Health Dynamics
eISSN: 3006-5518
Publisher: Knowledge Dynamics
DOI: https://doi.org/10.33846/hd30805

*Original Research*

# Community Compliance and Usage of Insecticide-Treated Nets (ITNs) for Malaria Prevention in the Upper River Region of The Gambia

**Babucarr Jassey[1,2,*], Ririh Yudhastuti[3,*], Heny Arwati[4], Lamin Ceesay[2], Ebrima Jatta[5], Yankuba Fabureh[6], Baba Ceesay[2,6], Omar Jallow[2,6], Samuel S Gomez[2,6], Ousman F Bojang[2,6], Alfusainey Manneh[6] and Khuliyah Candraning Diyanah[1,3]**

[1]Doctorate Degree Program in Public Health, Faculty of Public Health, Universitas Airlangga, Surabaya, East Java 60115, Indonesia
[2]Department of Public Health Services, Ministry of Health, Quadrangle, Banjul, FC3F+QWC, The Gambia
[3]Department of Environmental Health, Faculty of Public Health, Universitas Airlangga, Surabaya, East Java 60115, Indonesia
[4]Department of Parasitology, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[5]Catholic Relief Services, 40 Atlantic Road, Fajara, Serekunda, P.O. Box 2361, Serekunda, The Gambia
[6]National Malaria Control Program, Ministry of Health, FC3F+QWC; Box 273, Banjul, The Gambia

**Article history**
Received: 23 May 2026
Revised: 15 August 2026
Accepted: 16 August 2026
Published Online: 22 August 2026

***Correspondence:**
Ririh Yudhastuti
Address: Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia.
Email: ririhyudhastuti@fkm.unair.ac.id
Babucarr Jassey
Address: Department of Public Health Services, MoH, The Gambia.
Email: baxjas@gmail.com; babucarr.jassey-2023@fkm.unair.ac.id

**How to cite this article:** Jassey B, Yudhastuti R, Arwati H, Ceesay L, Jatta E, Fabureh Y, Ceesay B, Jallow O, Gomez SS, Bojang OF, Manneh A, Diyanah KC. Community Compliance and Usage of Insecticide-Treated Nets (ITNs) for Malaria Prevention in the Upper River Region of The Gambia. *Health Dynamics*, 2026, 3(8), 348-359. https://doi.org/10.33846/hd30805



## ABSTRACT

**Background:** Insecticide-treated nets (ITNs) are an important malaria prevention measure, but household ownership does not always translate into consistent use. Understanding community compliance and barriers to ITN utilization is essential for effective malaria control. This study assessed ITN utilization usage patterns and community compliance in the Upper River Region (URR) of The Gambia to better understand the gap between possessing a net and using it correctly. **Methods:** A community-based study was conducted across seven districts in the URR: Sandu, Jimara, Wulli East, Wulli West, Basse (Fulladu East), Tumana, and Kantora. Data were collected from 1,000 households through interviewer-administered questionnaires and direct environmental observations. The Community Compliance Index (CCI) framework was used to assess nightly ITN use, knowledge of ITN benefits, barriers to use, and the physical condition and hanging of nets. **Results:** ITN ownership was high, with 94.2% of respondents reporting sufficient nets for household members, while 78.5% reported sleeping under a net every night. Knowledge of ITN benefits was high, but consistent use was affected by nighttime heat, overcrowded sleeping areas, and inadequate net maintenance. Direct observations showed that 68.3% of nets were properly hanging over sleeping areas, indicating a gap between reported use and observed readiness for use. **Conclusion:** Despite high ITN ownership and awareness, environmental discomfort and household structural constraints remain important barriers to consistent utilization in the URR. Malaria control programs should complement ITN distribution with behavior-change interventions addressing proper net hanging, maintenance, and heat-related discomfort.

**Keywords:** Disease prevention; health behavior; knowledge attitudes and practice; KAP; insecticide-treated nets; malaria

# 1. INTRODUCTION

Malaria remains one of the most significant global health challenges, with the greatest burden occurring in sub-Saharan Africa. Despite substantial progress in malaria prevention and control, transmission persists in many endemic settings, particularly where environmental, socioeconomic, and health-system conditions continue to support mosquito transmission. The World Health Organization (WHO) continues to identify insecticide-treated nets (ITNs) as a central component of malaria vector control, although progress is increasingly affected by challenges such as insecticide resistance and gaps in access and use.[1] ITNs protect individuals by providing a physical barrier against mosquitoes and exposing vectors to insecticides, making consistent use an important component of household-level malaria prevention.[2,3]

The effectiveness of ITN programmes, however, depends not only on distribution and household ownership but also on whether nets are consistently and correctly used. Across sub-Saharan Africa, a persistent gap has been observed between ITN access, ownership, and actual utilization. Recent evidence shows that although ITN ownership has increased substantially, utilization remains influenced by household characteristics, socioeconomic conditions, demographic factors, and local environmental circumstances.[4,5] Studies from Ethiopia, Ghana, Nigeria, and other malaria-endemic settings have similarly reported that education, household size, socioeconomic status, knowledge of malaria prevention, and other household characteristics are associated with ITN use.[6-9] These findings indicate that providing households with ITNs does not necessarily guarantee consistent protection.

Recent studies have also highlighted the importance of physical and environmental conditions in shaping ITN use. Discomfort associated with high nighttime temperatures is an important barrier, particularly in tropical settings where sleeping under a net may increase perceived heat and reduce willingness to use it consistently.[9,10] In The Gambia, experimental research demonstrated that improved household ventilation can reduce indoor temperature and malaria mosquito entry, suggesting that housing conditions may influence both comfort and malaria exposure.[9] Other barriers reported in previous studies include inadequate sleeping space, overcrowding, damaged nets, difficulties with proper hanging, and limited replacement of worn nets.[4,6,10] These factors are particularly relevant in rural communities where household infrastructure and living conditions vary considerably.

