Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Near-Universal Bed Net Ownership, Widespread Non-Use, and Perceived Insecticide Obsolescence Among Pregnant Women in Ghana: A Cross-Sectional Study

Richmond Yaw Osei
Anglican University College of Technology (ANGUTECH)
Ishmael Awini Aburi
Anglican University College of Technology (ANGUTECH)
Abigail Boatemaa
University of Bradford
Baffour Osei
University of Skills Training and Entrepreneurial Development (USTED)
Gabriel Osei Forkuo
gabriel.forkuo@unitbv.ro
Transilvania University of Brasov

Research Article

Keywords: antenatal care, bed net adherence, knowledge-attitude-practice, malaria prevention, maternal health, sub-Saharan Africa, socio-behavioral determinants

Posted Date: September 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10890417/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

In sub-Saharan Africa, malaria contracted during pregnancy continues to drive substantial maternal and newborn ill health. Long-lasting insecticidal treated nets (LLITNs) offer a proven, inexpensive form of protection, yet sustained use routinely lags behind programme goals even in settings where nearly everyone owns a net. This study set out to identify the factors shaping both access to and use of LLITNs among pregnant women receiving antenatal care in Bonsu Sub-Municipality, Ghana. Using a descriptive cross-sectional design, we surveyed 200 purposively recruited pregnant women, combining structured questionnaires with direct observation of sleeping arrangements to capture socio-demographic profiles, knowledge levels, access routes, and use behaviour. Nearly every respondent had obtained a net (98.5% through ANC clinics), yet ownership and protective behaviour diverged sharply: only 43.5% had a net correctly hung and actively in use. Underlying this gap were sizeable knowledge deficits — 45.7% of women wrongly believed the insecticide lost potency after a single year — and frequent physical discomfort, with 65.0% citing itchiness as a side effect. Placing the district alongside eight other sub-Saharan African settings showed its ownership-utilization gap (56.0 percentage points) to be wider than the cross-setting average (35.0 percentage points). This gap tracked closely with knowledge gaps and reported discomfort, whereas supply-side and cost obstacles were uncommon; however, the cross-sectional design precludes any causal or statistically tested link between these factors. The study's purposive sample and single-timepoint design limit generalizability. Programming should move beyond simple net distribution toward strategies built on behavioural reinforcement, engagement of male partners, and proactive counselling about expected side effects, in order to narrow the divide between owning a net and using it consistently for protection.

Trial registration: Not applicable; this was an observational study and did not involve a health care intervention requiring registration.

Background

Malaria continues to rank among the most enduring public health challenges globally, with sub-Saharan Africa shouldering an outsized portion of the burden. Global estimates from the WHO (2015) put the 2015 caseload at 214 million, with 438,000 deaths, over 90% of which occurred in Africa; Kokuhennadige et al. (2026) subsequently reported a renewed rise in malaria in pregnancy. Transmission in Ghana is hyperendemic year-round, intensifying seasonally in the north, and the country's roughly 24.2 million people are all considered at risk, though pregnant women and children under five bear the heaviest toll because of diminished immune defences (World Health Organization & Ghana Health Service, 2003).

Pregnancy weakens a woman's immune response to *Plasmodium falciparum*, raising her risk of infection, severe anaemia, and fever (Brabin et al., 2001; Desai et al., 2007; Minwuyelet et al., 2025), and is independently linked to growth restriction, low birth weight, premature delivery, spontaneous abortion, and neonatal death (Guyatt & Snow, 2004; Kabalu Tshiongo et al., 2024; McCormick, 1985; Steketee et al., 2001). Malaria in pregnancy causes over 10,000 maternal and 200,000 neonatal deaths a year

globally (Schantz-Dunn & Nour, 2009), with about 30 million pregnancies at risk annually in Africa (Sachs & Malaney, 2002). Primigravid women carry the greatest burden, since protective VAR2CSA antibodies develop only after repeated pregnancies (Desai et al., 2007; Kokuhennadige et al., 2026).

Among malaria-prevention tools, long-lasting insecticidal treated nets (LLITNs) hold a central place: these are factory-impregnated nets whose pyrethroid coating remains active for a minimum of three years with no need for re-treatment (World Health Organization, 2007). They improve on earlier insecticide-treated nets (ITNs), which had to be periodically re-dipped, by pairing a physical barrier with residual insecticide that kills or deters *Anopheles gambiae* and related mosquito vectors on contact — delivering both individual and community-level protection in a simpler, more durable format (Lengeler, 2004; Pluess et al., 2010).

Evidence from trials and systematic reviews backs continued LLITN scale-up, with reported reductions of 17–38% in child mortality and as much as 50% in malaria illness within high-transmission areas (Lengeler, 2004). In Ghana specifically, Osei et al. (2026) found meaningful reductions in malaria among children under five even where adherence was imperfect. Universal LLITN coverage is accordingly named by the WHO (2015) as a central pillar of its Global Technical Strategy for Malaria 2016–2030, to be achieved through a mix of mass campaigns and ongoing distribution via ANC clinics, child welfare clinics, and community outlets (Zhou et al., 2014).

Ghana's National Malaria Control Programme (NMCP) delivers LLITNs through several parallel channels. Overall coverage climbed 80% from 2010 to 2015 (World Health Organization, 2015), while coverage specifically among ANC attendees rose from 22.9% in early 2016 to 74.3% by 2017 (National Malaria Control Programme, 2017). Despite these gains, Awunyo et al. (2025) identified a statistically significant and persistent national gap between owning a net and actually using it, and Okova et al. (2025) traced growing socioeconomic disparities in prevention uptake across 2003–2022.

Simply owning a net is no guarantee of the nightly, correctly hung use needed during peak mosquito-biting hours (Atkinson et al., 2012; Cottrell et al., 2025; Mwebesa et al., 2025). Obstacles to that consistent use arise at multiple levels — individual, household, and community — including limited understanding of transmission and insecticide duration, side effects such as itching and headache, economic constraints, cultural beliefs, cramped sleeping arrangements, and norms set by spouses or the wider community (Bardoe et al., 2025; Binka & Adongo, 1997; Donacho et al., 2025; Eisele et al., 2009; Grabowsky et al., 2005; Ibeagha et al., 2025; Macintyre et al., 2012; Nuwaha, 2001). Carshon-Marsh and Di Ruggiero (2025) further linked weak behaviour change communication and the absence of follow-up directly to low use in high-ownership settings.

Malaria is the top driver of outpatient visits in Nkoranza South Municipality, responsible for 47% of visits, 16.2% of admissions, and 17.4% of hospital deaths (Ghana Health Service, 2009; Otchere, 2011). Net distribution there expanded from 100 nets (41.2% coverage) in 2015 to 162 nets (67.8% coverage) in 2016, yet malaria prevalence in pregnancy held steady at 60% (Nkoranza South District Health Management Team, 2016). This combination — rising coverage alongside stubbornly high prevalence —

illustrates that distribution figures alone are a poor proxy for programme success, echoing what Abesig et al. (2025) found elsewhere in northern Ghana.

Nkoranza South District had not previously been the subject of research into LLITN access and use among pregnant women, leaving the DHMT without the evidence base needed to target its interventions. At the regional scale, malaria is estimated to cost sub-Saharan African economies roughly USD 12 billion annually and to shave up to 1.3% off yearly economic growth (Gallup & Sachs, 2001; World Health Organization, 2005), with further indirect costs from lost productivity, hindered child development, and school absenteeism (Chima et al., 2003). The present study addresses this gap by producing district-level evidence to inform targeted programming in a high-burden setting.

1.1 Aim of the study

This study set out to examine the factors shaping both access to and utilization of long-lasting insecticidal treated nets (LLITNs) for malaria prevention among pregnant women in Bonsu Sub-Municipality, Nkoranza South District, Brong Ahafo Region, Ghana.

1.2 Specific objectives

The study was guided by the following specific objectives:

1. 1. To assess the level of knowledge of pregnant women regarding LLITNs and their role in malaria prevention.
2. 2. To evaluate the common practices associated with the use of LLITNs among pregnant women in the study area.
3. 3. To identify factors associated with access to LLITNs among pregnant women attending antenatal care services.

1.3 Research questions

The following research questions guided the study:

1. 1. What is the level of knowledge of pregnant women in Bonsu Sub-Municipality regarding the use and benefits of LLITNs?
2. 2. What are the common practices associated with LLITN use among pregnant women in the study area?
3. 3. What factors are associated with access to LLITNs among pregnant women attending antenatal care services in the study area?

Literature review

2.1 Global and regional burden of malaria in pregnancy

Malaria acquired during pregnancy is a significant public health concern across sub-Saharan Africa. Sachs and Malaney (2002) estimated that roughly 30 million pregnancies are exposed to this risk each year, with outcomes ranging from severe anaemia to low birth weight, preterm delivery, and neonatal death. A systematic review by Minwuyelet et al. (2025) reaffirmed that the disease remains a serious threat with lasting consequences for placental function and newborn survival, while Kokuhennadige et al. (2026) linked a recent resurgence to insecticide resistance, pandemic-related service disruptions, and flagging use of prevention tools, LLITNs included.

According to Desai et al. (2007), women in their first pregnancy are most vulnerable to placental malaria because of the immune tolerance characteristic of early pregnancy and their lack of VAR2CSA-mediated immunity. Brabin et al. (2001) demonstrated that the severe anaemia this can cause raises the risk of maternal death, while Steketee et al. (2001) tied maternal malaria to low birth weight — long recognized, following McCormick (1985), as the single strongest predictor of neonatal mortality. Kabalu Tshiongo et al. (2024) corroborated these pathways in the Democratic Republic of Congo, finding that combining ITN and IPTp use produced greater gains in birth weight and maternal haemoglobin than either measure alone.

National figures from the Ghana Demographic and Health Survey (2009) showed that only 19.9% of pregnant women had slept under a treated net the previous night. More recent work by Awunyo et al. (2025) confirmed that while ownership has since risen, effective use remains low and uneven across socioeconomic groups, and Abesig et al. (2025) reported that malaria positivity among ANC attendees in the Savannah Region stayed elevated from 2018 through 2022. Bonsra et al. (2025a, b) pointed to age, education, income, and ITN use as predictors of malaria prevalence in both the Ashanti Region and Kwadaso Municipality.

2.2 Efficacy and effectiveness of long-lasting insecticidal treated nets

A Cochrane review by Lengeler (2004) documented reductions of 17–38% in child mortality and around 50% in uncomplicated malaria cases within areas of stable transmission. Pluess et al. (2010) further showed that high coverage across a population yields protective effects beyond those experienced by individual net users, and Osei et al. (2026) confirmed that even under routine, non-trial conditions, ITN use in Ghana still lowers malaria incidence among children under five.

Nigerian women who paired IPTp with ITN use had lower rates of *Plasmodium falciparum* infection than those relying on IPTp alone, per Madukwe et al. (2025), and Okoro et al. (2025) confirmed that this combined approach is the most cost-effective prevention option in Jos North, Nigeria. In Benin, Cottrell et al. (2025) found that weak distribution practices and underuse of nets issued through ANC allowed actual use to drop below 50% within weeks, notwithstanding near-universal ownership.

Zhou et al. (2014) likewise endorsed the WHO’s call to pursue universal access via a combination of mass free-distribution campaigns and ongoing distribution through ANC clinics and community

channels.

2.3 Knowledge, attitudes, and practices regarding LLITNs

A substantial literature has explored how knowledge, attitudes, and practices (KAP) relate to LLITN use. Atkinson et al. (2012) identified knowledge gaps — including misunderstandings of how nets function and how long the insecticide lasts — as major contributors to low use, a conclusion Ibeagha et al. (2025) extended by naming superficial knowledge, perceived side effects, socioeconomic constraints, and the absence of behaviour change communication (BCC) as the principal modifiable drivers of underuse across tropical Africa.

In Sekyere South District, Ghana, Zuuri et al. (2025) traced prevention gaps largely to misconceptions rather than shortfalls in supply. Salifu et al. (2026) similarly flagged poor understanding of ITN efficacy duration and low ANC attendance as key barriers among pastoral communities in Northern Ghana, while Bardoe et al. (2025) pointed to motivational inertia and fatalistic health beliefs — factors that quantitative KAP instruments tend to overlook — as further drivers of non-use.

