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Preserving nets, protecting children: an evaluation of factors influencing the utilization and physical integrity of long-lasting insecticidal nets among under-five children in Osun State, Nigeria

Olufemi Oroge¹, Temitope Olumuyiwa Ojo^{2*}, Baderinwa Opeyemi Akanji³, Bamgboye Morakinyo Afolabi⁴ and Akeem Babatunde Bello¹

Abstract

Background Malaria remains a significant public health challenge in Africa where it is the most important vectorborne disease. Nigeria bears the largest burden, with pregnant women and children under 5 years being more affected. Although, long lasting insecticidal nets (LLINs) remain effective for control, its use has been suboptimal. Hence this study assessed, household ownership, physical integrity and use of LLINs among children.

Methods A community-based, cross-sectional study was carried out among 1642 households using a multistage sampling technique in Osun State, Nigeria. A pretested, interviewer-administered questionnaire was used to obtain information on socio-demographic characteristics and use among under-fives. LLINs were inspected for physical integrity and cleanliness. A binary logistic regression analysis was conducted to identify factors influencing LLIN use by under-fives.

Results The mean age of children was 32.2 ± 16.5 months. Most households, 1586 (96.6%) had an LLIN while 165 (10.4%) did not hang their net. Holes were present in LLINs in 360 (22.7%) households and 196 (12.4%) had dusty or stained nets. Most households, (1259; 79.4%), had at least one LLIN for every 2 household members and survey participants reported that 1331 (83.9%) under-fives slept under an LLIN the night before the survey. Factors associated with reported LLIN use were; older parents/guardians aged 50–59 years (AOR: 3.02; 95% CI 1.50–6.09), having a post-secondary education (AOR: 2.56; 95% CI 1.31–5.00), having LLIN obtained < 12 months (AOR: 4.27; 95% CI 2.39–7.64), households with one LLIN for every 2 members (AOR: 1.65; 95% CI 1.15–2.37) and households with clean nets (AOR 2.75; 95% CI 1.89–4.00) had increased odds of reported LLIN utilization by under-five children.

Conclusion Although LLIN ownership and reported use were high in this study, gaps exist between ownership and reported use of LLINs. About one-fourth of LLINs had poor physical integrity. To maximize LLIN effectiveness

*Correspondence: Temitope Olumuyiwa Ojo linktopeojo@yahoo.com Full list of author information is available at the end of the article



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in households, it is important to ensure the continued free distribution of nets and emphasize messages to parents/ guardians on proper care, maintenance, and use of nets.

Keywords Long lasting insecticidal nets, Net integrity, Under-fives, LLIN use

Background

Malaria remains a significant global public health challenge, particularly in Africa where it remains the most important vector-borne disease [1]. Several interventions have been introduced over the years to address the burden of malaria. However, among the core interventions recommended by the World Health Organization (WHO) for malaria vector control and prevention, the use of long-lasting insecticidal net (LLIN), has been credited with significantly reducing the global burden of malaria in recent years [2]. LLINs are impregnated with insecticides that repel and kill mosquitoes upon contact, and are designed to remain effective for several years. Also, the sustained insecticidal action of LLINs plays an important role in reducing the mosquito vector population and consequently, malaria transmission [3].

The widespread use of LLIN can reduce all-cause childhood mortality by 20%, and avert as many as 370,000 child deaths per year in Africa [4]. In Nigeria, this strategy has been adopted through the mass distribution of LLINs at community and household levels, the aim is to ensure one net to two persons at risk, and continuous distribution through antenatal care (ANC) services and the national programme on immunization (NPI) channels [5]. However, the utilization of nets in the country is still suboptimal with the national average for net ownership, still at about 55% [6]. Moreover, only 41% of under-five children slept under an LLIN in a 2021 national survey [7].

