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Dynamics of Household Ownership, Usage and Washing Pattern of Long Lasting Insecticidal Nets in Three Rural Communities in Ikorodu, Lagos State, Nigeria

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Abstract

Introduction: Long-lasting efficacy of LLINs can be compromised by use and washing habits. We therefore investigated the use and washing pattern of LLIN in Ikorodu area of Lagos, Nigeria.

Methods: A quasi-experimental study of randomly selected and consented 310 and 240 mothers of children under 10 years pre- and post-intervention respectively was conducted using household survey semi-structured questionnaire. Data were analyzed using SPSS version 20 software.

Results: Of 550 respondents interviewed in the two phases, 192 (34.9% [35.8% pre-intervention *vs.* 33.7% post-intervention)] lived in one-room apartments. Their ages ranged from 19 to 73 years (mean: 42.4 years *vs.* 39.9 years). Most (55.6%) had minimum of secondary education and were traders (26.5%). In pre- and post-intervention, 92.3% and 95.8% correctly knew mosquito bite as the transmission route of malaria. Only 67.4% and 50.0% owned LLINs pre- and post-intervention respectively. In contrast, 57.4% and 40.8% actually used LLINs same period respectively. Reasons for LLIN non-use included: "it's hotter to sleep under LLIN" (10.6% *vs.* 18.9%). LLIN washing reduced (35.5% to 30.8%) with increased use of mild soaps (38.2% *vs.* 100.0%) compared to harsh soaps (81.8% *vs.* 0.0%). None (0.0%) of the respondents washed their LLINs more than recommended 5 times a year post-intervention compared to 68.2% pre-intervention. LLIN ownership and use were not significantly determined by respondents' locality, age, education and housing structure post-intervention ($p>0.05$) unlike pre-intervention ($p<0.05$).

Conclusion: Results showed low LLIN use despite high levels of knowledge of mosquito bites being the source through which malaria spreads in populations studied. Health education on LLIN use and consequences of washing habits on LLIN long-lasting efficacy need be intensified in the communities, emphasizing LLIN benefits and how to appropriately wash it for effective malaria prevention. This is important if malaria elimination is to be realized in Lagos and Nigeria in general.

Keywords: Ownership; Washing pattern; LLIN; Household; Rural community; Nigeria

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Introduction

Malaria, which is preventable and treatable, remains the most debilitating mosquito-borne disease in sub-Saharan Africa and a formidable global health and socio-economic problem despite a century of research and control efforts, particularly in Nigeria where it is holoendemic [1-3]. It is transmitted by infected female *Anopheles* mosquitoes, and because there is currently no vaccine available, vector control is one of the most important means of malaria prevention [4].

Long Lasting Insecticide-treated Nets (LLINs) are now standard for the prevention and control of malaria [4,5]. The Nigeria Government and international partners undertook many interventions including the free distribution of LLINs to pregnant women and children under five years of age in order to achieve the Millennium Development Goal (MDG) target of 80% coverage by 2015 [6]. About 78 million LLINs were delivered between 2014 and 2016 in Nigeria, representing 25.9% of 301 million LLINs delivered to sub-Saharan Africa [1]. In the period 2016 to 2018, about 295 million LLINs were distributed in 11 High Burden to High Impact (HBHI) countries, of which 116 million (39%) were distributed to communities in the Democratic Republic of the Congo and Nigeria.

By 2018, access to LLINs was estimated to range between 40% and 60% in Nigeria a few other HBHI countries in Africa [7]. The High Burden to High Impact (HBHI) country-led approach launched in November 2018 by the World Health Organization (WHO) and the Roll Back Malaria (RBM) Partnership to End Malaria is a mechanism to support 11 highest burden countries that include Burkina Faso, Cameroon, the Democratic Republic of the Congo, Ghana, India, Mali, Mozambique, Niger, Uganda, the United Republic of Tanzania and Nigeria to get back on track to achieve the Global Technical Strategy for Malaria milestones. The approach includes the four key response elements that include political will, strategic information, better guidance and coordinated response for effective and equitable delivery of evidence-informed mix of interventions aimed at reducing malaria-related mortality and morbidity. These 11 countries account for 70% of the global estimated case burden and 71% of global estimated deaths from malaria [3].

Taking a cue from the RBM program, the Lagos State government declared the *Eko* Free Malaria treatment program in 1998 for all under-five children at its various health facilities. The State provides LLINs and Intermittent Preventive Treatment of malaria in pregnancy (IPTp) to pregnant women during visits to antenatal clinics and LLINs to under-five children on completion of immunization [8]. Presently, the State government has distributed over 4.2 million LLINs to the aforementioned groups using hospital-based and house-to-house approaches as of 2012 [9].