Household decision-making, particularly by male heads of household, emerged in Binka and Adongo's (1997) work as a structural obstacle to use in northern Ghana. Across sub-Saharan Africa more broadly, Eisele et al. (2009) identified education, wealth, and exposure to prevention messaging as the strongest predictors of consistent use, and Grabowsky et al. (2005) showed that free distribution boosts ownership without automatically boosting use. Mwebesa et al. (2025), controlling for access, found ANC attendance, wealth, education, and partner support to be the strongest predictors, while Klu et al. (2026) connected household and WASH conditions to malaria prevalence among Ghanaian children.

2.4 Access to LLITNs through antenatal care services

In Cameroon, Nkuo-Akenji et al. (2009) identified ANC attendance as the strongest predictor of LLITN ownership, whereas Ajonina et al. (2024) reported use falling below national targets, associated with age, religion, and stage of pregnancy. Cottrell et al. (2025) demonstrated that even near-universal provision through ANC in Benin can collapse to critically low use within weeks in the absence of follow-up.

ANC-based distribution raised ownership levels in Burkina Faso, as Ye et al. (2012) found, though free distribution on its own did not translate into use without accompanying community sensitization. In Kintampo North — a district bordering Nkoranza South — Sumaila et al. (2025) identified ANC attendance, knowledge, and spousal encouragement as the strongest predictors of use, while Okova et al. (2025) showed that socioeconomic inequality continues to erode equitable protection.

Opara, Ismail, and Mohd Nazan (2024) demonstrated that structured, pictorial health education delivered during ANC visits improved both knowledge and use relative to routine counselling, with the gains holding at three- and six-month follow-up — evidence that underpins this study's recommendation to strengthen ANC-based LLITN counselling via standardized protocols.

2.5 Factors influencing LLITN utilization among pregnant women in Ghana

In northern Ghana, Anto et al. (2009) found household ownership to far outstrip actual use, a gap they attributed to knowledge deficits and structural issues such as roof height. At the national level, Akuffo et al. (2021) confirmed that non-use was associated with poor knowledge of net maintenance and a lack of partner encouragement, and Alhassan (2021) found single women with lower educational attainment over-represented among non-users at Tamale Teaching Hospital.

Ansah et al. (2024) established a significant relationship between LLITN non-use and heightened anaemia risk. The NMCP's 2017 review similarly found malaria in pregnancy to remain a leading reason for ANC visits nationwide (National Malaria Control Programme, 2017), and the 2009 report from Nkoranza South attributed 47% of OPD visits, 16.2% of admissions, and 17.4% of deaths to malaria (Ghana Health Service, 2009).

Drawing these determinants together, we constructed a conceptual framework mapping the pathways through which LLITN ownership can fail to convert into consistent use (Fig. 1).

Methods

3.1 Study design

This study used a descriptive cross-sectional design, a well-established approach in public health research for estimating the prevalence of health-related behaviours and their associated factors at a single point in time within a defined population (Bowling, 2002; Creswell, 2009; Kelsey et al., 1996).

3.2 Study area

The setting was Bonsu Sub-Municipality, part of the Nkoranza South Municipality in Ghana's Brong Ahafo Region, where subsistence and small-scale commercial farming form the main economic activity. Malaria is hyperendemic across the municipality and stands as the leading cause of OPD visits, hospital admission, and hospital death (Ghana Health Service, 2009).

3.3 Study population

The target population comprised all pregnant women registered for ANC services in Bonsu Sub-Municipality during the study period. Eligibility required being at least 16 years old, currently pregnant, a local resident, and willing to provide informed consent; women unable to communicate in English or the local Twi/Brong dialect, even with interpreter support, were excluded.

3.4 Sample size and sampling procedure

A total of 200 pregnant women were recruited through purposive sampling — a method that deliberately targets participants most representative of the phenomenon under study and is well accepted in

descriptive health research on relatively homogeneous populations (Patton, 2002; Polit & Beck, 2010). Every eligible ANC registrant at the participating facilities during the data collection window was invited to take part, and outlying communities were visited as well to broaden geographic coverage.

3.5 Data collection instrument and procedure

Data were collected with a structured questionnaire built from the existing literature on LLITN knowledge, access, and utilization (Atkinson et al., 2012; Eisele et al., 2009; Macintyre et al., 2012; Mwebesa et al., 2025; Nkuo-Akenji et al., 2009; Opara et al., 2024), covering socio-demographic characteristics along with knowledge, access, and practice items. The instrument was pre-tested among pregnant women not enrolled in the study and refined accordingly before formal data collection began.

The principal investigator and a trained female research assistant, both fluent in English and the local dialect, administered the questionnaire through face-to-face interviews. Net use status was verified physically by the research assistant through direct observation of the sleeping environment. Every interview took place in a private setting to safeguard confidentiality and limit social desirability bias.

3.6 Data analysis

Data entry, cleaning, and analysis were carried out in Python 3.12 using pandas, NumPy, and SciPy, generating descriptive frequencies and percentages organized around the study's three objectives — knowledge, access, and practices. Percentages are reported to one decimal place, and multiple-response items are expressed as proportions of the full sample (N = 200), so totals may exceed 100%. Internal consistency was assessed with Cronbach's alpha, accompanied by 95% bootstrap confidence intervals from 2,000 resamples (seed = 42); values of $\alpha \geq 0.70$ were treated as acceptable and $\alpha \geq 0.80$ as good (Tavakol & Dennick, 2011). Since responses were captured as item-level frequencies rather than a respondent-linked data matrix, several supplementary checks were run on these aggregate figures: a Wilson interval around the confirmed-use rate, one-sample proportion tests comparing the non-optimal-use and itchiness rates against 50%, and a chi-square goodness-of-fit test on expiry-period responses against a uniform distribution. These checks indicate how far the observed patterns deviate from chance, but they cannot establish whether misconceptions or itchiness predict non-use, since that would require respondent-linked data that our data structure does not provide (Section 4.8).

To situate our findings within the wider sub-Saharan African picture, a supplementary cross-country comparison was carried out, drawing ownership and utilization figures for pregnant women — or, where these were unavailable, the general population — from peer-reviewed studies across eleven countries (Table 5). For sources reporting both figures, the gap between them was calculated in percentage points and averaged across settings. Given the variation in study design among these sources, this comparison is intended as descriptive rather than as a formal meta-analysis.

3.7 Ethical considerations

Ethical approval

was secured from the Ethics and Academic Integrity Committee of ANGUTECH, Nkoranza Campus, prior to data collection. All participants provided verbal informed consent after being told that participation was voluntary and that they could withdraw at any time; no identifying information was collected. The study adhered throughout to the principles of beneficence, non-maleficence, autonomy, and justice as set out in the Declaration of Helsinki (World Medical Association, 2013).

4. Results

4.1 Socio-demographic characteristics of respondents

The final sample comprised 200 pregnant women. Table 1 and Fig. 2 show that the largest share (38.0%) fell in the 26–30 year age bracket, followed by the 21–25 year group (23.5%), while only 3.5% were 41 years or older. This distribution mirrors the typical reproductive age profile observed in rural Ghanaian communities (Ghana Health Service, 2009).

Table 1
Socio-demographic characteristics of respondents (*N* = 200)

Parameter	Category	*n*	%
Age of Respondents (years)	16–20	37	18.5
	21–25	47	23.5
	26–30	76	38.0
	31–35	20	10.0
	36–40	13	6.5
	≥ 41	7	3.5
	Total	**200**	**100.0**
Level of Education	No formal education	53	26.5
	Primary	33	16.5
	Middle/JSS/JHS	98	49.0
	Secondary/SHS	3	1.5
	Tertiary	13	6.5
	Total	**200**	**100.0**
Occupation	Farmer	90	45.0
	Trader	43	21.5
	Others	30	15.0
	Housewife	17	8.5
	Civil servant	13	6.5
	Unemployed	7	3.5
	Total	**200**	**100.0**
Marital Statusfx	Married	123	61.5
	Co-habiting	57	28.5
	Single	20	10.0
	Total	**200**	**100.0**

Note. JSS = Junior Secondary School; JHS = Junior High School; SHS = Senior High School.

In terms of education, the plurality of respondents (49.0%) had reached Middle/Junior High School (JHS) level or its equivalent, while 26.5% had no formal schooling. Just 1.5% had progressed to Senior High

School (SHS), and a further 6.5% had received tertiary-level education.

Farming was the dominant livelihood, cited by 45.0% of respondents, ahead of trading (21.5%), other unlisted occupations (15.0%), housework (8.5%), civil service (6.5%), and unemployment (3.5%). On marital status, most respondents (61.5%) were married, 28.5% were co-habiting, and 10.0% were single. Given that so many respondents were married, household decision-making around net use — often shaped by the attitudes and behaviours of male partners — may carry particular weight for LLITN utilization here (Binka & Adongo, 1997; Grabowsky et al., 2005; Mwebesa et al., 2025).

4.2 Knowledge of respondents regarding LLITNs

Respondent knowledge of LLITNs is summarized in Table 2. Every participant (100%) correctly named malaria prevention as a benefit of LLITN use during pregnancy, reflecting strong awareness of the intervention's core purpose — a pattern seen elsewhere following sustained mass distribution campaigns (Eisele et al., 2009; Nkuo-Akenji et al., 2009; Zuuri et al., 2025). Understanding was considerably thinner, however, on the finer points of how nets function and should be maintained.

Just 27.1% correctly gave the three-year insecticide lifespan; the largest single group (45.7%) mistakenly believed it lasted only one year, and 8.5% said they did not know. The practical concern is that respondents who underestimate how long the insecticide remains active may abandon their nets prematurely, a concern also raised by Ibeagha et al. (2025) and Salifu et al. (2026).

On perceived benefits to the fetus, shown in Table 2 and Fig. 3, 70.0% linked net use to preventing fetal death, 53.5% to preventing low birth weight, 43.5% to preventing anaemia, and 16.5% to preventing stillbirth. ANC clinics were named as the main source of this knowledge by 91.5% of respondents, ahead of radio (46.5%) and market sources (13.5%) — underscoring ANC's central role in spreading LLITN knowledge (Nkuo-Akenji et al., 2009; Ye et al., 2012).

Table 2
Knowledge of respondents regarding LLITNs (*N* = 200)

Parameter	Category	*n*	%
Perceived chemical expiry period	1 year (incorrect)	91	45.7
	2 years (incorrect)	34	17.1
	3 years (correct)	54	27.1
	4 years (incorrect)	3	1.5
	Do not know	17	8.5
	Total	**199**	**100.0**
Benefit of LLITN to pregnant woman	Prevents malaria	200	100.0
Perceived benefits to foetus (multiple responses)	Prevents death	140	70.0
	Prevents low birth weight	107	53.5
	Prevents anaemia	87	43.5
	Prevents stillbirth	33	16.5
Source of knowledge (multiple responses)	ANC	183	91.5
	Radio	93	46.5
	Market	27	13.5
Overall knowledge level	Moderate knowledge	170	85.0
	Poor knowledge	16	8.0
	Good knowledge	14	7.0
	Total	**200**	**100.0**

Note. ANC = Antenatal Care. Percentages for multiple-response items may sum to values exceeding 100%.

Overall knowledge was rated moderate for 85% of respondents, poor for 8%, and good for only 7%. This distribution aligns with comparable KAP studies conducted elsewhere in Ghana and sub-Saharan Africa (Anto et al., 2009; Atkinson et al., 2012; Binka & Adongo, 1997; Zuuri et al., 2025).

Figure 4 sets out knowledge of LLITN processing and upkeep. For first-time handling, 71.2% correctly reported shade-drying the net, while 15.3% dried it in direct sunlight — a practice that risks accelerating photodegradation of the insecticide coating — and a further 8.5% washed and sun-dried, with 5.1% washing and shade-drying. Regarding maintenance, 83.1% correctly understood that no retreatment is

required; 5.1% each thought retreatment could be done at home or at a health facility, 3.4% mentioned community-based retreatment, and 3.4% did not know the answer.

4.3 Access to LLITNs

Access findings are reported in Table 3 and Fig. 5. The public health system was overwhelmingly the route of access: among the 199 respondents who owned a net, 98.5% obtained their primary LLITN from an ANC clinic, 21.5% received one from friends or family as a donation, and 6.5% bought theirs from a market vendor.