Across many Nigerian states, challenges related to LLIN ownership and utilization persist despite gains achieved over the years [8, 9]. Although, progress has been made in distributing LLINs to households [5], ensuring their consistent and correct use remains a concern. For instance, the 2021 Malaria Indicator Survey in Nigeria indicated that the use of LLINs by under-fives varies across states, ranging from 78.1% in Adamawa to 9.2% in Lagos, while Osun State had 35.1% [7]. A number of factors have been identified as responsible for this trend including, poor access to LLINs, and socio-economic disparities, among others [10, 11]. Furthermore, despite the benefits conferred by the use of LLINs, regional studies have observed deteriorations in the physical state and integrity of the nets, depending on their care and usage patterns, before the expired duration of use [12, 13].

Hence, understanding the dynamics of LLIN ownership and usage among under-five children is vital to designing effective interventions that can bridge these gaps and contribute to reducing the malaria burden in the region. Also, by assessing the current state of LLIN ownership and utilization, this research aims to provide insights into the challenges as well as opportunities that may be applicable for improving LLIN coverage and effectiveness. The study, therefore, aimed to investigate the availability, physical integrity and reported utilization of long-lasting insecticidal nets among under-five children in households within Osun State, Nigeria.

Methods

Study design, sampling technique and population

This community-based, cross-sectional study was conducted in Osun state, southwest Nigeria using a multistage sampling technique. Osun State is one of 36 states in the country with a population of 4.4 million persons, according to 2022 population projection estimates [14]. Administratively, the state is made up of three senatorial districts comprising 30 local government areas (LGA) and 332 wards. The agency of government that oversees malaria control activities is the State Malaria Elimination Program (SMEP) and it is domiciled in the State Ministry of Health. The SMEP has conducted periodic LLIN distribution in the state with the aid of international partners. Hence it is expected that almost all households should have LLIN.

Inclusion criteria: Study participants were parents or guardians of under-fives in households in the study location. Participants must have resided for at least one year in the study location, be at least 18 years old and provide informed consent.

Exclusion criteria: Participants who were visitors or not usual residents in the study area as well as persons who were ill and could not answer survey questions were excluded.

Sample size estimation

Using the formula for cross-sectional studies, a design effect of 1.6, prevalence of 89.2% for net retention [15] and standard normal deviate for a 95% confidence limit, a sample of size of 1650 was estimated for this study.

Sampling

Participants were recruited via multistage sampling technique. Four local government areas (LGA) were selected from each of the 3 senatorial districts in Osun state using simple random sampling (each senatorial district has 10 LGAs). Thus, a total of 12 LGAs were selected throughout the state at the first stage. In the second stage, four wards were selected using simple random sampling from each selected LGA. For the third stage, a street/settlement was selected using simple random sampling from each selected ward.

At the last sampling stage, in each selected street/ community starting from a randomly selected building in a clockwise direction, an eligible respondent (parent/ guardian of under-five) was interviewed in every alternate building till thirty-five eligible respondents were recruited. If there were no eligible respondents in a building, then eligible respondents were recruited from the next building. In selected buildings with more than one eligible respondent, only one respondent was selected for interview using a simple random sampling technique (balloting). In streets where there were fewer than 35 eligible respondents, the enumerators continued recruitment of respondents in a contiguous street to meet up with the required number.

Data collection and analysis Recruitment and training of research assistants

Fourteen research assistants were recruited and trained for data collection. They came from a health sciences background with enough experience in similar studies. The enumerators were not staff of SMEP, did not introduce themselves as such and did not wear the SMEP insignia during data collection. They were fluent in the native language as well as in English and conversant with the study locations. The three-day training included plenary sessions, role-plays, questions and answer sessions and also field practice. They went through each item on the questionnaire for data collection during training.

Data collection tool and procedures

A pretested, interviewer-administered questionnaire was used to obtain information from respondents. The study instrument was pre-tested among 100 respondents in a local government area that was not covered by this study and this corresponds to about 6% of the study sample size. The pre-test gauged the acceptability of the questions to the respondent and their ease of comprehension. After the pre-test, ambiguous questions and those eliciting inappropriate responses were re-assessed and revised. For instance, the question on "average monthly income" was finally kept open-ended as opposed to 'income bands' because, during the pretest, many respondents were consistently selecting the lower bands even when they obviously did not belong to such income brackets. The final data collection tool was a 2-paged instrument with 27 questions that were aggregated under the following sections: socio-demographic characteristics of respondents, availability and reported use of LLINs for under-fives and current state (physical integrity and cleanliness) of the LLIN. For households with multiple children in this age group, the obtained information was restricted to the youngest child. On average it took about 15 min to administer the questionnaire. Field data collectors were supervised daily by the authors for data quality and consistency and reviewed for accuracy. Each evening, all the forms were reviewed for completeness, and daily briefings helped maintain open communication and ensured data quality.