The Gambia has made important efforts to strengthen malaria prevention through the National Malaria Control Programme (NMCP), including ITN distribution, health education, indoor residual spraying in selected areas, and community-based malaria activities. Nevertheless, malaria transmission remains seasonal, and rural communities continue to require sustained access to effective vector-control interventions. Recent national evidence from The Gambia found that ITN utilization among children under five was 63.4% and identified individual, household, and community characteristics as important determinants of use.[11,12] Although this study provides important national evidence, its focus was on children under five using secondary data from the 2019–2020 Demographic and Health Survey.[13] It therefore does not fully describe household-level compliance across the wider population or the physical condition and actual placement of nets within households.

The Upper River Region (URR) represents an important setting for examining these issues because of its predominantly rural population and the variation in household characteristics and living environments across its districts. Understanding ITN utilization in this setting requires more than measuring whether households own nets. It is also necessary to examine whether household members report using nets consistently, whether they understand their protective benefits, and whether nets are physically available, properly hung, and maintained.[14] Direct observation can provide additional information that may not be captured through self-reported household surveys alone.

Despite the growing literature on ITN ownership and utilization, evidence combining self-reported behavior with direct household observation remains limited in the Gambian context, particularly in the URR. The existing national evidence identifies important determinants of ITN use, but there is still a need for context-specific information on the gap between reported compliance and observed household practices. Addressing this gap is important because high ownership and awareness may create an inaccurate impression of effective protection if nets are not consistently used, properly installed, or adequately maintained.

Therefore, this study assessed ITN utilization and community compliance among households in the Upper

River Region of The Gambia using a Community Compliance Index (CCI) framework. By combining interviewer-administered household surveys with direct environmental observations, the study examined reported nightly ITN use, knowledge of ITN benefits, barriers to utilization, and the physical condition and hanging of nets. The findings are intended to provide context-specific evidence to support malaria prevention strategies that address not only ITN distribution but also the behavioral, environmental, and household factors that influence consistent use.

## 2. METHODS

### *2.1 Study Area and Period*

The study was conducted in the Upper River Region (URR) of The Gambia, a predominantly rural region where malaria transmission remains an important public health concern. The study covered seven districts: Basse (Fulladu), Garawol, Kantora, Sandu, Wulli West, and Wulli East. This region is an important operational for the National Malaria Control Programme (NMCP) as The Gambia continues to strengthen malaria control and move toward malaria elimination. Data were collected through community-based fieldwork involving household interviews and direct observations conducted by trained personnel.

### *2.2 Study Design and Population*

A community-based cross-sectional study was conducted to assess household ITN utilization and community compliance with malaria prevention practices in the URR. The source population comprised households residing in the selected districts. The study population consisted of eligible household members from selected households who participated in the survey.

A total of 1,000 households were included in the study. The households were selected to provide representation across different geographic locations and socio-demographic characteristics within the study area. Information was collected from household respondents regarding ITN ownership and utilization, knowledge of malaria prevention, attitudes toward ITN use, barriers to consistent use, and household practices related to net maintenance.

### *2.3 Eligibility Criteria*

Households were eligible for inclusion if they were located within the selected study communities, were resident in the study area during the data-collection period, and had a household member available to respond to the interviewer-administered questionnaire. Participants were required to be willing to participate and provide informed consent before data collection.

Households or individuals were excluded if they were not resident in the selected communities during the study period, were unavailable to participate during the data-collection period, or declined to provide informed consent. Households for which the required questionnaire information or direct observation could not be completed were also excluded from the analysis.

### *2.4 Sampling Procedures and Sample Distribution*

Participants were selected from communities across the study districts in the URR. The study included households from Fulladu (Basse), Kantora (Fatoto), Sandu, Wulli East, Wulli West, Jimara, and Tumana. A total of 1,000 households were included and distributed across the participating districts as follows: Fulladu (Basse), 200 households; Kantora, 180; Sandu, 160; Wulli East, 150; Wulli West, 140; Jimara, 100; and Tumana, 70.

The distribution was designed to achieve broad geographic coverage and capture variation in household characteristics and malaria prevention practices across the URR. The participating households included different socio-demographic and occupational groups, including farmers, teachers, drivers, and civil servants. Household-level information was collected from respondents who met the eligibility criteria and consented to participate.

### *2.5 Study Variables and Measurements*

The primary outcomes were ITN utilization and community compliance with recommended malaria prevention practices. ITN utilization was assessed using self-reported frequency of sleeping under an ITN and direct observation of whether nets were appropriately positioned over sleeping areas.

Independent variables included socio-demographic characteristics such as age, sex, education level, occupation, and household size. Behavioral and knowledge variables included understanding of ITN benefits, perceived comfort when sleeping under a net, and household net maintenance practices.

Potential barriers to ITN compliance included nighttime heat, overcrowding, and concerns about the smell or chemicals associated with mosquito nets. Environmental and household observations included the presence of stagnant water, housing characteristics such

as screened windows and eaves, and the physical condition, hanging, and positioning of ITNs.

### *2.6 Data Collection Tools and Procedures*

Data were collected using a structured interviewer-administered questionnaire and a direct observation checklist. The questionnaire included items assessing household characteristics, ITN ownership and utilization, knowledge of ITN benefits, attitudes toward ITN use, and perceived barriers to consistent utilization. Attitudinal and behavioral statements were assessed using a five-point Likert scale ranging from strongly disagree to strongly agree.