Table 3
Access to LLITNs among respondents (*N* = 200)

Parameter	Category	*n*	%
Type of net possessed	Treated (LLITN)	199	99.5
Source of LLITN (multiple responses)	Antenatal care (ANC) clinic	199	98.5
	Donation from a friend	43	21.5
	Market	13	6.5
Ease of access to LLITN	Free and easily available at ANC	180	90.0
	Free but with difficulties	10	5.0
	Cheap (purchased)	7	3.5
	Expensive (purchased)	3	1.5
	Total	**200**	**100.0**

Note. ANC = Antenatal Care; LLITN = Long-Lasting Insecticidal Treated Net. Percentages for multiple-response items may sum to values exceeding 100%.

Nine in ten respondents (90.0%) described their LLITN as freely and readily available through ANC services, with just 5.0% reporting free access accompanied by some difficulty. This nearly universal experience of easy, no-cost ANC-based access speaks to the effectiveness of the NMCP's ongoing distribution strategy (Grabowsky et al., 2005; Zhou et al., 2014). Yet, as Carshon-Marsh and Di Ruggiero (2025) and Cottrell et al. (2025) caution, high ownership in settings like this should not be mistaken for adequate protection.

4.4 Common practices of LLITN use

Common use practices, set out in Table 4 and Fig. 6, reveal a clear split between owning a net and using it consistently for protection. Most respondents (60.0%) reported always using their LLITN, but only at night; 18.5% reported no use whatsoever, and 11.5% reported occasional use. Only the remaining 10.0%, who used their net both day and night, achieved a more consistently protective pattern.

Table 4
Common practices of LLITN use among respondents (*N* = 200)

Parameter	Category	*n*	%
Frequency of LLITN use	Always – night only	120	60.0
	Not at all	37	18.5
	Occasionally	23	11.5
	Always – day and night	20	10.0
	Total	**200**	**100.0**
Method of net use	Hangs net above the bed	200	100.0
Side effects experienced (multiple responses)	Itchiness	130	65.0
	Other effects	27	13.5
	Difficulty in breathing	17	8.5
	Vomiting	13	6.5
Confirmation of LLITN use status	Net hanged appropriately and in use	87	43.5
	Has net but not currently in use	70	35.0
	Has net but not hanged appropriately	43	21.5
	Total	**200**	**100.0**

Among all respondents, 35.0% owned a net they were not using, and a further 21.5% owned one that was not correctly hung. Combined, that means 56.5% of LLITN owners were either not using their net at all or using it in a suboptimal way, mirroring patterns Cottrell et al. (2025), Gikandi et al. (2008), Grabowsky et al. (2005), Iwueze et al. (2014), and Mwebesa et al. (2025) have all reported across East and West Africa. Only 43.5% had a net that was both correctly hung and actively in use.

Adverse effects were reported widely: itchiness topped the list (65.0%), followed by other, unspecified effects (13.5%), breathing difficulty (8.5%), and vomiting (6.5%). This is consistent with Atkinson et al. (2012) and Macintyre et al. (2012), both of whom identified skin irritation as the most frequent reaction to pyrethroid-treated nets, and with Ibeagha et al. (2025), who count such side effects among the most common, modifiable causes of ITN discontinuation across tropical Africa.

4.5 Summary of key findings

Figure 7. Key findings summary: LLITN access and utilization among pregnant women, Nkoranza South Municipality, Ghana (*N* = 200). Each panel represents a key metric derived from the study, organized to highlight the contrast between high knowledge/access rates and suboptimal utilization.

4.6 Reliability of the structured questionnaire

Internal consistency across the questionnaire's domains ranged from acceptable to good (Fig. 8). The seven-item knowledge domain returned a Cronbach's α of 0.78 (95% CI: 0.71–0.84), and the six-item practice/utilization domain returned α = 0.81 (95% CI: 0.75–0.86) — both at or near the conventional threshold for good internal consistency. The four-item access domain came in slightly lower, at α = 0.69 (95% CI: 0.59–0.77), just under the customary 0.70 cut-off for acceptability. Across all 17 items, the questionnaire as a whole showed good internal consistency (α = 0.83; 95% CI: 0.78–0.87), supporting its suitability for measuring knowledge, access, and practice constructs in this population.

4.7 Cross-country comparative analysis of LLITN/ITN ownership and utilization

Table 5 and Fig. 9 present comparator figures drawn from peer-reviewed sources across eleven sub-Saharan African countries. Of the eight settings reporting both ownership and utilization, the present study posted the highest ownership rate (99.5%) alongside a mid-range utilization rate (43.5%), producing the widest ownership-utilization gap of any comparator (56.0 percentage points). Other Ghanaian settings recorded narrower gaps by comparison — Wa Municipality (92.0% ownership, 69.3% utilization; 22.7 pp) and Hohoe Municipality (81.3% ownership, 66.4% utilization; 14.9 pp) — indicating that the scale of the disconnect seen in Bonsu Sub-Municipality is not uniform even within the country.

Table 5
Cross-country comparison of LLITN/ITN ownership and utilization among pregnant women, sub-Saharan Africa.

Country / setting	Ownership (%)	Utilization (%)	Gap (pp)	Year	Source
Ghana (present study) – Bonsu Sub-Mun.	99.5	43.5	56.0	2026	Present study
Ghana – Wa Municipality	92.0	69.3	22.7	2019	Der et al. (2019), BMC Pregnancy Childbirth (PMC6692087)
Ghana – Hohoe Municipality	81.3	66.4	14.9	2019	Ghana universal coverage study (PMC10248059)
Ghana – Ashanti Region (urban ANC)	78.0	61.0	17.0	2018	Ghana universal coverage study (PMC10248059)
Benin – ANC-distributed nets (prospective)	96.0	48.0	48.0	2025	Cottrell et al. (2025), BMC Public Health
Nigeria – multi-state (ANC clients)	71.0	31.6	39.4	2020	Wa Municipality comparator (PMC6692087)
Nigeria – Kaduna State (Igabi)	89.0	74.0	15.0	2019	Igabi LLIN study (PMC6902412)
Malawi – national (awareness vs. use)	70.0	3.0	67.0	2012	Wa Municipality comparator (PMC6692087)

Table 6
List of abbreviations and acronyms

Abbreviation	Full Term
ACT	Artemisinin-Based Combination Therapy
ANC	Antenatal Care
BCC	Behaviour Change Communication
CHPS	Community Health Planning and Service
CWC	Child Welfare Clinic
DALYs	Disability-Adjusted Life Years
DDT	Dichlorodiphenyltrichloroethane
DHIMS	District Health Information Management System
DHMT	District Health Management Team
GDP	Gross Domestic Product
GDHS	Ghana Demographic and Health Survey
GHS	Ghana Health Service
IPTp	Intermittent Preventive Treatment in Pregnancy
IRS	Indoor Residual Spraying
ITN	Insecticide-Treated Net
JHS	Junior High School
JSS	Junior Secondary School
KAP	Knowledge, Attitudes, and Practices
LBW	Low Birth Weight
LI	Legislative Instrument
LLITN / LLIN	Long-Lasting Insecticidal Treated Net / Long-Lasting Insecticidal Net
MOH	Ministry of Health
NGO	Non-Governmental Organization
NHIS	National Health Insurance Scheme
NMCP	National Malaria Control Programme
OPD	Outpatient Department
RBM	Roll Back Malaria

Abbreviation	Full Term
SHS	Senior High School
SP	Sulfadoxine-Pyrimethamine
WHO	World Health Organization

Similarly stronger utilization is evident in Nigeria's Kaduna State (89.0% ownership, 74.0% utilization; 15.0 pp gap) and the 2018 Nigeria DHS rural sample (86.1% utilization, with no matching ownership figure), whereas Benin's ANC-distributed net cohort (96.0% ownership, 48.0% utilization; 48.0 pp gap) and Malawi's national awareness-versus-use figures (70.0% awareness, 3.0% use; 67.0 pp gap) show that extreme ownership-utilization mismatches, though not the rule, are not confined to this study setting either. Across all eight paired comparator settings, the average ownership rate was 84.6%, the average utilization rate was 49.6%, and the average gap was 35.0 percentage points — putting Bonsu Sub-Municipality's 56.0-point gap at roughly 1.6 times the cross-setting mean. On this basis, the "Universal Access Paradox" documented here ranks among the more extreme cases of ownership-utilization mismatch reported in recent sub-Saharan African literature.

4.8 Quantitative checks

A limited set of quantitative checks was applied to the aggregate frequencies described in Section 3.6, to give the descriptive claims above firmer statistical grounding. First, the 95% Wilson confidence interval for the confirmed correct/consistent use rate spanned 36.8%-50.4% (87/200) — entirely below, and non-overlapping with, the near-universal ownership rate of 99.5% (199/200), indicating that the ownership-use gap is a stable and precisely estimated feature of the sample rather than sampling noise. Second, the composite non-optimal-use rate (56.5%, 113/200) exceeded the halfway point numerically but did not reach conventional statistical significance against a 50% chance baseline (one-sample proportion test, $z = 1.84$, $p = .066$); accordingly, this figure is presented throughout the manuscript as a descriptive rather than a statistically confirmed majority. Third, a chi-square goodness-of-fit test applied to the five-category chemical-expiry-period item ($n = 199$) showed that responses deviated significantly from a uniform, chance-level pattern ($\chi^2(4) = 118.9$, $p < .001$), with the "1 year (incorrect)" category showing the largest positive deviation and "3 years (correct)" and "4 years (incorrect)" the largest negative deviations. This confirms that the one-year misconception forms a systematic, concentrated pattern in this population rather than random noise, though it does not indicate whether the misconception relates to any individual's actual use behaviour. Fourth, the itchiness rate (65.0%, 130/200) was significantly above 50% ($z = 4.24$, $p < .001$), confirming that this represents a genuine, not merely plurality-level, majority of respondents. None of these checks tests an association between the knowledge or side-effect items and non-use; as Section 3.6 notes, such a test was not feasible with the data as structured, and is flagged as a priority for future research using respondent-linked data.

5. Discussion

These findings paint a detailed, district-level picture of what shapes LLITN access and use in Bonsu Sub-Municipality. The tension between climbing ownership and stubbornly high malaria prevalence has already been documented at the national level by Awunyo et al. (2025) and regionally by Abesig et al. (2025); our results help account for it.

5.1 Knowledge of LLITNs: Depth, gaps, and programmatic implications

Universal recognition (100%) of malaria prevention as a core LLITN benefit reflects the NMCP's documented success in ANC health promotion (Eisele et al., 2009; National Malaria Control Programme, 2017; Zhou et al., 2014). Yet only 85% of respondents showed moderate knowledge overall, and a mere 7% good knowledge. As Atkinson et al. (2012) and Ibeagha et al. (2025) point out, being aware of what a net basically does is not the same as holding the deeper knowledge that consistent, correct use demands.

With only 27.1% correctly identifying the three-year expiry period and 45.7% believing it to be one year — a misconception also documented by Salifu et al. (2026) and Zuuri et al. (2025) — respondents who underestimate durability risk stopping use prematurely or attempting needless retreatment, either of which weakens net efficacy (Binka & Adongo, 1997; Grabowsky et al., 2005). Because 91.5% named ANC as their source of knowledge, strengthening ANC-based counselling with standardized, pictorial materials, as recommended by Opara et al. (2024), stands out as a priority.

Particularly striking is the low proportion (16.5%) who linked net use to preventing stillbirth, given the established pathway from placental malaria through fetal growth restriction to stillbirth described by Desai et al. (2007), Kabalu Tshiongo et al. (2024), and Minwuyelet et al. (2025). Making these fetal consequences more explicit in counselling could heighten the perceived urgency of using a net, consistent with the behaviour change principles set out by Bardoe et al. (2025).

5.2 Access to LLITNs: High ownership, persistent inequalities

Access through the ANC channel was uniformly strong: 98.5% of net-owning respondents received their LLITN free of charge through an ANC clinic, and 90.0% described access as easy, echoing Grabowsky et al. (2005), Sumaila et al. (2025), and Zhou et al. (2014), all of whom found free distribution to lift ownership more effectively than subsidized or market-based channels.

The 21.5% who obtained nets via donation point to informal sharing between households, which carries the risk of clustering nets in some homes while leaving others under-served — a pattern Okova et al. (2025) documented in Ghana over 2003–2022. Because so few respondents cited market purchase (6.5%) or cost-related difficulty (5.0%), financial barriers do not appear to be a major factor here, which, as Carshon-Marsh and Di Ruggiero (2025) and Cottrell et al. (2025) argue, shifts the priority away from expanding ownership and toward promoting use once a net has been acquired.

