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Nicole Keusch                                          Date

Sleeping Space Characteristics and Intra-household Sleeping Arrangements in Eastern
Madagascar

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B.A., University of Michigan, 2009

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An abstract of

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# Abstract

Sleeping Space Characteristics and Intra-household Sleeping Arrangements in Eastern Madagascar

by Nicole Keusch

**Background/Objective:** Relatively little is known about sleeping arrangements and intra-household mosquito net use in Madagascar—information that is needed to guide information, education and communication campaigns associated with malaria control activities. The objective of this thesis is to describe intra-household sleeping arrangement patterns in order to support an assessment on factors associated with mosquito net use.

**Methodology:** A community-based, cross sectional household survey using a three-stage cluster sample design was conducted on the East Coast of Madagascar April-May 2010 to evaluate long-lasting insecticidal net (LLIN) ownership and use after a large bednet campaign. A probability sample of households was selected and a standard questionnaire, which included an inventory or roster of each household member, bednet and sleeping space. Demographic information and information linking each household member to the sleeping space used the night before the survey was recorded. Intra-household, sleeping arrangements were analyzed and described and stratified by type of sleeping space and LLIN coverage or non-coverage. Multivariable models were constructed to explore factors associated with selected sleeping arrangement patterns. .

**Results:** On average there were 1.7 sleeping spaces per household and the average number of persons per sleeping space decreased as the number of sleeping spaces per household increased. Among all sleeping spaces, the most commonly occurring sleeping arrangement is one or more children aged 5 to 14 years with no other person-type categories present. As the number of sleeping spaces per household increased, the proportion sleeping spaces with single person-type sleeping arrangements increased, whereas the proportion of sleeping spaces occupied by three or more person-type sleeping arrangements decreased. The sleeping arrangement patterns for temporary sleeping spaces and sleeping spaces not covered by LLINs differed from the sleeping arrangement patterns for all household-sleeping spaces.

**Discussion:** An important pattern observed was the relationship between at least one man aged 15 to 49 years, at least one woman aged 15 to 49 years and at least one child under the age of 5 years sharing a sleeping space. This relationship hinged on the woman aged 15 to 49 years, who was significantly associated with sharing a sleeping space with each of the other two person-types, whereas men aged 15 to 49 and children under the age of 5 years were much more likely to share a sleeping space when a woman aged 15 to 49 years was present. This suggests women aged 15 to 49 in general may be an important priority target population when addressing intra-household LLIN coverage and use.

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## Acknowledgements

# Introduction and Rationale

Malaria typically presents as an acute febrile illness caused by the *Plasmodium* parasite, which is most commonly transmitted through the bite of anopheline mosquitos. While 108 countries had ongoing malaria transmission in 2009, including countries in Asia, Latin America, the Middle East and Europe, the most malaria cases and 90 percent of malaria deaths occur in sub-Saharan Africa [1]. As malaria is a treatable infection, prompt diagnosis and treatment of non-complicated malaria cases with artemisinin-based combination therapy (ACTs) is an important aspect of malaria control in terms of reducing morbidity, preventing deaths and reducing the continued transmission of the parasite.  However, vector control through the use of insecticide-treated nets (ITNs) and indoor residual spraying (IRS) with insecticides, are the most effective ways to significantly prevent and reduce malaria at the community level [1].  National Malaria Control Programs and partner organizations plan and implement a combination of these and other interventions for malaria control at national levels.

In Africa, the types of *Anopheles* mosquitos that transmit malaria typically bite during the nighttime, thus sleeping under mosquito nets can provide individual protection from malaria infection [2]. The free distribution of insecticide-treated nets (ITNs), specifically long-lasting insecticidal nets (LLINs) is one of the three primary interventions for effective malaria control recommended by the World Health Organization's Global Malaria Programme (WHO/GMP)[3]. While the use of any mosquito net by individuals provides a physical barrier from vector mosquitos, thus protecting them from malaria infection, use of ITNs has an added benefit through the use of pyrethroid or other insecticides which further reduces vector-human contact

through the reduction of the overall vector population [3]. The use of LLINs, has become an important malaria control intervention, as their use has shown a significant reduction in nationally reported rates of both all-cause and malaria mortality and morbidity in children [4]. Use by pregnant women is also associated with reductions in prevalence of malaria in pregnancy, miscarriages and low birth weight infants [2]. For the optimal benefit, WHO/GMP recommends full LLIN coverage of all persons at risk of malaria, as high levels of community coverage lead to community-wide benefits by reducing the vector population and reduced transmission of the parasite [3, 5]. These recommendations and findings led to the widespread scale-up of full coverage distribution programs in Africa in order to achieve the United Nations Millennium Development Goals by 2015 [3].

Madagascar is an island nation located off the southeastern coast of Africa, with an estimated population of 21 million persons in 2009. The 111 health districts in Madagascar are divided into five operational zones based on malaria transmission patterns. Malaria transmission is highest and occurs throughout most of the year in the East and West, seasonally during the rainy season in the Fringe area, and transmission is unstable or episodic in both the Central Highlands and the South (Figure 1)[6]. While transmission varies greatly by operational zone, malaria is endemic in 90 percent of the country, and the entire population is considered at risk for malaria infection [6].

**Figure 1 Malaria Operational Zones in Madagascar**
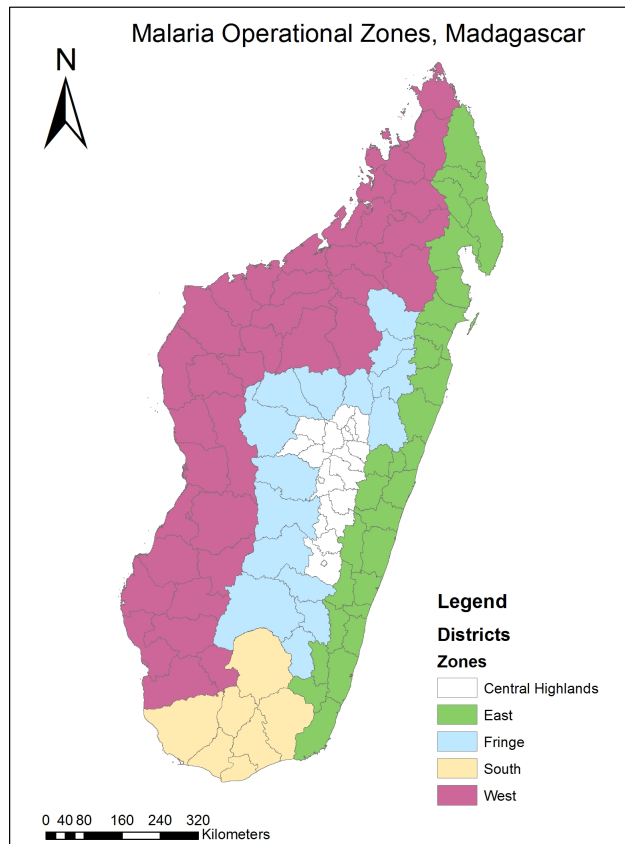


The Malagasy government established a National Malaria Control Program (NMCP) in 1998

aimed at reducing malaria morbidity and mortality. A national strategy was developed with

interventions including, promoting ITN use, indoor residual spraying (IRS) campaigns,

epidemiological surveillance, chemoprophylaxis for pregnant women and improved case

management [7]. The African Summit on Roll Back Malaria in Abuja, Nigeria was the

commitment in April 2000 by 53 African governments to halve the malaria mortality in Africa

by 2010 [8]. Madagascar committed to the Abuja Declaration targets in 2002 and the in-country

Roll Back Malaria (RBM) partnership with WHO, UNICEF, the UNDP, bilateral cooperation

agencies, nongovernment organizations (NGOs) and civil society was established [7]. This

partnership helped to facilitate increased funding for the NMCP and a rapid scale up of malaria control interventions from 2005 onward, which led to a consistent yearly decline in malaria morbidity since 2003 [7]. Despite these efforts, malaria remained a serious problem in Madagascar. It was still the second highest cause of morbidity in children in 2007, and was the primary cause of hospital mortality until the year 2009 [7]. With new international recommendations set by the WHO in 2007, the NMCP in Madagascar revised their strategy for LLIN distribution with the goal of meeting international standards and targets for reduction of malaria morbidity and mortality [3].

