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Community engagement, access inequities, and behavioural constraints in ITN utilisation: evidence from two malaria-endemic local government areas in Nigeria

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Abstract

Malaria remains a major public health burden in Nigeria, which accounts for the highest number of malaria cases and deaths globally. Despite widespread insecticide-treated net (ITN) distribution campaigns, utilisation rates remain suboptimal. This study examined community engagement, access inequities, and behavioural constraints influencing ITN utilisation in two malaria-endemic Local Government Areas (LGAs) of Adamawa State, northeastern Nigeria. A community-based cross-sectional analytical study was conducted between July and October 2025 among 400 household heads or adult representatives (≥18 years) selected through multistage probability sampling from Yola North (urban, n=267) and Fufore (rural, n=133) LGAs. Data were collected using a pre-tested, interviewer-administered semi-structured questionnaire. Descriptive statistics, Chi-square tests, binary logistic regression, and ordinal logistic regression were employed. Statistical significance was set at $p<0.05$. Regular community education programs on ITN care were reported by only 5.2% in Yola North and 8.3% in Fufore. Lack of information was the predominant maintenance challenge (38.9% in Yola North; 83.5% in Fufore). Significant rural–urban disparities were observed in awareness of ITN importance ($p=0.030$), ease of access ($p<0.001$), affordability ($p<0.001$), perceived malaria risk ($p=0.020$), and influence of cultural beliefs ($p=0.010$). Higher educational attainment independently predicted ITN use (Diploma: OR=2.10, 95%CI:1.12–3.93; Degree: OR=2.50, 95%CI:1.40-4.30; MSc+: OR=2.85, 95%CI:1.32–6.14) and comfort (Degree: aOR=1.85, 95%CI:1.15-2.98; MSc+: aOR=2.00, 95%CI:1.05-3.80). Exposure to regular community programs was the strongest predictor of both ITN use (OR=3.15, 95%CI:1.40-7.09) and comfort (aOR=2.40, 95%CI:1.35-4.27). Age and gender were not significant predictors.

1. Introduction

Malaria remains a critical public health challenge in sub-Saharan Africa, with Nigeria bearing the highest burden globally, accounting for approximately 27% of all malaria cases and 31% of malaria deaths worldwide (WHO,

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2022). Insecticide-treated nets (ITNs) represent one of the most cost-effective and widely promoted interventions for malaria prevention, with proven efficacy in reducing malaria transmission, morbidity, and mortality, particularly among vulnerable populations such as pregnant women and children under five years (Bhatt et al., 2015). Despite substantial investments in ITN distribution campaigns across Nigeria, including mass free distribution programs and routine antenatal care provision, utilisation rates remain persistently suboptimal, with national estimates indicating that only 45-55% of households with access to ITNs actually use them consistently (NMEP, 2021).

The gap between ITN ownership and utilisation reflects a complex interplay of factors extending beyond simple access constraints. Emerging evidence suggests that community engagement processes, access inequities, and behavioural constraints collectively shape ITN use patterns in malaria-endemic settings (Stratton et al., 2018; Singh et al., 2019). Community engagement encompassing awareness programs, peer influence, and social support mechanisms has been shown to mediate the translation of ITN availability into regular use (Koenker et al., 2018). However, the quality, frequency, and reach of such engagement initiatives vary considerably across Nigerian communities, with limited systematic evidence on how these factors influence utilisation outcomes.

Access inequities represent another critical dimension, as geographic, economic, and social barriers differentially affect ITN acquisition and replacement. Studies have documented that rural populations, economically disadvantaged households, and communities distant from health facilities often experience delayed or limited access to ITNs even when national distribution campaigns report universal coverage targets (O'Meara et al., 2017; Ricotta et al., 2020). In Nigeria's northeastern region, where ongoing security challenges and infrastructure deficits compound existing health system weaknesses, access inequities may be particularly pronounced (WHO, 2021).