Besides administering the questionnaire, the survey team inspected all LLINs that were hanged to assess their physical integrity. The authors supervised field data collectors daily for data quality, consistency and accuracy. Questionnaires were reviewed daily for completeness, while daily briefings were done to ensure uniformity and consistency of data collection procedures.

Data analysis

Data was entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Data entry was performed by trained clerks and they conducted regular visual inspections to ensure accuracy, completeness, and consistency. In addition, supervisors regularly crosschecked a sample of entries against original survey forms to detect and correct discrepancies, thereby maintaining data integrity throughout the process.

For data analysis, univariate data were summarized using frequencies and proportions while at the bivariate level, the chi-square test was used to determine the association between sociodemographic variables and the reported use of LLIN. The outcome variable was "reported LLIN use" while explanatory variables were the sociodemographic characteristics of respondents and data associated with net usage. Multivariable binary logistic regression analysis using adjusted odds ratio and 95% confidence intervals, was subsequently conducted to determine the predictors of net use. For all analyses, a p-value of less than 0.05 was taken as statistically significant.

Ethical consideration

Ethical approval was obtained from the Health Research and Ethics Committee of the Osun State Ministry of Health (Ethics No: OSHREC/PRS/569T/431). Informed consent was obtained from all participants after explaining the purpose, risks and benefits of the study. Participation was voluntary and confidentiality was assured. Data were stored on a password-protected computer only accessible to the investigator. This study was conducted as a preliminary to the net distribution campaign of 2023, hence all households regardless of study participation received new nets, were educated on proper care of the nets and assisted to hang them as appropriate. In addition, the study complied with the Declaration of Helsinki on conducting research among human subjects [16].

Results

The total number of respondents with completed questionnaires was 1642. Table 1 shows the sociodemographic characteristics of respondents. The mean age of parents was 40.5 ± 11.6 years, while for children, it was 32.2 ± 16.5 months. Slightly more than one-third of parents/guardians, 573 (34.9%) were within the 30 to 39 years age group while 989 (60.2%) were females. Most respondents, 1462 (89.0%) were married and 845 (51.5%) had secondary education and almost half, 796 (48.5%) were traders. Majority, (1049; 63.9%) belonged to house-holds with 4 to 6 members. For the under-fives, most, (1378; 83.9%) were males.

Table 2 shows the availability, physical condition and reported use of LLINs. Most households, (1586; 96.6%) currently had at least one LLIN. In addition, majority of households, 1259 (79.4%), had universal LLIN coverage i.e., at least one LLIN was available to 2 household members. Among household members, children were usually prioritized to sleep under LLIN, (1379; 84.0%). Most children, (1331; 83.9%) slept under the LLIN, a night before the survey. Most respondents, 1574 (99.2%) received the net during the free net campaign distributions while more than one-thirds, (631; 39.8%) had two nets hanged and in use. Furthermore, 1191 (75.1%) respondents obtained the oldest net about 23 months prior while there were no holes in inspected LLINs across 1226 (77.3%) households. The majority, 1139 (80.2%) and 1390 (87.6%) tied the net to nails on the wall and had clean nets, respectively.

Table 3 shows the association between sociodemographic characteristics of respondents and selected net characteristics and usage of LLINs by under-five children in the sampled households. Among the sociodemographic characteristics, the age of parents (p=0.008), level of education of parents (p=0.001), occupation (p=0.035), and household size (p=0.024) were significantly associated with net usage by under-five children in sampled households. As regards LLIN characteristics, cleanliness of the net (p<0.001), physical integrity of the net (p=0.014), number of years since the oldest net was obtained (p<0.001), and the availability of one LLIN for every two household members (p=0.001) were significantly associated with net usage among under-five children.