Achieving ITN coverage of the most vulnerable populations (pregnant women and children under the age of 5 years) has long been a priority for the NMCP. Prior to 2009, ITNs had been distributed, when available, through three methods: (1) Targeted populations were reached through free distribution during sub-national integrated immunization campaigns as well as (2) routine distribution during antenatal clinic visits and immunization visits for children under one year old, and (3) the general population was targeted through the sale of highly subsidized LLINs (approximately $1.50 USD per LLIN) in urban centers [9-11]. In 2008 the NMCP revised its ITN coverage strategy, as outlined in the *National Strategic Plan for Malaria Control, in view of pre-elimination 2008-2012*, to rapidly scale up malaria control activities and expand the target population for ITN coverage to prioritize universal coverage of two LLINs per household. This target applied to 91 of 111 health districts-where malaria was endemic (NMCP 2008) [3]. While earlier methods resulted in an increase in LLIN ownership of at least one LLIN per household from the years 2004 to 2008, there remained a large gap to achieve the targeted two LLINs per

household goal, as only 34% of households in targeted endemic zones reported owning at least two LLINs in 2007 [9].

To meet universal coverage goals, initially defined as two LLINs per household, the NMCP and the local RBM partnership planned a phased approach for a mass free LLIN distribution campaign, with the first two phases occurring in November and December 2009. These phases of the distribution took place for an estimated population of 3.8 million people living in 19 health districts on the East Coast of Madagascar. All LLINs were delivered free-of-cost at the community level to ensure coverage of at least two LLINs per household even in remote or resource poor areas. More than 1,730,000 LLINs were distributed as part of this campaign.

Following the first two phases of the mass free LLIN distribution campaign, the NMCP and partners conducted an evaluation to assess coverage and LLIN use before the final phase of the distribution in November 2010, for the remaining 72 health districts targeted for the intervention. The evaluation was designed to assess LLIN coverage and use at the household level in order to evaluate the first to phases of the distribution campaign and make any necessary changes prior to the final phases. In addition to the standard evaluation indicators sleeping space information was collected because the NMCP and the RBM partners recognized that relatively little was known about sleeping arrangement patterns and intra-household net use—information that was needed in order to guide the information, education and communication (IEC) campaigns associated with malaria control activities. Although studies have been completed in Madagascar and across

sub-Saharan Africa assessing ownership and use of LLINs, more information was needed on how household members are prioritized for intra-household LLIN use [12, 13].

The purpose of this thesis is to systematically identify intra-household sleeping arrangement patterns in order to support an assessment on factors associated with mosquito net use in Madagascar. An exploratory analysis was completed in order to address the following questions:

- What patterns of gender, age and familial role are associated with intra-household sleeping arrangements in Madagascar?
- How are intra-household sleeping arrangement patterns associated with sleeping space type and location?

This information on intra-household sleeping arrangement and sleeping space allocation will provide a foundation for further investigation that incorporates information on LLIN use and sleeping behavior. This will allow an assessment on the impact intra-household sleeping arrangement patterns have on intra-household LLIN use to be completed in the future.

There have been no systematically completed studies in Madagascar on intra-household sleeping arrangement patterns or sleeping space allocation in relation to malaria prevention activities or otherwise. This analysis will provide the baseline information necessary to determine the effects sleeping arrangements have on LLIN use, especially when there are insufficient LLINs for all household members. While the analysis will be most significant for Malaria prevention activities, it may also prove useful for research on other communicable diseases, reproductive health programs or health interventions targeted at the household level.

**Definition of Terms**

*A. Household:* For the purposes of this analysis, and in conjunction with previous studies

completed in Madagascar, a household was defined as all persons (related or not) regularly

eating from the same food pot, who recognize the same head of household and live in a

structure with one or more rooms.

*B. Insecticide treated net (ITN):* A mosquito net that repels, disables or kills mosquitos coming

in contact with insecticide on the net [3]. There are two forms of ITNs, the first of which are

*Conventionally treated nets*—mosquito nets that have been treated by being dipped in WHO-

recommended insecticide.  Conventionally treated nets need to be retreated after three

washes or at least once a year to ensure insecticide efficacy [3]. The second type are *Long*

*lasting insecticidal nets (LLINs),* defined by WHO as, "a factory-treated mosquito net made

with netting material that has insecticide incorporated within or bound around the fibers. The

net must retain its effective biological activity without retreatment for at least 20 WHO

standard washes under laboratory conditions and three years of recommended use under field

conditions" [3]. Since 2006 and during the universal coverage distribution campaign in 2009

in Madagascar, all ITNs that were distributed were LLINs and therefore the term can be used

interchangeably in the context of Madagascar.

*C. Coverage:* Coverage refers to the measure of access to a mosquito net. For example coverage

of a sleeping space would indicate there was a mosquito net allocated to that sleeping space,

however, it does necessarily imply the use.

*D. Single person-type category:* All persons are categorized into 6 basic groups in this analysis

because the intra-household relationships are unknown. A sleeping space with a single

person-type arrangement would be a sleeping space composed of one or more individual of

the same group, with no individuals from other groups present in the same sleeping space. For example, a single person-type sleeping arrangement would be one or more children aged 5 to 15 years, with no other person-type categories present. A multiple person-type category would be a sleeping arrangement composed of a combination of more than one of the person categories, for example, at least one man aged 15 to 49 years and at least one woman aged 15 to 49 years.

# Literature Review

The importance of identifying cultural patterns for intra-household sleeping arrangements and

sleeping space allocation in order to determine their effect on LLIN use has been realized in

recent years; however, very few studies systematically identifying and analyzing these

relationships have been completed in Africa, and there are no published studies from

Madagascar. This is likely due to the complex nature of the survey design, as it calls for

recording rosters of all household members, mosquito nets and sleeping spaces and relating the

items within the survey.  As no relevant studies have been completed in Madagascar and many

malaria interventions are standard across the region, the review of literature was expanded to all

studies in sub-Saharan Africa. Furthermore, given there are very few studies that systematically

link the three categories, household members, mosquito nets and sleeping spaces, this thesis will

review studies that address the following areas: intra-household use of mosquito nets, the

acceptability of mosquito nets in relation to sleeping arrangements, qualitative data on sleeping

arrangements and use of mosquito nets, and studies that fully address sleeping arrangements and

mosquito net use.


WHO guidelines regarding malaria prevention over the last 15 years have changed guided by

evaluation and research results, including target LLIN coverage measures and use goals. The

literature on intra-household mosquito net use was reviewed in the context of these

recommendations. Many African countries began implementing the Roll Back Malaria (RBM)

guidelines following the RBM African summit in Abuja, Nigeria [14]. Initially, in 2000, there

was a very low level of ITN coverage and ownership of one or more ITNs per household,

estimated to be two percent across the continent [15]. Early ITNs were nets requiring manual

coating and re-coating with an insecticide solution one to two times a year and these were distributed preferentially to biologically vulnerable groups—pregnant women and young children—often through the use of vouchers [15]. These vouchers were distributed by a wide range of methods, but were most commonly distributed during antenatal care visits, at routine immunization visits for infants, and during integrated immunization campaigns [15-17]. The World Health Assembly (WHA) set the targeted coverage of ITNs in Africa at 60 percent of vulnerable groups by 2005, and then later revised it to expand to 80 percent coverage of vulnerable groups by 2010 [15]. This called for the expansion of distribution programs in many African countries and drew on a limited international supply [18].

The guidelines for distribution of mosquito nets officially changed in 2008. Data showed considerable benefits in targeting all at-risk age groups for free or highly subsidized LLIN coverage, rather than just pregnant women and children [19]. This recommendation resulted in a significant scale up of ITN coverage in African countries near the end of the decade. By 2009, 23 African countries had changed their strategic plans to provide ITNs for all age groups at risk for malaria and were moving toward universal coverage—most typically defined as one ITN per every two persons, or one ITN per sleeping space [20, 21]. By 2010, many countries achieved a 40 to 80 percent coverage of households with at least one LLIN [15], and continued to improve national strategies for ITN access and use.

