0.95, 1.43)
No	265 (72.0)	103 (28.0)	Reference

The results showed that pregnant women who consistently slept under an ITN were more likely to be influenced by a radio or billboard advertisement than by a free ITN (RR: 1.48; 95% CI: 1.24, 1.76). On the other hand, pregnant women who consistently used their net were also more likely to believe that it could be harmful to sleep under an ITN (RR: 1.23; 95% CI: 1.06, 1.42). No significant differences were observed in other sociodemographic characteristics, pregnancy history, ANC use, or sociocultural factors.

Table 5
Factors Associated with Consistent Insecticide-Treated Net (ITN) Use During Pregnancy.

Characteristic	Always ITN use n = 279	Did not always use ITN n = 212	RR (95% CI)
Knowledge of malaria			
Knowledge of malaria score (mean (sd))	6.3 (1.3)	6.4 (1.4)	0.98 (0.94, 1.02)
Socio-cultural factors			
Who decides if an ITN is used during pregnancy? n (%)			
Respondent	51 (68.0)	24 (32.0)	0.94 (0.71, 1.23)
Husband/partner	21 (72.4)	8 (27.6)	Reference
Respondent and husband jointly	165 (75.3)	54 (24.7)	1.04 (0.82, 1.32)
Someone else	44 (68.8)	20 (31.2)	0.95 (0.72, 1.25)
Bed net factors			
# Bed nets owned during pregnancy; n (%)			
1-bed net	130 (46.3)	61 (57.6)	Reference
≥ 2 bed nets	151 (53.7)	45 (42.4)	1.13 (1.00, 1.28)

Discussion

Malaria remains a significant public health challenge in Malawi, necessitating multifaceted initiatives to combat its prevalence. Key strategies include the distribution of long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS), both critical for vector control[21, 27]. The Malawian National Malaria Control Programme established guidelines in 2002 to achieve at least 60% LLIN coverage, which was subsequently increased to 80% by 2005, supported by funding from the Global Fund and the US President's Malaria Initiative[27, 1, 21]. Despite these efforts, the country has encountered challenges such as inadequate vector control and insecticide resistance, which complicate malaria management as noted by Chanda et al., 2015. Between 2002 and 2012, more than 18 million LLINs were distributed, leading to an increase in household coverage from 27% to 58%[27, 21]. However, the rise in malaria cases from 2.85 million in 2002 to over 6.74 million in 2010 highlighted the limitations of relying solely on these interventions[27, 1]. This situation underscores the necessity for an integrated vector management approach, which could potentially yield improved outcomes in malaria control as noted by

Hamuza et al., 2024[21, 27]. In addition to vector control, addressing treatment-seeking behaviours among caregivers of young children is crucial. A study utilising multivariate binary logistic regression and geospatial analysis identified traditional authorities in Malawi, where caregivers exhibited varied health-seeking behaviours toward childhood malaria.

Notably, despite certain areas showing late treatment-seeking patterns, many mothers sought care within 24 hours of symptom onset[21–23, 1]. This suggests that targeted interventions could enhance prompt treatment-seeking in communities where delays are prevalent as noted by Price et al., 2023[21, 1]. The implementation of house improvement (HI) strategies has emerged as a complementary measure to traditional insecticidal methods. A mixed-methods study assessing the fidelity of community-led HI in southern Malawi found that while initial adherence to the intervention was strong, it declined over time owing to various socioeconomic challenges. Addressing these barriers through community education and consistent training is essential for sustaining HI initiatives as noted by Tizifa et al., 2024[21, 1]. Finally, the introduction of the RTS, S malaria vaccine has demonstrated promise in enhancing malaria prevention efforts. A longitudinal qualitative study revealed that caregiver trust in the vaccine significantly influenced uptake, with most caregivers expressing positive attitudes towards RTS and S in the final round of interviews. Understanding the factors that facilitate or hinder vaccine acceptance can inform future vaccination campaigns in Malawi as noted by Price et al. 2023[21, 5–8].

A study conducted on 500 recently pregnant women in Ekwendeni, Malawi, revealed that 73% of women who owned an ITN consistently used it during their pregnancy. Only 4% of ITN owners claimed that they had never accessed it during pregnancy. Of the women surveyed, 51.2% reported being faithful during their pregnancies. The findings of this study did not conclusively determine the factors that contribute to ITN adherence. Women who owned two or more nets were slightly more likely to continuously use an ITN throughout pregnancy, whereas Muslim women were significantly less likely to do so[21, 18–19].