After increasing from 8% in the 2008 to 40% in 2010, 50% in 2013, 69% in the 2015, national household ownership of LLINs in Nigeria dropped to 61% in 2018. In contrast, use of LLINs among children under 5 years of age has increased over the past 10 years from 5% in 2008 to 52% in 2018. Similarly, use of LLINs by pregnant women has increased from 6% to 58%. A higher percentage of children in rural (57%) than urban (45%) areas were reported to have slept under LLINs. A similar pattern was observed among pregnant women (65% and 45%, respectively) [10]. The 2013 National Demographic Health Survey in the country showed a poor use of LLINs by pregnant women (25.6%) and children less than five years (18.0%) in Lagos [11]. The 2015 Nigeria Malaria Indicator Survey showed that 44.3% of households visited in Lagos had at least one LLIN while actual use in the State was only 11% [12].

The proportion of the population with access to Long Lasting Insecticide-treated Nets (LLINs) and sleeping under one as a cost-effective and efficacious method of controlling malaria has steadily increased in sub-Saharan Africa including Nigeria over the past 10 years [2,7,13]. Currently, there are several brands of LLINs on the market which have received approval by World Health Organization Pesticide Evaluation Scheme (WHOPES) as LLINs. The long-lasting efficacy of these LLINs however can be compromised by use, washing habits and physical conditions of the nets [14].

It is consequent to the dearth of evidence-based information on the ownership, usage and washing pattern of LLINs in Nigeria, particularly Lagos State, that this study on the dynamics of LLIN use and washing pattern was conducted in Ikorodu area of Lagos State where systematic study on the above issues has not been conducted. This study is part of a larger WHO-funded study that assessed the impact of insecticide resistance on the efficacy of Insecticide Residual Spray (IRS) and LLIN in 3 ecological settings of Nigeria.

Methods

Study design

This was a quasi-experimental study [15] of randomly selected 310 and 240 mothers of children under 10 years conducted between July 2015 and May 2016. The intervention phase of the study involved delivery of two LLIN packs to all households of study participants where children of target age therein were recruited and continuous health education activities were also carried out.

Preparatory to the data collection phase, an advocacy was first paid to the Lagos State Ministry of Health to inform them of the study and obtain approval for the same. Similar visits were made to each of the administrators at the Ikorodu Local Government Area (LGA) and to the communities guided by the LGA Malaria Control Officer. In each community, a community mobilization meeting was held between the researchers and the community leaders.

Study locations

The study was conducted in three rural communities (Bayeku, Oreta and Imota) in Ikorodu LGA of Lagos State, Nigeria (Figure 1) where malaria is perennial with about 97% of the population at risk of the disease [16]. There is high transmission of malaria during the rainy season between April and November [17] in these areas. Though Bayeku and Oreta are coastal communities bounded to the south by the Lagos Lagoon, Imota is hinterland bounded in the east by a boundary with Agbowa-Ikosi, a town in Epe LGA. The communities surveyed were of comparable socio-economic characteristics. Economically dependent on the fishing and farming. The people in these communities are predominantly of Yoruba ethnic group with few other tribes such as the *Egun*, each with their own distinct language. However, Yoruba is the language spoken by most of the people. Inhabitants of the communities include adherents to several religions faiths, including Christianity, Islam and traditional worship.

Anopheles gambiae, An. coluzzii and *An. arabiensis* are the three major vectors of malaria in Nigeria. These mosquitoes have developed resistance to different insecticides. Data on pyrethroids resistance intensity and resistance mechanisms from six vector surveillance sites (Lagos, Ogun, Edo, Anambra, Kwara and Niger) in Nigeria revealed high pyrethroid resistance associated with increased activities of metabolic enzymes (P450 + GST) in *An. gambiae* and *An. coluzzii* from Lagos and Ogun States in South West Nigeria [18]. The most prevalent species of malaria parasites in the communities of the LGA like other parts of the country is *Plasmodium falciparum* (>95%) [16].

Study population

Mothers of children under 10 years of age who were part of a larger WHO-funded study that assessed the impact of insecticide resistance on the efficacy of Insecticide Residual Spray (IRS) and LLIN in the study communities constituted the target population for this arm of study being primary care givers of children who are vulnerable to malaria.

Sampling procedures

The communities studied in the LGA were selected using purposive sampling based on sites that showed resistance and non-resistance to insecticides in the country. One respondent who mostly was the mother of children under 10 years of age per household the purposively selected for interview. These persons gave answers for other family members.

Data collection procedures

The approach to data collection in the study provided some elements of a quasi-experimental research design; pre-intervention, intervention and post-intervention [15].

Pre-intervention

Both qualitative and quantitative procedures were used to collect baseline data before intervention within a period of two weeks in July 2015. The qualitative data were collected using Focus Group Discussions (FGD) and In Depth Interviews (IDIs). A total of 6 FGD sessions and 6 IDIs were held among study population in the communities. The quantitative data were collected through household survey using semi-structured questionnaires that were administered by trained research assistants. A total of 310 mothers of children less than 10 years of age were interviewed in the household survey. Physical examination of LLINs in use was also conducted to ascertain the physical condition of the nets. Each house where selected households reside was assigned a code for easy identification for follow-up during the intervention ad post-intervention phases.