**Intra-household use of mosquito nets**
Following the initial recommendation to prioritize biologically vulnerable groups (pregnant women, children under five years of age, and infants), there was a concerted effort to measure

not only household access to mosquito nets, but intra-household prioritization of the use of mosquito nets. Prior to the promotion of these recommendations, a systematic literature review of studies spanning from 1992 to 2000 on intra-household mosquito net use found, there was a large discrepancy between possession of mosquito nets and use by vulnerable populations, particularly for children under the age of five years, in most African countries [22]. This contradicts the data published in the early 2000s, which overwhelmingly reported that vulnerable groups were prioritized for household mosquito nets.

While there are conflicting reports among studies and regions as to which vulnerable group was most prioritized for intra-household use of ITNs, infants, children under five years of age, and pregnant women were always prioritized for mosquito net use over household members aged 5-24 years of age and adult men. This prioritization was observed in a number of studies at the community level [23-26], as well as with large, international studies using nationally standard household survey methods [27-30]. Further, not only were vulnerable groups prioritized for mosquito net use, but were often also prioritized with the newest mosquito nets, those in the best condition, and for intra-household allocation of insecticide treated mosquito nets (ITN) over non-treated mosquito nets [24, 31]. This coupled with the finding that adult males and other non-target groups rarely exclusively used mosquito nets [24, 27], indicates that education campaigns on the protection of vulnerable populations with mosquito nets were effective in many countries across Africa.

Intra-household access to mosquito nets was a strong predictor for use among vulnerable groups across many countries [22, 24, 28-30, 32]. Eisele found that a low person-to-mosquito-net ratio within households was the most consistent predictor for children under the age of five years using a mosquito net across 15 African countries [30]. For example, the mean number of household members per ITN in Senegal was 6.8 persons, with 36.1% of children under five years of age sleeping under an ITN the previous night; compared to Uganda with a mean intra-household-ITN-to-person ratio of 4.0, with 53.7 percent of children under the age of five years sleeping under an ITN the previous night [30]. This was supported by Ricotta in a subsequent study of 10 African countries, where pregnant women were significantly more likely to use mosquito nets in households that achieved universal coverage of one mosquito net for every two persons in a household [29]. This association between increased intra-household access to mosquito nets and increased coverage of vulnerable populations indicated a need for expanded intra-household net ownership in order to ensure mosquito net use by vulnerable groups. This substantiates the shift in international recommendations and national programs to move towards universal coverage rather than targeting only vulnerable groups, [15] and aligns with the current WHO recommendation that all household members sleep under an ITN during transmission season; and in the case that there are insufficient ITNs to cover all household members, young children and pregnant women should be prioritized [21].

**Acceptability of mosquito nets in relation to sleeping arrangements**
An association between mosquito net use and household space management was found in several studies in both East and West Africa. Sleeping space types posed different levels of technical difficulty related to hanging and using mosquito nets. Mosquito nets were significantly more likely to be hung over permanent sleeping spaces, such as over beds or in dedicated bedrooms,

than over sleeping spaces in multi-use rooms [23, 33, 34]. In Kenya, mosquito nets hanging

during the day were almost always used the previous night, demonstrating the association

between permanent sleeping spaces and use of mosquito nets within households [33]. Adults and

infants more often used permanent sleeping spaces, whereas children were more likely to occupy

temporary sleeping spaces in multi-use rooms [33-35]. In multi-use rooms, there is a marked

difference in space management during the day versus during the night. Materials not used at

night are often moved to the periphery of the space and mats are rolled out for use [34]. Even in

the case that households had sufficient mosquito nets to cover all household members, they often

did not hang mosquito nets over sleeping spaces in multi-use rooms due to the technical

inconvenience of hanging and removing the mosquito nets each day [33, 35-37]. Other technical

barriers to hanging mosquito nets over multi-use sleeping spaces included difficulty hanging

mosquito nets due to household construction (especially finding four points in round houses),

difficulty entering and exiting mosquito nets in the dark, sleeping mats not fitting appropriately

under mosquito net, and inability to keep a mosquito net in place over a sleeping mat [35-38].

**Sleeping arrangements and use: qualitative data**

A variety of physical factors were associated with the use of the mosquito net. Untreated,

moderately-damaged mosquito nets still offer protective benefits when compared to no mosquito

net at all [39]; however, ITNs that are greater than 12 months old were less likely to be used than

those less than 12 months old [24, 28, 32, 40]. Qualitative data demonstrates this could be due to

lack of perceived effectiveness as insecticide wears off and the mosquito net becomes damaged

[35]. This perception might be valid, as insecticide can wear off at varying rates depending on

local conditions, care and use, and LLINs may have a lower insecticide lifespan than the original

manufacturer specifications of three to five years [41-43]. Additionally, in some settings conical mosquito nets were preferred to traditional rectangular mosquito nets, as the single hanging point removed some technical barriers associated with hanging and using mosquito nets, especially in multi-use space [35]. Other factors such as color or brand are culturally more appropriate or preferred on a country-to-country basis [44].

Qualitative studies have described various social barriers to intra-household mosquito net use. The disruption of sleeping arrangements has been reported as a major social barrier to mosquito net use for temporary sleeping spaces. In Kenya, children were more likely than other household members to shift their sleeping arrangements or be displaced from their normal sleeping spaces to accommodate guests [33, 36]. Groups of children often sleep together, and the mosquito nets distributed are sometimes not large enough to accommodate cultural group sleeping patterns [34]. Further, space where groups sleep often can only accommodate hanging one mosquito net, which may not provide sufficient coverage and often does not reach to the ground where they are sleeping [35]. Similarly, men and older boys have been reported to practice changing sleeping behaviors, which leads to decreased mosquito net use, as compared to other household members. This can be due to cultural norms, which keep men and boys out of the household later and sleeping elsewhere more often than other household members [26, 44]. In comparison, women and young children tended to have more stable sleeping patterns and sleeping arrangements, allowing for more regular mosquito net use [44]. Women more typically shared one room, including young girls whose male siblings tended to sleep elsewhere together, so the mother could watch over the girls. These culturally appropriate sleeping arrangements need to be accounted for when allocating mosquito nets to particular household members [34, 37].

Environmental factors were associated with barriers to mosquito net use in both quantitative and qualitative data across many countries. Increased temperature and discomfort were frequently cited as reasons for not using mosquito nets [13, 22, 36-38]. Use of a mosquito net in the hot season was seen as uncomfortable, claustrophobic and confining [37]. A second common environmental barrier associated with mosquito net use was the decreased use of mosquito nets when there was perceived low mosquito density [34-36, 38]. Mosquito nets were often reported as used to prevent the nuisance of mosquitos biting in the night; therefore, even in transmission season, mosquito nets may not be used if there was perceived low mosquito density [34]. Both of these environmental considerations have significant implications for malaria prevention programs, especially for countries where the hot season and high transmission season are aligned.

**Sleeping arrangements and use**
While intra-household allocation and use of mosquito nets was commonly inferred using supporting qualitative data, very few studies systematically investigated what intra-household sleeping arrangements are culturally common and how these arrangements affect mosquito net use. In order to address these questions, rosters listing each household member, each sleeping space, and each mosquito net are needed as well as information on the location where each individual sleeps and the specific LLIN assocated with each sleeping space (or lack of). This allows the systematic identification of where household members sleep, with whom they sleep, and whether a mosquito net was used. Graves et al. used this design in Ethiopia, and analyzed mosquito net use on both the mosquito net and the individual level; however, sleeping arrangements were not reported as part of the study [28]. Despite an overall increase in mosquito

net ownership, a decrease in use was observed, and was attributed to the high intra-household density of mosquito nets that may have exceeded household needs. The author found females were more likely than males to use mosquito nets, and persons aged 24-49 years old were the household members most likely to sleep under a mosquito net [28]. Furthermore, undamaged mosquito nets were more likely to be used than damaged mosquito nets, highlighting the need for care and repair of mosquito nets within the country program [28].

