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Coverage and use of insecticide-treated bed nets in households with children aged under five years in Liberia

L. L. Bawo,[1] A. D. Harries,[2,3] T. Reid,[4] M. Massaquoi,[5] R. Jallah-Macauley,[6] J. J. Jones,[7] C. S. Wesseh,[1] J. Enders,[7] L. Hinneh[7]

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Setting: St John's District, Grand Bassa County, Liberia.
Objectives: In households with children aged <5 years, to examine the coverage and use of long-lasting insecticide-treated bed nets (LLINs), factors associated with non-use and the characteristics and conditions of bed nets.
Design: Cross-sectional study involving interviews with mothers and visual inspection of LLINs.
Results: Of 663 households visited, 492 (74%) had no LLIN and 135 (20%) had one LLIN. Of 171 households with LLINs, these were consistently used by 73 (43%) children. The main reasons for inconsistent use included LLINs being old or damaged, and LLINs generating too much heat for 20–30% of children. Visual inspection of LLINs in 130 households showed that 98% of LLINs were white, 20% were not hung above the child's sleeping place, 30% had holes, 84% were double-bed sized and 82% had been washed in the previous 6 months.
Conclusion: Despite reports of 100% LLIN coverage in St John's District, this study showed that only a quarter of households had an LLIN, over half of the children used LLINs inconsistently and the LLINs had several deficiencies. More surveys should be conducted to determine the true coverage of LLINs in Liberia, and measures must be taken to improve the use of LLINs.

Malaria is a major cause of morbidity and mortality in the under-five population in sub-Saharan Africa. An estimated 216 million cases of malaria occurred globally in 2010, with 81% of the global burden affecting the World Health Organization (WHO) African Region.[1] In the same year, there were around 655 000 deaths from malaria, with 86% of these deaths occurring in children aged <5 years.[1,2] The economic impact is also high, with malaria being responsible for an almost 12 billion dollar loss in gross domestic product (GDP) each year in the African region and accounting for slower economic growth in the region (−1.3%).[3]

The global malaria control strategy consists of five main interventions, one of which is the provision of long-lasting insecticide-treated bed nets (LLINs).[4] The use of LLINs has been viewed as a simple and effective initiative that could be widely scaled up in malaria-endemic countries in sub-Saharan Africa.[5] Good progress has been reported. In 2010, an estimated 145 million people in sub-Saharan Africa received an LLIN, 50% of households were estimated to have at least one LLIN and 96% were reported to have had access to its protective features.[1] The Abuja Summit of 2000 had set a target that by the year 2010, 80% of vulnerable groups (pregnant women and children) would be sleeping under an LLIN.[6] However, proper hanging up of nets and long-term retention of nets have posed significant challenges to attaining this specific target.[7] In addition, in households with low numbers of LLIN per household member, the access of children to LLINs may be compromised.[8] More information is needed about the use of LLINs in routine conditions for these vulnerable groups, especially children.

Liberia is a small country in West Africa where malaria is endemic. There is a national malaria control programme and reported good coverage of LLINs. However, malaria continues to be a leading cause of outpatient department (OPD) attendance and in-patient mortality amongst children under the age of 5 years.[7] The reasons for this disparity are not clear, but may reflect other components of the national malaria control strategy not being effectively implemented, inappropriate use of LLINs or poor quality LLINs, as has been reported from other African countries.[5]

The aim of the current study was to examine LLIN use in households in one district in Liberia for children under the age of 5 years. Specific objectives were to record and document 1) the characteristics of the households surveyed, including the number and use of LLINs within these households, 2) factors associated with non-use of LLINs by children under 5 years of age, and 3) characteristics and condition of LLINs from visual inspection.

METHODS

Design

This was a cross-sectional study using a structured questionnaire 1) to interview mothers of children under the age of 5 years in St John's District, Grand Bassa County, Liberia, and 2) to visually inspect LLINs.