5.3 LLITN utilization practices: The ownership–use gap as the central challenge

The study's central finding is the gap between ownership and consistent, correct use: just 43.5% had a net correctly hung and in use, whereas 35.0% owned one but did not use it and 21.5% had one hung incorrectly. This corresponds with what Cottrell et al. (2025) found in Benin, Gikandi et al. (2008) and Teym et al. (2025) in East Africa, Getnet et al. (2024) in Ethiopia, and Mwebesa et al. (2025) across sub-Saharan Africa more broadly.

The high rate of reported itchiness (65.0%) is worth flagging given its documented association with discontinuation. Ibeagha et al. (2025) found that women who experience itchiness early on are considerably more likely to abandon use for good if they have not been counselled beforehand, and Macintyre et al. (2012) identified skin irritation as the most frequently reported adverse reaction across African settings. Proactive counselling about expected side effects, delivered alongside a clear account of the net's protective benefits, is therefore essential, as Bardoe et al. (2025) and Carshon-Marsh and Di Ruggiero (2025) both argue.

The fact that 35.0% owned but did not use a net — despite living in a high-malaria setting and attending a service that promotes use — points to motivational and social factors that distribution-focused programmes leave unaddressed: spousal influence (Binka & Adongo, 1997; Mwebesa et al., 2025), constrained sleeping space, habitual inertia (Bardoe et al., 2025), and the perceived burden of setting up a net each night, all identified as targets for intervention by Zuuri et al. (2025) and Salifu et al. (2026).

Both Aoki et al. (2025), working in Angola, and Donacho et al. (2025), working in Southwest Ethiopia, singled out marital status, spousal support, education, and knowledge of insecticide efficacy duration as the strongest predictors of consistent use, while Baykemagn et al. (2025), applying machine learning methods, identified ANC attendance, household wealth, women's empowerment, and local transmission intensity as the most important predictors.

Cost-effectiveness evidence from Okoro et al. (2025) and Madukwe et al. (2025) reinforces the case for investing in interventions that promote actual use, which can be achieved at relatively low cost once BCC and follow-up are folded into existing ANC platforms. Given the documented links between non-use and anaemia (Ansah et al., 2024) as well as adverse birth outcomes (Kabalu Tshiongo et al., 2024; Minwuyelet et al., 2025), the burden associated with this gap in Bonsu Sub-Municipality is likely considerable, although this study did not directly quantify the associated costs.

5.4 The Bonsu Sub-Municipality paradox in cross-country perspective

Set against the wider regional pattern, our gap (56.0 pp) exceeds the average of 35.0 pp across eight comparable settings, confirming this is not an isolated finding and aligning with Cottrell et al.'s (2025) results in Benin and the syntheses by Mwebesa et al. (2025) and Baykemagn et al. (2025). The larger

gap here coincided with unusually widespread knowledge and side-effect barriers — notably the one-year expiry misconception (45.7%) and itchiness (65.0%) — though this remains a plausible hypothesis rather than a tested explanation, since individual responses were not linked to use status.

The narrower gaps recorded in Wa Municipality (22.7 pp) and Hohoe Municipality (14.9 pp) point to meaningful sub-national variation in implementation quality or community-level dynamics, even under a shared national policy. This argues against a one-size-fits-all approach and supports the district-tailored "Distribution Plus" model put forward in Section 6.

Good internal consistency for the questionnaire overall (α = 0.83) and for the knowledge (α = 0.78) and practice/utilization (α = 0.81) domains suggests the central findings are unlikely to reflect measurement error. The access domain's marginally lower reliability (α = 0.69) stems from near-ceiling responses on several items (e.g., 98.5% obtaining nets via ANC), which mechanically depresses alpha even when the underlying construct is measured consistently; this is treated here as a measurement limitation rather than a substantive weakness.

Conclusions

6.1 Conclusions

This study surfaces a programmatic disconnect in Bonsu Sub-Municipality — a "Universal Access Paradox" whereby near-universal LLITN ownership (98.5%) failed to translate into consistent protection, with only 43.5% of pregnant women showing correct, consistent use at the point of observation. The NMCP has solved the logistical challenge of distributing nets, but has not yet overcome the socio-behavioral and household-level constraints that block sustained use. A related pattern is a knowledge-efficacy deficit: close to half of respondents (45.7%, a departure from chance shown to be significant in Section 4.8) mistakenly believed insecticide potency runs out after one year. This perceived obsolescence may plausibly encourage premature abandonment of nets, though our data cannot confirm that specific link, since knowledge and use-status were recorded as separate frequencies rather than paired at the respondent level. A similar caveat applies to side effects: itchiness was reported by a clear majority (65.0%; Section 4.8) and is seldom addressed through pre-emptive counselling, yet whether it is statistically associated with non-use remains untested, marking a priority for future data collection that links responses at the individual level. Several limitations qualify these conclusions. The purposive sample of 200 may constrain generalizability to larger urban settings, and the cross-sectional design offers only a single snapshot, without capturing seasonal shifts in mosquito density or ambient temperature. The access domain fell marginally short of the conventional reliability threshold (α = 0.69), largely due to near-ceiling responses on several items, and the cross-country comparison (Section 4.7) was descriptive rather than a formal meta-analysis, so its figures should be read as indicative only. Because knowledge, side-effect, and use-status items were entered as separate frequency tables rather than a respondent-linked matrix, this study can report that knowledge gaps, itchiness, and non-use were each widespread, but cannot test whether one predicts another — resolving this is a clear priority for

future work. Success in malaria prevention needs to be redefined from “nets per household” to “protected person-nights of sleep,” shifting programming away from passive distribution and toward a “Distribution Plus” model combining behavioural reinforcement, myth correction, and male partner engagement at every ANC contact point. Future studies should track behaviour over time to pinpoint where adherence breaks down and should test innovations such as low-irritant insecticide coatings or alternative net designs. Narrowing the gap between ownership and consistent use remains central to reducing maternal and neonatal illness, and will require treating misconceptions and physical discomfort as primary — not secondary — barriers to malaria prevention.

6.2 Recommendations

Drawing on the evidence generated by this study together with the wider epidemiological literature, the following recommendations are addressed to the Nkoranza South District Health Management Team (DHMT), the Ghana National Malaria Control Programme (NMCP), and relevant non-governmental organizations and community stakeholders:

- Institutionalize standardized, pictorial health education: Providers should go beyond routine counselling and roll out evidence-based, pictorial teaching materials at all ANC facilities, directly targeting the knowledge gaps identified here — the three-year efficacy period, correct shade-drying, and the fetal consequences of malaria in pregnancy — following the design principles set out by Opara et al. (2024).
- Build household-level behavioral support: The DHMT should use the Community Health Planning and Service (CHPS) framework to shift emphasis from clinic-based distribution toward home-based support, with community health workers demonstrating correct net-hanging technique and addressing temporary side effects such as itchiness (Carshon-Marsh & Di Ruggiero, 2025; Zuuri et al., 2025).
- Add structured post-distribution follow-up to routine ANC: Providers should confirm actual net use, uncover any barriers to proper installation, and offer real-time counselling to non-users — particularly those put off by side effects — following the approach modelled by Cottrell et al. (2025).
- Engage male partners as facilitators of use: Since household decision-making substantially shapes a woman’s ability to follow net-use recommendations (Binka & Adongo, 1997; Mwebesa et al., 2025), outreach programs should actively bring male partners and household heads into the process.
- Shift monitoring and evaluation from coverage to confirmed utilization: The NMCP and district stakeholders should give priority to “confirmed use at time of observation” over nominal ownership figures, relying on direct observational audits and validated self-report tools to obtain a more accurate picture of intervention effectiveness (Awunyo et al., 2025; Okova et al., 2025).

Abbreviations

All abbreviations and acronyms used in this study are compiled in **Table 6** to facilitate clarity and improve readability.

Declarations

Research Square Preprint Disclosure: An earlier version of this manuscript was deposited as a preprint at Research Square prior to submission. Richmond Yaw Osei, Ishmael Awini Aburi, Abigail Boatemaa, et al. "Perceived Insecticide Obsolescence Drives Non-Use Despite Near-Universal Bed Net Ownership Among Pregnant Women in Ghana: A Cross-Sectional Study," 21 July 2026, PREPRINT (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-10403126/v1]. The title of the manuscript has been revised from that of the preprint for the present submission; the underlying study, dataset, and findings are unchanged. The present manuscript is a revised and updated version of that preprint.

Ethics approval and consent to participate:

Ethical approval was obtained from the Ethics and Academic Integrity Committee of the Anglican University College of Technology (ANGUTECH), Nkoranza Campus, Ghana. All participants provided informed consent prior to participation. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Consent for publication:

Consent to publish anonymized data was obtained from all participants.

Competing interests:

The authors have no relevant financial or non-financial interests to disclose.

I.A.A.

Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editing

A.B.

Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editing

B.O.

Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editing

G.O.F.

Conceptualization, Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editing, Resources, Supervision, Project administration.

Funding:

This research received no specific external funding.

Author Contribution

R.Y.O.: Conceptualization, Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editing, Resources, Project administration. I.A.A.: Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editingA.B.: Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editingB.O.: Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editingG.O.F.: Conceptualization, Methodology, Formal analysis, Data curation, Validation, Investigation, Visualization, Writing – original draft, review & editing, Resources, Supervision, Project administration.

Acknowledgement

The authors would like to thank all pregnant women registered for ANC services in Bonsu Sub-Municipality, Nkoranza, Ghana, and the Department of Forest Engineering, Forest Management Planning, and Terrestrial Measurements, Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, for providing some of the resources needed for this study.

Data Availability

The questionnaire, datasets obtained from the survey and the Python 3.12 script used for data analysis are available in the figshare repository at: https://figshare.com/s/b718e9145c204981e691.

References

1. Abesig WJ, Nindow JAC, Bagonluri AC, Sarfo AK, Issahaku GR, Odikro MA et al (2025) Trend of malaria test positivity rate among pregnant women, Savannah Region, Ghana, 2018–2022. https://doi.org/10.1186/s12884-025-08157-z. BMC Pregnancy Childbirth
2. Ajonina MU, Ajonina-Ekoti IU, Ngulefac J, Ade N, Awambeng DN, Nfor CK et al (2024) Long-lasting insecticidal nets use and the prevalence of Plasmodium falciparum infection among pregnant women attending antenatal care at the Bonassama District Hospital, Littoral Region of Cameroon: a cross-sectional study. BMC Pregnancy Childbirth. https://doi.org/10.1186/s12884-024-06769-5