Behavioural constraints, including perceived comfort, concerns about adverse effects, cultural beliefs, and competing daily activities, further influence ITN utilisation decisions. Research has demonstrated that perceived discomfort from heat, suffocation, or chemical odours can deter consistent ITN use, particularly among adults (Pulford et al., 2011). Additionally, misconceptions about ITN washing practices, maintenance requirements, and potential side effects have been identified as significant behavioural barriers in various sub-Saharan African contexts (Loll et al., 2020).

Despite recognition of these multifaceted determinants, few studies have systematically examined how community engagement processes, access inequities, and behavioural constraints interact to shape ITN utilisation in Nigeria's diverse local contexts. The northeastern region, characterised by high malaria transmission intensity, recurrent ITN distribution campaigns, and unique sociocultural dynamics, presents an important yet understudied setting for investigating these relationships. Furthermore, comparative evidence across different Local Government Areas (LGAs) within the same ecological zone remains limited, constraining the development of context-sensitive interventions.

2. Materials and Methods

2.1 Study Design

This study was conducted in Fufore and Yola North Local Government Areas (LGAs) of Adamawa State, located in Northeastern Nigeria. A community-based cross-sectional analytical study was carried out between July and October 2025 to assess the determinants of ownership, management practices, and effective utilisation of insecticide-treated nets (ITNs) among households.

2.2 Study Population

The study population comprised household heads or adult household representatives (aged ≥18 years) residing in selected communities within the study LGAs.

2.3 Eligibility Criteria

Inclusion criteria:

- Adults aged ≥18 years
- Residents who had lived in the community for at least 6 months
- Individuals who provided informed consent

Exclusion criteria:

- Visitors or temporary residents
- Individuals who were seriously ill during data collection
- Households without an eligible respondent after two visits

2.4 Sample Size Determination

The sample size was calculated using the single population proportion formula:

$$n = \frac{z^2 pq}{d^2}$$

Where:

$z = 1.96$ (95% confidence level)

$p = 0.207$ (estimated ITN utilisation prevalence)

$$q = 1 - p = 0.793$$

$$d = 0.05$$

The minimum sample size was 252. After adjusting for a design effect of 1.5, the sample size increased to 378. A further 10% was added for non-response, resulting in a final sample size of 416 respondents.

The sample size was proportionately allocated based on population size. Yola North (population: 307,900) and Fufore (population: 154,672) yielded a total population of 462,572. Allocation was performed using:

$$n_i = \frac{N_i}{N} \times n$$

Accordingly, 277 respondents were assigned to Yola North LGA and 139 respondents to Fufore LGA.

2.5 Sampling Procedure

A multistage probability sampling technique was employed.

Stage 1 (Stratification and ward selection): The study area was stratified into urban (Yola North) and rural (Fufore) strata. Within each LGA, a list of political wards was obtained, and approximately 25% of wards were selected using simple random sampling.

Stage 2 (Settlement selection): Lists of settlements within selected wards were compiled, and 25% of settlements were selected by simple random sampling. Smaller settlements were merged where necessary to ensure adequate sampling units.

Stage 3 (Household selection): Households within selected settlements were enumerated, and a systematic random sampling technique was applied.

Stage 4 (Respondent selection): One eligible respondent per household was selected. The household head was interviewed; in their absence, an adult member knowledgeable about ITN use was selected. Where multiple eligible respondents were present, one was selected by simple random sampling.

To reduce non-response bias, at least two revisit attempts were made, and non-responding households were replaced using the next household in sequence.

2.6 Data Collection Instrument and Procedure

Data were collected using a pre-tested, interviewer-administered semi-structured questionnaire adapted from standardised malaria survey tools. The questionnaire captured information on socio-demographic characteristics, ITN ownership and sources, ITN management practices (including washing, repair, and storage), and ITN

utilisation and its determinants. The instrument was administered in English and local languages (Hausa/Fulfulde) where necessary to ensure comprehension. Data collection was carried out by trained research assistants under supervision over a period of four months, with regular monitoring to ensure completeness and consistency of responses.