The results of this study are consistent with those of the Malaria Indicator Survey conducted in 2009, which found that 77% of pregnant women in households using ITNs slept beneath them the night before the survey [22, 1–4]. The findings also align with the Ekwendeni Mission Hospitals Health Management Information System (HMIS) data on pregnant women aged 15 to 49 years at the time of the survey, which showed that 55% of all pregnant women and 76% of those who owned a bed net reported using one. However, the overall ITN coverage and utilisation in Ekwendeni had not yet reached the UN Secretary-General's target of achieving universal coverage of malaria interventions by 2010 [23, 11, 40].

Despite the prevalence of ITN ownership in the study population, 23% of women did not have an ITN during their index pregnancy, underscoring the significance of expanding ITN access. To achieve this, "catch-up" and "keep-up" tactics inspired by childhood immunisation programs have become increasingly popular[24, 18]. These tactics involve the widespread distribution of free ITNs (catch-up) and the regular provision of ITNs or subsidised vouchers to pregnant women and/or children through public health clinics or commercial outlets (keep-up) [25, 6, 16]. Consequently, the coverage and usage of ITNs significantly increased in the intervention areas. Moreover, free mass ITN distribution or voucher

programs with financial assistance have been shown to successfully increase coverage, utilisation, and distribution equity throughout the intervention areas [26, 11]. Despite these initiatives' success in increasing ITN ownership and usage, the percentage of ITN users remains lower than that of ITN owners. According to recent data, only 23% of pregnant women in that study used ITNs the night before the survey, even though the percentage of households owning ITNs climbed to 65% in that study [25, 30, 38].

According to survey data from African countries, there have been increases in both ITN ownership and use in intervention areas, with a doubling of ITN ownership and use among pregnant women over survey periods of 3–5 years[26, 22]. This increase may be attributed to national ITN promotional activities such as reducing or eliminating taxes and tariffs, creating demand, lowering the cost of nets through subsidies or vouchers, providing free mass distribution programs, and/or stimulating the commercial market [27, 12, 19]. However, there are differences in the percentage of pregnant women who sleep under an ITN and the percentage of families that own an ITN.

Previous research has explored various aspects related to bed net ownership or use during pregnancy, in addition to the studies mentioned above that assessed the impact of distribution tactics or governmental attempts to promote ITN coverage and use. One study investigated the correlates of bed net ownership during pregnancy among 351 women in Congo who were enrolled in ANC programs and received ITNs [27, 3]. Another study examined the correlates of bed net use the night before delivery among 976 Kenyan women who had given birth in the previous year [27, 12–14]. Two additional studies explored the characteristics of bed net owners and non-owners regarding the use of bed nets during pregnancy. The first study involved a cohort of 293 postpartum women who gave birth in a Tanzanian hospital without any issues and defined ITN utilisation as ITN use for more than 75% of pregnancies [28]. The second study, a community-based study of 976 Kenyan women, did not define the use of ITNs during pregnancy [28].

Several studies have explored the sociodemographic factors associated with Internet use during pregnancy. In one such study, women aged 30 years or older had a nearly four-fold higher likelihood of using the Internet compared to those under the age of 20 (OR: 3.8; 95 per cent CI: 1.3, 5.0), while women aged 20–29 years had a 2.5-fold higher likelihood of owning a net compared to those under the age of 20 (OR: 2.5; 95 per cent CI: 1.5, 9.4) [29, 32]. However, two studies, including ours, found no relationship between age and internet usage [29]. Similarly, no correlation was found between net use and either marital status or education in our study or two previous studies [29, 32]. In two studies, parity was examined as a predictor of Internet use, but only one study found a significant relationship. In that study, primiparous women were less likely to use the Internet than multiparous women (RR: 0.46; 95 per cent CI: 0.22, 0.97) [29]. However, our study and others found no correlation between parity and internet usage [30]. In one study, participants' knowledge of malaria was assessed, and a high score was linked to a more than twice as high risk of using the Internet as a low score [30]. However, in our study, no correlation was found between bed-net usage and malaria score knowledge.