Baume and Marin touch on a systematic analysis, enumerating household members and mosquito nets as part of their study [27]. Although they did not include a sleeping space analysis, they identified that across all six countries surveyed the most common sleeping group was a woman of reproductive age and a child under five years old, typically accompanied by another child or adult [27]. Unlike a similar study in Uganda [45], Baume and Marin concluded that children under five years were not more likely to use a mosquito net because they were sleeping with the mother. Rather, they were the household members most commonly under a mosquito net across all six countries, irrespective of sleeping with the mother [27].

Perhaps the most relevant example of this study design was completed by Fernando et al., which investigated mosquito net use across three ethnic groups in both the high and low transmission seasons in Sri Lanka [38]. Household members and LLINs were enumerated, and sleeping arrangements under LLINs were recorded for each household. Overall LLIN use was high during the low transmission season, with coverage reaching 90 percent, and increased during high transmission season to 96 percent. Among all ethnic groups, most commonly reported reasons

for non-use were heat and the absence of mosquitos during low transmission season, and having no space to hang the LLIN during high transmission season [38]. While sleeping arrangements varied by ethnic group, children under five years were always the most prioritized household members for LLIN use. Preference was given to mothers to share LLINs with children under five years old during transmission season amongst Sinhalese, while adults in Tamil and Muslim households tended to vacate LLINs in the transmission season to allow other siblings to share the net with children under five years old [38]. Among all three ethnic groups, use of LLINs by pregnant women was low, indicating a need for further education on the benefits of LLIN use to pregnant women in Sri Lanka [38]. This systematic identification and linking of all household members, sleeping arrangements, and LLINs in households in Sri Lanka allowed Fernando et al. to identify notable cultural patterns, and tailor their malaria prevention programs and IEC materials to address LLIN use among each ethnic group.

# Methodology

**Study Design**

A community-based, cross sectional household survey using a three-stage cluster sample design

was conducted. The survey took place in April and May 2010, just after the rainy season in

Madagascar.

This household survey had two purposes. The first was to conduct a post campaign evaluation to

measure ITN coverage and use at the community level for the 19 districts that were part of the

first two phases of the universal coverage campaign. The second purpose was to address the

objectives associated with the exploratory analysis of this thesis.

**Population and Sample size**

The survey was sub-national, and focused on the 4 regions and 19 districts along the east coast of

Madagascar, that were targeted for the first two phases of the universal coverage campaign

(Figure 2). Phase I of the campaign occurred in 12 districts and phase II in 7 districts, taking

place in November and December 2009, respectively.

**Figure 2 Districts included in Phase I and II of the universal coverage campaign**



Phase I and II of the LLIN Universal Coverage Campaign in 2009

N

Legend

Districts

**19 Districts included in 2009 campaign**

December 2009

November 2009

Kilometers
0 45 90   180   270   360
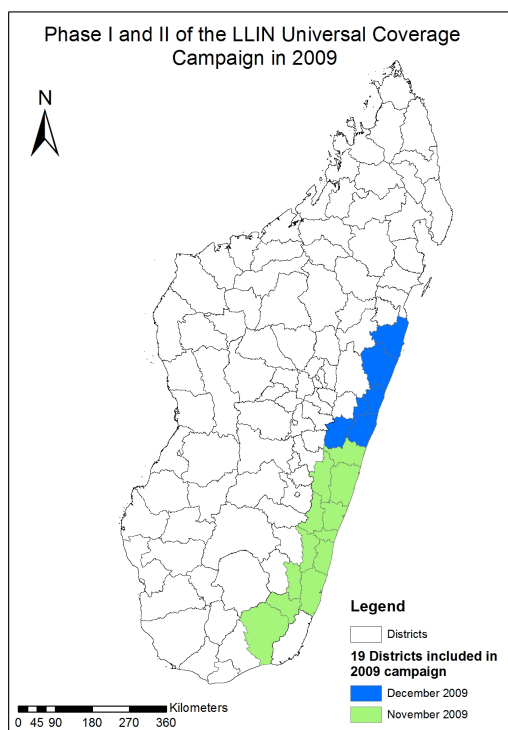
**Table 1 List of Districts included in the 2009 Universal Campaign**

| Distribution Month | Region | District |
|---|---|---|
| November 2009 | Vatovavy Fitovinany | IFANADIANA<br>IKONGO<br>MANAKARA ATSIMO<br>MANANJARY<br>NOSY-VARIKA<br>VOHIPENO |
| | Atsimo Atsinanana | BEFOTAKA<br>FARAFANGANA<br>MIDONGY-ATSIMO<br>VANGAINDRANO<br>VONDROZO |
| | Anosy | AMBOASARY |
| December 2009 | Antsinanana | ANTANAMBAO MANAMPONTSY<br>VOHIBINANY<br>MAHANORO<br>MAROLAMBO<br>TOAMASINA I<br>TOAMASINA II<br>VATOMANDRY |

**Sampling Procedures**[1]

Three-stage cluster sampling was conducted. Ten districts of the 19 were selected using

probability proportional to population size (PPS) sampling (Figure 3). Population estimates were

based on official district estimates extrapolated from the last national census conducted in 1993,

which estimated the population of Madagascar at 19.7 million in 2008. Within each of the

districts, nine fokontany (villages) were selected by PPS in the fokontany. All households within

the selected enumeration areas were then mapped using Personal Digital Assistant (PDA)-based

global positioning software (GPS) technology. Twenty-five households were selected for

interviews by random sampling using the household listing created by the GPS mapping[1].

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[1] Adapted from the study protocol with the permission of the authors

**Figure 3 Map of the sampled districts for the study**



2009 Universal Coverage Campaign Districts Sampled in Study

Legend

10 Sampled Districts

Universal Coverage Campaign Districts

0 35 70 140 210 280 Miles
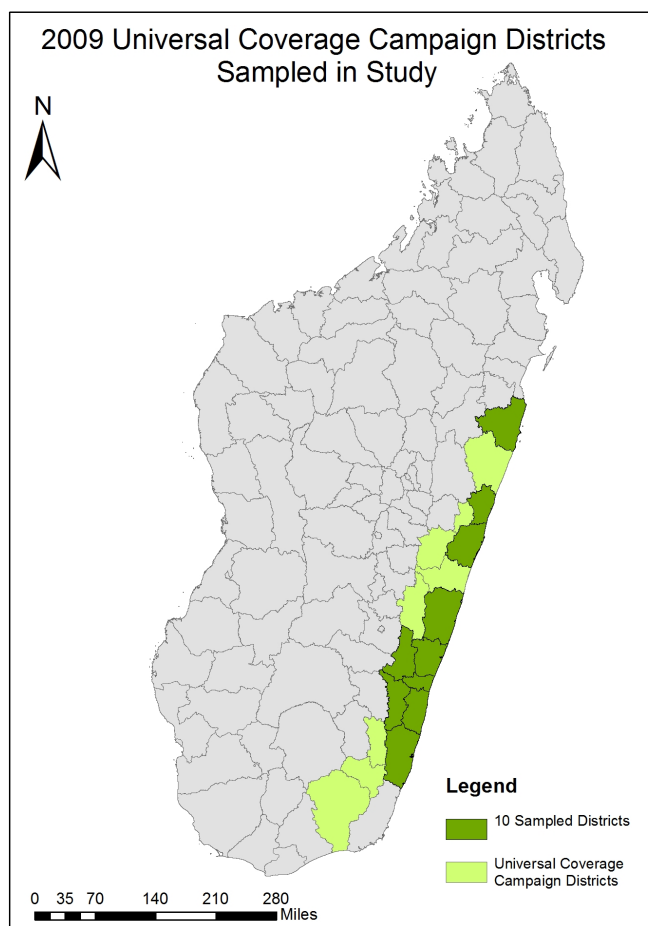
**Table 2: List of 10 Districts Sampled by Region**

| Region | District |
|---|---|
| Vatovavy Fitovinany | FARAFANGANA VANGAINDRANO VONDROZO |
| Atsimo Atsinanana | IKONGO MANAKARA MANANJARY VOHIPENO |
| Antsinanana | MAHANORO TOAMASINA I VATOMANDRY |

**Sample size**[2]

The study design was designed to be "self-weighting" so that each household had an equal probability of being selected. The main outcome used for the sample-size calculations was the proportion of children under the age of five years sleeping under an ITN the previous night during the rainy season five months after the LLIN campaign distribution. The assessment was designed to have at least 80 percent power to estimate the usage of ITNs by children less than five years (specified as 60 percent) within a range of 5 percent, assuming a non-response rate of 15 percent and a design effect of three, and that 60 percent of the households have a child under the age of five years. The survey had a target sample size of 2,250 households.