Setting

Liberia is situated on the coast of West Africa, with a population of 3.6 million and an under 5 mortality rate of 235 per 1000 population.[9] Liberia shares borders with Sierra Leone, Guinea and the Ivory Coast. Malaria is endemic in the country, and in children under the age of 5 years malaria is the leading cause of OPD attendance (38%) and the top cause of in-patient deaths, where it accounts for 42% of paediatric in-patient mortality.[7] Liberia has had a national malaria control programme for many years, with current interventions focused on LLINs, annual indoor residual spraying of households,

AFFILIATIONS
1 Ministry of Health and Social Welfare, Monrovia, Liberia
2 International Union Against Tuberculosis and Lung Disease, Paris, France
3 London School of Hygiene & Tropical Medicine, London, UK
4 Médecins Sans Frontières, Operational Centre Brussels, Luxembourg
5 Clinton Health Access Initiatives, Monrovia, Liberia
6 Rebuilding Basic Health Services, Monrovia, Liberia
7 National Malaria Control Program, Monrovia, Liberia

CORRESPONDENCE
Luke L Bawo
Ministry of Health and Social Welfare
Monrovia, Liberia, West Africa
Tel: (+231) 886 909 945
email: lukebawo@yahoo.com

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TABLE 1 Progress with national malaria control interventions in Liberia, 2008–2010[10]

Malaria control intervention	Coverage *n**	
Long-lasting insecticide-treated bed nets distributed in Liberia	2 481 551	
Cases treated for malaria using artemisinin-combination therapy	2 358 372	86% of malaria cases (confirmed and non-confirmed)
Pregnant women receiving a second dose of intermittent presumptive treatment for malaria	111 724	21.8% of pregnant women
Households protected by indoor residual insecticide spraying	60 000	8.8% of households

*Number of persons or households.

intermittent presumptive treatment of malaria in pregnant women, early diagnosis of malaria by microscopy or rapid diagnostic tests, and effective treatment with artemisinin-based combination therapy.[10] Progress with the national malaria control strategy has been good, and updated information is provided in Table 1.[10]

The study site was St John's District in Grand Bassa County, located in South Central Liberia. The population of the district is 11 000, of whom 1900 are under 5 years of age.[11] The leading causes of morbidity, particularly among children under the age of 5 years, are malaria, diarrhoea, respiratory infections and worms. Malaria accounts for 65% of under five consultations, and is more prevalent during the rainy season (annual rainfall 4500 mm). St John's District, like the rest of Liberia, has rainy and dry seasons, each lasting 6 months of the year. Temperatures range from 23° to 32°C, with high humidity. The district has 2200 households, and as part of the district's malaria control activities every household is meant to have an LLIN, with a reported coverage of 50% to 100% between 2009 and 2010.[12] Despite this, the proportion of under five malaria cases has increased, and in 2009 and 2010, confirmed under five cases of malaria accounted for 49% and 65% of total under five consultations, respectively.[13]

Study population

Mothers with any children under the age of 5 years in selected households in St Johns District were included in the study, which was conducted in the month of May 2012. The sample size for households to be surveyed was calculated with 95% confidence intervals and was based on 50% frequency of poor LLIN usage (with the worst acceptable result being 45%), giving the number of households needing to be evaluated as 327. Taking the cluster and design effect into account, the number of households to be assessed was estimated at 654, which was rounded off to 660. The next phase of selecting villages and households was based on the two stage cluster sampling methodology endorsed and used by the World Health Organization for the Expanded Program on Immunization (EPI) Cluster Surveys.[14] Using this method, 33 villages were selected from the total listing of all villages in the district, and 20 households were randomly selected from within each village for interviews.

Data variables

Data variables were collected during interviews with the mothers, providing the following characteristics for each household: age, education and average monthly household income; number and demographic characteristics of children living in the household; availability, number and use of LLINs in the household, with use categorised as consistent (defined as the use of a LLIN each night for the previous 7 nights for children under the age of 5 years) or not, and also as used or not by the children during the previous night. Acceptable LLIN coverage of a household was defined as at least three nets per household.[10] Permission to inspect LLINs was requested from each household that had an LLIN.