Trained personnel conducted the household interviews in languages understood by the participants. Before data collection, the research personnel were oriented on the study procedures and use of the questionnaire and observation checklist. Direct household observations were conducted to complement the self-reported information. These observations assessed whether ITNs were available and hanging over sleeping areas and documented their general physical condition, including visible damage or poor maintenance.

### *2.7 Data Quality Management*

Data quality was maintained through the use of standardized data-collection instruments and trained personnel. Interviewers followed the same questionnaire and observation procedures across participating communities. Direct observations were used to provide an objective assessment of selected ITN-related practices and to compare observed conditions with participants' reported behavior.

Completed questionnaires were reviewed for completeness before inclusion in the final dataset. The collected data were subsequently cleaned and organized before statistical analysis.

### *2.8 Data Processing and Analysis*

The collected data were cleaned and organized into a final dataset for analysis. Descriptive statistics were used to summarize the socio-demographic characteristics of the study population and the distribution of ITN ownership, utilization, attitudes, knowledge, and reported barriers to use.

The analysis also examined observed household practices, including the physical condition and hanging of ITNs. A Community Compliance Index (CCI) framework was used to assess community compliance with selected ITN-related malaria prevention practices. The CCI incorporated relevant indicators of reported behavior, knowledge, and observed household practices to provide an overall assessment of community compliance.

Multivariable logistic regression analysis was subsequently used to identify factors associated with consistent ITN utilization. Adjusted odds ratios (AORs), 95% confidence intervals (CIs), and corresponding p-values were reported. Statistical significance was assessed at the 5% level.

### *2.9 Ethical Considerations*

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was granted by the Scientific Coordinating Committee of MRC Gambia and the Gambia Government and MRCG Joint Ethics Committee (Project ID/Ethics Ref: 32973). Approval was also obtained from the National Malaria Control Programme of The Gambia.

Before participation, trained personnel explained the study objectives, procedures, potential benefits, and participants' rights in a language they understood. Written informed consent was obtained from all participants. For participants who were unable to read or write, consent was documented using a thumbprint. Participation was voluntary, and participants were informed that they could withdraw from the study at any time without any consequences to their access to healthcare services.

Confidentiality and privacy were maintained throughout the study. The collected information was securely handled, and no personally identifying information was included in the analysis or reporting of the findings.

## 3. RESULTS

### *3.1 Socio-Demographic Profile of the Community*

A total of 1,000 participants from selected communities in the Upper River Region (URR) of The Gambia were included in the study. Participants were aged 19 to 70 years, with a mean age of approximately 41 years. Both male and female respondents were represented across the participating communities. Most respondents had primary or secondary education, while smaller proportions had no formal education or tertiary

education. Farming was the most frequently reported occupation, alongside teaching, driving, and civil service.

The average household size was approximately six members, although larger households, with up to nine members, were also reported. These characteristics provided representation across different age groups, educational backgrounds, and occupations, within the participating communities (Table 1).

**Table 1.** Socio-demographic characteristics of study participants

| Variable | Frequency (n) | Percentage (%) |
|---|---|---|
| Age | | |
| 18–30 years | 239 | 23.9 |
| 31–45 years | 308 | 30.8 |
| 46–60 years | 275 | 27.5 |
| 61 years and above | 178 | 17.8 |
| Sex | | |
| Male | 512 | 51.2 |
| Female | 488 | 48.8 |
| Education Level | | |
| No formal education | 179 | 17.9 |
| Primary | 199 | 19.9 |
| Secondary | 265 | 26.5 |
| Tertiary | 357 | 35.7 |
| Occupation | | |
| Skilled manual worker | 226 | 22.6 |
| Farmer | 172 | 17.2 |
| Civil servant | 161 | 16.1 |
| Teacher | 84 | 8.4 |
| Driver | 77 | 7.7 |
| Business owner | 75 | 7.5 |
| Housewife | 74 | 7.4 |
| Health worker | 68 | 6.8 |
| Student | 63 | 6.3 |

The study population was predominantly rural, and the average household size was approximately six members, although larger households with up to nine members were commonly observed in districts such as Garawol in Kantora and Foday Kunda in Wulli East. Farming was the most frequently reported occupation among respondents, alongside other occupations such as teaching, driving, and civil service. The diversity in age, sex, education level, household size, and occupation enhanced the representativeness of the study population across the participating communities in the URR.

### *3.2 Sleeping Patterns and ITN Utilization*

The study found exceptionally high levels of insecticide-treated net (ITN) access and utilization among participating households all districts. Most respondents s strongly agreed that their households possessed enough nets for everyone who sleeps in the house. Most respondents strongly agreed that their households had enough nets for everyone who slept in the household (94.2%). Similarly, 78.5% strongly agreed that household members slept under an ITN every night. Protection of vulnerable household members was also highly reported, with 85.1% strongly agreeing that children and pregnant women used ITNs.

However, reported utilization was accompanied by lower levels of net maintenance and observed readiness for use. Approximately 62.4% of respondents agreed or strongly agreed that torn nets were repaired, while 71.8% agreed or strongly agreed that old nets were replaced. Direct observation found that 64.0% of nets were in good physical condition, and 68.3% were observed hanging over sleeping areas (Table 2).

### *3.3 Attitude Toward ITN Utilization*

Participants demonstrated high levels of knowledge regarding the protective benefits of ITNs. The highest mean score was observed for understanding why sleeping under a net helps prevent malaria (mean = 4.62). Participants also reported a high level of agreement with teaching younger household members how to use nets properly (mean = 4.38).