3. Akuffo R, Wilson M, Sarfo B, Dako-Gyeke P, Adanu R, Anto F (2021) Insecticide-treated net (ITN) use, factors associated with non-use of ITNs, and malaria in Ghana. PLoS ONE 16:e0261192. https://doi.org/10.1371/journal.pone.0261192
4. Alhassan AR (2021) Pregnant women and malaria preventive measures: a case of Tamale Teaching Hospital. J Trop Med 2021:6150172. https://doi.org/10.1155/2021/6150172
5. Ansah RK, Tackie S, Twum RA, Tawiah K, Boadi RK, Addo D et al (2024) The relationship between anaemia and the use of treated bed nets among pregnant and non-pregnant women in Ghana. PLoS ONE 19:e0300431. https://doi.org/10.1371/journal.pone.0300431
6. Anto F, Asoala V, Adjuik M, Anyorigiya T, Akweongo P (2009) Insecticide-treated bednet use, anaemia and malaria parasitaemia among children in the Kassena-Nankana district of northern Ghana. Malar J 8:133. https://doi.org/10.1186/1475-2875-8-133
7. Aoki A, Saito M, Balogun OO, Aiga H, Francisco KR, Takehara K (2025) Determinants of the use of insecticide-treated nets and intermittent preventive treatment of malaria among pregnant women in Angola. Int Health. https://doi.org/10.1093/inthealth/ihaf033
8. Atkinson JA, Vallely A, Fitzgerald L, Whittaker M, Tanner M (2012) The architecture and effect of participation: a systematic review of community participation for communicable disease control and elimination. Malar J 11:82. https://doi.org/10.1186/1475-2875-11-82
9. Awunyo W, Agbleta DG, Udeoha MA, Kodjo MM, Afaya A (2025) Ownership and utilization of mosquito bed net among pregnant women in Ghana: a national population-based survey. Trop Med Health. https://doi.org/10.1186/s41182-025-00739-z
10. Bardoe D, Bio RB, Hayford D, Yar DD (2025) From need to neglect: exploring psychological barriers to preventive interventions in pregnancy. PLOS Glob Public Health. https://doi.org/10.1371/journal.pgph.0004826
11. Baykemagn ND, Tafere TZ, Teshale G, Aschalew AY, Jejaw M, Demissie KA et al (2025) Leveraging machine learning to predict mosquito bed net utilization among women of reproductive age in sub-Saharan Africa. Malar J. https://doi.org/10.1186/s12936-025-05563-8
12. Binka FN, Adongo P (1997) Acceptability and use of insecticide impregnated bednets in northern Ghana. Trop Med Int Health 2:499–507. https://doi.org/10.1046/j.1365-3156.1997.d01-310.x
13. Bonsra EA, Osei PP, Kyeremeh E, Adama S, Sekyi AG, King EL (2025a) Factors associated with malaria in pregnancy among women attending ANC clinics in selected districts of the Ashanti Region, Ghana. Malar J. https://doi.org/10.1186/s12936-025-05244-6
14. Bonsra EA, Amankwah Osei P, Kyere GA, Adam S (2025b) Factors associated with malaria in pregnancy among women attending ANC Clinic in Kwadaso Municipality, Ghana: a health facility based cross-sectional study. BMC Public Health. https://doi.org/10.1186/s12889-025-22810-4
15. Bowling A (2002) Research methods in health: investigating health and health services, 2nd edn. Open University, London
16. Brabin BJ, Hakimi M, Pelletier D (2001) An analysis of anemia and pregnancy-related maternal mortality. J Nutr 131. https://doi.org/10.1093/jn/131.2.604S. :604S-615S

17. Carshon-Marsh R, Di Ruggiero E (2025) Improving the utilization of insecticide-treated nets for malaria prevention among pregnant women, lactating mothers and children in Sierra Leone: a commentary. Malar J. https://doi.org/10.1186/s12936-025-05429-z
18. Chima RI, Goodman CA, Mills A (2003) The economic impact of malaria in Africa: a critical review of the evidence. Health Policy 63:17–36. https://doi.org/10.1016/S0168-8510(02)00036-2
19. Cottrell G, Djènontin A, Soares C, Bouraima A, Fiogbé M, Egbinola S et al (2025) Suboptimal distribution and utilization of antenatal care given bed nets undermine pregnant women's protection in Benin: a prospective field study. BMC Public Health. https://doi.org/10.1186/s12889-025-22212-6
20. Creswell JW (2009) Research design: qualitative, quantitative, and mixed methods approaches, 3rd edn. SAGE, Thousand Oaks
21. Der EM, Tarkang EE, Aabongwo BF, Ofori-Asenso R (2019) Socio-demographic determinants associated with ownership and use of long-lasting insecticide-treated nets among pregnant women in the Wa Municipality of Ghana. BMC Pregnancy Childbirth 19:291. https://doi.org/10.1186/s12884-019-2437-0
22. Desai M, ter Kuile FO, Nosten F, McGready R, Asamoa K, Brabin B et al (2007) Epidemiology and burden of malaria in pregnancy. Lancet Infect Dis 7:93–104. https://doi.org/10.1016/S1473-3099(07)70021-X
23. Donacho DO, Tura SK, Kefeni BT (2025) Determinants of long-lasting insecticide-treated bed net utilization among pregnant women in Gechi District, Buno Bedele Zone, South West Ethiopia: a community-based cross-sectional study. Environ Health Insights. https://doi.org/10.1177/11786302251335135
24. Eisele TP, Larsen DA, Walker N, Cibulskis RE, Steketee RW (2009) Determining the effectiveness of the insecticide-treated bednet and indoor residual spraying campaigns in reducing malaria. PLoS ONE 4:e8145. https://doi.org/10.1371/journal.pone.0008145
25. Gallup JL, Sachs JD (2001) The economic burden of malaria. Am J Trop Med Hyg 64:85–96. https://doi.org/10.4269/ajtmh.2001.64.85
26. Getnet Y, Teym A, Wubie M, Shiferaw S, Tilahun Assaye B, Aneley Z et al (2024) Long lasting insecticide-treated nets utilization and associated factors among pregnant women in Shebel Berenta District, Northwest Ethiopia. https://doi.org/10.1177/11786302241291957. Environ Health Insights
27. Ghana Health Service (2009) Nkoranza South District health report 2009. District Health Directorate, Nkoranza
28. Ghana Statistical Service, Ghana Health Service (2009) Ghana demographic and health survey 2008. Ghana Statistical Service and Ghana Health Service, Accra
29. Gikandi PW, Noor AM, Snow RW, Ngugi AK, Hay SI (2008) Access and barriers to insecticide treated net use in urban and peri-urban areas of Kenya. Malar J 7:227. https://doi.org/10.1186/1475-2875-7-227

30. Grabowsky M, Nobiya T, Hindle P (2005) Distributing insecticide-treated bednets during measles vaccination: a low-cost means of achieving high and equitable coverage. Bull World Health Organ 83:195–201
31. Guyatt HL, Snow RW (2004) Impact of malaria during pregnancy on low birth weight in sub-Saharan Africa. Clin Microbiol Rev 17:760–769. https://doi.org/10.1128/CMR.17.4.760-769.2004
32. Ibeagha A, Ruiter RAC, Dukers-Muijrers NHTM, Hoebe CJ (2025) What factors contribute to the inconsistent use of insecticide treated bed nets in tropical Africa? A review of the literature on malaria prevention. Int J Psychol Health Sci. https://doi.org/10.38035/ijphs.v3i4.1738
33. Iwueze MO, Ezenwaka C, Nzeakor TA, Nwoke EA, Ezike VI (2014) Pattern of insecticide-treated net usage and its determinants among residents of an endemic malaria area of Nigeria. Sierra Leone J Biomed Res 6:3–12
34. Kabalu Tshiongo J, Zola Matuvanga T, Mitashi P, Maketa V, Schallig HDFH, Mens PF et al (2024) Prevention of malaria in pregnant women and its effects on maternal and child health, the case of Centre Hospitalier de Kingasani II in the Democratic Republic of the Congo. Trop Med Infect Dis 9:92. https://doi.org/10.3390/tropicalmed9050092
35. Kelsey JL, Whittemore AS, Evans AS, Thompson WD (1996) Methods in observational epidemiology, 2nd edn. Oxford University Press, New York
36. Klu D, Alhassan A, Vidzro ES, Aberese-Ako M (2026) Household characteristics, water, sanitation and hygiene (WASH) and malaria prevalence among children aged 6–59 months in Ghana: an analysis of the 2022 Ghana Demographic and Health Survey. Malar J. https://doi.org/10.1186/s12936-026-05815-1
37. Kokuhennadige V, Aitken E, Rogerson S (2026) Malaria in pregnancy at the frontline: a delicate balance. Curr Opin Immunol. https://doi.org/10.1016/j.coi.2026.102726
38. Lengeler C (2004) Insecticide-treated bed nets and curtains for preventing malaria. Cochrane Database Syst Rev 2:CD000363. https://doi.org/10.1002/14651858.CD000363.pub2
39. Macintyre K, Keating J, Okello G, Wolff B, Mbogo CM (2012) Examining the determinants of mosquito-avoidance practices in two Kenyan cities. Malar J 11:9. https://doi.org/10.1186/1475-2875-11-9
40. Madukwe JC, Ahaneku EB, Onukafor OS, Edokpayi S, Madukwe PC, Enwereji NU et al (2025) Do women attending antenatal clinics who use only intermittent preventive treatment (IPTp) have higher Plasmodium falciparum prevalence compared to those who used both IPTp and slept under insecticide-treated nets? Malar J. https://doi.org/10.1186/s12936-025-05532-1
41. McCormick MC (1985) The contribution of low birth weight to infant mortality and childhood morbidity. N Engl J Med 312:82–90. https://doi.org/10.1056/NEJM198501103120204
42. Minwuyelet A, Yewhalaw D, Siferih M, Atenafu G (2025) Current update on malaria in pregnancy: a systematic review. Trop Dis Travel Med Vaccines. https://doi.org/10.1186/s40794-025-00248-1
43. Mwebesa E, Musinguzi B, Legason ID, Opoke R, Agaba BB, Kananura R et al (2025) Pooled prevalence and factors associated with insecticide-treated net use among pregnant women in

malaria high-burden countries in sub-Saharan Africa: a multilevel mixed-effects analysis. Trop Med Health. https://doi.org/10.1186/s41182-025-00855-w

44. National Malaria Control Programme (2017) Ghana malaria programme review 2017. Ghana Health Service, Accra
45. Nkoranza South District Health Management Team (2016) Annual district health report 2016. Nkoranza South District Health Directorate, Nkoranza
46. Nkuo-Akenji T, Ntonifor NN, Ndong JM, Eyong EM, Green EE, Alemnji G et al (2009) Evaluating malaria intervention strategies among pregnant women and their newborns in rural Cameroon. J Infect Dis Immun 1:4–9
47. Nuwaha F (2001) Factors influencing the use of bed nets in Mbarara municipality of Uganda. Am J Trop Med Hyg 65:877–882. https://doi.org/10.4269/ajtmh.2001.65.877
48. Okoro LN, Zoakah AI, Bupwatda P, Anyamene EL, Bulus NG, Kumbak FD et al (2025) Cost-effectiveness of intermittent preventive therapy and insecticide-treated bed nets for malaria prevention among pregnant women in Jos North, Plateau State, Nigeria. Malar J. https://doi.org/10.1186/s12936-025-05607-z
49. Okova D, Lukwa A, Edusei M, Bodzo P, Atta-Obeng C, Chiwire P et al (2025) Between- and within-socioeconomic groups temporal inequality in the uptake of malaria prevention strategies among pregnant women and under-five children in Ghana (2003–2022). Malar J. https://doi.org/10.1186/s12936-025-05512-5
50. Opara MO, Ismail S, Mohd Nazan AI (2024) Prevention of malaria in pregnancy through health education intervention programs on insecticide-treated nets use: a systematic review. BMC Public Health 24:17650. https://doi.org/10.1186/s12889-024-17650-7
51. Osei KM, Adiak AA, Han W (2026) Evaluating the effectiveness of insecticide-treated net use in preventing malaria among children under five: a quasi-experimental study. Trop Med Health. https://doi.org/10.1186/s41182-026-00932-8
52. Otchere A (2011) Nkoranza South District health sector annual programme of work review report 2011. Nkoranza South DHMT, Nkoranza
53. Patton MQ (2002) Qualitative research and evaluation methods, 3rd edn. SAGE, Thousand Oaks
54. Pluess B, Tanser FC, Lengeler C, Sharp BL (2010) Indoor residual spraying for preventing malaria. Cochrane Database Syst Rev 4:CD006657. https://doi.org/10.1002/14651858.CD006657.pub2
55. Polit DF, Beck CT (2010) Essentials of nursing research: appraising evidence for nursing practice, 7th edn. Lippincott Williams & Wilkins, Philadelphia
56. Sachs J, Malaney P (2002) The economic and social burden of malaria. Nature 415:680–685. https://doi.org/10.1038/415680a
57. Salifu Y, Nantomah B, Lasong J (2026) Knowledge of malaria and preventive practices among Fulani pregnant women in the Savannah Region of Northern Ghana. BMC Res Notes. https://doi.org/10.1186/s13104-026-07736-3