For the campaign distribution, a household was defined as "all persons eating from the same food pot," which agrees with the definition used in previous surveys in Madagascar. The "ménage ordinaire" (ordinary household) is the unit of observation from the 1993 census. It refers to all people living in the same dwelling, related by family ties or not, sharing the principal meals, and recognizing the authority of one person: the head of the household. The following are considered as "ménage ordinaire": couples living alone or with their children (married or not married), one spouse living alone or with their children (married or not married), brothers or sisters living together, or one person living alone and sustaining themselves.

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[2] Adapted from the protocol with permission from the authors

**Study Questionnaire and Procedures**[3]

Ten teams conducted the survey, one for each of the 10 selected districts, with each team

consisting of 4 surveyors, 1 supervisor, and 4 local guides.

A customized questionnaire with appropriate skip patterns and data checks was developed and

programmed into the PDAs using Visual CE® (Version 11, Syware Inc., Cambridge, MA).  All

questionnaire forms were translated into French and standard Malagasy.

Each household was administered a detailed questionnaire following a standard format. This

included inventoried rosters of household members, bednets, and sleeping spaces. Household-

level questions focused on bednet ownership; type, quantity and quality of nets; campaign

participation; information, education and communication (IEC); community health worker

(CHW) household visits; net hang-up; and old net use. Information was collected for all

household members regarding demographic characteristics and bednet use. Individual bednets

and sleeping spaces were characterized and inventoried.

**Enumeration**[3]

An accurate sampling frame needed to be created at the time of the study for each enumeration

area. Each team used their PDAs equipped with GPS receivers, with the assistance of a local

guide, to map and record each household in the selected enumeration area.  After mapping, the

team members transferred the GPS data to each other's PDA using the beam/Bluetooth function,

so that all team members would have a complete map of the enumeration area. On each PDA, the

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[3] Adapted from the study protocol with permission of the authors

databases were then automatically combined to obtain a complete listing of all households in the enumeration area. This listing was used as the sampling frame.

The GPS Sample program (custom software, CDC, Atlanta GA) on the PDA was then used to randomly select 25 households from the sampling frame [46]. Once the team members divided up the list of selected households, each navigated back to the selected households using the navigation function of the GPS program and conducted the interview. The interviewer then explained the survey procedures, explained benefits and risks, and obtained informed consent from the interviewee to participate. The selected interviewee was, in general, the self-identified, head of the household, or another adult present and willing to participate.

**Data Collection and Entry**

Hand-held computers were used for data collection in the field. Data were entered into PDAs using Visual CE®, a database product used for PDA-based data collection, incorporating skip patterns and rigorous data checking at the point of data collection. Upon survey completion, the PDAs were returned to the principal investigators who downloaded and aggregated the collected data into a desktop database in Microsoft® Access. All data collected were turned over to the Ministry of Health and Family Planning.

**Data Analysis**

Data from the Microsoft® Access database were transferred to Stata® version 10 (Stata Corporation, College Station, Texas, USA) for verification, data cleaning, and analysis for the post campaign evaluation. The Stata® database files were then converted to SAS® for the analysis

associated with this thesis. Due to multi-stage clustering and the fact that each district has a different sampling weight, specialized analysis survey procedures using SAS® (proc survey) were used to produce valid estimates and calculate standard errors using the sampling weights. Descriptive statistical analysis was undertaken to describe the main features of the data in quantitative terms. Tests for association were completed using the Proc SurveyFreq procedure with the Wald Chi Square test for association. No adjustments were made for multiple comparisons, as this was an exploratory analysis.

The Proc SurveyLogistic procedure was used to create three logistic regression models. The dependent variables modeled were sleeping spaces shared by at least one woman of reproductive age and at least one child under the age of 5 years, sleeping space with at least one man aged 15 to 49 years and at least one woman of reproductive age, and sleeping spaces with at least one man aged 15 to 49 years and at least one child under the age of 5 years. The models adjusted for all other person categories possibly present in the sleeping space, household wealth quintile, number of household sleeping spaces, and whether the sleeping space was permanent or temporary as independent variables in the logistic regression.

A section of the questionnaire addressed the overall status of housing and living quarters. These questions were adapted from the 2000 Multiple Indicator Cluster Survey (MIS) and 2003-2004 Demographic and Health Survey (DHS) and were used to develop a wealth index using principal component analysis [47, 48]. Questions included: type of materials used in construction of the

housing dwelling, ownership of certain assets, and water sources. An economic score was assigned to each of the values of the economic questions and used to determine an overall economic wealth indicator for each household using the first principal component. Households were assigned to one of five economic quintiles using categories and cut-offs established previously by the 2008 Demographic and Health Survey [49]. Quintile 1 represents the poorest households, and quintile 5 the wealthiest.

For the purposes of this thesis, mosquito net ownership and use results are presented for two categories: LLINs and non-LLINs (including ever-treated nets, non-treated nets, and those with unknown treatment status). The standard RBM indicators of ITN ownership and use were not included in the analysis because the difference between LLIN and ITNs inventoried was negligible and the program objectives set by the NMCP in Madagascar are based on LLIN ownership and use.

Familial relationships between household members were not recorded, could not be discerned and are therefore not reported. Household members were categorized into six basic groups: adults over the age of 50 years, men aged 15-49 years, not pregnant women (aged 15-49 years), pregnant women (15-49 years), children aged 5 to 14 years, and children under the age of 5 years. In relation to sleeping spaces person categories were analyzed using two methods, (1) dichotomously, at least one of the person category per sleeping space was present, and (2) a quantitative count of each individual present, for example there were two children under the age of 5 years per sleeping space.

Two men aged 15 to 49 years were removed from the sleeping space analysis because they were

never assigned a sleeping space ID at the time of the study.

**Ethical Considerations**
The evaluation protocol and questionnaire were reviewed by the Madagascar Ministry of Health

Ethics Review Board and the Centers for Disease Control and Prevention Ethical Review

Committee. The evaluation was approved by both entities and deemed as non-research by CDC.


There were no known risks involved with this evaluation and participation was voluntary. Oral

consent was obtained from the interviewee prior to collecting survey data.

# Results

## Population Description and Characteristics

There were 2,211 households surveyed in this study. When divided into wealth quintiles, there was approximately 17.5 percent of the population in the poorest quintile, compared to 23.5 percent in the wealthiest quintile (Table 3). Within the households, 3,720 sleeping spaces were inventoried. On average there were 1.7 sleeping spaces per household. Nearly all of these sleeping spaces were located inside a household, with only 0.6 percent of sleeping spaces located outdoors. There were very few temporary sleeping spaces, 5.7 percent, and the majority of sleeping spaces were reported as permanent. LLIN coverage of sleeping spaces in the population was high, at 77.1 percent of sleeping spaces covered (Table 4). There were 3,340 sleeping spaces that were occupied by one or more persons and 380 sleeping spaces that had no persons sleeping in them. Of the unoccupied spaces, 74.4 percent were permanent sleeping spaces, and the majority of unoccupied spaces were in households with 2 or 3 sleeping spaces (Table 4, Table 5). A larger proportion of temporary sleeping spaces were unoccupied, compared to permanent sleeping spaces (Table 4, Table 5).