Intervention

Distribution of long lasting insecticide treated nets in the communities

Following the baseline data collection, 620 LLINs (PermaNet™ 2.0 and Duranet®) were distributed, two LLINs to each of the 310 households initially interviewed during the baseline phase of the study in the three communities [Bayeku (176); Oreta (232); and Imota (212)]. The 11-month intervention activities included continuous information, Education and Communication/Behavioral Change Communication (IEC/BCC) activities through which health education on malaria: Cause, signs and symptoms, preventive measures with emphasis on use of LLINs and the benefits of sleeping in LLIN were carried out in the communities.

Post-intervention

The evaluation included another round of household survey of 240 of the 310 households earlier surveyed at the pre-intervention time using systematic random sampling. The phase involved the replication of both the qualitative and quantitative data collection procedures in May 2016.

The questionnaire probed the socio-demographic characteristics of the respondents, their knowledge of cause of malaria, their knowledge of cause and prevention of malaria and use of LLIN, household sleeping pattern with LLIN and their practices relating to LLIN use and wash. Administrative approvals were obtained from the State and LGA authorities as well as from the traditional leaders at the community level respectively prior to commencement of the study. Ethical approval was obtained from the Institutional Review Board of the Nigerian Institute of Medical Research, Lagos (Reference number IRB/14/257). The respondents' informed consent was obtained before recruitment to participate in the study. This is in addition to community approval and consent obtained through advocacy visits by the research team to the selected communities for meetings with community leaders during which the purpose and objectives of the study were explained to them.

Data Analysis

Following the data collection, the questionnaires were screened, edited for clarity, completeness and uniformity of the responses, and then coded. The coded data were entered into the computer using SPSS version 20 software. Statistical analyses of the data set included univariate analysis to show the relative frequency distribution of each variable on the questionnaire, and bivariate analyses (Chi Square statistical tests) at a 95% level of significance to examine associations between selected independent and dependent variables relative to the study objectives. The qualitative data from the FGDs and IDIs were analyzed using the textual analysis program, Text base Beta, developed by Bo Summerlund and distributed by Qualitative Research Management of Desert Hot Springs, California, Text base Beta software [19,20]. First, the tape recorded discussions in local language were transcribed and back-translated into English language. Second, the transcripts were subsequently typed, summarised, categorized, coded and sorted into text segments according to similarities and differences in individual opinions and views based on themes arising from the discussion guides.

Results

A total of 550 respondents [Bayeku (30.5%); Oreta (35.6%); and Imota (33.8%)] were interviewed in the two phases. Of 550 interviewed in the two phases, 192 (44.0% [47.1% pre-intervention *vs.* 38.9% post-intervention)] lived in one-room apartments. Their ages ranged from 19 to 73 years (mean: 42.4 *vs.* 39.9 years; median 33.0 *vs.* 38.0 years). Most (55.6%) had minimum of secondary education, were traders (26.5%) and housewives (20.2%). Respondents were predominantly married (82.1%) ad of Christian (67.3%) and Islamic (30.7%) faiths. Their monthly income pre-intervention ranged from ₦10,000.00 (US$27.78) to ₦75,000.00 (US$208.33) with an average of ₦44,523.81 (US$123.68) and median of ₦45,000.00 (US$125.00). The respondents' monthly income post-intervention ranged from ₦3,000.00 (US$8.33) to ₦55,000.00 (US$152.78) with an average of ₦19,539.22 (US$54.28) and median of ₦12,000.00 (US$33.33).

The number of people per respondent's household pre-intervention ranged from 1 to 9 (mean=4, median=4) while number of children per household ranged from 1 to 8 (mean=2, median=2) and number of under-five children ranged from 1 to 3 (mean=1, median=1). The number of people per respondent's household post-intervention however ranged from 1 to 9 (mean=4, median=4) while number of children per household ranged from 1 to 5 (mean=3, median=3) and number of under-five children ranged from 1 to 3 (mean=2, median=2) (Table 1).

Knowledge of Mosquito Bite as Route of Malaria Transmission among Respondents

The women were asked question to ascertain their knowledge of the cause of malaria. Table 2 shows that pre- and post-intervention, 92.3% and 95.8% correctly knew mosquito bite as the transmission route of the malaria-causing parasite respectively. Chi Square statistical tests showed that pre-intervention, respondents' education (χ^2=21.5, df=4, p=0.000) significantly influenced their knowledge of mosquito bite as route of malaria transmission with a range of 95.8% among those with at least secondary education to 75.0% among those with no formal education. In contrast, their ages had no positive correlation with their knowledge of mosquito bite as the route of malaria transmission as there was no significant difference in the knowledge of the young and old respondents. Post-intervention, respondents' locality (χ^2=0.209, df=2, p=0.901), education (χ^2=1.320, df=3, p=0.724) and age (χ^2=1.963, df=3, p=0.580) had no significant influence on their knowledge of mosquito bite as route of malaria

Table 1: Socio-demographic characteristics of respondents.