Table 4 shows the association between selected characteristics and the physical integrity of nets in households sampled. A higher proportion of large households (>6 members) had LLINs with holes (p=0.001), also, a higher proportion of those no universal LLIN coverage had nets with holes. A higher proportion of households with dusty or stained nets had holes in the LLIN (p < 0.001).

Tables 5 and 6 shows the predictors of reported LLIN use by under-five children, and physical integrity of LLIN respectively in households using binary logistic regression. Respondents aged 50 to 59 years compared to those below 30 years (AOR: 3.02; 95% CI 1.50-6.09; p=0.002), respondents with post-secondary education compared to those with no formal education (AOR: 2.56; 95% CI: 1.31-5.00, p=0.006). Furthermore, children aged less than 12 months compared with those aged 48 to 59 months (AOR: 1.68; 95% CI 1.03-2.74; p=0.038), clean nets compared with dirty nets (AOR: 2.75; 95% CI 1.89–4.00; p < 0.001), oldest net obtained less than 12 months (AOR: 4.27; 95% CI 2.39–7.64; p<0.001), 12 to 23 months (AOR: 2.49; 95% CI 1.43-4.32; p=0.001), and 24 to 35 months (AOR: 5.83; 95% CI 3.03-11.20; p < 0.001), compared to those obtained 36 months or more, and households with one LLIN for every 2 members compared those without it (AOR: 1.65; 95% CI 1.15–2.37; p=0.006), all had increased odds of reported use of the LLIN by under-five children in the household (Table 5).

Pertaining to the physical integrity of LLIN, households with more than 6 members compared those with less than 4 members (AOR: 1.88; 95% CI 1.04–3.40; p=0.036), households with 4 or more LLINs available compared with those with one (AOR: 3.89; 95% CI 1.83– 8.27; p<0.001), and households with dirty nets compared with those with clean nets (AOR: 5.15; 95% CI 3.56–7.44; p<0.001) all had increased odds of having LLINs with poor physical integrity (having holes in the net).

Discussion

This study assessed household ownership, physical integrity, and LLIN utilization among under-five children in Osun State Nigeria. This study showed that most households had an LLIN and majority of under-five children slept under the LLIN the night before the survey. This may probably suggest that the repeated net campaigns by malaria stakeholders in the study are yielding results. This finding is commendable as it shows that one of the key targets of the Nigeria National Malaria Strategic

 Table 1
 Sociodemographic characteristics of respondents

Variables	Frequency (n = 1642)	Percentage (%)	
Age of parent/guardian (years) (Mean: 40.5 ± 11.6)			
<30	278	16.9	
30–39	573	34.9	
40–49	481	29.3	
50–59	185	11.3	
≥60	125	7.6	
Sex of parent/guardian			
Male	653	39.8	
Female	989	60.2	
Religion			
Christianity	801	48.8	
Islam	804	49.0	
Others	37	2.3	
Marital status of parent/guardian			
Single	74	4.5	
Married	1462	89.0	
Widow/Separated/divorced	106	6.5	
Level of education			
No formal education	129	7.9	
Primary education	337	20.5	
Secondary education	845	51.5	
Post-Secondary education	331	20.2	
Occupation of parent/guardian			
Unemployed/student	66	4.0	
Artisan	263	16.0	
Trader/business	796	48.5	
Civil servants/Clergy	168	10.2	
Farmers	349	21.3	
Household size			
<4 members	438	26.7	
4–6 members	1049	63.9	
>6 members	155	9.4	
Age of child (months) (Mean: 32.2 ± 16.5)			
<12	264	16.1	
12–23	246	15.0	
24–35	378	23.0	
36–47	383	23.3	
48–59	371	22.6	
Sex of child			
Male	838	51.0	
Female	804	49.0	

Plan of improving access and utilization of vector control interventions to at least 80% of the target population by 2025, is being met in Osun State [5]. This finding is higher than the 2018 and 2021 national averages [5, 7, 17] and values obtained for LLIN ownership and utilization in other states of the country [8, 10, 18]. It also indicates a remarkable increase compared to similar studies done in the state previously [9, 19]. Moreover, the findings are similar to that from a study in Ethiopia where reported LLIN use was about 82% among under-fives [20].