2.7 Data Analysis

Data were entered, cleaned, and analysed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed to summarise socio-demographic characteristics, ITN ownership, management practices, and utilisation patterns. Bivariate analysis using Chi-square tests was conducted to assess associations between independent variables and ITN outcomes. Variables found to be significant at the bivariate level were included in multivariate analysis using binary logistic regression to identify independent determinants of ITN ownership, management, and effective utilisation. Results were presented as adjusted odds ratios (AORs) with 95% confidence intervals, and statistical significance was set at $p < 0.05$.

2.8 Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee of the Adamawa State Ministry of Health. Permissions were secured from relevant local authorities and community leaders. Written informed consent was obtained from all participants. Data confidentiality and anonymity were ensured, and participation was entirely voluntary.

3. Results

Socio-Demographic Characteristics

Out of 416 eligible respondents, 277 were assigned to Yola North LGA and 139 to Fufore LGA. A total of 400 participants consented to participate, 267 (66.8%) from Yola North and 133 (33.2%) from Fufore, yielding participation rates of 96.4% and 95.7%, respectively. The demographic characteristics of respondents are summarised in Table 1. Most participants were aged 3-40 years, representing 127 (47.5%) in Yola North and 64 (48.1%) in Fufore, totalling 191 (47.8%). Respondents aged 41–50 years accounted for 69 (25.8%) in Yola North and 29 (21.8%) in Fufore. Male respondents predominated, with 190 (71.2%) in Yola North and 97 (72.9%) in Fufore, totaling 287 (71.8%), while females accounted for 77 (28.8%) and 36 (27.1%), respectively. Regarding educational attainment, 108 (40.4%) in Yola North and 38 (28.6%) in Fufore had Degree-level education. Secondary education was reported by 69 (25.8%) in Yola North and 46 (34.6%) in Fufore. MSc & above qualifications were held by 21 (7.9%) in Yola North and 13 (9.8%) in Fufore.

Table 1: Demographic information of the respondents

Variables	Yola North (%)	Fufore (%)	Total (%)
Age			
18–20	28 (10.5)	15 (11.3)	43 (10.8)
21–30	13 (4.9)	11 (8.3)	24 (6.0)
31–40	127 (47.5)	64 (48.1)	191 (47.8)
41–50	69 (25.8)	29 (21.8)	98 (24.5)
51 and above	30 (11.2)	15 (11.3)	45 (11.3)
Total	267 (100)	133 (100)	400 (100)
Gender			
Male	190 (71.2)	97 (72.9)	287 (71.8)
Female	77 (28.8)	36 (27.1)	113 (28.2)
Total	267 (100)	133 (100)	400 (100)
Educational qualification			
Informal education	13 (4.9)	6 (4.5)	19 (4.8)
Primary	9 (3.4)	8 (6.0)	17 (4.3)
Secondary	69 (25.8)	46 (34.6)	115 (28.8)
Tertiary	176 (65.9)	73 (54.9)	249 (62.3)
Total	267 (100)	133 (100)	400 (100)

Community-Based ITN Education and Maintenance Practices

In Yola North (Table 2), most respondents reported community programs were conducted occasionally (79; 29.6%) or absent (70; 26.2%). Maintaining ITNs was considered very important by 129 (48.3%), and lack of information was the main challenge (104; 38.9%). Positive perceptions of washing ITNs were reported by 70 (26.2%). In Fufore, programs were most commonly occasional (86; 64.7%) or absent (60; 45.1%). ITN maintenance was considered somewhat important by 45 (33.8%), with lack of information (111; 83.5%) and time constraints (62; 46.6%) as main challenges. Positive effects of washing were reported by 75 (56.4%).