**Table 3 Description of inventoried households**

| Number of Households surveyed n=2,211 | N | % | Weighted % (CI) |
|---|---|---|---|
| Average number of persons per household | | 4.0 | 4.1 (3.8 – 4.4) |
| Range of persons per household | 1-18 | | |
| Households by wealth quintile | | | |
| 1 (poorest) | 433 | 19.6 | 17.5 (5.5 -29.6) |
| 2 | 654 | 29.6 | 24.1 (10.0 – 38.2) |
| 3 | 546 | 24.7 | 20.36 (7.6 – 33.2) |
| 4 | 309 | 14.0 | 14.5 (11.5 – 17.6) |
| 5 (wealthiest) | 269 | 12.2 | 23.5 (0 – 58.4) |

**Table 4 Description of inventoried sleeping spaces**

| Number of Sleeping Spaces inventoried n=3,720 | N | % | Weighted % (CI) |
|---|---|---|---|
| Average number of sleeping spaces per household | | 1.7 | 1.8 (1.6 – 2.0) |
| Range of Sleeping spaces per household | 1-8 | | |
| Indoor sleeping spaces | 3698 | 99.4 | 99.5 (99.1 – 100.0) |
| Outdoor sleeping spaces | 21 | 0.6 | 0.48 (0.1 – 0.9) |
| Permanent sleeping spaces | 3505 | 94.2 | 94.2 (89.6 – 98.8) |
| Temporary sleeping spaces | 211 | 5.8 | 5.7 (1.2 – 10.2) |
| Sleeping spaces covered with LLIN | 2914 | 78.3 | 77.1 (72.5 – 81.6) |

**Table 5 Description of unoccupied sleeping spaces**

| N=380 | N | % | Weighted % (CI) |
|---|---|---|---|
| Permanent | 284 | 74.7 | 80.0 (65.3 - 94. 7) |
| Temporary | 94 | 24.7 | 19.5 (5.2 – 33.9) |
| Indoors | 375 | 98.7 | 99.4 (98.4 – 100) |
| Outside | 5 | 1.3 | 0.6 (0 -1.6) |
| By household sleeping space count | | | |
| 2 sleeping spaces | 206 | 54.2 | 45.3 (35.3 – 55.4) |
| 3 sleeping spaces | 84 | 22.1 | 24.6 (20.6 – 28.6) |
| 4 sleeping spaces | 61 | 16.1 | 20.79 (13.9 – 27.7) |
| 5 or more sleeping spaces | 29 | 7.6 | 9.32 (4.0 – 14.6) |

A total of 8,867 individuals were inventoried as a part of the study. Of these individuals, 98.4 percent slept in the household the previous night. Children aged 5 to 14 years made up the largest proportion of the population at 28.4 percent, and pregnant women the smallest proportion, at 2.4 percent (Table 6). On average there were 4.1 persons per household and 2.4 persons per sleeping space. The average number of persons per sleeping space decreased as the number of sleeping spaces per household increased, ranging from an average of 2.92 persons per sleeping space in households with one sleeping space to an average of 1.24 persons per sleeping space in a household with 5 or more sleeping spaces (Table 7).

**Table 6 Description of inventoried persons**

| Total individuals inventoried n=8,867 | N | % | Weighted % (CI) |
|---|---|---|---|
| Children under the age of 5 years | 1372 | 15.5 | 14.8 (11.9 – 17.6) |
| Children aged 5-14 years | 2538 | 28.6 | 28.4 (26.3 -30.5) |
| Not pregnant, women (15-49 years) | 2012 | 22.7 | 23.6 (20.8 – 26.4) |
| Pregnant women (15-49 years) | 243 | 2.7 | 2.4 (1.6 – 3.1) |
| Men (15-49 years) | 1842 | 20.8 | 20.8 (18.4 – 23.2) |
| Adults over the age of 50 years | 860 | 9.7 | 10.0 (8.6 – 11.5) |
| Slept in the house last night | 8716 | 98.3 | 98.4 (97.2 – 99.5) |
| Slept under an LLIN last night | 7343 | 84.3 | 84.2 (79.6 – 88.8) |

**Table 7 Average persons per sleeping space by number of sleeping spaces per household in all recorded sleeping spaces**

| n=3,720 sleeping spaces | | Range | Median | Mean | Weighted Mean (CI) |
|---|---|---|---|---|---|
| Persons per sleeping space | | 0 - 15 | 2 | 2.4 | 2.3 (2.0 – 2.6) |
| By household sleeping space number | | | | | |
| 1 sleeping space n=1,044 | Persons per sleeping space | 0 - 15 | 2 | 2.9 | 2.9 (2.7 – 3.2) |
| 2 sleeping spaces n=1,820 | Persons per sleeping space | 0 - 10 | 2 | 2.3 | 2.3 (2.1 – 2.5) |
| 3 sleeping spaces n=576 | Persons per sleeping space | 0 - 11 | 2 | 2.0 | 1.9 (1.7 – 2.1) |
| 4 sleeping spaces n=208 | Persons per sleeping space | 0 - 10 | 1 | 1.8 | 1.57 (1.3 – 1.8) |
| 5 or more sleeping spaces n= 72 | Persons per sleeping space | 0 - 9 | 1 | 1.4 | 1.2 (0.9 – 1.6) |

In all sleeping spaces, there are nearly an equal average number of males and females, and slightly more adults than children per sleeping space. After breaking children into two categories (under 5 years of age and 5 to 14 years of age) the person category occupying the largest proportion of sleeping spaces is women of reproductive age, 15 to 49 years, with at least one woman in 52.6 percent of all sleeping spaces. Men aged 15 to 49 years followed this, and were in

40.7 percent of all sleeping spaces, while children aged 5 to 14 years were in 39.8 percent of all sleeping spaces. The majority of sleeping spaces were occupied by both genders, with female-only spaces occurring more frequently than male-only sleeping spaces (Table 8).

**Table 8 Description of sleeping spaces by person categories**

| Persons per sleeping space | Range | Mean | Weighted Mean (CI) |
|---|---|---|---|
| Average number of males | 0 - 7 | 1.1 | 1.1 (0.9 – 1.3) |
| Average number of females | 0 - 8 | 1.3 | 1.2 (1.1 – 1.4) |
| Average number adults (≥15 years) | 0 - 8 | 1.3 | 1.3 (1.2 -1.4) |
| Number of children (≤14 years) | 0 - 8 | 1.1 | 1.0 (0.7 – 1.2) |
| **Frequency of at least one of the person category in a sleeping space** | **N** | **%** | **Weighted % (CI)** |
| Children (≤14 years) | 2177 | 58.5 | 55.1 (44.7 – 65.6) |
|  Children under the age of 5 years | 1101 | 29.6 | 26.9 (18.6 – 35.2) |
|  Children aged 5-14 years | 1546 | 41.6 | 39.8 (34.0 – 45.6) |
| Women of reproductive age (15- 49 years) | 2023 | 54.4 | 52.7 (47.8 – 57.5) |
|  Pregnant women | 243 | 6.5 | 5.4 (3.3 – 7.4) |
|  Women aged 15-49 years | 1800 | 48.4 | 47.7 (44.3 – 51.2) |
| Men aged 15 - 49 years | 1611 | 43.3 | 40.7 (37.1 – 44.4) |
| Adults over the age of 50 years | 694 | 18.7 | 18.3 (14.1 – 22.4) |
| Only females | 729 | 19.6 | 20.0 (17.9 – 22.0) |
| Only males | 554 | 14.9 | 13.7 (11.8 – 15.6) |
| At least one of each<br> Man aged 15-49 years<br> Woman aged 15 - 49 years | 1141 | 30.7 | 29.5 (26.7 – 32.2) |
| At least one of each<br> Woman of reproductive age<br> Any child (≤14 years) | 1345 | 36.1 | 33.3 (25.1 – 41.6) |
|  A woman of reproductive age<br> Child under the age of 5 years | 888 | 23.9 | 21.8 (14.4 – 29.2) |