According to various sources, one of the major obstacles to the widespread ownership and utilisation of ITNs in Africa is the high cost of these nets and their limited availability for purchase by local vendors [31, 8]. Two studies investigated wealth indicators as potential correlates of net usage during pregnancy, yielding inconsistent results[32]. While one study found that using a bed net during pregnancy was associated with a lower wealth level (OR: 2.5; 95 per cent CI: 1.4, 4.7), another study [33, 52] found that net usage was linked to radio ownership, which is indicative of a higher wealth status (OR: 2.3; 95 per cent CI: 1.0, 5.5). The analysis of homes with nets in the current study revealed that women in the poorest families were more likely to use a net during pregnancy than those in less impoverished households. Additionally, the likelihood of using a net during pregnancy was nearly twice as high when more than one net was owned (OR: 1.9; 95 per cent CI: 1.0, 3.8) [34]. Our research suggests that pregnant women who own two or more nets in their homes are slightly more likely to consistently use a net than those who own only one ITN net.

The following limitations apply to this study. It is possible that the insecticide on some of the ITNs mentioned in this study was ineffective during the exposure period. Consequently, the prevalence of effective ITN use during pregnancy might have been overestimated[35]. A net was commonly defined as having been treated with insecticides if it had been retreated within the previous 12 months. However, according to a Tanzanian study, net users wash their nets four to seven times a year on average with soap, and 67% of nets reported to have undergone retreatment in the previous 12 months had insufficient insecticide (less than 5 mg/m2) [36, 3, 9]. The type of net was the most suitable proxy in this situation because we were unable to develop a set of questions that could be asked promptly and consistently to provide an accurate assessment of ITN status during the most recent pregnancy. All but one of the women stated that the net they slept beneath most frequently during pregnancy was either a long-lasting ITN or a net that had been treated with insecticides. Of the women who owned a bed net, 46% reported using a long-lasting ITN (PermaNet, Olyset, or Interceptor), which was recognised by the WHO[37]. An additional five per cent of women used KO nets, which are marketed as durable ITNs [38–40].

We did not enquire about the age of the ITN or its most recent retreatment from women whose nets comprised the remaining 49%, which were identified as pretreated ITNs. Moreover, social desirability bias may lead to differential misclassification of the outcome, resulting in an artificially elevated estimate because our outcome measures were dependent on self-report[41–43, 3]. Women who are cognisant of the benefits and recommendations of ITN therapies, for instance, may be more inclined to report consistently utilising them, even when they do not. As we did not ascertain the source of women's nets, we could only investigate the extent to which free net distribution programs increased usage for this demographic. Recall bias may also have resulted in non-differential misclassification, which would have biased the results towards the null hypothesis. Lastly, women who experienced pregnancy loss before the third trimester were not included in our study. This group may have distinct factors influencing ITN ownership and use compared with the general population.

Several aspects of this study's methodology have enhanced the robustness of our findings. This study used a random sample of pregnant women recently drawn from the population. Throughout the interviews, various visual aids were employed to mitigate recall bias. One such instrument was the development of a pregnancy history calendar that delineates each pregnancy over time[44, 1, 52]. Participants were requested to record their use of ITNs during each of the three trimesters after they were shown the trimesters on a calendar. ITN use during pregnancy was stratified according to the trimester. Dividing pregnancy into trimesters and evaluating net usage by trimester provides a more precise method to determine the variability in bed net usage that may arise due to seasonal variations and potential shifts in a woman's perception of risk as her pregnancy progresses. The study design precluded the use of the conventional single question, "Did you sleep beneath a bed net last night?" Women were retrospectively interviewed about their behaviour during previous pregnancies. However, it has been posited that enquiring about women's use individually in each trimester, rather than relying on a single question, could yield a more accurate representation of ITN usage during pregnancy[45, 29]. Visual aids were used to facilitate communication between the interviewer and the respondent. A comprehensive conceptual framework was developed to provide the foundation for the questionnaire. The data were analysed using a quantitative methodology.

Following the completion of the interviews, we returned to the participants' residences and installed a durable rectangular ITN. To enhance convenience, we utilised various attachment points and instructed the participants on how to secure the net during the day to optimise the space[46–48, 24]. We hypothesised that providing and installing the string and nails would increase the likelihood of net utilisation. The process of providing and installing nets elucidated the challenges participants faced in their daily ITN use within this environment. These dwellings were frequently confined, small, and poorly ventilated. During our interview, we attempted to pose an open-ended question regarding potential modifications to ITNs that could facilitate easier regular use[49–51, 8, 1]. However, this question proved challenging for the participants to answer; consequently, it was ultimately removed from the survey. Of the responses received, one-third indicated that increased living space or improved ventilation would facilitate more frequent net use[52–54, 3].