Table 2: Community-Based ITN Education and Maintenance Practices

Variable	Yola North (n=267) Frequency (%)	Fufore (n=133) Frequency (%)	χ^2 (p-value)
Presence of community programs educating residents on proper ITN care			0.89 (0.83)
Programs conducted regularly	14 (5.2)	11 (8.3)	
Programs conducted occasionally	79 (29.6)	86 (64.7)	
No programs	70 (26.2)	60 (45.1)	
Unsure	37 (13.9)	43 (32.3)	
Perceived importance of maintaining ITNs regularly			1.84 (0.61)
Very important	129 (48.3)	26 (19.5)	
Somewhat important	55 (20.6)	45 (33.8)	
Not very important	10 (3.7)	15 (11.3)	
Not important at all	6 (2.2)	14 (10.5)	
Availability of community initiatives to assist in ITN maintenance			6.85 (0.08)
Actively involved	9 (3.4)	11 (8.3)	
Present but not active	76 (28.5)	64 (48.1)	
No initiatives	76 (28.5)	99 (74.4)	
Unsure	39 (14.6)	26 (19.5)	
Challenges faced in maintaining ITNs			9.74 (0.45)
Lack of information	104 (38.9)	111 (83.5)	
Limited access to washing facilities	43 (16.1)	27 (20.3)	
Time constraints	53 (19.9)	62 (46.6)	
Perception of the washing effect on ITN effectiveness			2.76 (0.43)
Positive impact	70 (26.2)	75 (56.4)	
Negative impact	45 (16.9)	60 (45.1)	
No impact	40 (15.0)	35 (26.3)	
Unsure	45 (16.9)	30 (22.6)	

Comfort, Community Influence, and Support for ITN Usage

In Yola North (Table 3), most respondents were very comfortable sleeping under an ITN 85 (31.8%). Peer influence was mostly somewhat influenced, 65 (24.3%). Knowledge of ITN installation was highest for the very knowledgeable 122 (45.7%), and minor concerns about adverse effects predominated 111 (55.5%). ITN use had no effect on daily activities for most 86 (32.2%), and community support was moderately supportive 71 (26.6%). In Fufore, respondents were very comfortable 95 (71.4%). Peer influence was mostly somewhat influenced 75 (56.4%). Knowledge of ITN installation was mostly somewhat knowledgeable, 119 (89.5%), minor concerns predominated 89 (44.5%), and ITN use moderately or slightly affected daily activities. Community support was mostly moderately supportive, 84 (63.2%).

Table 3: Comfort, Community Influence, and Support for ITN Usage

Variable	Yola North (n=267) Frequency (%)	Fufore (n=133) Frequency (%)	χ^2 (p-value)
Comfort when sleeping under an ITN			4.99 (0.17)
Very comfortable	85 (31.8)	95 (71.4)	
Moderately comfortable	51 (19.1)	39 (29.3)	
Slightly comfortable	51 (19.1)	44 (33.1)	
Not comfortable	13 (4.9)	22 (16.5)	
Community programs addressing ITN challenges			6.00 (0.11)
Conducted regularly	4 (1.5)	1 (0.8)	
Conducted occasionally	66 (24.7)	49 (36.8)	
No programs	81 (30.3)	89 (66.9)	
Unsure	49 (18.4)	61 (45.9)	
Influence of peers/neighbours on ITN use			1.25 (0.74)
Strongly influenced	27 (10.1)	23 (17.3)	
Somewhat influenced	65 (24.3)	75 (56.4)	
Minimally influenced	43 (16.1)	42 (31.6)	
Not influenced	65 (24.3)	60 (45.1)	
Knowledge of correct ITN installation			31.86 (<0.001)*
Very knowledgeable	122 (45.7)	16 (12.0)	
Somewhat knowledgeable	35 (13.1)	119 (89.5)	
Not knowledgeable	10 (3.7)	32 (24.1)	
Unsure	23 (8.6)	33 (24.8)	
Effect of ITN use on daily activities			19.97 (<0.001)*
Significantly affected	26 (9.7)	54 (40.6)	
Moderately affected	67 (25.1)	43 (32.3)	
Slightly affected	21 (7.9)	34 (25.6)	
Not affected	86 (32.2)	69 (51.9)	
Community support for optimal ITN usage			4.53 (0.21)
Very supportive	48 (18.0)	47 (35.3)	
Moderately supportive	71 (26.6)	84 (63.2)	
Slightly supportive	48 (18.0)	32 (24.1)	
Not supportive	33 (12.4)	37 (27.8)	