## Sleeping Arrangements by Sleeping Spaces in all Households

Among all sleeping spaces in the study population, the most commonly observed sleeping arrangement was a sleeping space that included one or more children aged 5 to 14 years and no other person-type categories (Figure 4). This sleeping arrangement occurred in 12.1 percent of

all sleeping spaces. As household sleeping space numbers increased, the pattern for the

proportion of sleeping spaces with this sleeping arrangement also increased, and it remains the

most common sleeping arrangement for all households, households with two or more sleeping

spaces, and households with three or mores sleeping spaces.
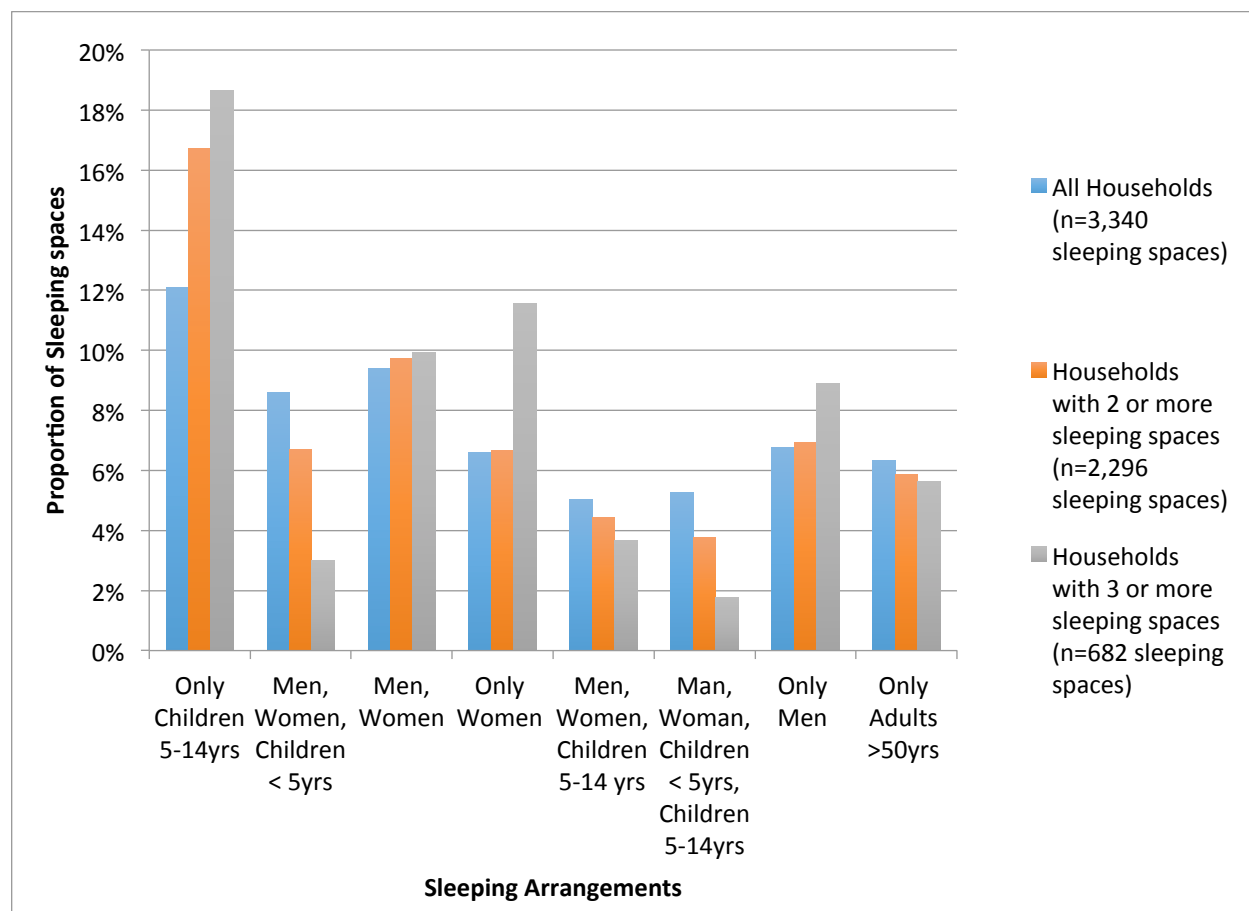


**Figure 4 Most frequently occurring sleeping arrangements by sleeping space**

A similar pattern was observed for other single person-type category sleeping arrangements. The

proportion of sleeping spaces containing one or more men aged 15 to 49 years with no other

person categories, and those containing one or more (not pregnant) women aged 15 to 49 years

and no other person categories, increased as the number of sleeping spaces per household

increased (Figure 4). The proportion of sleeping spaces with only men aged 15 to 49 years was 6.8 percent of sleeping spaces when analyzed in the subset of all households, compared to 8.9 percent of sleeping spaces in households with three or more sleeping spaces. The proportion of sleeping spaces occupied only by non-pregnant women aged 15 to 49 years increased more dramatically, occupying 6.6 percent of sleeping spaces in all households, and almost twice that proportion (11.5 percent) of all sleeping spaces in households with three or more sleeping spaces (Table S3).

The proportion of sleeping spaces occupied by sleeping arrangements including three or more person categories all decreased as the number of sleeping spaces per household increased. The most common occurrences of sleeping arrangements with three or more person categories sharing a sleeping space include both men aged 15-49 years and women aged 15-49 years, as well as the addition of one or more children aged 5 to 14 years or children under the age of 5 years (Figure 4).

The proportion of sleeping spaces occupied by only adults over the age of 50 years and those occupied with a combination of at least one of each, man aged 5 to 14 years and (not pregnant) woman aged 15 to 49 years remained relatively stable regardless of number of sleeping spaces per household. The sleeping arrangement of only adults over the age of 50 years experienced a slight decrease, while the combination of men and women a slight increase, as the number of sleeping spaces per household increased.

**Most commonly occurring sleeping arrangements among sleeping spaces covered by LLINs**
While intra-household sleeping arrangements may affect access to and the use of LLINs within

the population, and is yet to be determined, it was also deemed possible that LLIN coverage may

determine the sleeping arrangement itself. The most commonly occurring sleeping arrangements

by sleeping space in all households were stratified by LLIN coverage to compare sleeping

arrangements of sleeping spaces that were covered to those that were not covered. The majority

of sleeping spaces in the population were covered by an LLIN (77.1 percent), and the sleeping

arrangement patterns for sleeping spaces covered with an LLIN resembled the sleeping