Limitations

This study exhibited several limitations that warrant consideration when interpreting the findings. Firstly, recall bias may have influenced the data, as participants were required to recollect details about malaria, antimalarial use, and ITN use during their pregnancies. Although a pregnancy history calendar incorporating national holidays was utilised to facilitate recall, this approach may not fully mitigate inaccuracies resulting from memory decay. Furthermore, self-reporting may introduce social desirability bias, particularly in reporting behaviours such as bed net usage or clinic visits, as participants might overreport behaviours perceived as socially desirable rather than actual practices.

The study's data collection period, spanning from November 2023 to January 2024, represents a relatively brief timeframe, potentially limiting the generalisability of the findings across other periods of

the year. Seasonal variations in malaria transmission or ITN use may not be fully captured within this narrow temporal scope. Moreover, the geographic scope was confined to the Ekwendeni catchment area in Malawi, which could restrict the applicability of the findings to other regions or countries with differing socioeconomic, environmental, or healthcare contexts.

An additional limitation is the exclusion of non-birth cases; women who did not reach the third trimester or experienced pregnancy loss before this period was not included, potentially omitting key insights into the impact of malaria on the full spectrum of pregnancy outcomes. Furthermore, despite the translation of the survey from English to Chichewa and subsequent back-translation, subtle nuances may have been lost, potentially affecting the participants' comprehension of certain questions.

The sample's demographic limitations are noteworthy. By focusing exclusively on women aged 15–40 years who had recently given birth, the study excluded women aged > 40 years and those with different pregnancy outcomes or complications, which may restrict the applicability of the findings to a broader population. The survey may also not have accounted for all potential confounding variables, such as coexisting health conditions, accessibility of healthcare facilities, or other preventive practices, such as indoor spraying.

While the questionnaire was pre-tested and incorporated items from standardised tools, it may not have fully accounted for local sociocultural contexts, potentially affecting response accuracy in certain sociodemographic and sociocultural aspects. Additionally, although ITN ownership and usage were assessed, the survey did not gather details on the quality, condition, or effectiveness of the nets, which could have influenced malaria prevention outcomes.

Finally, the exclusive reliance on a single data collection method (questionnaires) limits the depth of insight achievable, as it precludes observational data or in-depth qualitative information on participant practices, attitudes, and challenges related to ITN usage or malaria prevention. These limitations suggest that future studies may benefit from additional methods, broader participant inclusion, and an extended timeframe to enhance the validity and generalisability of the findings.

Conclusion

In conclusion, we assessed the correlation between ITN owners' use of ITNs throughout pregnancy. We were unable to determine the exact reason why women did not follow the WHO guidelines for always using an ITN during pregnancy, despite the observation of some minor connections. It is unclear which policies would be effective in boosting ITN utilisation until more reliable use predictors are found. Our experience with installing nets in this environment, however, points to potential household-level barriers to ITN installation, such as the size of the sleeping room around the ITN and the absence of suitable fixture points for ITN hanging. These factors may have a significant, unmeasured impact on ITN usage. Therefore, we recommend obtaining more information about each household's ability to support the installation of ITNs. Such datasets could offer valuable insights into interventions aimed at enhancing ease of use and compliance with everyday Internet usage. A multifaceted approach is imperative to

combat malaria in Malawi effectively. This approach should encompass strategies for vector control, enhancement of healthcare-seeking behaviours, implementation of structural improvements to dwellings, and deployment of vaccination programmes. Such a comprehensive strategy is crucial for mitigating malaria's impact on the nation's population.

Implications for Practice

The findings of this study have significant implications for malaria prevention among pregnant women in Malawi, particularly in rural Ekwendeni. Despite awareness of insecticide-treated nets (ITNs) benefits, their consistent use during pregnancy remains suboptimal, highlighting the gap between ownership and utilisation. Health practitioners must prioritise behavioural change communication beyond distribution campaigns to address barriers like excessive heat, inadequate space, and misconceptions about insecticide safety during pregnancy. Integrating ITN education into antenatal care (ANC) visits could improve compliance, with midwives providing guidance on proper installation. The study's finding that media advertisements influenced consistent ITN use emphasises the importance of mass communication for malaria prevention. Partnerships with radio stations and faith-based organisations can strengthen culturally sensitive campaigns targeting pregnant women and household decision-makers. Interventions should ensure households have multiple nets to accommodate family members, while practical assessments of household infrastructure should address installation barriers. The Ministry of Health and partners implementing the National Malaria Strategic Plan (2023–2030) should focus on community engagement, ITN usage monitoring, and user convenience indicators. Improving ITN adherence requires a multisectoral approach integrating health education, infrastructure support, and social influence to achieve malaria control and protect maternal health in Malawi.