However, some studies have demonstrated that ownership of an LLIN does not necessarily translate to use Table 2 Availability, net hanging status physical condition and reported use of LLIN

Variables	Frequency (n)	Percentage (%)
Currently have LLIN (n = 1642)		
Yes	1586	96.6
No	56	3.4
Number of LLIN available (n = 1586)		
1	145	9.1
2	756	47.7
3	579	36.5
4 or more nets	106	6.7
One LLIN available for every 2 household members (universal coverage)		
Yes	1259	79.4
No	327	20.6
How LLIN was procured		
It was distributed free	1574	99.2
It was bought	12	0.8
LLIN currently hanged and in use (n = 1586)		
None	165	10.4
1	613	38.7
2	631	39.8
3	148	9.3
4 or more nets	29	1.8
Who usually sleeps under the LLIN in this household ($n = 1586$) ^a		
Men	806	50.8
Women	1238	78.1
Children	1379	84.0
Child < 5 years reportedly slept under LLIN last night		
Yes	1331	83.9
No	255	16.1
How long ago was the oldest LLIN obtained		
<12	526	33.2
12–23	665	41.9
24–35	320	20.2
≥36	75	4.7
Cleanliness of the net		
Clean	1390	87.6
Dirty (dusty or stained)	196	12.4
Physical integrity of the net		
No holes	1226	77.3
At least one hole present	360	22.7
How LLIN was hanged ($n = 1421$)		
Tied to nails on wall with string or rope	1139	80.2
Tied to ceiling with string or rope	282	19.8

^a Multiple responses allowed

[8], and this was also shown in this study, where one in ten households did not hang the LLINs, despite having them at home. Therefore, it is important to identify and address the factors that prevent people from using LLINs effectively. The universal coverage of LLIN, defined as having at least one LLIN available to every two household members [3, 21], was also commendable in this study as roughly eight out of every ten households had universal LLIN coverage. Findings from other African countries in recent times varied from, 64.1% in Kenya [22], to 76.3% in Mozambique [23]. This finding also shows that the State may be on course to achieve

 Table 3
 Association between selected socio-demographic

 characteristics and the reported use of LLIN by under-five
 children across households

Characteristics	Slept under LLIN last night (n = 1331)		Did not sleep under LLIN last night (n=255)		Statistical comparison
	%	Ν	%	Ν	
Age of guardian/parent (years)					
<30	217	81.3	50	18.7	
30–39	453	81.9	100	18.1	$\chi^2 = 13.912$
40–49	386	83.9	74	16.1	p=0.008
50–59	168	92.8	13	7.2	•
≥60	107	85.6	18	14.4	
Marital status of parent/guardia	n				
Single	56	80.0	14	20.0	$\chi^2 = 3.971$
Married	1182	83.7	231	16.3	p=0.137
Widow/Separated/divorced	93	90.3	10	9.7	
Level of education of parent/qu	ardian				
No formal education	103	81.7	23	18.3	
Primary education	258	78.2	72	21.8	$x^2 = 22.269$
Secondary education	678	83.6	133	16.4	p<0.001
Post-Secondary education	292	91.5	27	8.5	•
Occupation					
Unemployed/student	47	74.6	16	25.4	
Artisan	1211	83.4	42	16.6	$\chi^2 = 10.367$
Trader/business	638	83.4	127	16.6	p=0.035
Civil servants/Clergy	151	91.0	15	9.0	•
Farmers	284	83.8	55	16.2	
Household size					
<4 members	359	84.9	64	15.1	$\chi^2 = 7.461$
4–6 members	857	84.7	155	15.3	p = 0.024
>6 members	115	76.2	36	23.8	
Age of child (months)					
<12	229	88.1	31	11.9	
12-23	193	83.9	37	16.1	$\chi^2 = 5.156$
24–35	304	83.3	61	16.7	p=0.272
36–47	312	84.1	59	15.9	
48–59	293	81.4	67	18.6	
Sex of child					
Male	676	83.0	138	17.0	$\chi^2 = 0.949$
Female	655	84.8	117	15.2	p=0.330
Cleanliness of the net					
Clean	1202	86.5	188	13.5	$\chi^2 = 54.332$
Dirty (dusty or stained)	129	65.8	67	34.2	p<0.001
Physical integrity of the net					
No holes	1044	85.2	182	14.8	$\chi^2 = 6.087$
At least one hole present	287	79.7	73	20.3	p=0.014
How long ago was the oldest LLIN obtained (months)					
<12	460	87.5	66	12.5	
12-23	531	79.8	134	20.2	$\chi^2 = 51.989$