Characteristics	Pre-intervention Number (%)	Post-intervention Number (%)	Total Number (%)
Community			
Bayeku	88 (28.4)	80 (33.3)	168 (30.5)
Oreta	116 (37.4)	80 (33.3)	196(35.6)
Imota	106 (34.2)	80 (33.3)	186 (33.8)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Age (in years)			
15-24	29 (9.4)	2 (0.8)	31 (5.6)
25-54	277 (89.4)	202 (84.2)	479 (87.1)
55-64	3 (1.0)	33 (13.8)	36 (6.5)
≥ 65	1 (0.3)	3 (1.3)	4 (0.7)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Education			
No formal education	8 (2.6)	39 (16.3)	47 (8.5)
Primary	41 (13.2)	109 (47.4)	150 (27.3)
Secondary	118 (38.1)	47 (19.6	165 (30.0)
Tertiary	96 (31.0)	45 (18.8)	141 (25.6)
Other	47 (15.2)	0 (0.0)	47 (8.5)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Occupation			
Unemployed	39 (12.6)	25 (10.4)	64 (11.6)
Housewife	76 (24.5)	35 (14.6)	111 (20.2)
Farming	6 (1.9)	48 (20.0)	54 (9.8)
Artisan	22 (7.1)	22 (9.2)	44 (8.0)
Trading	90 (29.0)	56 (23.3)	146 (26.5)
Civil servant	39 (12.6)	27 (11.3)	66 (12.0)
Professional	30 (9.7)	23 (9.6)	53 9.6)
Other	8 (2.6)	4 (1.7)	12 (2.2)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Marital status			
Never married	31 (10.0)	22 (9.2)	53 (9.6)
Married	255 (82.3)	202 (84.2)	457 (83.1)
Divorced	15 (4.8)	12 (5.0)	27 (4.9)
Widowed	9 (2.9)	5 (2.1)	14 (2.5)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Religion			
No religion	1 (0.3)	0 (0.0)	1 (0.2)
Christianity	207 (66.8)	163 67.9)	370 (67.3)
Islam	97 (31.3)	72 (30.0)	169 (30.7)
Traditional	5 (1.6)	5 (2.1)	10 (1.8)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Monthly income			
< ₦30,000 ($83.33)	10 (3.2)	36 (15.0)	46 (8.4)
₦30,000 ($83.33) – ₦50,000 ($138.89)	16 (5.2)	14 (5.8)	30 (5.5)
> ₦50,000 ($138.89)	16 (5.2)	1 (0.4)	17 (3.0)
Indifferent	268 (86.5)	189 (78.8)	457 (83.1)
Total	310 (100.0)	240 (100.0)	550 (100.0)
Housing structure			
Single family house	146 (47.1)	68 (28.3)	214 (38.9)
Duplex	46 (14.8)	21 (8.8)	67(12.2)
Two/Three bedroom flat	7 (2.3)	18 (7.5)	25 (4.5)
Mini flat	0 (0.0)	17 (7.1)	17 (3.1)
Room & parlour	0 (0.0)	35 (14.6)	35 (6.4)
Single room	111 (35.8)	81 (33.7)	192 (34.9)
Total	310 (100.0)	240 (100.0)	550 (100.0)

transmission.

Ownership and Use of LLIN among Respondents

Only 67.4% and 50.0% owned LLINs pre- and post-intervention respectively as presented in Table 3. In contrast, Table 4 shows that 57.4% and 40.8% used LLINs same period respectively. Results in Tables 3, 4 showed that the number of households that actually used their LLINs of those that owed the products decreased from 85.7% pre-intervention to 81.7% post-intervention.

The number of LLINs owned per household ranged from 1 to 7 with an average of one LLIN pre-intervention while the range was 1 to 4 LLINs post-intervention with an average of one LLIN. Number of LLINs owned per household further showed that 66.0% compared to 73.3% owned only one LLIN pre- and post-intervention respectively while 34.0% and 26.7% owned at least two LLINs pre- and post-

Table 2: Respondents' perceived cause of malaria.

Perceived cause of malaria	Pre-intervention (n=310) Number (%)	Post-intervention (n=240) Number (%)
Cold	8 (2.6)	0 (0.0)
Dirty surroundings	62 (20.0)	38 (15.8)
Eating ad food	6 (1.9)	8 (3.3)
Mosquito bite	286 (92.3)	230 (95.8)
Sun heat	2 (0.6)	0 (0.0)
Getting rained on	2 (0.6)	0 (0.0)
Stagnant water	102 (32.9)	19 (7.9)

Table 3: Household LLIN ownership among respondents.

Response	Pre-intervention Number (%)	Post-intervention Number (%)	Total Number (%)
Yes	209 (67.4)	120 (50.0)	229 (58.4)
No	101 (32.6)	120 (50.0)	321 (41.6)
Total	310 (100.0)	240 (100.0)	550 (100.0)

Table 4: Household LLIN use among respondents.