Implications for Policy

The findings of this study have significant implications for malaria prevention policy in Malawi and similar settings. Despite advancements in ITN ownership through national distribution campaigns, consistent utilisation during pregnancy remains suboptimal. This necessitates policy refinements that prioritise both distribution and sustained usage. Policymakers within the Ministry of Health and NMCP should incorporate behavioural, infrastructural, and socio-cultural factors into malaria prevention strategies. Policies should advocate for household assessments to identify barriers to net installation and usability, as structural constraints like limited sleeping spaces and poor ventilation impede ITN use. Revising guidelines to include ITN installation during community campaigns and ANC visits could enhance utilisation rates. Media exposure strongly influences ITN adherence, highlighting the need for policy support toward mass media–based health promotion. Allocating resources for radio and community theatre programs can ensure public awareness across rural populations. Policies should strengthen collaboration between health institutions, faith-based organisations, and local leaders to address cultural misconceptions and promote ITN use. In alignment with the Malawi National Malaria Strategic Plan (2023–2030), policymakers should prioritise monitoring ITN utilisation indicators and expand metrics to include behavioural outcomes. Strengthening supply chains to ensure the timely

replacement of worn nets, alongside targeted subsidies for vulnerable groups, will help sustain progress. Policy must shift from distribution-focused approaches to emphasising accessibility, behavioural reinforcement, and household convenience to ensure pregnant women consistently benefit from ITN protection.

Implications for Research

This study identifies several research gaps that necessitate further investigation to improve malaria prevention among pregnant women in Malawi. Although the ownership of insecticide-treated nets (ITNs) is high, the factors influencing consistent utilisation remain complex and not fully comprehended. Future research should adopt mixed methods approaches to capture both the quantitative prevalence and qualitative aspects of ITN use, including perceptions, household dynamics, and environmental constraints. Further exploration is required to examine the impact of household structure and spatial limitations on ITN installation and comfort. Detailed ethnographic or observational studies could offer deeper insights into how physical living conditions and socio-cultural norms influence consistent ITN usage. Additionally, future research should evaluate the effectiveness of community-based interventions that integrate ITN provision with installation support, health education, and behavioural nudges. Another critical area of research involves understanding the role of communication strategies, particularly radio and faith-based messaging, in sustaining behaviour change. Assessing how different message framing and frequency affect ITN adherence could inform the design of evidence-based health promotion campaigns. Longitudinal studies are also recommended to assess seasonal variations in ITN use and their correlation with malaria incidence among pregnant women. Integrating environmental data, such as temperature and humidity, could enhance predictive models for malaria risk and guide the timing of targeted interventions. Finally, implementation research should focus on how policy changes, such as community-based ITN distribution through antenatal care (ANC) or home visits, affect actual utilisation rates. Developing and validating tools to measure "ease of ITN use" and "household readiness" would provide practical indicators for program monitoring and evaluation. Collectively, future research should aim to generate actionable evidence to bridge the gap between ITN ownership and consistent utilisation, ensuring that malaria prevention efforts translate into improved maternal and neonatal outcomes.

Abbreviations

ITN
Insecticide-treated net
RR
Relative risk
CI
Confidence interval
ANC
Antenatal care
LLIN

Long-lasting insecticidal nets
HI
House improvement
HMIS
Health Management Information System
UN
United Nation
WHO
World Health Organisation
IRS
Indoor residual spraying
US
United States

Declarations

Ethical Approval and Consent to Participate

The Office of Postgraduate Studies at Copperbelt University's Ethical Approval Committee granted ethical permission to participate in this study. Before their involvement in the research process, all the participants provided written informed consent. The study participants were made aware of their complete autonomy to choose whether to engage in the study and that they could choose to stop answering questions at any point during the interview. No names were mentioned in the interviews or reports, and the responses were kept private.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflicts of interest. The funding source did not influence the research project design, data collection, analysis, interpretation, writing of the paper, or decision to publish the findings.