Table 3 (continued)

Characteristics	Slept unde last n (n = 1	r LLIN ight 331)	Did not Stati sleep com under LLIN last night (n = 255)		Statistical comparison
	%	Ν	%	Ν	
24-35	293	91.6	27	8.4	p<0.001
≥36	47	62.7	28	37.3	
Availability of one LLIN for every coverage)	/ 2 hous	ehold i	memb	ers (un	iversal
Yes	1077	85.5	182	14.5	$\chi^2 = 11.910$
No	254	77.7	73	22.3	p = 0.001

Bold values are for variables that were statistically significant at p < 0.05

the WHO recommendation on universal LLIN coverage [3]. However, there is still need for targeted interventions in the study area to promote LLIN use among caregivers of under-fives.

In most households, children and women were prioritized to sleep under the LLIN. Women and children, compared to youths and men, have been shown to be regular users of LLINs in literature [2, 20, 21, 23]. A major reason for this may be because women and children are often perceived to have higher risk of malaria infection [22]. Consistent with the belief in the heightened susceptibility of young children to malaria, the majority of under-five children in this survey reported sleeping under an LLIN the previous night.

Furthermore, the physical integrity and cleanliness of the nets were maintained in most of the households. This result could be attributed to the fact that a significant portion of the households surveyed acquired their oldest LLINs within the past two years. The physical durability of nets has been strongly linked with duration of use with median survival rates of 3.7 years observed in past studies [13]. This means that replacing LLINs every few years may ensure their continued effectiveness in providing households with long-lasting protection against malaria.

A higher proportion of younger children (<3 years) slept under the LLIN. Findings from other published works in sub-Saharan African countries support this [20, 24]. Younger children may be prioritized to sleep under bed nets, especially when LLINs are insufficient for all household members, as compared to older children aged 4–5 years [25]. Another possible reason is the common practice of younger children sleeping with their mothers under LLINs until they are fully weaned [8]. This practice in the study area could contribute to the higher reported LLIN use among children under 3 years compared to older children.

Characteristics	No holes i (n = 1226)	No holes in LLINLLIN has(n = 1226)(n = 36)		holes	Statistical comparison
	n	%	%	n	
Household size					
<4 members	331	78.1	92	21.7	$\chi^2 = 4.812$
4–6 members	789	78.0	223	22.0	p=0.090
>6 members	106	70.2	45	29.8	
Number of LLIN available (n = 1586)					
1	110	75.9	35	24.1	$\chi^2 = 17.388$
2	599	79.2	157	20.8	p=0.001
3	422	72.9	157	27.1	
4 or more nets	95	89.6	11	10.4	
One LLIN available for every 2 household members (ur	niversal coverage)				
Yes	988	78.5	271	21.5	$\chi^2 = 4.793$
No	238	72.8	89	27.2	p=0.029
How LLIN was procured					
It was distributed free	1219	77.4	355	22.6	$\chi^2 = 2.479$
It was bought	7	58.3	5	41.7	p=0.115
How long ago was the oldest LLIN obtained					
<12	410	77.9	116	22.1	
12–23	494	74.3	171	25.7	$\chi^2 = 7.901$
24–35	259	80.9	61	19.1	p=0.048
≥36	63	84.0	12	16.0	
Cleanliness of the net					
Clean	1135	81.7	255	18.3	$\chi^2 = 121.482$
Dirty (dusty or stained)	91	46.4	105	53.6	p<0.001
How LLIN was hanged (n = 1421)					
Mainly tied to nails on wall with string or rope	901	79.1	238	20.9	$\chi^2 = 2.435$
Mainly tied to ceiling with string or rope	211	74.8	71	25.2	p=0.119