Data collection

Data were collected using a structured questionnaire based on interview with the mother. The questionnaire was developed from previous examples of work conducted in other countries and adapted to the Liberian context; it was pre-tested in a community of rural Monrovia, the capital city, and was later mass-printed after adjustment. Interviews were conducted by teams of trained interviewers with prior experience in conducting interviews in rural areas. After the interviewer had introduced him/herself to the mother, he/she presented a copy of the informed consent form to the mother along with a detailed explanation of the interview's purpose and content.

Data entry, analysis and statistics

Data were extracted from the completed questionnaires by data-entry clerks, and double-entered into an EpiData (EpiData Association, Odense, Denmark) electronic file. Frequencies and percentages were calculated as appropriate. In the analysis and reporting, full confidentiality was preserved and only aggregate information was provided.

TABLE 2 Characteristics of households surveyed and use of long-lasting insecticide-treated bed nets in St John's District, Liberia

Characteristic	*n* (%)
Households surveyed	663
Occupants per household	
1–2	12 (2)
3–4	197 (30)
⩾5	454 (68)
Children per household	
1–2	98 (19)
3–4	216 (41)
⩾5	208 (40)
Age of mothers interviewed, years	
<15	0
15–19	67 (10)
20–24	112 (17)
25–29	148 (22)
30–34	132 (20)
⩾35	204 (31)
Maternal education	
No education	440 (66)
Primary	170 (26)
Secondary	51 (8)
Higher or other	2
Personal monthly income (LRD)	
No monthly income	163 (25)
⩽100	98 (15)
101–300	74 (11)
301–500	97 (15)
501–1000	139 (21)
⩾1001	92 (13)
LLINs per household	
No LLIN	492 (74)
1	135 (20)
2	30 (5)
3	5 (1)
⩾4	1

LRD = Liberian dollar (US$1 = 70 LRD); LLIN = long-lasting insecticide-treated bed net.

The study was approved by the Médecins Sans Frontières Ethics Review Board for the analysis of routinely collected programme data and by the Ethics Advisory Group of the International Union Against Tuberculosis and Lung Disease, Paris, France. Ethics approval was similarly obtained from the Liberian Institute for Biomedical Research Ethics Committee.

RESULTS

Characteristics of households and utilisation of LLINs

There were 663 households visited, the characteristics of which are shown in Table 2. The mean number of occupants per household was six, the mean number of children per household was four and the mean age (± standard deviation) of the mothers interviewed was 30 (± 8) years. The majority of the mothers had received no formal school education. Most of the mothers were poor, with 495 (75%) having no personal source of income. There were 492 (74%) households with no LLIN, with most of the remainder having one LLIN. Only six (1%) households fulfilled the malaria control definition of LLIN coverage (i.e., three nets per household). Of 171 households that had an LLIN for a child under the age of 5 years, the net was consistently used by 73 (43%) children and had been used the night before by 120 (70%) children.

Factors associated with non-usage of LLINs by children aged <5 years

For the 98 children who did not consistently use the LLIN and the 51 who had not slept under the LLIN the night before, the six main reasons, which were not mutually exclusive, are shown in Table 3. The reasons for each category were generally similar, except that no mother forgot to hang the net the night before the interview. Having an old LLIN, an LLIN that generated too much heat or an LLIN that was damaged was a factor said to be responsible for inconsistent use or non-use the previous night for 20–30% of the children.

Characteristics and condition of LLINs from visual inspection

The characteristics and condition of LLINs were documented for 130 (76%) households with a bed net (Table 4). Almost all the LLINs were white, nearly 80% were hanging above the child's sleeping place, about one third had holes, the majority of LLINs were double-bed size and 82% had been washed within the last 6 months, with nearly half of these washed in the last month. The issue of size is important: in many of the households visited, a double-bed size net exceeded the size of the sleeping place, and even on occasions the size of the room (Figure).