Response	Pre-intervention Number (%)	Post-intervention Number (%)	Total Number (%)
Yes	178 (57.4)	98 (40.8)	276 (50.2)
No	132 (42.6)	142 (59.2)	274 (49.8)
Total	310 (100.0)	240 (100.0)	550 (100.0)

Table 5: Who slept under LLIN in respondents' households the night before survey.

Response	Pre-intervention (n=178) Number (%)	Post-intervention (n=98) Number (%)
Pregnant mother	100 (56.2)	18 (18.4)
Under five children	88 (49.4)	19 (19.4)
Children over 5 years	46 (25.8)	11 (11.3)
Father	67 (37.6)	7 (7.1)

intervention respectively.

The LLIN use duration ranged from 1 to 36 months with an average of 7.5 months pre-intervention compared to LLIN use duration that ranged from 1 to 11 months with an average of 3 months and median of 4 months post-intervention. The LLIN use duration pre-intervention in Bayeku, Oreta and Imota was 8.7, 6.1 and 8.2 months respectively (χ^2=60.09, df=40, p=0.021) compared to 7.7, 7.2 and 4.4 months post-intervention respectively (χ^2=41.00, df=24, p=0.017).

LLIN ownership (χ^2=31.57, df=4, p=0.00) and use (χ^2=16.61, df=4, p=0.00) pre-intervention were positively associated with education as illustrated in Figure 2 where more respondents with higher education owned and used LLIN than those with little or no education. In contrast, respondents' level of education had no significant positive correlation with their ownership (χ^2=3.06, df=3, p=0.382) and use (χ^2=4.04, df=3, p=0.258) of LLIN post-intervention as illustrated in Figure 3. Similarly, LLIN ownership and use were not significantly determined by respondents' locality, age and housing structure post-intervention (p>0.05).

Only twenty-eight (9.0%) of respondents purchased their LLINs for household use pre-intervention while the 91.0% got theirs through public LLIN distribution campaigns. The cost of the LLINs purchased by the 28 respondents ranged from ₦1,000.00 (US$2.78) to ₦2,500.00 (US$6.94) with a mean of ₦1,628.57 (US$4.52) and median of ₦1,500.00 (US$4.17).

Following the physical examination of LLINs in the rooms of the 178 respondents who were actually using their LLINs pre-intervention, the treated nets of 84.3% were found to be in hanging positions with physical conditions of 94.4% of the nets intact (not torn/without holes). On the contrary, 100.0% respondents who actually use their LLINs post-intervention had their nets in hanging positions and intact (not torn/without holes).

When asked about the household arrangements under LLIN, only 56.2% and 49.4% of the respondents' households that actually use their LLINs had under-five children and pregnant women slept under LLIN a night before survey pre-intervention compared to 18.4% and 19.4% who did respectively post-intervention as shown in Table 5.

Reasons for not Using LLIN

When the respondents were asked about what they perceived as restraints to LLIN use by the people in their communities pre-intervention, they mentioned: inconveniences relating to LLIN use (e.g. hanging problem) (210, 67.7%); it causes heat/hot to sleep under (153, 49.3%); durability concerns as LLIN is perceived to get worn out and tear easily (126, 40.6%); gets dirty/stained and must wash frequently (102, 32.9%); add some people don't like the shape of the net (94; 30.3%).

On a personal note, the most echoed reasons for LLIN non-use by respondents as presented in Table 6 were: "it's too hot" (25.0% *vs.* 30.8%) and "no mosquitoes around" (29.5% *vs.* 25.3%).

Respondents' LLIN Washing and Drying Practices

In the pre-intervention phase, only 110 (35.5%) of 310 respondents reported ever washing their LLINs. Of these, 43.6% washed the LLINs every two months while 37.3% and 18.2% claimed to do same every 3 to 5 months and monthly respectively while 0.9% could not remember. The women claimed to wash their LLINs 1 to 6 times a year with a mean of 2 times per year. The average annual washing rate per net pre-intervention in Bayeku, Oreta and Imota was approximately 2 times respectively (χ^2=13.92, df=10, p=0.177). The LLINs were mostly washed using harsh soaps/detergents (82.9%),

Table 6: Respondents' perceived reasons for LLIN non-use in their households.

Reasons for LLIN non-use	Pre-Intervention (n=132) Number (%)	Post-intervention (n=146) Number (%)
No mosquitoes around	39 (29.5)	37 (25.3)
Net not available in the community	16 (12.1)	56 (38.4)
LLINs cause heat	33 (25.0)	45 (30.8)
Can't afford it	9 (6.8)	8 (5.5)
No response	35 (26.5)	0 (0.0)