Table 4 Association between selected characteristics and physical integrity of LLIN in households

Bold values are for variables that were statistically significant at p < 0.05

In addition, the level of education of parents was also significantly associated with LLIN. Parents with higher levels of education were more likely to ensure their children slept under LLINs. This has been observed in previous studies conducted in Nigeria [9], Ethiopia [26], and Ghana [27]. This may be attributed to the increased knowledge and understanding of malaria and its prevention methods among educated individuals [9, 28, 29]. This further attests to the fact that educational attainment of parents or guardians is a major social determinant of child health.

Children in households where LLINs were observed to be clean were more likely to report using LLINs and this aligns with past findings in the literature [29, 30]. Worn-out or dirty nets may raise concerns about their ability to protect against mosquito bites or be perceived as uncomfortable or unattractive, leading to reduced use [31]. This finding brings into focus the important role of proper LLIN maintenance in malaria prevention. Proper cleaning of LLINs and replacing them at due time may have an enhanced effect on malaria control.

Households with more than six members and four or more nets were more likely to have LLINs with holes. This could be attributed to increased handling and wear from frequent use, as larger households tend to place greater demand on available bed nets [31]. To better understand the reasons underlying net damage in larger households and those with more than four nets, more research is, needed to examine how the usage pattern, maintenance practice, net quality, and other environmental factors influence the durability and physical integrity of LLINs. The results may inform targeted interventions for improving malaria control in such contexts.

In addition, future studies will be required to deepen the understanding of contextual factors that may hinder the effective use of LLINs. Such research may employ an approach that integrates both quantitative and qualitative methodologies to explore issues such as cultural beliefs,

Variables	Adjusted odds ratio	95% CI	P-value
Age of guardian/parent (years)			
< 30 (Ref)	1		
30–39	0.98	0.64-1.47	0.897
40–49	1.08	0.70-1.69	0.725
50–59	3.02	1.50-6.09	0.002
≥60	1.20	0.61-2.36	0.592
Marital status of parent/guardian			
Widow/Separated/divorced (Ref)	1		
Single	0.22	0.21-1.42	0.283
Married	0.15	0.29-1.21	0.195
Level of education of parent/guardian			
No formal education (Ref)	1		
Primary education	0.83	0.47-1.46	0.519
Secondary education	1.24	0.72- 2.15	0.442
Post-Secondary education	2.56	1.31-5.00	0.006
Occupation			
Unemployed/student (Ref)	1		
Artisan	1.62	0.78-3.37	0.200
Trader/business	1.59	0.81-3.14	0.180
Civil servants/Clergy	1.91	0.80-4.55	0.144
Farmers	1.40	0.68–2.87	0.360
Household size			
<4 members (Ref)	1		
4–6 members	0.94	0.67-1.34	0.744
>6 members	0.69	0.40-1.20	0.191
Age of child (months)			
< 12	1.68	1.03-2.74	0.038
12–23	1.33	0.82-2.14	0.238
24–35	1.19	0.79-1.80	0.403
36–47	1.22	0.81-1.84	0.346
48–59 (Ref)	1		
Sex of child			
Male	0.86	0.64-1.15	0.310
Female (Ref)	1		
Cleanliness of the net			
Clean	2.75	1.89–4.00	< 0.001
Dirty (dusty or stained) (Ref)	1		
Physical integrity of the net			
No holes	1.18	0.84-1.66	0.352
At least one hole present (Ref)	1		
How long ago was the oldest LLIN obta	ined (months)	
<12	4.27	2.39–7.64	< 0.001
12–23	2.49	1.43-4.32	0.001
24–35	5.83	3.03-11.20	< 0.001
≥ 36 (Ref)	1		
One LLIN available for every 2 househol	d members (u	universal cover	rage)
Yes	1.65	1.15-2.37	0.006
No (Ref)	1		