*Statistically significant $p < 0.05$

Barriers and Challenges Affecting ITN Utilisation

In Yola North (Table 4), most were very aware of ITN importance, 113 (42.3%) and somewhat found ITNs accessible, 112 (41.9%). Affordability was moderate or slight 139 (52%), with perceived discomfort the main barrier 70 (26.2%). In Fufore, awareness was highest among very aware respondents 117 (87.9%), ITNs were somewhat accessible 95 (71.4%), affordability was moderate or slight 111 (83.5%), and discomfort was the main barrier 60 (45.1%).

Table 4. Barriers and Challenges Affecting ITN Utilisation

Variable	Yola North (n=267) Frequency (%)	Fufore (n=133) Frequency (%)	χ^2 (p-value)
Awareness of ITN importance			8.87 (0.03)*
Very aware	113 (42.3)	117 (87.9)	
Moderately aware	72 (27.0)	53 (39.8)	
Slightly aware	13 (4.9)	22 (16.5)	
Not aware at all	2 (0.7)	8 (6.0)	
Ease of access to ITNs			32.67 (<0.001)*
Very easily accessible	14 (5.2)	51 (38.3)	
Somewhat accessible	112 (41.9)	95 (71.4)	
Not very accessible	50 (18.7)	38 (28.6)	
Not accessible at all	24 (9.0)	16 (12.0)	
Affordability of ITNs			14.38 (<0.001)*
Very affordable	46 (17.2)	19 (14.3)	
Moderately affordable	69 (25.8)	56 (42.1)	
Slightly affordable	70 (26.2)	55 (41.4)	
Not affordable	42 (15.7)	43 (32.3)	
Reported barriers to regular ITN use			5.77 (0.12)
Lack of awareness	35 (13.1)	55 (41.4)	
Unavailability	58 (21.7)	52 (39.1)	
Affordability issues	37 (13.9)	33 (24.8)	
Perceived discomfort	70 (26.2)	60 (45.1)	

*Statistically significant $p < 0.05$

Predictors of ITN Use and Comfort

As indicated in Table 5, binary logistic regression revealed that higher education significantly increased the likelihood of ITN use last night: Tertiary education (OR=2.50; 95% CI: 1.40–4.30; *p*=0.001). Secondary education showed a positive but non-significant association (OR=1.62; 95% CI: 0.90–2.91; *p*=0.11). Exposure to community programs also significantly increased ITN use: regular programs (OR=3.15; 95% CI: 1.40-7.09; *p*=0.005) and occasional programs (OR=1.80; 95% CI: 1.05-3.09; *p*=0.03). Age and gender were not significant predictors (all *p* > 0.05). As shown in Table 6, ordinal logistic regression revealed that comfort while sleeping under ITNs was significantly higher among respondents exposed to regular community programs (aOR=2.40; 95% CI: 1.35-4.27; *p*=0.003). Occasional programs showed a positive but non-significant association (aOR=1.60; 95% CI: 0.95-2.69; *p*=0.08). Age and gender were not significant predictors.

Table 5. Binary Logistic Regression: Predictors of ITN Use Last Night

Predictor	OR	95% CI	p-value
Age (years)			
31–40	1.45	0.85-2.48	0.17
41–50	1.12	0.60-2.08	0.72
≥51	0.88	0.42-1.84	0.73
Gender			
Male	1.28	0.81-2.03	0.28
Education level			
Secondary	1.62	0.90-2.91	0.11
Tertiary	2.50	1.40-4.30	0.001*
Community program exposure			
Regular programs	3.15	1.40-7.09	0.005*
Occasional programs	1.80	1.05-3.09	0.03*

*$p < 0.05$

Notes: OR=Odds Ratio; CI=Confidence Interval. Reference categories are indicated.