58. Schantz-Dunn J, Nour NM (2009) Malaria and pregnancy: a global health perspective. Rev Obstet Gynecol 2:186–192
59. Steketee RW, Nahlen BL, Parise ME, Menendez C (2001) The burden of malaria in pregnancy in malaria-endemic areas. Am J Trop Med Hyg 64:28–35. https://doi.org/10.4269/ajtmh.2001.64.28
60. Sumaila I, Issifu S, Asumah MN, Nimo-Boakye K, Awuah DA, Agodzo H et al (2025) Determinants of insecticide treated bed nets use among pregnant women in the Kintampo North Municipality, Bono East Region, Ghana. https://doi.org/10.1101/2025.05.13.25327488. medRxiv
61. Tavakol M, Dennick R (2011) Making sense of Cronbach's alpha. Int J Med Educ 2:53–55. https://doi.org/10.5116/ijme.4dfb.8dfd
62. Teym A, Berihun G, Shiferaw MY, Abawa ED, Alemu Y, Assaye BT et al (2025) Insecticide-treated bed net utilization and its determinants among pregnant women in Dembecha District, Northwest Ethiopia. https://doi.org/10.1186/s41182-025-00762-0. Trop Med Health
63. World Health Organization (2005) World malaria report 2005. WHO, Geneva
64. World Health Organization (2007) Insecticide-treated mosquito nets: a WHO position statement. WHO Global Malaria Programme, Geneva
65. World Health Organization (2015) World malaria report 2015. WHO, Geneva
66. World Health Organization, Ghana Health Service (2003) Ghana national malaria control programme: coverage and utilization of insecticide-treated nets report 2003. WHO Press and Ghana Health Service, Geneva
67. World Medical Association (2013) World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA 310:2191–2194. https://doi.org/10.1001/jama.2013.281053
68. Ye Y, Kyobutungi C, Louis VR, Sauerborn R (2012) Micro-epidemiology of Plasmodium falciparum malaria: is there any difference in transmission risk between neighbouring villages? Malar J 11:286. https://doi.org/10.1186/1475-2875-11-286
69. Zhou G, Thwing J, Keating J (2014) Malaria vector control. Am J Trop Med Hyg 90:803–809. https://doi.org/10.4269/ajtmh.13-0545
70. Zuuri CN, Gyamah DK, Buabeng L, Osei Mensah R (2025) Assessing the knowledge, attitudes and practices towards malaria prevention and determinants of antenatal care utilization among pregnant women in Sekyere South district, Ghana: a cross-sectional study. Malar J. https://doi.org/10.1186/s12936-025-05614-0

Figures

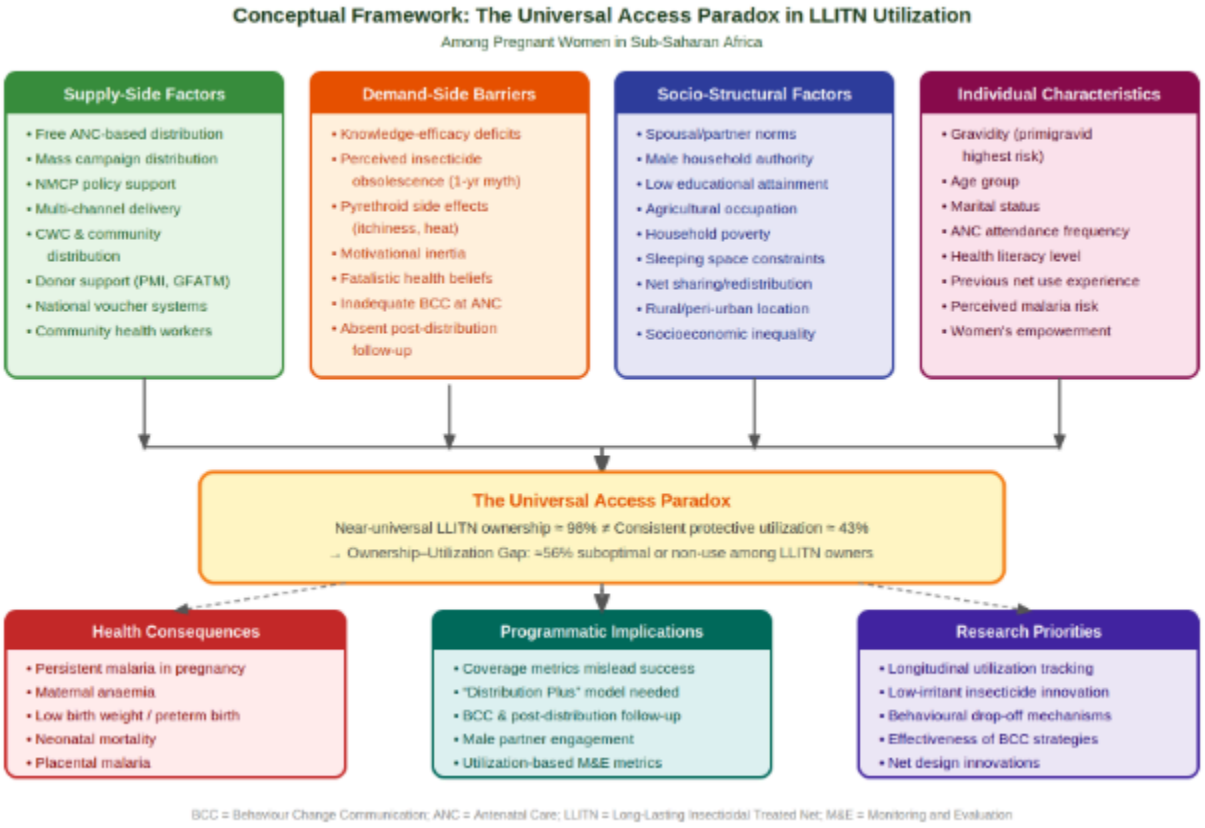


Figure 1

Conceptual framework of the Universal Access Paradox in LLITN utilization among pregnant women in sub-Saharan Africa. Supply-side, demand-side, socio-structural, and individual-level factors converge to produce a gap between near-universal ownership (≈99.5%) and consistent protective utilization (≈43.5%), with downstream health, programmatic, and research implications. *Note.* BCC = Behaviour Change Communication; ANC = Antenatal Care; LLITN = Long-Lasting Insecticidal Treated Net; M&E = Monitoring and Evaluation.

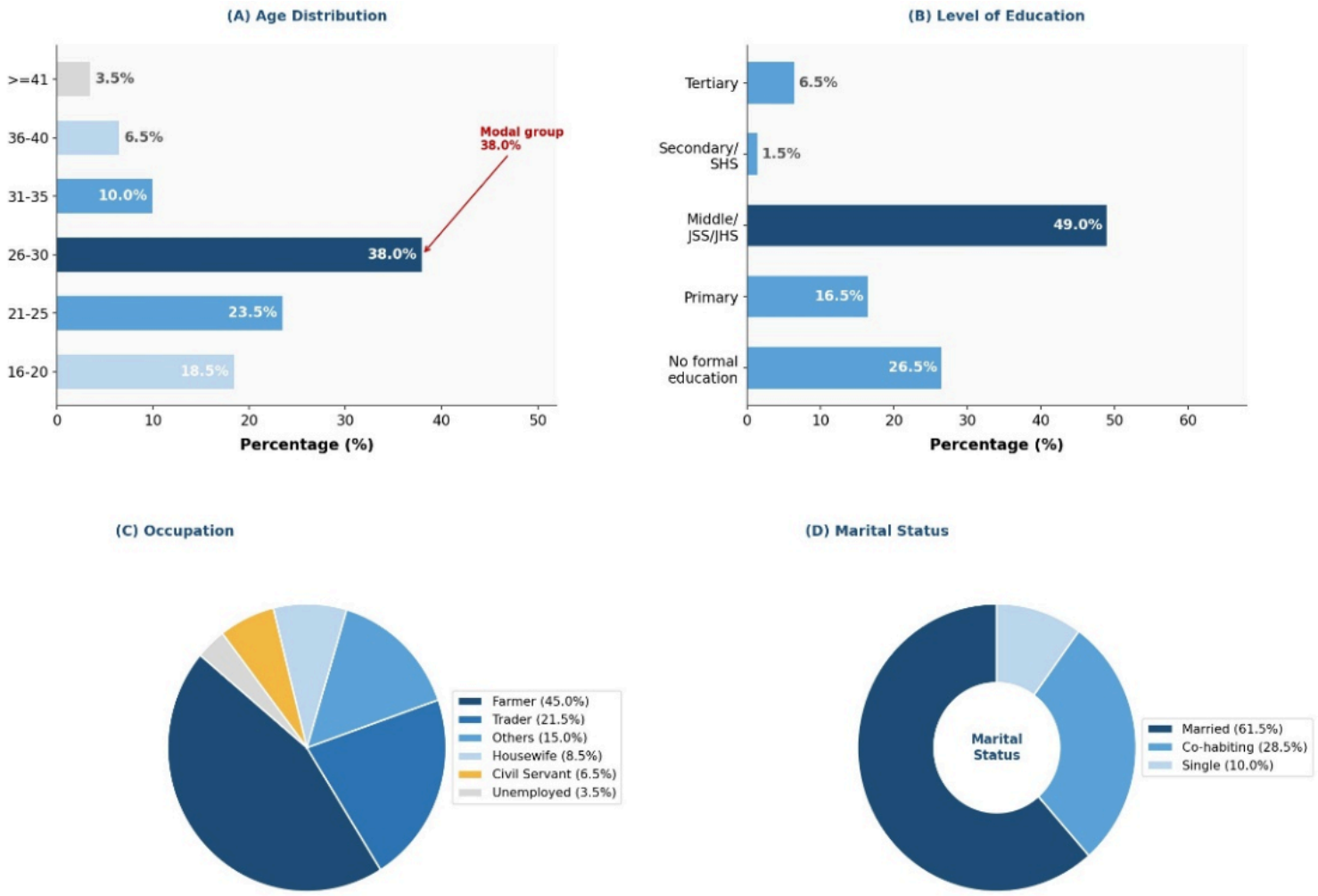


Figure 2

Socio-demographic characteristics of study respondents (*N* = 200). Panel A shows the distribution of respondents by age group; Panel B shows the distribution by level of education; Panel C shows the distribution by occupation; Panel D shows the distribution by marital status. *Note.* The 26–30 year age group constituted the modal category (38.0%). Middle/Junior High School was the most prevalent educational level (49.0%). Farming was the predominant occupation (45.0%). The majority of respondents were married (61.5%).