Author Details

[1]Department of Public Health, The Copperbelt University-DDEOL, Kitwe, Zambia, [2]Synod of Livingstonia Health Department, Mzuzu, Malawi. [2]Synod of Livingstonia Health Department, Mzuzu, Malawi. [2]Synod

of Livingstonia Health Department, Mzuzu, Malawi.

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Figures

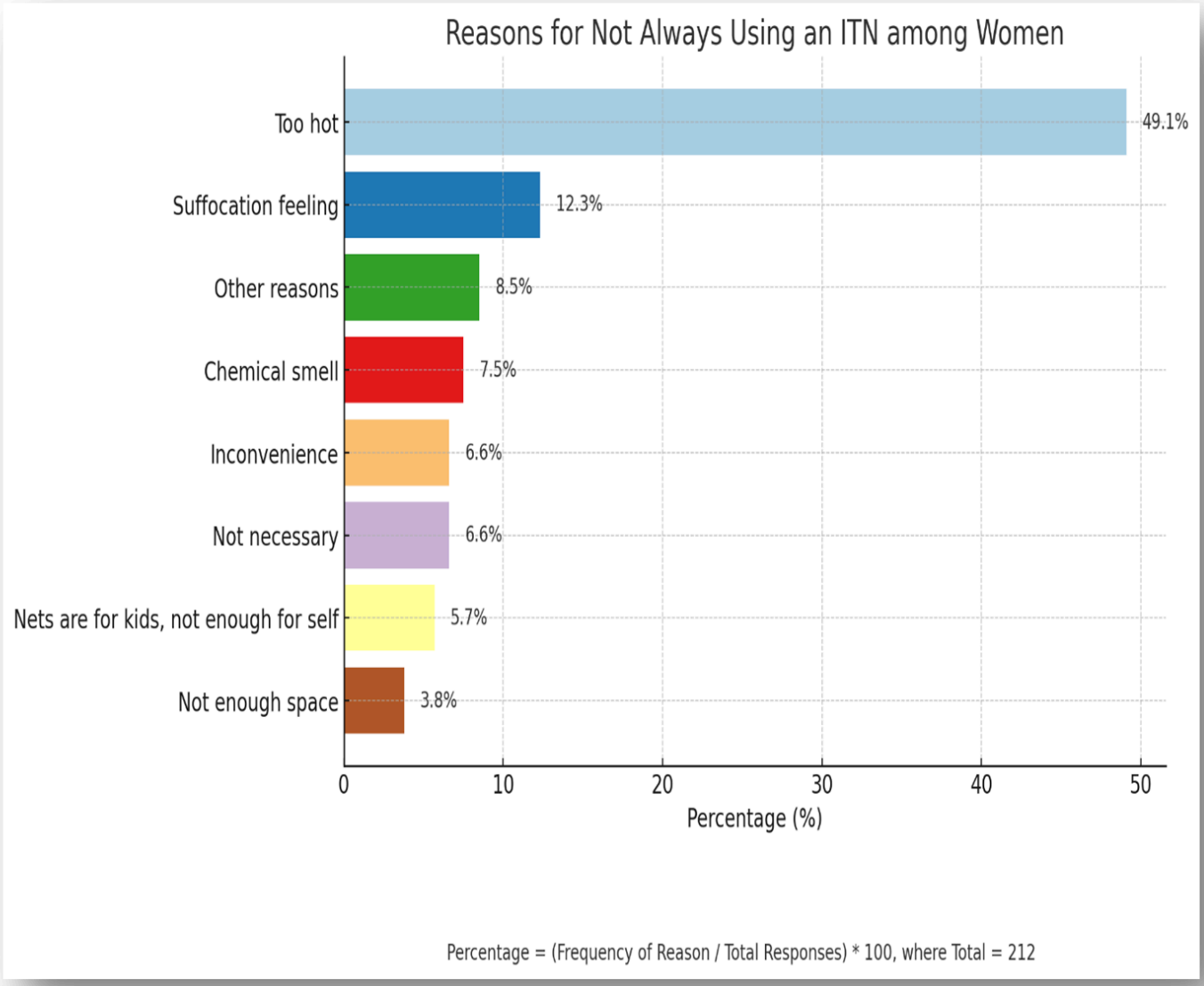


Figure 1

Reasons for Not Always Using an Insecticide-Treated Net (ITN) Among Women.