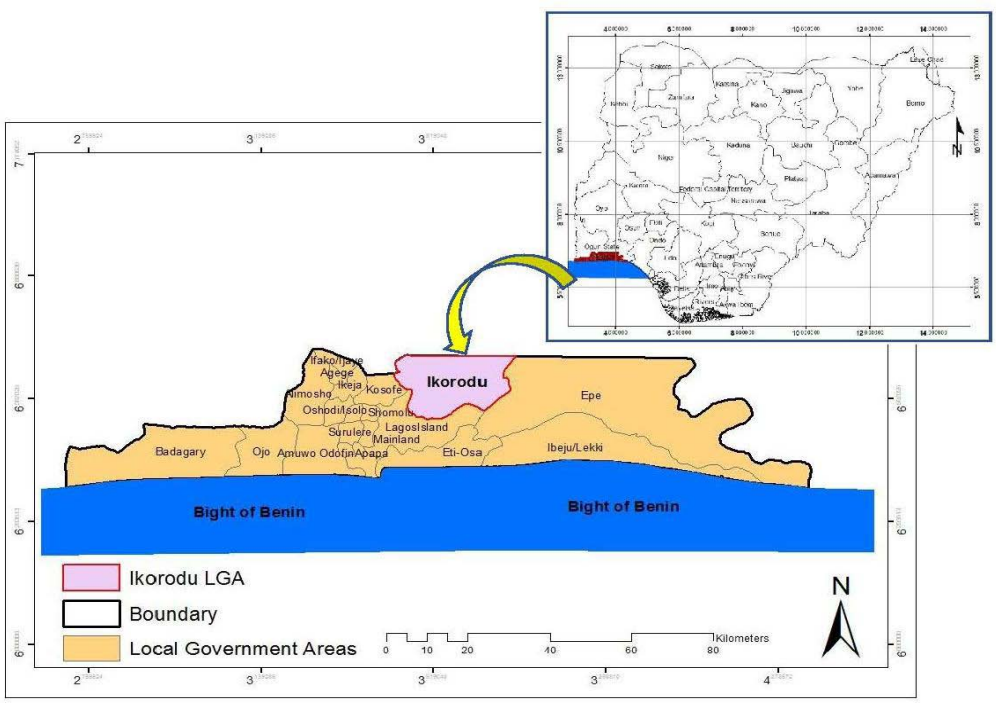

Figure 1: Map of Lagos State showing the study LGA.

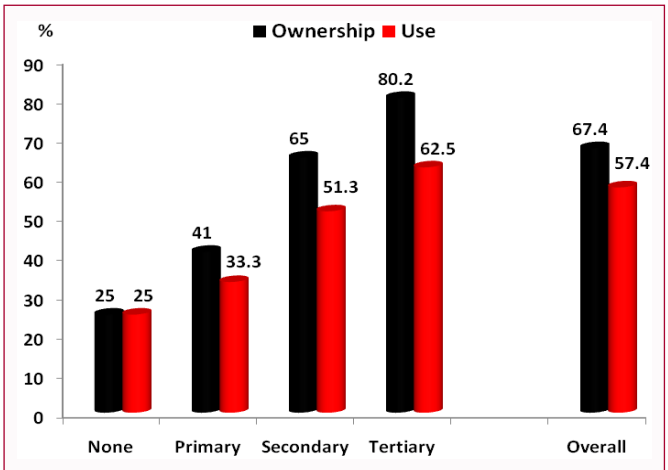

Figure 2: LLIN ownership and use according to respondents' education pre-intervention.

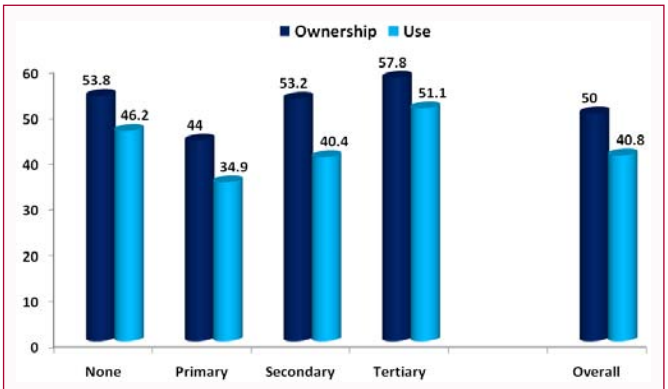

Figure 3: LLIN ownership and use according to respondents' education post-intervention.

toilet soaps (38.2%) and 0.9% reported to have simply rinsed their LLINs in water.

How often LLIN is washed among respondents reduced post-intervention (30.8%) with increased use of toilet soaps (100.0%) and none reporting use of harsh soaps/detergents. Of the 74 who reported to have washed their LLINs, 88.4% washed the LLINs every two months, 13.5% every 3 to 5 months and 5.4% reported to do same monthly. The women washed their LLINs 2 to 5 times with an average of 5 times within the one-year intervention period. Similarly as recorded pre-intervention, the average annual washing rate per net post-intervention in Bayeku, Oreta and Imota was approximately 2 times respectively (χ^2=16.83, df=4, p=0.002). Chi-square statistical tests showed that education had no significant relationship with respondents' probability of ever having washed their LLIN and washing of LLIN using the appropriate soap pre-intervention (p>0.05) as illustrated in Figure 4 and post-intervention where all 74 (100.0%) who reported to have washed their LLINs did so using toilet soaps regardless of their level of education (p>0.05).