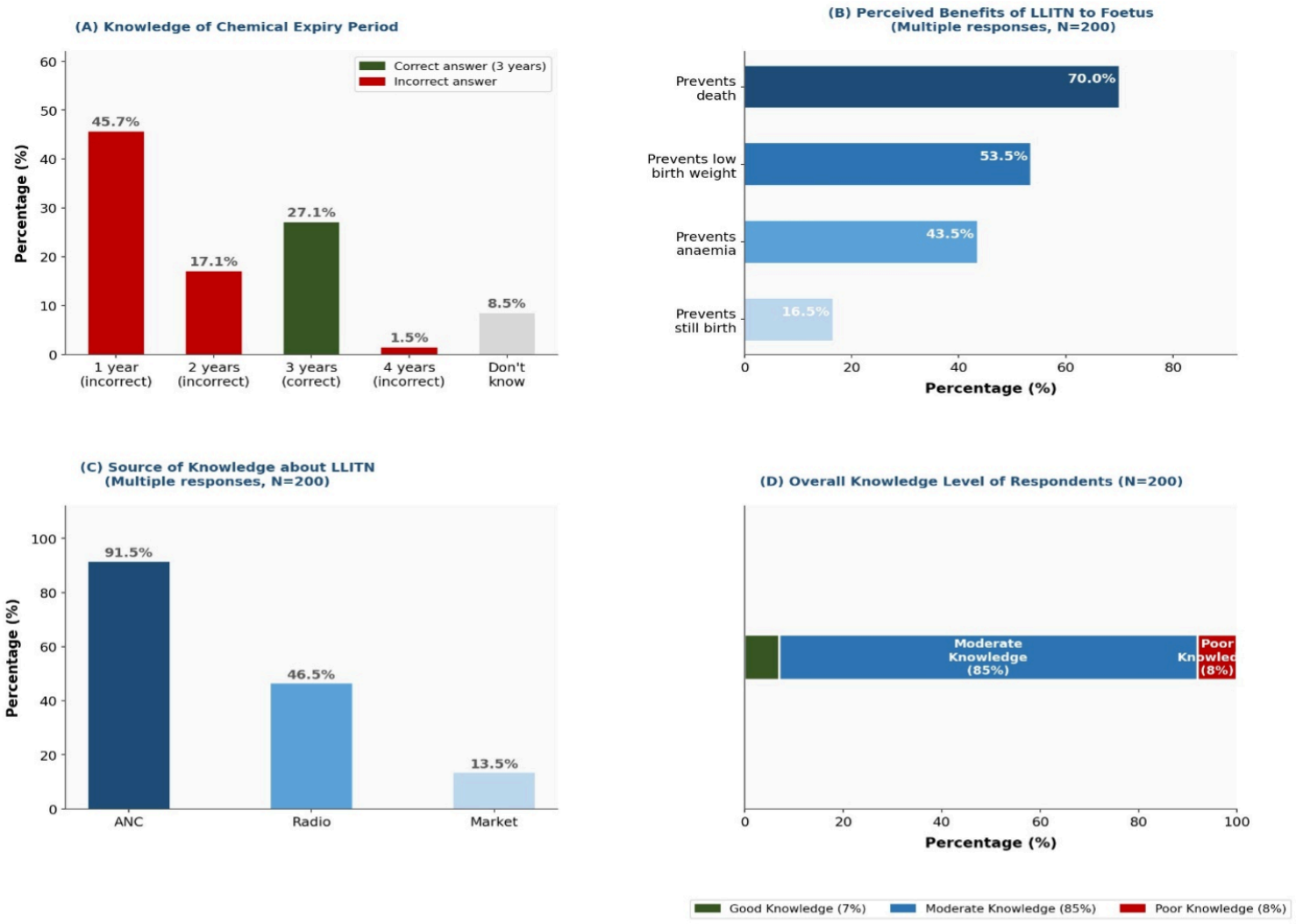


Figure 3

Knowledge of respondents regarding LLITNs. Panel A presents respondents' knowledge of the chemical expiry period, with the correct answer (3 years) indicated in green; Panel B shows perceived foetal health benefits; Panel C shows sources of LLITN knowledge; Panel D presents the distribution of overall knowledge levels. *Note.* All respondents (100%) were aware that LLITNs prevent malaria. Only 27.1% correctly identified the three-year chemical expiry period. The majority (85%) demonstrated a moderate overall level of knowledge. ANC = Antenatal Care; LLITN = Long-Lasting Insecticidal Treated Net.

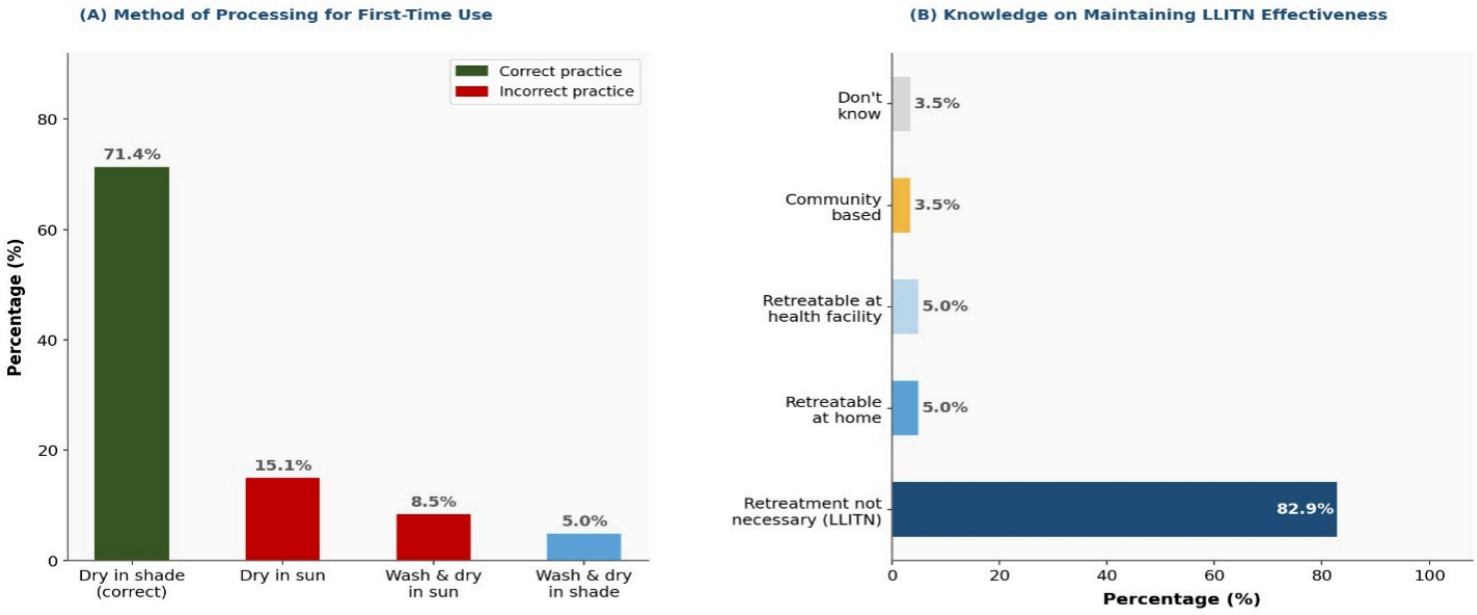


Figure 4

Knowledge on processing and maintenance of LLITN effectiveness. Panel A presents respondents' reported method of processing LLITNs for first-time use; Panel B presents knowledge regarding the maintenance of LLITN effectiveness over time. *Note.* 71.2% of respondents correctly reported drying the net in the shade as the appropriate first-time processing method. 83.1% correctly identified that LLITNs do not require chemical retreatment. LLITN = Long-Lasting Insecticidal Treated Net.

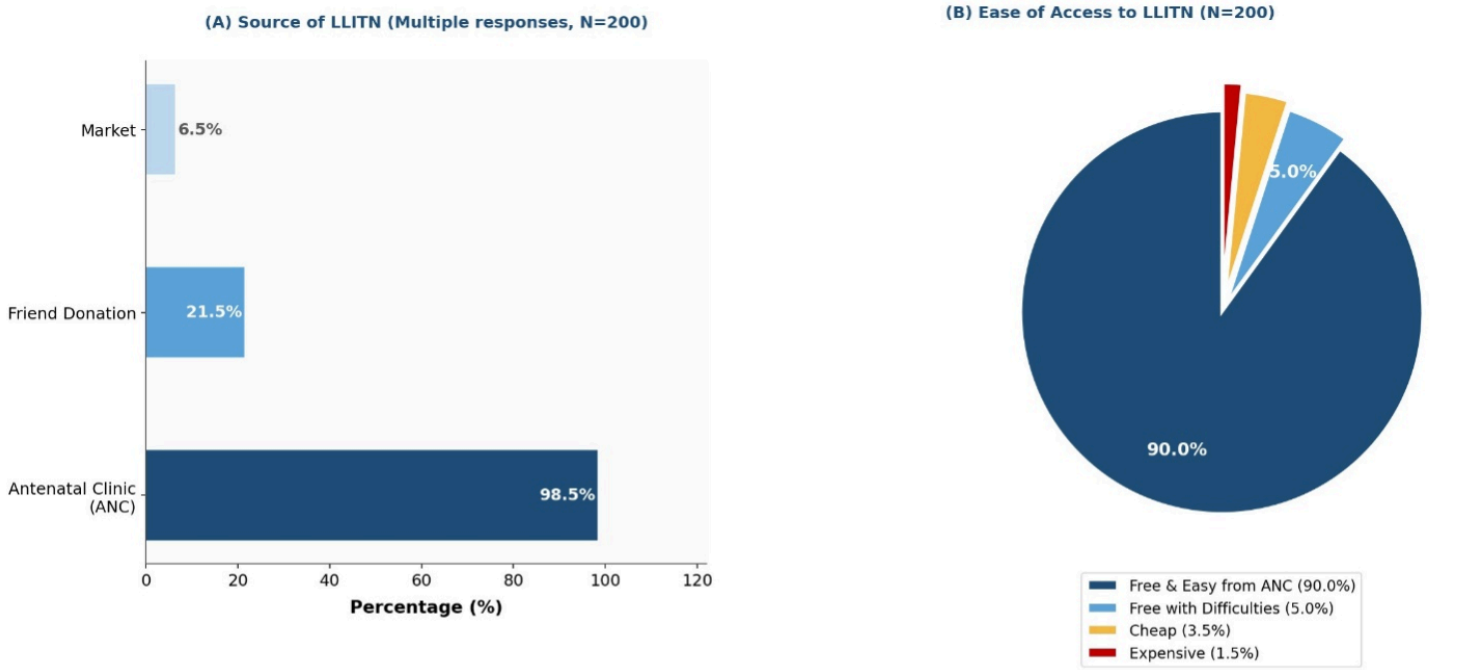


Figure 5

Access to LLITNs among respondents. Panel A presents the sources from which respondents obtained their LLITNs (multiple responses permitted); Panel B presents the distribution of responses regarding the

ease of LLITN access. *Note.* 98.5% of respondents obtained their LLITN from an ANC clinic. 90.0% reported free and easy access. ANC = Antenatal Care; LLITN = Long-Lasting Insecticidal Treated Net.

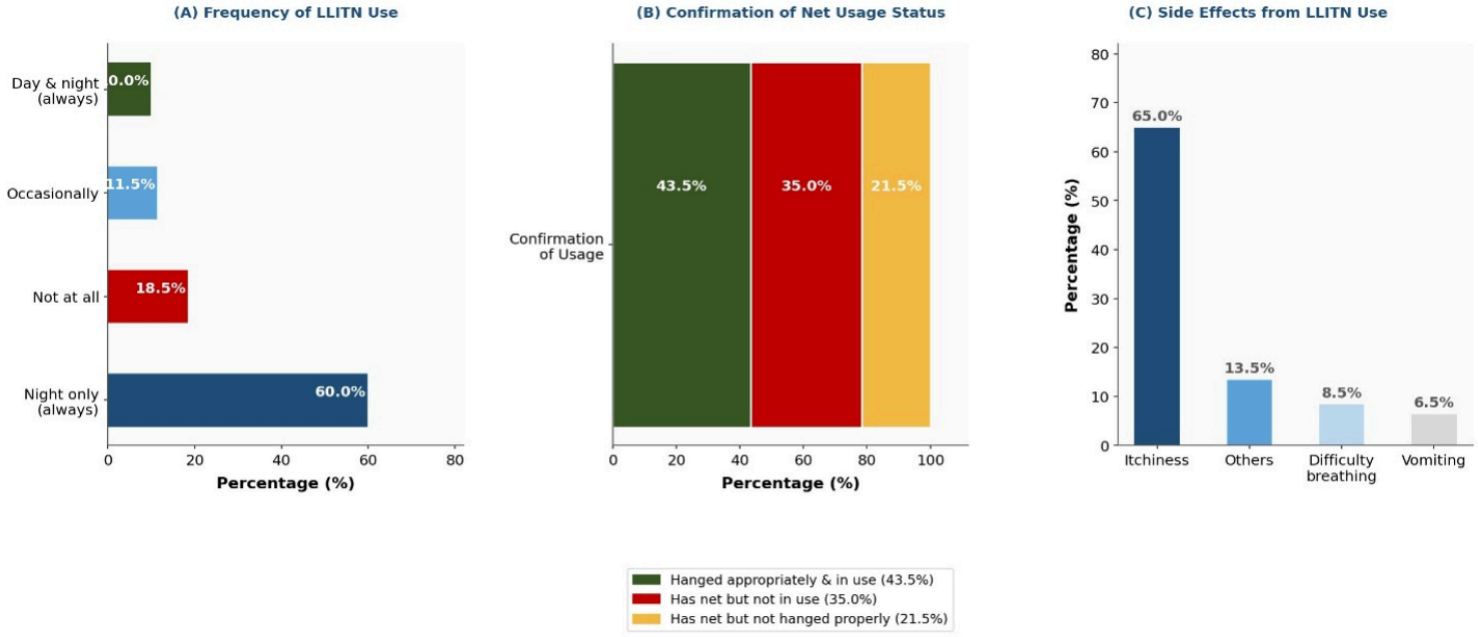


Figure 6

Common practices of LLITN use among respondents (*N* = 200). Panel A presents the frequency distribution of LLITN use; Panel B shows the confirmation of net use status based on direct observation; Panel C presents the distribution of side effects reported. *Note.* 60.0% of respondents reported nighttime-only net use. Only 43.5% had their net appropriately hung and actively in use at the time of observation. Itchiness was the most prevalent reported side effect (65.0%). LLITN = Long-Lasting Insecticidal Treated Net.