**Table 2.** Sleeping patterns and ITN utilization.

| Variables | Indicators | Frequency (%) |
|---|---|---|
| Household net access | Enough nets for everyone (Strongly agree) | 94.2% |
| Consistent usage | Sleep under a net every night (Strongly agree) | 78.5% |
| Vulnerable protection | Children/pregnant women use nets (Strongly agree) | 85.1% |
| Net repair behavior | Nets are repaired when torn (Agree/strongly agree) | 62.4% |
| Net replacement | Old nets are replaced (Agree/strongly agree) | 71.8% |
| Observed condition | Nets observed to be in good physical condition | 64.0% |
| Hanging compliance | Net observed to be hanging over the bed | 68.3% |

This table highlights the transition from owning a net to actually utilization and maintaining it.

Heat was an important reported barrier to ITN use, with a mean score of 4.12. In contrast, concern about the smell or chemicals in mosquito nets had a relatively low mean score (2.15), while overcrowding as a barrier also received a relatively low mean score (2.45). Perceived comfort while sleeping under a mosquito net was moderate (mean = 3.84) (Table 3).

**Table 3.** Study participants' attitude towards ITN utilization

| Statement | Mean score (1–5 scale) | Level of agreement |
|---|---|---|
| I understand why sleeping under a net helps prevent malaria. | 4.62 | Very high |
| I feel comfortable sleeping under a mosquito net. | 3.84 | Moderate |
| I worry about the smell or chemicals in mosquito nets. | 2.15 | Low |
| Heat makes it uncomfortable to sleep under a mosquito net. | 4.12 | High |
| There are too many people for the available nets. | 2.45 | Low |
| I teach younger family members how to use nets properly. | 4.38 | High |

These results represent the community's general perception of nets as a preventive tool.

### *3.4 District Variations in Compliance and Barriers*

Reported compliance strengths and barriers varied across the participating districts. Basse (Fulladu East) showed high awareness of ITN benefits, while Wulli East had strong reported practices related to teaching younger household members about net use. Wulli West showed strong trust in local health workers. Active participation in community cleaning was reported in Kantora, while Sandu showed strong participation during ITN distribution campaigns. Tumana demonstrated good acceptance of malaria prevention messages, whereas Jimara showed positive attitudes toward protecting children and pregnant women.

The main barriers also varied between districts. These included overcrowded sleeping areas, nighttime heat, concerns about net chemicals or smells, limited household space for proper net hanging, and poor maintenance or delayed replacement of damaged nets (Table 4).

**Table 4.** District variations in compliance and barriers

| District | High Compliance Strengths | Primary Barriers to Use |
|---|---|---|
| Basse (Fulladu East) | High awareness of ITN benefits. | Distance to health facilities for treatment. |
| Wuli East | High rates of teaching younger members' net use. | Overcrowded rooms making hanging difficult. |
| Wuli West | Strong trust in local health workers (Public health officers). | Intense nighttime heat. |
| Kantora | Active participation in community cleaning. | Worries about net chemicals/smells. |
| Sandu | Strong community participation during distribution campaigns. | High nighttime temperatures reducing comfort during sleep. |
| Tumana | Good acceptance of malaria prevention messages. | Limited household space for proper net hanging. |
| Jimara | Positive attitudes toward protecting children and pregnant women. | Poor net maintenance and delayed replacement of damaged nets. |

This table highlights the transition from owning an ITN to consistently using and maintaining it, while showing the district-specific strengths and barriers that may influence community compliance.

### *3.5 Environmental Observations and Behavioral Factors*

Overall, participants demonstrated strong knowledge of malaria prevention and the benefits of ITNs. However, the findings suggest that knowledge alone did not necessarily translate into consistent utilization. Heat was particularly prominent as a reported barrier in Wulli West and Sandu, while limited sleeping space was an important constraint in larger households.

Direct environmental observations identified additional conditions relevant to malaria prevention. Stagnant water, open containers, puddles, and seasonal pools were observed within approximately 50 metres of more than 60% of households visited. Many houses had

unscreened windows or eaves, potentially increasing mosquito entry into sleeping areas. In a small number of households, observers also noted nets being used for purposes other than sleeping protection, such as covering nursery beds or seedlings.

### *3.6 Factors Associated with ITN Utilization*

A multivariable logistic regression analysis was conducted to identify factors associated with ITN utilization after adjusting for other household and individual characteristics. Education, household size, heat discomfort, housing structure, and knowledge of ITN benefits were significantly associated with ITN utilization (Table 5).

Participants with primary or higher education had higher odds of ITN utilization compared with those without formal education (AOR = 2.15; 95% CI: 1.45–3.20; $p = 0.002$). Participants from households with fewer than five members also had higher odds of utilization compared with those from households with five or more members (AOR = 2.48; 95% CI: 1.62–3.80; $p < 0.001$).

Participants who disagreed or were neutral regarding heat discomfort had higher odds of ITN utilization than those who agreed or strongly agreed that heat made sleeping under a net uncomfortable (AOR = 3.12; 95% CI: 1.85–5.24; $p < 0.001$). Having screened windows or eaves was also positively associated with ITN utilization (AOR = 1.95; 95% CI: 1.20–2.85; $p = 0.005$). Adequate knowledge of ITN benefits was similarly associated with higher odds of utilization (AOR = 1.88; 95% CI: 1.15–2.65; $p = 0.012$).