TABLE 3 Factors associated with non-use of long-lasting insecticide-treated bed nets by children aged <5 years in St John's District, Liberia

Factors associated with non-use of LLIN	Children who did not consistently use the LLIN (n = 98) n (%)	Children who did not sleep under a LLIN the night before the interview (n = 51) n (%)
Old bed nets	29 (29)	16 (31)
Bed nets generating too much heat	21 (21)	10 (20)
Bed nets damaged or with holes	21 (21)	15 (29)
Mothers forgot to drop the bed net over the bed	10 (10)	0
Bed nets that could not be hung over the sleeping place	7 (7)	11 (22)
Dirty bed nets or bed nets taken down for washing	6 (6)	6 (12)

LLIN = long-lasting insecticide-treated bed net.

TABLE 4 Characteristics and conditions of long-lasting insecticide-treated bed nets used by children aged <5 years in the surveyed households in St John's District, Liberia

Characteristic	n (%)
Bed nets inspected	130
Bed net colour	
White	128 (98)
Blue	1 (1)
Green	1 (1)
Bed nets hanging above the child's sleeping place	
Yes	102 (79)
Presence of holes in the bed nets	
Yes	42 (32)
Bed net size	
Single bed	21 (16)
Double bed	108 (84)
Bed nets washed in the last 6 months	
Yes	107 (82)

DISCUSSION

The findings of this study, that a quarter of households had an LLIN, are in contrast to previous reports from the national malaria control programme that in 2010 the coverage of LLINs in St John's District was 100%. The reasons for this disparity need to be understood. It is possible that much has changed with bed net coverage in the intervening 2 years and it is also possible that the nets may have passed their effective life span. If not, then questions must be asked about the accuracy of the sources of data that inform national reports. The poor coverage of LLINs and the inconsistent use of nets that we have documented in this study are in keeping with the information obtained from out-patient

FIGURE A typical rural household and a long-lasting insecticide-treated bed net in St John's District, Liberia.

attendances and in-patient mortality statistics that there is a large and increasing burden of malaria in under-five children. The mean ratio of 4.9 household residents per LLIN in Liberia is consistent with studies carried out in other endemic African countries (6.8 in Senegal, 3.7 in Tanzania and 3.98 in Southern Ethiopia).[8,15] These numbers indicate that there are many household members with few nets per household, which in turn leads to some household members being excluded from sleeping under the net: in some instances, this would be children under one year of age.

Prior to the study, 70% of children under the age of 5 years in households that owned at least one LLIN had slept under the net, with 43% of them using the nets consistently for the previous 7 nights. The literature reveals a range of 58–69% of children under the age of 5 years sleeping under an LLIN during the previous night.[8,15,16] The factors associated with the non-use of LLINs in St John's district in this study were diverse, and included nets being old, nets generating too much heat or nets being taken down for washing. These results are consistent with findings of other studies carried out in the African Region.[8,15,16,17]

The strengths of this study are that a large number of households were surveyed as a result of taking into account the cluster and design effect, the questionnaire was designed from a template used previously in Africa for determining use of LLINs, the questionnaire was pre-tested prior to the actual study, interviews were carried out by teams of people who had been trained for 2 days, and all collected data were double-entered into an EpiData electronic file. The reporting format of this study also adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies.[18] Limitations include the fact that the questions relied on maternal recall and the responses may have been prone to recall bias. St John's District is rural and poor, mothers had lower levels of education and household sizes were larger than the national average,[19] and the district and households therefore may not have been representative of the country.

There are some useful take home messages from this study. First, a more widespread survey of different districts in Liberia should be carried out using the same questionnaire to obtain a more accurate picture of LLIN coverage and use in the national population. This would better inform the national malaria control programme about the degree of implementation of an important component of the disease control strategy. Second, there needs to be a better and more formal system of allowing damaged, holed and old bed nets to be repaired or replaced and oversize bed nets to be changed to a smaller size to fit the house or room, so that where households are using the nets these are as effective as possible. White is not a good colour for the LLIN, and in rural areas can result in house-proud mothers often washing the nets because of their dirty appearance, with the result that the nets may not be used and the long-lasting insecticide gradually removed. Third, in the hot weather, when mosquitoes may be at their maximum numbers, the generation of heat from within the nets is a serious challenge to their regular use, and innovative ways of making nets user-friendly need to be found. Fourth, the malaria control programme should think of how best to conduct regular monitoring and supervision so that the use and condition of LLINs can be objectively evaluated. Finally, there needs to be sustained community education about the value of LLINs and the need for regular, consistent use.