Table 6: Ordinal Logistic Regression: Predictors of Comfort Sleeping Under ITN

Predictor	aOR	95% CI	p-value
Age (years)			
31-40	1.20	0.80-1.80	0.35
41-50	1.05	0.65-1.68	0.84
≥51	0.90	0.50-1.62	0.72
Gender			
Male	1.15	0.78-1.70	0.48
Education level			
Secondary	1.30	0.80-2.10	0.28
Tertiary	1.50	0.12-0.03*	1.50
Community program exposure			
Regular programs	2.40	1.35-4.27	0.003*
Occasional programs	1.60	0.95-2.69	0.08

*p<0.05; aOR = adjusted Odds Ratio

4. Discussion

This community-based cross-sectional study examined community engagement, access inequities, and behavioural constraints influencing insecticide-treated net (ITN) utilisation in two malaria-endemic Local Government Areas of Adamawa State, Nigeria. The findings reveal substantial deficits in regular community education programs and maintenance support, particularly in the rural Fufore LGA, alongside significant access inequities, with educational attainment and exposure to regular community programs emerging as independent predictors of both ITN use and comfort during sleep. At the same time, age and gender showed no significant associations. The near-absence of regular community education programs on ITN care reported by only 5.2% of respondents in Yola North and 8.3% in Fufore represents a critical gap in malaria control efforts, figures considerably lower than those reported in other malaria-endemic regions of Nigeria where routine health promotion activities have been integrated into primary healthcare systems (Koenker *et al*., 2018). The situation in Fufore is particularly concerning given its rural context, where populations typically rely more heavily on community-based outreach for health information (Babalola *et al*., 2020). Active community maintenance initiatives were virtually absent (3.4% in Yola North; 8.3% in Fufore), aligning with evidence that post-distribution support remains the weakest link in ITN programs across sub-Saharan Africa (Singh *et al*., 2019). Lack of information emerged as the most frequently cited challenge to ITN maintenance, reported by 38.9% of respondents in Yola North and 83.5% in Fufore, and the marked rural–urban disparity likely reflects differential exposure to health messaging concentrated in urban areas through mass media, health facilities, and NGO activities. This finding supports the access inequities framework proposed by O'Meara *et al*. (2017), wherein rural populations face systematic disadvantages in receiving both the hardware (nets) and software (information) components of malaria control.

Despite these challenges, a majority of respondents perceived ITN maintenance as important. However, the proportion considering it "very important" was substantially lower in Fufore (19.5%) than in Yola North (48.3%), a difference that may reflect lower awareness, competing priorities, or fatalistic attitudes toward malaria prevention commonly observed in highly endemic, resource-limited settings (Pulford *et al*., 2011). Encouragingly, perceptions of washing practices on ITN effectiveness were predominantly positive in both LGAs (26.2% positive in Yola North; 56.4% in Fufore), suggesting that where information does reach communities, it is largely accepted. However, the substantial proportion of respondents who were unsure or held negative perceptions (approximately 50% in Yola North and 45% in Fufore) indicates persistent knowledge gaps that targeted community engagement could address. Comfort while sleeping under ITNs was generally high, with 31.8% of Yola North and 71.4% of Fufore respondents reporting being "very comfortable." The unexpectedly higher comfort level in Fufore despite lower education and awareness may be explained by differences in housing construction (e.g., more open ventilation reducing heat retention), lower ambient nighttime temperatures, or adaptation effects, as previous

research has documented that perceived comfort is a stronger predictor of ITN use than objective physical comfort and that communities adapt to ITN use over time (Loll *et al*., 2020). Community engagement programs addressing ITN challenges were predominantly absent in both LGAs (30.3% Yola North; 66.9% Fufore), and regular programs were virtually nonexistent, which likely contributes substantially to the information deficits documented elsewhere. Peer and neighbour influence on ITN use was modest, with only approximately one-quarter of respondents reporting being "somewhat" or "strongly" influenced. While social influence effects on health behaviours are well-established (Latkin & Knowlton, 2015), their modest magnitude here suggests that ITN use decisions in these communities remain largely individual rather than socially normative.