Table 5. Factors associated with ITN utilization

| Variables | Category | AOR | 95% CI | *p*-value |
|---|---|---|---|---|
| Education level | Primary or higher | 2.15 | 1.45-3.20 | 0.002* |
| | None (Ref) | 1.00 | | |
| Household size | Less than 5 members | 2.48 | 1.62-3.80 | <0.001* |
| | 5 or more (Ref) | 1.00 | | |
| Heat discomfort | Disagree/neutral | 3.12 | 1.85-5.24 | <0.001* |
| | Agree/strongly agree (Ref) | 1.00 | | |
| Housing structure | Windows/eaves screened | 1.95 | 1.20-2.85 | 0.005* |
| | Unscreened (Ref) | 1.00 | | |
| Knowledge of benefits | Adequate knowledge | 1.88 | 1.15-2.65 | 0.012* |
| | Poor knowledge (Ref) | 1.00 | | |

*Statistically significant at $p < 0.05$

## 4. DISCUSSION

This community-based study assessed insecticide-treated net (ITN) utilization and factors associated with consistent use among adult household heads in the Upper River Region (URR) of The Gambia. The findings show a clear distinction between household access to ITNs and their consistent use. Although 94.2% of respondents reported having enough nets for household members, only 78.5% strongly agreed that household members slept under a net every night. Direct observation further showed that 68.3% of nets were hanging over sleeping areas at the time of the household visit. These findings suggest that high household access does not necessarily translate into consistent or observable utilization. This distinction is important for malaria control programmes because ownership and distribution indicators alone may overestimate the level of protection achieved at household level.

The reported utilization in this study was higher than the 63.4% ITN utilization reported among children under five years in a recent national analysis of The Gambia. However, the comparison should be interpreted cautiously because the study populations and outcome definitions differed. The national analysis focused specifically on children under five years using nationally representative data, whereas the present study assessed adult household heads and household-level ITN practices in the URR.[5,7] The relatively high utilization observed in the present study may therefore reflect differences in population characteristics, geographical setting, and the role of respondents as household decision-makers. International evidence also demonstrates considerable variation in ITN utilization across malaria-endemic settings. For example, a recent

study in Dembecha District, Ethiopia, reported ITN utilization of 46.5% among pregnant women, while 67.8% of ITNs were observed hanging over beds.[3,15] The difference between reported utilization and observed hanging in that study is comparable to the pattern observed in the present study and supports the value of combining self-reported information with direct household observation.

### *Education and Knowledge as Determinants of ITN Utilization*

Education and knowledge were positively associated with ITN utilization in the present study. Respondents with primary or higher education had more than twice the odds of ITN utilization compared with those without formal education (AOR = 2.15; 95% CI: 1.45–3.20). Adequate knowledge of ITN benefits was also positively associated with utilization (AOR = 1.88; 95% CI: 1.15–2.65). These findings are consistent with evidence from other malaria-endemic settings. A systematic review and meta-analysis among pregnant women in Ethiopia found that literate women were substantially more likely to use ITNs than women without formal education, while knowledge of ITNs was also positively associated with utilization.[16,17] Similarly, evidence from East African countries has demonstrated associations between educational attainment, malaria-related knowledge, and ITN utilization.[17-19]

The consistency of these findings suggests that knowledge remains an important component of household malaria prevention. However, the present study also demonstrates that knowledge alone may not be sufficient to ensure consistent use. Respondents reported high levels of understanding of the protective benefits of ITNs, yet utilization remained lower than household access. This suggests that health education may have limited effects when households face practical barriers to using nets. Behaviour-change interventions should therefore be accompanied by measures that address the physical and environmental conditions in which ITNs are used.

### *Household Size and Sleeping-Space Constraints*

Household size was another important factor associated with ITN utilization. Respondents living in households with fewer than five members had significantly higher odds of ITN utilization than those in larger households (AOR = 2.48; 95% CI: 1.62–3.80). This finding is consistent with evidence from Ethiopia, where women from households with fewer than five members had higher odds of ITN utilization (AOR = 2.53; 95% CI: 1.65–3.87).[20] Evidence from analyses of Demographic and Health Survey data in East Africa has also identified household size as an important factor associated with ITN use.[21,22]

A plausible explanation is that household size affects sleeping arrangements and the practical ability to install sufficient nets. In larger households, several people may sleep in the same room, making it difficult to hang and properly tuck multiple nets. The issue may therefore be less about willingness to use ITNs and more about the physical limitations created by household size and available sleeping space. Previous research has similarly identified household sleeping arrangements and the availability of sleeping spaces as factors influencing ITN utilization.[4,18] In the URR, malaria prevention messages should therefore take household sleeping arrangements into account rather than assuming that possession of an adequate number of nets automatically means that every household member can use one comfortably.

### *Heat Discomfort as a Major Barrier to ITN Use*

Heat discomfort emerged as one of the strongest factors associated with ITN utilization in this study. Respondents who disagreed or were neutral that heat made sleeping under an ITN uncomfortable had more than three times the odds of ITN utilization compared with those who agreed or strongly agreed that heat was a problem (AOR = 3.12; 95% CI: 1.85–5.24). This finding is particularly relevant to The Gambia, where previous experimental studies have demonstrated relationships between housing design, indoor temperature, ventilation, mosquito density, and human comfort.[23,24]

Research conducted in rural Gambian communities has shown that improved ventilation can reduce indoor temperatures while also influencing mosquito density and nighttime comfort.[25,26] These findings provide a plausible environmental explanation for the strong association between heat discomfort and ITN utilization observed in the present study. Importantly, the finding does not indicate that ITNs are ineffective. Rather, it suggests that the physical environment in which ITNs are used can influence people's willingness and ability to use them consistently.