CONCLUSION

Despite reports of 100% LLIN use in one district in Liberia, this survey in over 650 households, in which there was one or more children under the age of 5 years, revealed that only a quarter of households had an LLIN. In those households with an LLIN, less than 50% of children used their bed nets consistently, with several deficiencies in the nets being associated with non-use. More surveys should be carried out in Liberia to determine the true coverage of LLINs, and various measures should be put in place to increase better use of nets by children at risk of malaria.

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Contexte : District de St John, comté de Grand Bassa, Libéria.
Objectifs : Dans les ménages comportant des enfants âgés <5 ans, examiner la couverture et l'utilisation des filets de lit traités par des insecticides à longue durée d'action (LLIN), les facteurs associés à leur non-utilisation ainsi que les caractéristiques et l'état d'entretien des filets de lit.
Schéma : Etude transversale comportant des interviews avec les mères et l'inspection visuelle des LLIN.
Résultats : Sur 663 ménages visités, 492 (74%) ne possédaient pas de LLIN et 135 (20%) en avaient un seul. Sur les 171 ménages avec LLIN, ceux-ci étaient utilisés de manière régulière par 73 enfants (43%). Les raisons principales de leur utilisation irrégulière ont comporté l'ancienneté ou les détériorations des LLIN, ainsi que le fait qu'avec les LLIN la température était trop élevée chez 20 à 30% des enfants. L'inspection visuelle des LLIN dans 130 ménages a montré que 98% des LLIN étaient blancs, 20% ne pendaient pas au-dessus du lieu de sommeil de l'enfant, 30% comportaient des trous, 84% avaient la taille d'un lit double et 82% avaient été lavés au cours des 6 mois précédents.
Conclusion : En dépit des rapports signalant une couverture de 100% des LLIN dans le district de St John, cette étude a montré qu'un quart seulement des ménages avaient un LLIN, que plus de la moitié des enfants utilisaient les LLIN de manière irrégulière et que les LLIN comportaient plusieurs déficiences. Un plus grand nombre d'études devrait être menées afin de déterminer la véritable couverture des LLIN au Libéria et des mesures doivent être prises pour accroître un meilleur usage de ces LLIN.

Marco de referencia: El distrito de Saint John del condado de Grand Bassa en Liberia.
Objetivos: Examinar la cobertura y la utilización de los mosquiteros impregnados con insecticidas de acción prolongada en hogares de niños de <5 años de edad, los factores asociados con la falta de su uso y las características y estado de los mosquiteros.
Método: Se llevó a cabo un estudio transversal mediante entrevistas con las madres e inspección visual de los mosquiteros.
Resultados: De los 663 hogares que se visitaron, 492 (74%) no contaban con mosquiteros impregnados con insecticidas de acción prolongada y en 135 de los hogares restantes (20%) existía uno de estos mosquiteros. En los 171 hogares dotados de mosquiteros, estos eran utilizados de manera constante por 73 niños (43%). Las principales razones de la inconstancia del uso fueron que los mosquiteros estaban viejos o dañados y que generaban demasiado calor en 20% a 30% de los niños. La inspección visual de los mosquiteros en 130 hogares puso en evidencia que 98% de ellos eran blancos, 20% no estaban colgados sobre el sitio donde dormía el niño, 30% estaban perforados, 84% eran de tamaño para cama doble y 82% habían sido lavados en los últimos 6 meses.
Conclusión: Pese a los informes de 100% de cobertura con los mosquiteros impregnados con insecticidas de acción prolongada en el distrito de Saint John, los resultados del estudio indican que solo un cuarto de los hogares poseía un mosquitero, más de la mitad de los niños lo usaban de manera inconstante y que los mosquiteros presentan varias deficiencias. Es preciso realizar nuevas encuestas que determinen la cobertura real en Liberia y tomar las medidas encaminadas a fomentar un mejor uso de estos mosquiteros.

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