The drying practices after washing the LLINs among respondents

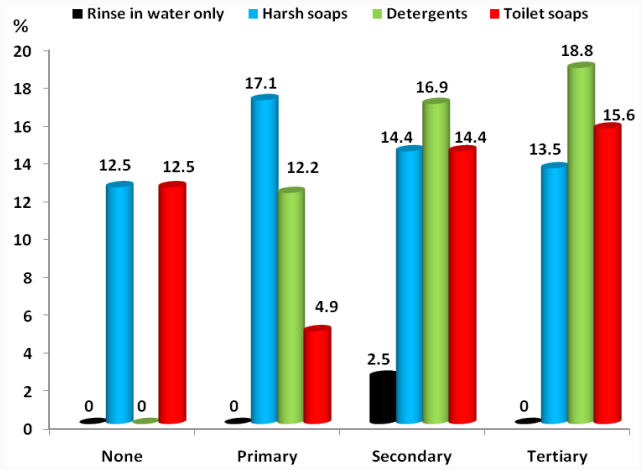

Figure 4: LLIN washing pattern among respondents according to education pre-intervention.

showed improvement as all 74 (100.0%) who reported to have washed their LLINs avoided drying their nets in the direct sunlight post-intervention. This is contrary to only 17 (15.5%) of 110 who reported that they avoided drying their nets in the direct sunlight after washing their nets compared to 84.5% who dried their nets in the direct sunlight pre-intervention.

Discussion

This paper documented the dynamics of ownership, usage and washing pattern of LLINs and how these dynamic factors may impact the effective lifetime of LLINs in three rural communities of Lagos State, Nigeria. The arm of study on which the paper is based was limited, focusing only on one geographic setting of the country and not taking account of insecticide retention analysis to determine the insecticidal bio-efficacy and fabric integrity of the LLINs.

It is interesting to note that Table 1 included never married woman knowing that it is mentioned in the study design that the surveys were done by interviewing the mothers of children under 10 years. A large number of this group of unmarried respondents are constituted by a significant number of the young adults aged 15 to 24 years having children out of wedlock which could be attributed to mean age at first sexual intercourse and high prevalence of unintended pregnancy and childbearing among unmarried young women reported by Adebowale et al. [21] in Lagos State, Nigeria.

The high correct knowledge of mosquito bite as the route of malaria transmission exhibited by most respondents regardless of some misconceptions about the cause of malaria by a few is commendable. This success could be attributed to the many years of extensive community health education activities that have been implemented as a component of the malaria control program implemented by the three tiers of government (Federal, State and local) across the country.

The increased correct knowledge of mosquito bite as the route of malaria transmission and reduced misconceptions about the cause of malaria among the respondents studied post-intervention in Table 2 are attributable to the 12-month intervention activities carried out. The insignificant influence of respondents' locality, education and age post-intervention on knowledge of mosquito bite as the cause of malaria attest to the impact of the extensive health education activities carried out in the three communities among all strata of the study population regardless of education and age.

Results showed that LLIN use was low despite the high levels of knowledge of cause of malaria in populations studied. This shows that nearly 60% of the households studied were out of net coverage in the communities post-intervention compared to about 40% recorded pre-intervention. Hence, the Malaria Control Program implementer particularly in the Ikorodu LGA has to intensify efforts to ensure 100% LLIN coverage in communities therein. Considering the number of years of LLIN distribution campaigns to increase LLIN coverage in the country particularly Lagos State, the rate of LLIN use is anticipated to be higher than what was recorded in the study. The rates of LLIN use recorded pre- and post-intervention are nowhere near the RBM 2005 and 2010 targets of 60% and 80% net use respectively [22,23]. The low LLIN use compared to the high levels of knowledge of cause of malaria is in contrast to what is expected given that lack of knowledge about how malaria is spread interferes with the ability to take appropriate preventive measures [16]. The low LLIN use is not unconnected with the reasons echoed by respondents as restraints to wide use of nets in the communities studied. It is evident that a large number of households in the communities studied were not using the LLINs provided by the State Ministry of Health and other non-government agencies through LLIN distribution campaigns in recent past.

The low rate of LLIN post-intervention compared to pre-intervention however could be attributed to the season of the year when the two data sets were collected. The higher rate recorded pre-intervention could be explained by the need to prevent mosquito bites by the people due to the abundance of mosquitoes in July 2015 which is close to the peak of the rainy season in the rain forest zone of the country when the temperature is relatively cooler and the rains are intense and consistent with many breeding sites for mosquitoes compared to the post-intervention in May when the wet season is just commencing with inconsistent rainfall and a relatively higher temperature. This seasonal difference perhaps contributed to decrease in household LLIN use recorded post-intervention compared to pre-intervention among those who owed LLINs as more respondents in Table 6 attributed their non-use of LLIN to "it's too hot" when interviewed post-intervention in May 2016. The texture of the LLIN fiber being polyethylene may possibly contribute to the LLINs causing the heat reported by the concerned respondents. This is possible considering the fact that polyethylene is a good insulator as described by The Association of Plastics Manufacturers (Plastics Europe) [24] because of its poor heat conduction due to having virtually no free electrons available for conduction mechanisms like metal.