Similar concerns have been reported in other malaria-endemic settings. Heat and discomfort have been identified as barriers to ITN use among women and other household members, particularly in warm

environments.[7-9] The implication for malaria control in the URR is that ITN promotion should not be considered independently of housing conditions. Interventions that improve airflow while maintaining protection against mosquito entry may help reduce the tension between thermal comfort and vector protection.

### *Housing Structure and ITN Utilization*

Housing characteristics were also associated with ITN use. Respondents living in houses with screened windows or eaves had higher odds of ITN utilization (AOR = 1.95; 95% CI: 1.20–2.85). Because this study was cross-sectional, the association should not be interpreted as evidence that screened housing directly causes greater ITN utilization. Nevertheless, the finding is consistent with evidence that housing characteristics influence mosquito entry, indoor temperature, and malaria prevention.

Research from rural The Gambia has shown that house screening and improved ventilation can reduce mosquito entry while improving indoor thermal conditions.[11,25,27] A household-randomized trial conducted in the Upper River Region also found that improvements to housing, including screening of doors and windows and modifications to roofs and eaves, can provide additional protection against malaria when implemented alongside existing vector-control measures.[28] More recent experimental evidence has further demonstrated that screened windows can reduce entry of Anopheles gambiae while improved ventilation can reduce nighttime indoor temperatures.[29,30]

The association observed in this study may therefore reflect an interaction between housing quality, thermal comfort, mosquito exposure, and malaria-prevention practices. Households with better ventilation and screening may find ITN use more comfortable, may experience lower mosquito exposure, or may already have stronger malaria-prevention practices. Longitudinal or intervention studies would be needed to determine whether improvements in housing directly increase ITN utilization.

### *The Gap Between Reported Behaviour and Observed Practice*

An important finding of this study was the difference between reported household behaviour and direct observation. Although 78.5% of respondents reported consistent nightly ITN use, only 68.3% of nets were observed hanging over sleeping areas. This difference should not automatically be interpreted as evidence of inaccurate reporting because the observations were conducted during household visits and may not have coincided with nighttime sleeping arrangements. Nets may have been temporarily untied, folded, or stored during the day despite being used at night.

Nevertheless, the discrepancy demonstrates why reliance on self-reported ITN utilization alone may provide an incomplete picture of household compliance. A recent study in Ethiopia similarly reported differences between ITN utilization and the proportion of nets observed hanging over sleeping spaces.[7,8] Combining interviews with direct observation can therefore provide a more comprehensive assessment of household practices and identify practical barriers that may otherwise remain hidden.

This finding is particularly relevant to community-based malaria programmes. High reported compliance may indicate that households understand the recommended behaviour, whereas lower observed readiness may identify problems related to net hanging, household space, maintenance, or daily routines. Monitoring these dimensions separately may therefore provide a more useful assessment of programme performance than ownership or self-reported utilization alone.

### *Strengths and Limitations*

A major strength of this study was combination of interviewer-administered household data with direct environmental observation. This approach allowed reported ITN-related behaviours to be considered alongside the physical condition and positioning of nets. The inclusion of 1,000 households across 50 communities and seven districts also provided broad geographical coverage of the URR.

Several limitations should be considered. First, the cross-sectional design limits causal interpretation. Although education, household size, heat discomfort, housing structure, and knowledge were associated with ITN utilization, these factors cannot be established as causal determinants from the present study. Second, ITN utilization was partly based on self-reported behaviour and may therefore have been affected by recall or social-desirability bias. Third, direct observations were conducted during household visits and may not accurately represent nighttime net use. Fourth, the study was conducted in the URR and may not be generalizable to all regions of The Gambia because malaria

transmission, housing conditions, climate, and household practices vary geographically. Finally, seasonal variation in ITN use could not be fully assessed because of the cross-sectional design. Utilization may differ between the hot season and the rainy malaria-transmission period.

***Overall Interpretation***

Taken together, the findings indicate that the principal challenge in the URR is not simply whether households have ITNs, but whether household members can use them consistently under their actual living conditions. Education and knowledge were positively associated with utilization, but environmental discomfort, household size, and housing characteristics were also important. The findings therefore support an approach to malaria prevention in which ITN distribution is accompanied by practical household-level support, particularly regarding correct net hanging and maintenance, management of heat and ventilation, and adaptation of malaria-prevention messages to different household circumstances.

The main contribution of this study is the identification of a compliance gap between household access, self-reported utilization, and observed readiness for use. By combining household survey responses with direct observation, the study provides a more detailed picture of the practical barriers affecting ITN use in the URR. This evidence can help inform community-based malaria interventions that move beyond net distribution to address the household and environmental conditions that influence sustained utilization.

# 5. CONCLUSION

This study demonstrates that while insecticide-treated net (ITN) ownership and access is high across the Upper River Region (URR) of The Gambia, consistent nightly utilization remains lower than household access, indicating a gap between ownership and actual use. actual nightly utilization is shaped by a complex interplay of environmental discomfort and household structural limitations. Higher education, adequate knowledge of malaria prevention, smaller household size, and screened windows or eaves were positively associated with ITN utilization, while nighttime heat was a major barrier to consistent use. The difference between self-reported nightly use and observed nets hanging over sleeping areas further highlights the importance of considering both reported behaviour and actual household practices. These findings suggest that malaria prevention programmes should complement ITN distribution with practical community-based interventions addressing correct net hanging, maintenance, household sleeping arrangements, heat and ventilation. Future research should assess these factors across different seasons and evaluate interventions that can improve sustained ITN use. Moving toward malaria pre-elimination in The Gambia will require not only ensuring that households have ITNs, but also ensuring that they can use them consistently and correctly within their everyday living conditions.