Table 5 Binary logistic regression analysis of the predictors of reported use of LLIN by under-five children across households

Table 5 (continued)

Bold values are for variables that were statistically significant at p < 0.05

Table 6	Binary logistic regression analysis of the predictors of
poor phy	sical integrity of LLIN in households

Variables	Adjusted Odds Ratio	95% CI	P-value
Household size			
<4 members (Ref)	1		
4–6 members	0.91	0.64-1.29	0.587
>6 members	1.88	1.04-3.40	0.036
Number of LLIN available			
1 (Ref)	1		
2	3.84	1.53-9.63	0.004
3	3.04	1.37–6.72	0.006
4 or more nets	3.89	1.83-8.27	< 0.001
How LLIN was procured			
It was bought (Ref)	1		
It was distributed free	0.70	0.15-3.19	0.645
How long ago was the oldest	LLIN obtained		
<12 (Ref)	1		
12–23	1.20	0.89-1.63	0.232
24–35	0.89	0.61-1.30	0.555
≥36	0.76	0.33-1.78	0.532
Cleanliness of the net			
Clean (Ref)	1		
Dirty (dusty or stained)	5.15	3.56-7.44	< 0.001
How LLIN was hanged			
Mainly tied to nails on wall with string or rope (Ref)	1		
Mainly tied to ceiling with string or rope	1.18	0.86–1.63	0.308

Bold values are for variables that were statistically significant at p < 0.05

community dynamics, socio-economic and health system influences, as well as environmental conditions. This will be useful in generating evidence that may inform behaviour change interventions regarding LLINs use and care that are well adapted to the local contexts.

Conclusion

The study concludes that the reported use of LLINs among under-five children was high in the study area. While this is encouraging, there are still gaps to be addressed. For instance, about one in ten households failed to hang the LLINs despite being available and nearly a quarter of inspected nets exhibited poor physical integrity, characterized by holes. Addressing these challenges requires sustained efforts, focusing on two key components: first, ensuring the continued availability and accessibility of LLINs through sustained free distribution initiatives, and second, continual sensitization of caregivers about the proper care and consistent use of LLINs. These are necessary to maximize the impact of LLINs in reducing malaria transmission among under-fives.

Study limitations

The self-reported nature of the study findings may have introduced social desirability bias about net hanging and physical integrity. However, efforts were made to minimize this by conducting visual inspections of the nets to provide an objective assessment of their physical integrity. Furthermore, as this study was cross-sectional in nature, and done within Osun State, findings may not be generalizable to other states in the country.

Abbreviations

- ANC Antenatal care
- AOR Adjusted odds ratio
- LGA Local government area
- LLIN Long lasting insecticide nets
- SMEP State Malaria Elimination Program
- WHO World Health Organization

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Author contributions

Authors' contribution: OO and TOO conceived the study, participated in data analysis, and partly drafted the initial manuscript (introduction and discussion). BOA and BMA participated in data analysis and provided insightful inputs in the drafting of the manuscript's results and discussion. TOO and BOA worked on the tables and interpreted the results. All authors contributed to the discussion and approved the final version of the manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Health Research and Ethics Committee of the Osun State Ministry of Health (Ethics No: OSHREC/PRS/569T/431). All respondents gave voluntary informed consent after being informed of the study's risks and benefits. No personal identifying information was recorded and respondents' data were carefully uploaded on a passworded computer reserved for the study while being assured of the confidentiality of the information provided. The study methods were carried out in accordance with relevant guidelines and regulations. In addition, the study complied with the Declaration of Helsinki on conducting research among human subjects.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

¹Ministry of Health, Osogbo, Osun, Nigeria. ²Department of Community Health, Obafemi Awolowo University, Ile-Ife, Osun, Nigeria. ³Department of Community Health, Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria. ⁴Nigerian Institute of Medical Research, Yaba, Lagos, Nigeria.

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