Knowledge of correct ITN installation showed a stark urban–rural gradient: 45.7% of Yola North respondents were "very knowledgeable" compared to only 8.0% in Fufore. In comparison, 89.5% of Fufore respondents were only "somewhat knowledgeable" or less. This disparity is clinically significant, as incorrect installation substantially reduces ITN effectiveness (Bhatt *et al*., 2015), and the finding underscores the need for practical, demonstration-based interventions in rural areas rather than reliance on mass media campaigns alone. Concerns about adverse effects were predominantly minor, and most respondents reported that ITN use did not affect daily activities; the low level of significant concerns (13.5-16.5%) is reassuring and suggests that once ITNs are adopted, they are generally well-tolerated, though this minority represents a non-trivial barrier that could be addressed through targeted counselling (Atieli *et al*., 2011). Perceived discomfort emerged as the leading barrier to regular ITN use in both LGAs (26.2% Yola North; 45.1% Fufore), followed by unavailability and lack of awareness, a finding consistent with multi-country studies identifying heat and discomfort as primary reasons for non-use, particularly among adults (Pulford *et al*., 2011; Loll *et al*., 2020). Unavailability (21.7% Yola North; 39.1% Fufore) and affordability issues (13.9% Yola North; 24.8% Fufore) were substantially more pronounced in Fufore, confirming significant access inequities despite national mass distribution campaigns, which aligns with Ricotta *et al*. (2020) who documented that rural households in Nigeria are less likely to have received ITNs through campaigns and more likely to face out-of-pocket costs for replacement nets. Awareness of ITN importance was high in both LGAs, but awareness alone is insufficient to drive behaviour; the Health Belief Model would posit that perceived susceptibility, and perceived barriers must be accompanied by cues to action, such as community engagement programs to translate awareness into consistent behaviour (Rosenstock, 1974).

Educational attainment was a strong, dose-dependent predictor of ITN use the previous night. Compared to respondents with no formal education, those with a Diploma had 2.10 times higher odds of use, those with a degree had 2.50 times higher odds, and those with MSc or above had 2.85 times higher odds. This gradient suggests that education enhances ITN use not merely through literacy but through improved health literacy, self-efficacy, and ability to overcome practical barriers, and similar educational gradients in ITN use have been documented across sub-Saharan Africa (Singh *et al*., 2013; Stratton *et al*., 2018). Importantly, exposure to regular community programs was the strongest predictor (OR=3.15), indicating that well-designed, consistent engagement can partially compensate for lower educational backgrounds. Ordinal logistic regression examining comfort during ITN sleep produced remarkably similar results: higher education (Degree: aOR=1.85; MSc & above: aOR=2.00) and regular community programs (aOR=2.40) significantly predicted greater comfort, suggesting that comfort is not merely a physical sensation, but a perception shaped by knowledge, expectations, and normalisation through repeated exposure. Notably, age and gender were not significant predictors of either ITN use or comfort. While some studies have found lower use among older adults or gender differences (Atieli et al., 2011), the absence of such effects here may indicate that in these highly endemic communities, malaria risk is universally recognised. ITN use has become sufficiently normalised that demographic factors no longer differentiate users from non-users except for education and program exposure, which remain modifiable.

5. Conclusion

Community engagement for ITN education and maintenance is critically inadequate in two malaria-endemic LGAs in northeastern Nigeria, particularly in rural Fufore. Lack of information is the dominant challenge, and access

inequities in ITN availability and affordability are more pronounced in rural areas. Educational attainment and, most importantly, regular community programs are strong independent predictors of ITN use and comfort, while age and gender are not. Strengthening sustained, structured community engagement, addressing practical barriers such as discomfort and providing correct installation support could substantially improve ITN utilisation. Without such post-distribution investments, mass distribution campaigns alone will continue to underperform, perpetuating malaria transmission in vulnerable communities.

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