## Ethical Approval

Ethical approval was granted by the Scientific Coordinating Committee of MRC Gambia and the Gambia Government and MRCG Joint Ethics Committee (Project ID/Ethics Ref: 32973).

## Acknowledgement

The authors sincerely thank the Director of Health Services The Gambia, National Malaria Control Programme (NMCP), The Gambia, particularly the Programme Manager, Deputy Programme Manager, senior staff, the IT department, and the drivers for their guidance and support. We will like to send our sincere gratitude to CRS The Gambia and PATH Gambia for their technical input during the research. We also appreciate the Regional and District Health Directorates, field research assistants, data collectors, supervisors, drivers, community leaders, and all study participants in the Upper River Region for their valuable cooperation and contribution to this study.

## Competing Interests

All the authors declare that there are no conflicts of interest.

## Funding Information

No funds were received for this study.

## Underlying Data

Derived data supporting the findings of this study are available from the corresponding author on request.

# REFERENCES

1. World Health Organization. World malaria report 2024.

Geneva: World Health Organization; 2024. Available from: https://www.who.int/publications/i/item/9789240104440 (Accessed on 15 May 2026)
2. Haileselassie W, Adam R, Habtemichael M, David RE, Solomon N, Workineh S, Haider J, Belachew A, Deressa W, Yan G, Kassaw NA, Parker DM. Socio-demographic and economic inequity in the use of insecticide-treated bed nets during pregnancy: a survey-based case study of four sub-Saharan African countries with a high burden of malaria. Archives of Public Health. 2023;81(1):64. http://dx.doi.org/10.1186/s13690-023-01075-6
3. Firdaus MH, Wan Puteh SE, Sutan R, Abdul Manaf MR. Effectiveness of family health education in malaria elimination programmes: a scoping review. Malaria Journal. 2025;24(1):144. http://dx.doi.org/10.1186/s12936-025-05371-0
4. Terefe B, Habtie A, Chekole B. Insecticide-treated net utilization and associated factors among pregnant women in East Africa: evidence from the recent national demographic and health surveys, 2011–2022. Malaria Journal. 2023;22(1):349. http://dx.doi.org/10.1186/s12936-023-04779-w
5. Kassie GA, Adella GA, Gebrekidan AY, Gebeyehu NA, Gesese MM, Abebe EC, Mengstie MA, Seid MA, Tegegne KD, Feleke SF, Dejenie TA, Bantie B, Moges N, Kebede YS, Zemene MA, Dessie AM, Anley DT, Asgedom YS. Insecticide-treated bed net utilization and associated factors among pregnant women in Ethiopia: a systematic review and meta-analysis. Malaria Journal. 2023;22(1):223. http://dx.doi.org/10.1186/s12936-023-04655-7
6. Teym A, Berihun G, Shiferaw MY, Abawa ED, Alemu Y, Assaye BT, Abebe RB, Zeleke TK. Insecticide-treated bed net utilization and its determinants among pregnant women in Dembecha District, Northwest Ethiopia. Tropical Medicine and Health. 2025;53(1):129. http://dx.doi.org/10.1186/s41182-025-00762-0
7. Kebede W, Tolcha A, Soboksa NE, Negassa B, Kanno GG, Aregu MB. Utilization of Insecticide-Treated Nets in Households for Under-5 Children and Associated Factors in East Mesekan District, Gurage Zone, Southern Ethiopia. Environmental Health Insights. 2023;17. http://dx.doi.org/10.1177/11786302231164287
8. Mekuria M, Binegde DN, Derega J, Teferi Bala E, Tesfa B, Deriba BS. Insecticide-Treated Bed Net Utilization and Associated Factors Among Households in Ilu Galan District, Oromia Region, Ethiopia. Environmental Health Insights. 2022;16. http://dx.doi.org/10.1177/11786302221078122
9. Negasa K, Huluka TK, Yebassa MA, Waqkene T. Utilization of long-lasting insecticide-treated net and its associated factors among pregnant women in Dawo district, Southwest Shoa Zone, Oromia, Ethiopia, 2023. Frontiers in Public Health. 2024;11: 1261254. http://dx.doi.org/10.3389/fpubh.2023.1261254
10. Solanke BL, Soladoye DA, Birsirka IA, Abdurraheem A, Salau OR. Utilization of insecticide-treated nets and associated factors among childbearing women in Northern Nigeria. Malaria Journal. 2023;22(1):184. http://dx.doi.org/10.1186/s12936-023-04620-4
11. Jatta E, Carrasco-Tenezaca M, Jawara M, Bradley J, Ceesay S, D'Alessandro U, Jeffries D, Kandeh B, Lee DS-H, Pinder M, Wilson AL, Knudsen J, Lindsay SW. Impact of increased ventilation on indoor temperature and malaria mosquito density: an experimental study in The Gambia. Journal of the Royal Society Interface. 2021;18(178):20201030. http://dx.doi.org/10.1098/rsif.2020.1030
12. Jassey B, Yudhastuti R, Diyanah KC, Hourunisa H, Ridha MR, Indrayani R, Musfirah M, Sejati EN, Manjang B. Risk Factors of Malaria Transmission Dynamics Among Sand Mining Workers in the Kombos West Coast Region, The Gambia. Health Dynamics. 2024;1(4):117–129. http://dx.doi.org/10.33846/hd10403
13. Gambia Demographic and Health Survey. 2019-20 Demographic and Health Survey Summary Report The Gambia. The Gambia: Gambia Demographic and Health Survey; 2019. Available from: https://www.dhsprogram.com/ (Accessed on 15 May 2026)
14. World Health Organization. Malaria 2024 Gambia country profile. Geneva: World Health Organization; 2024. Available from: https://www.who.int/publications/m/item/malaria-2024-gmb-country-profile (Accessed on 15 May 2026)
15. Angesom T, Gebreyesus H, Gebremariam B. Long-Lasting Insecticidal Net Utilization and Associated Factors Among Pregnant Women in Asgede Tsimbla District, Northern Ethiopia, 2017. Environmental Health Insights. 2020;14:1-6. http://dx.doi.org/10.1177/1178630220919393
16. Elmosaad YM, Elhadi M, Khan A, Malik EM, Mahmud I. Communication for behavioural impact in enhancing utilization of insecticide-treated bed nets among mothers of under-five children in rural North Sudan: an experimental study. Malaria Journal. 2016;15(1):509. http://dx.doi.org/10.1186/s12936-016-1551-8
17. Balami AD, Said SM, Zulkefli NAM, Bachok N, Audu B. Effects of a health educational intervention on malaria knowledge, motivation, and behavioural skills: a randomized controlled trial. Malaria Journal. 2019;18(1):.41. http://dx.doi.org/10.1186/s12936-019-2676-3
18. Nkoka O, Chuang T-W, Chuang K-Y, Chen Y-H. Factors associated with insecticide-treated net usage among women of childbearing age in Malawi: a multilevel analysis. Malaria Journal. 2018;17(1):372. http://dx.doi.org/10.1186/s12936-018-2522-z
19. Fuge TG, Ayanto SY, Gurmamo FL. Assessment of knowledge, attitude and practice about malaria and ITNs utilization among pregnant women in Shashogo District, Southern Ethiopia. Malaria Journal. 2015;14(1):235. http://dx.doi.org/10.1186/s12936-015-0755-7
20. Elnour Z, Grethe H, Siddig K, Munga S. Malaria control and elimination in Kenya: economy-wide benefits and regional disparities. Malaria Journal. 2023;22(1):117. http://dx.doi.org/10.1186/s12936-023-04505-6
21. Ruyange MM, Condo J, Karema C, Binagwaho A, Rukundo A, Muyirukazi Y. Factors associated with the non-use of insecticide-treated nets in Rwandan children.