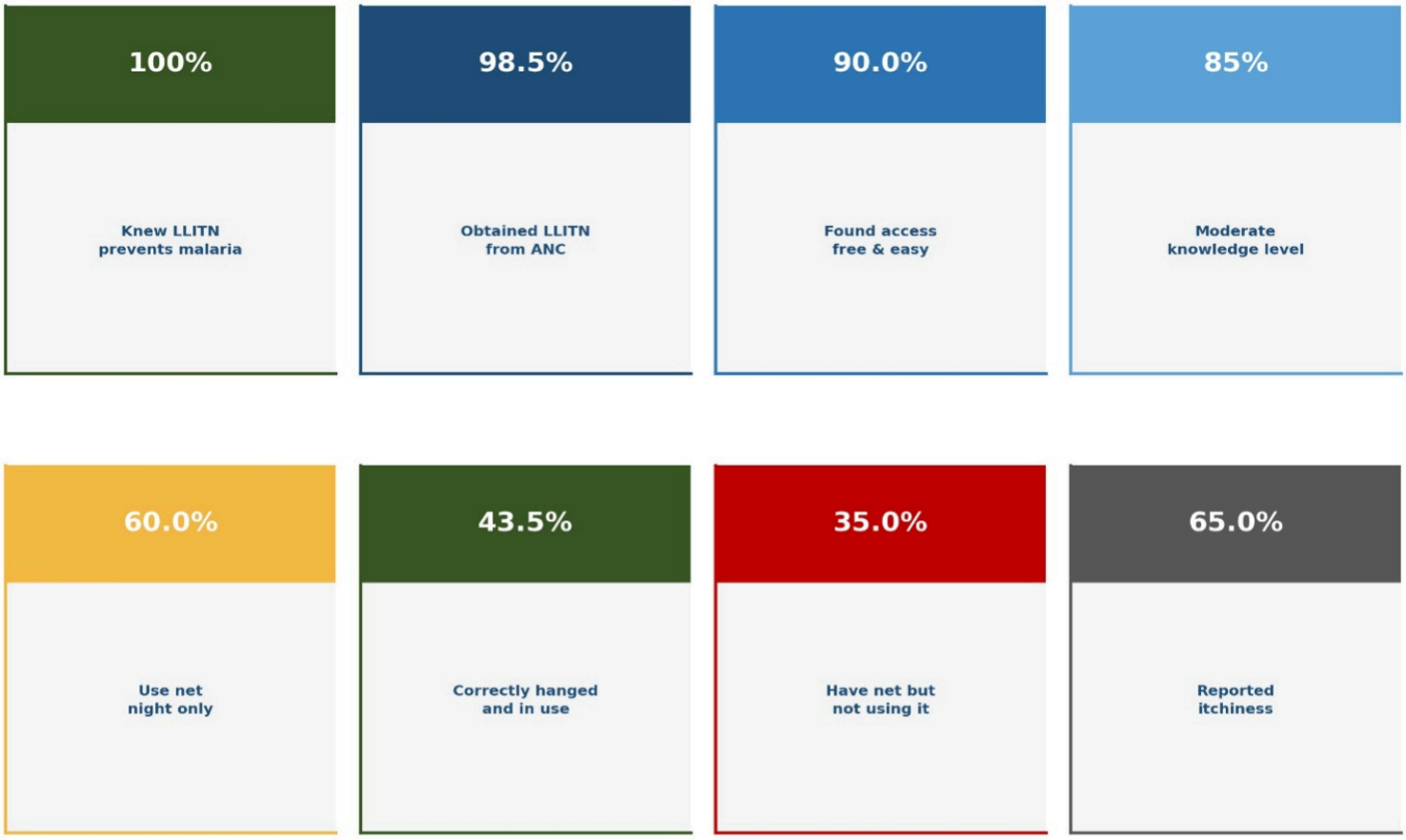


Figure 7

Key findings summary: LLITN access and utilization among pregnant women, Nkoranza South Municipality, Ghana (*N* = 200). Each panel represents a key metric derived from the study, organized to highlight the contrast between high knowledge/access rates and suboptimal utilization.

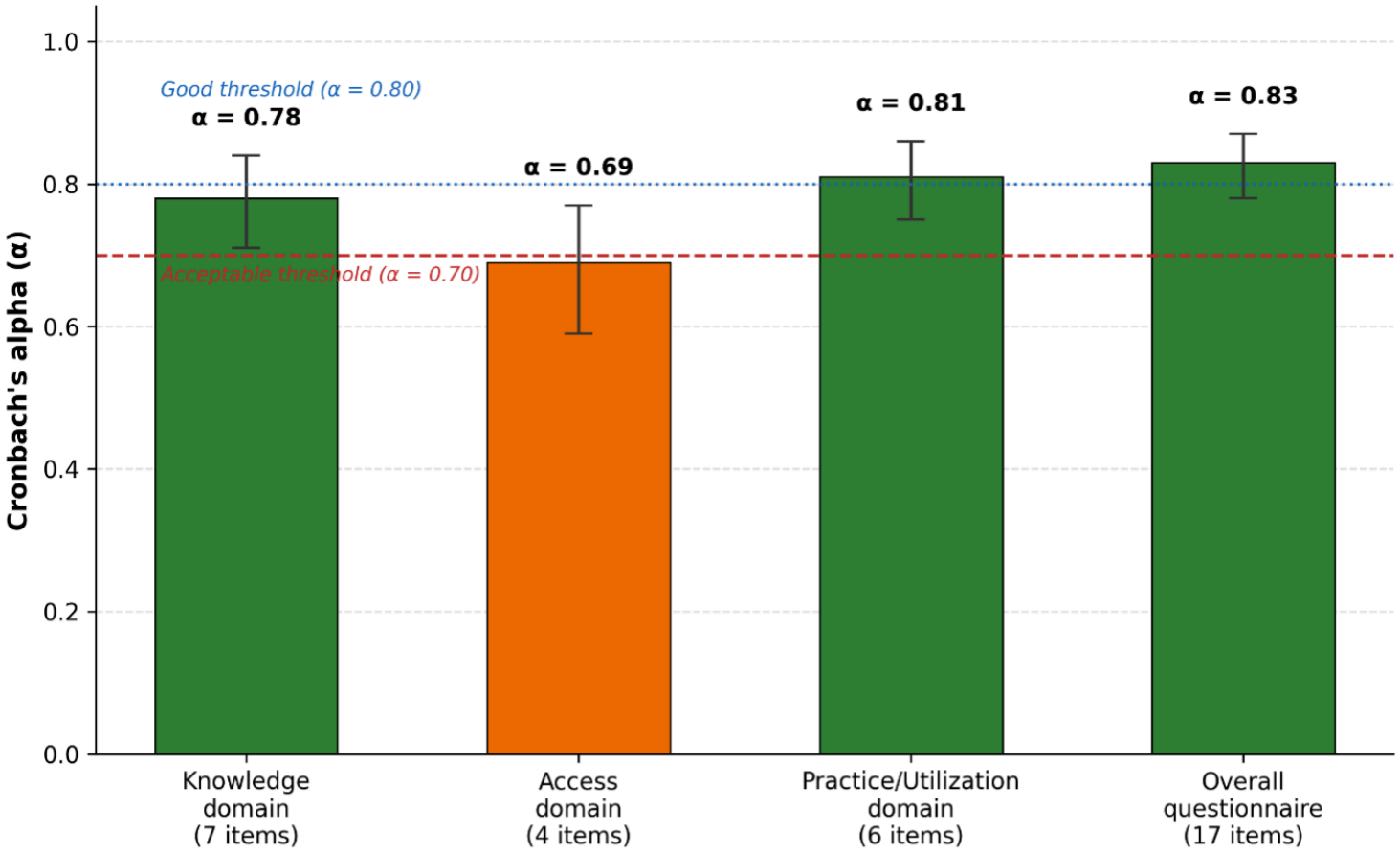


Figure 8

Internal consistency reliability of the structured questionnaire by domain, with 95% bootstrap confidence intervals. *Note.* Dashed red line denotes the conventional acceptable-reliability threshold (α = 0.70); dotted blue line denotes the good-reliability threshold (α = 0.80).

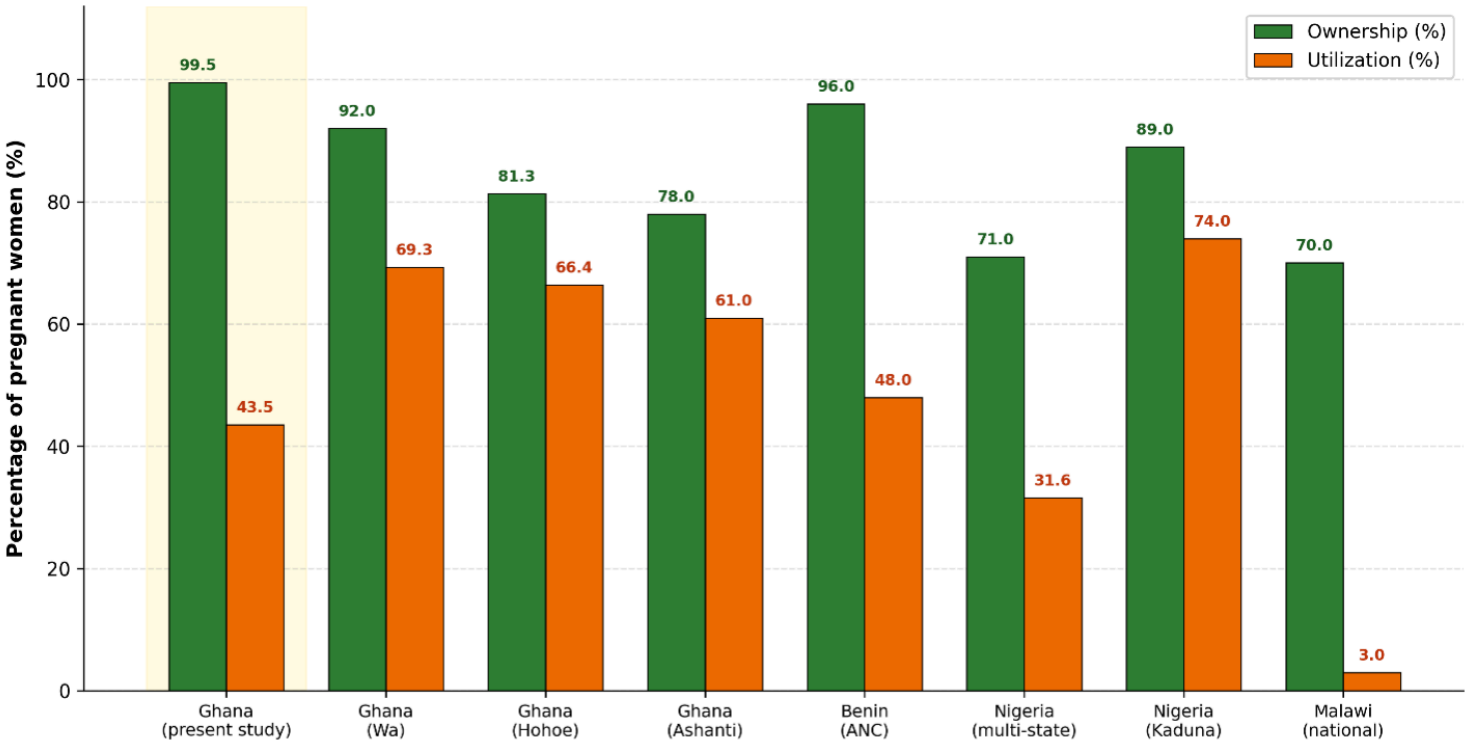


Figure 9

Cross-country comparison of LLITN/ITN ownership versus utilization among pregnant women in sub-Saharan Africa. The present study (highlighted) recorded the highest ownership rate among comparator settings reporting both metrics, alongside one of the largest ownership–utilization gaps. *Note. Note.* Gap = Ownership % − Utilization %, in percentage points. The present study (highlighted) is shown alongside the eight comparator settings reporting paired ownership and utilization data; the full 22-setting dataset, including settings reporting only utilization, is provided in the accompanying Excel workbook (Comparative_Data_and_Reliability.xlsx, Sheet: Cross-Country Comparison). ANC = Antenatal Care; LLITN = Long-Lasting Insecticidal Treated Net; ITN = Insecticide-Treated Net; pp = percentage points. Note: Data sources and full citations are provided in **Table 5.** ANC = Antenatal Care.