The household LLIN ownership and use reported in this study are higher than the finding of Adeneye et al. [25] among pregnant women and mothers of children under five years in Ogun State. Similarly, the trend of results show that the findings of this study are higher than the national average and household ownership and use of LLINs in Lagos State reported in the 2010 and 2015 Nigeria Malaria Indicator Surveys by National Population Commission Nigeria et al. [16] and National Malaria Elimination Program (NMEP) [12] respectively. This corroborates the assertion of the World Health Organization that the proportion of the population with access to Long Lasting Insecticide-treated Nets (LLINs) and sleeping under one as a cost-effective and efficacious method of controlling malaria has steadily increased in sub-Saharan Africa including Nigeria over the past decade. The rate

of LLIN use recorded pre-intervention is in the range reported by Anuse et al. [26] among households in two malaria endemic districts of the Odisha State, India but higher that the 41.7% reported among caregivers of children under 5 years in Ho municipality of Ghana [27]. The rate of household LLIN ownership and use recorded in this study is encouraging and not unconnected to the long standing LLIN distribution campaigns through government and non-government (including UNICEF and Global Fund) programs that have distributed millions of LLINs to increase coverage levels across the country including Lagos State. Nevertheless, based on the results, efforts need to be intensified with investment in additional resources to scale-up LLIN coverage by making the LLINs more abundantly available, accessible and affordable in the communities.

The low LLIN use reported in the study is not unconnected with the numerous reasons that were echoed as restraints to wide use of LLINs the communities studied as evident in Table 6 by the number of respondents who attributed their non-use to "no mosquitoes around" pre- and post- intervention.

Net ownership does not guarantee usage. The disparate pattern of household LLIN ownership and use reported in this study is consistent with those of earlier studies in Nigeria by National Malaria Elimination Program (NMEP) et al. [12], National Population Commission [Nigeria] et al. [16] and Adeneye et al. [25].

Given that LLINs offer personal protection from malaria and other insect borne diseases by imposing both physical and chemical barrier to human mosquito contact, and these protections can be compromised during normal household use, the longer period of LLIN usage and possibly the washing pattern and practices reported in this study pre-intervention compared to post-intervention perhaps explain the high number of physically damaged LLINs observed in the former compared to the latter.

In Table 5, the impact of the IEC/BCC intervention activities is observed to have reflected in the percentage decrease in the number of fathers who are mostly household heads who slept in LLIN compared to percentage increase in the number of children over 5 years old who slept in LLIN post-intervention. It is encouraging that the number of children under 5 years ad pregnant women remained highest in this regard although below the past RBM 2010 target of 80% [22,23]. This finding suggests the need for re-focusing IEC/BCC messages regarding the importance of LLIN use among children under 5 years and pregnant women in the communities.

On how frequent LLINs are washed by respondents studied, the fact that most respondents reported washing their LLINs at least once in every one to two months could be related to the numerous laterite roads and dusty environment in the communities. The dusts raised from the environment could be explained to probably make the nets prone to easily becoming dirty from dusts that frequently settle on them in the respondents' homes.

Health education on LLIN use and consequences of washing habits on LLIN long-lasting efficacy hence need be intensified in the communities, emphasizing LLIN benefits, the effects of household use and washing pattern that may profoundly impact the fiber quality and effective lifetime of insecticide treatment of the LLINs and how to appropriately wash and dry the LLINs for reduced malaria transmission, case incidence and related mortality. It is suggested that the LGA Malaria Control Program implementers develop and implement locally appropriate community and advocacy strategies to promote effective use of LLINs and avoid excessive washing and use of harsh soaps/detergents particularly how these could cause physical and insecticidal deterioration of LLINs. The communities should be adequately educated on these in order to increase the rate of LLIN use and avoid incorrect washing and drying practices. It is also recommended that IEC/BCC campaign messages emphasize the importance of LLIN care and repair as a means of extending the useful lifetime of LLINs. This is important if the target of WHO Global Technical Strategy for Malaria 2016-2030 of eliminating malaria in at least 35 countries by 2030 [28] is to be realized in Nigeria in general, and Lagos in particular.

Conclusions

The results offer insights for more pragmatic malaria control program planning and operationalization in the Ikorodu LGA where the study communities are located if the goal to achieve the strategic action plan on malaria elimination in the communities and the country at large is to be secured from the perspective of effective use of LLINs.

In view of reported low use of LLINs in the population studied, continuous public health education on LLIN use and the consequences of washing habits on LLIN long-lasting efficacy is desirable and need to be intensified in the communities. The needed focus and emphasis on ensuring the increased knowledge of benefits of using LLIN and the appropriate washing methods are met, is crucial to sustainability in achieving the malaria elimination target of the studied Lagos communities in particular and the country in general.

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