Malaria Journal. 2016;15(1):355. http://dx.doi.org/10.1186/s12936-016-1403-6

22. Ogunlesi TA. Maternal Socio-Demographic Factors Influencing the Initiation and Exclusivity of Breastfeeding in a Nigerian Semi-Urban Setting. Maternal and Child Health Journal. 2009;14(3):459–465. http://dx.doi.org/10.1007/s10995-008-0440-3
23. Konlan KD, Kossi Vivor N, Gegefe I, Hayford L. Factors associated with ownership and utilization of insecticide treated nets among children under five years in sub-Saharan Africa. BMC Public Health. 2022;22(1):940. http://dx.doi.org/10.1186/s12889-022-13347-x
24. Paaijmans KP, Huijben S. Taking the 'I' out of LLINs: using insecticides in vector control tools other than long-lasting nets to fight malaria. Malaria Journal. 2020;19(1):73. http://dx.doi.org/10.1186/s12936-020-3151-x
25. Carrasco-Tenezaca MJ. Malaria vector ecology and housing in The Gambia [Doctoral Thesis]. Durham, United Kingdom: Durham University; 2023. Available: https://etheses.durham.ac.uk/id/eprint/14812/ (Accessed on 15 May 2026)
26. Majambere S, Pinder M, Fillinger U, Ameh D, Conway DJ, Green C, Jeffries D, Jawara M, Milligan PJ, Hutchinson R, Lindsay SW. Is Mosquito Larval Source Management Appropriate for Reducing Malaria in Areas of Extensive Flooding in The Gambia? A Cross-over Intervention Trial. The American Society of Tropical Medicine and Hygiene. 2010;82(2):176–184. http://dx.doi.org/10.4269/ajtmh.2010.09-0373
27. Murta FLG, Marques LLG, Santos APC, Batista TSB, Mendes MO, Silva ED, Neto AVS, Fabiano M, Rodovalho SR, Monteiro WM, Lacerda MVG. Perceptions about malaria among Brazilian gold miners in an Amazonian border area: perspectives for malaria elimination strategies. Malaria Journal. 2021;20(1):286. http://dx.doi.org/10.1186/s12936-021-03820-0
28. Hakizimana E, Ingabire CM, Rulisa A, Kateera F, van den Borne B, Muvunyi CM, van Vugt M, Mutesa L, Bron GM, Takken W, Koenraadt CJM. Community-Based Control of Malaria Vectors Using Bacillus thuringiensis var. Israelensis (Bti) in Rwanda. International Journal of Environmental Research and Public Health. 2022;19(11):6699. http://dx.doi.org/10.3390/ijerph19116699
29. Kristan M, Abeku TA, Lines J. Effect of environmental variables and kdr resistance genotype on survival probability and infection rates in Anopheles gambiae (s.s.). Parasites & Vectors. 2018;11(1):560. http://dx.doi.org/10.1186/s13071-018-3150-8
30. Guerra CA, Gikandi PW, Tatem AJ, Noor AM, Smith DL, Hay SI, Snow RW. The Limits and Intensity of Plasmodium falciparum Transmission: Implications for Malaria Control and Elimination Worldwide. PLoS Medicine. 2008;5(2):e38. http://dx.doi.org/10.1371/journal.pmed.0050038