arrangement patterns for sleeping spaces in all households (Figure 2).
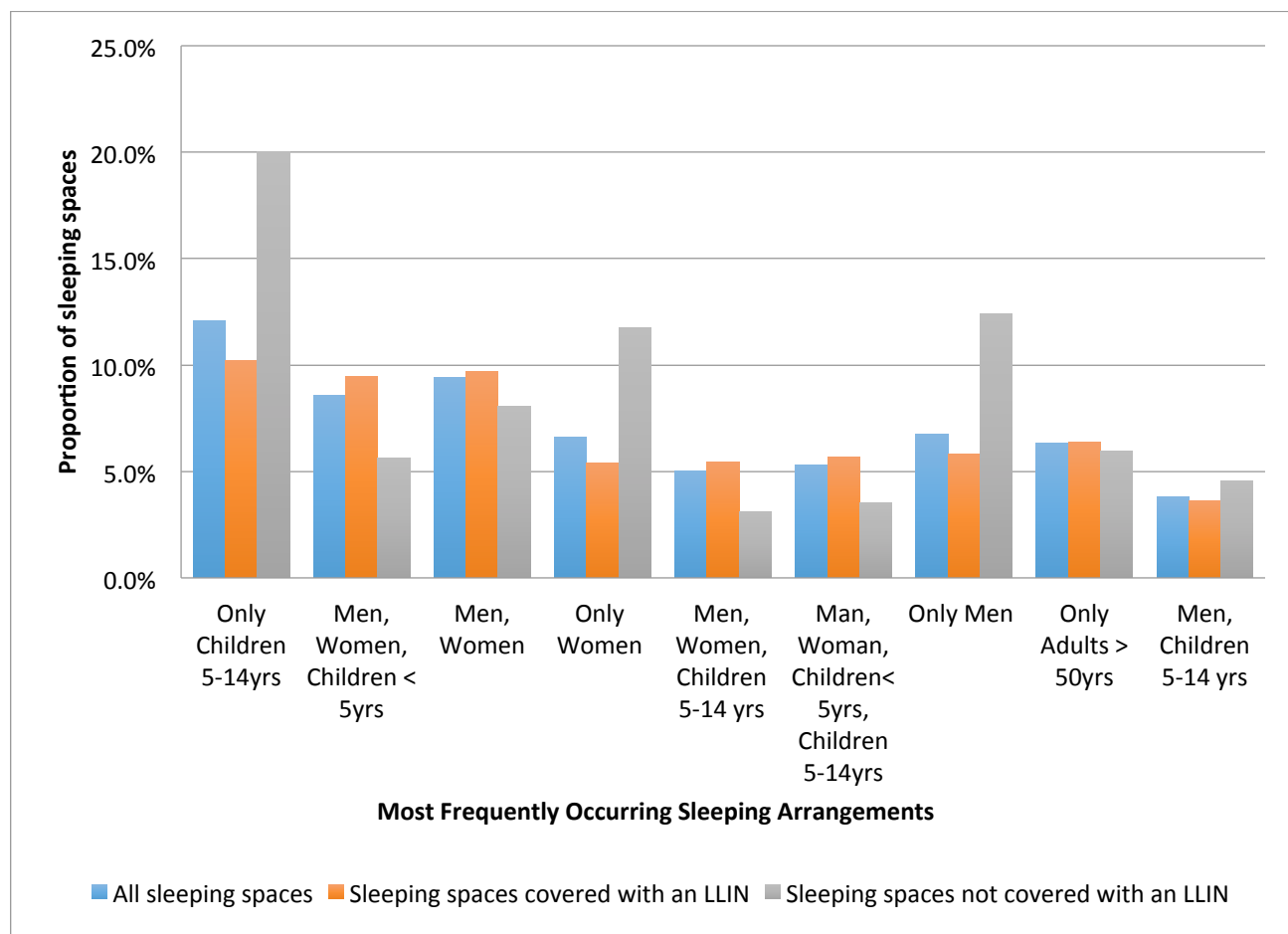


**Figure 5 Sleeping arrangements by sleeping space in all households, stratified by LLIN coverage**

Less than 25 percent of all sleeping spaces (n=3720) in the study were not covered by an LLIN and the sleeping arrangement patterns for these sleeping spaces were different than the overall patterns for the population. This indicated that there is an association between LLIN coverage of sleeping spaces and sleeping arrangements. Single person-type category sleeping arrangements accounted for a greater proportion of sleeping spaces not covered by an LLIN than those covered by an LLIN for all categories, except for adults over the age of 50 years. Sleeping arrangements including only men 15 to 49 years, only women 15 to 49 years, and only children aged 5 to 14 years accounted for a proportion of sleeping spaces not covered by an LLIN approximately twice as much as their respective categories in sleeping spaces covered by an LLIN (Figure 5). (Table S4, Table S5)

**Most commonly occurring sleeping arrangements among temporary sleeping spaces**
There were few temporary sleeping spaces inventoried in the study, accounting for 5.8 percent of all sleeping spaces. Of the 211 temporary sleeping spaces, 94 (19.5%) sleeping spaces were reported as unoccupied the night before the survey, and 117 spaces occupied. Sleeping arrangement patterns for these temporary spaces differ from the patterns of sleeping arrangements for sleeping spaces in all households. The proportion of single person-type-category sleeping arrangements is larger for temporary sleeping spaces than for sleeping spaces among all households, as is the sleeping arrangement for the combination of men aged 15 to 49 and children aged 5 to 14 years (Figure 3). The proportion of sleeping spaces occupied in temporary sleeping spaces as compared to all sleeping spaces was approximately equal or smaller for all other combination-person-category sleeping arrangements.
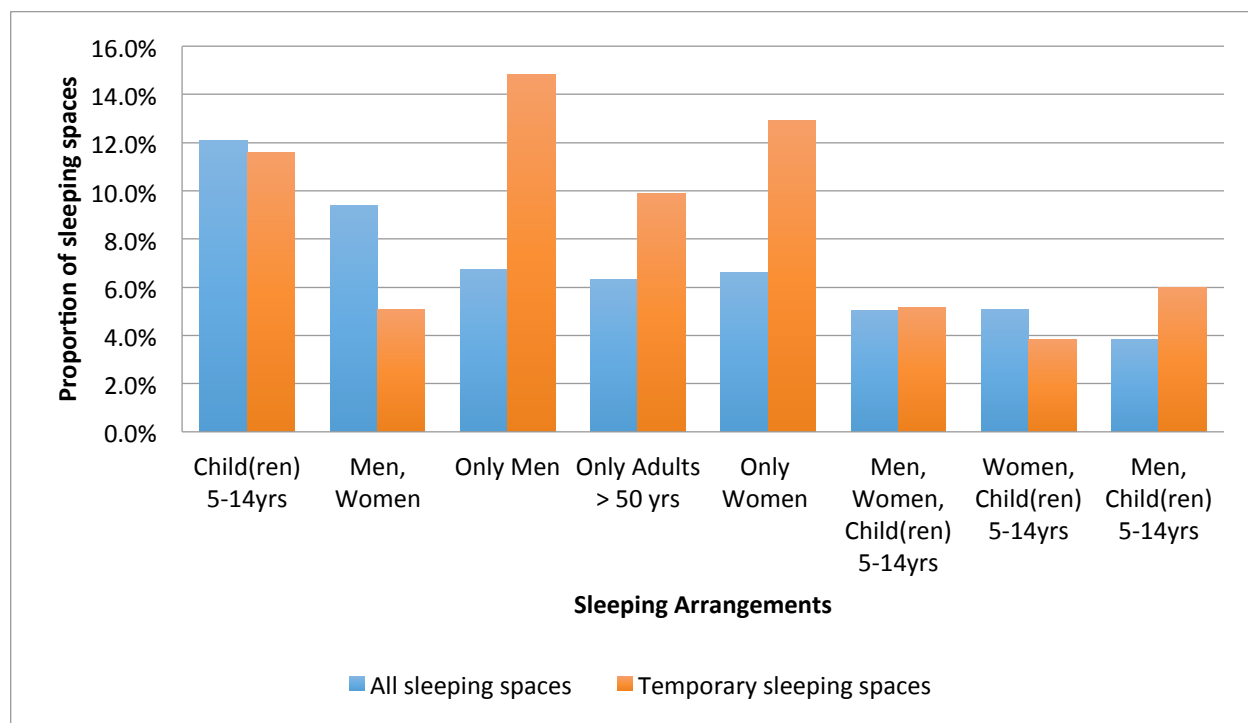
**Figure 6 Most commonly occurring sleeping arrangements for temporary sleeping spaces**

## Typical Sleeping Arrangements among Most Commonly Occurring Sleeping Spaces per Household

The proportion of households with one or two sleeping spaces was approximately equal, 42.1 percent and 42.0 percent respectively, and households with one or two sleeping spaces made up 84.2 percent of all households (Table S7). The majority of households with one sleeping space consisted of two to three persons, while the majority of households with two sleeping spaces consisted of four to five persons (Table S8 – S9). The most commonly occurring sleeping arrangement for households with one sleeping space and two to three persons included a man aged 15 to 49 years, a (not pregnant) woman aged 15 to 49 years, and a child under the age of 5 years. For households with two sleeping spaces and four to five persons, the most commonly occurring sleeping arrangement was two children aged 5 to 14 years in one sleeping space, and

in the second sleeping space a man aged 15 to 49 years and a (not pregnant) woman aged 15 to 49 years (Figure 4) (Table S10 – S11).
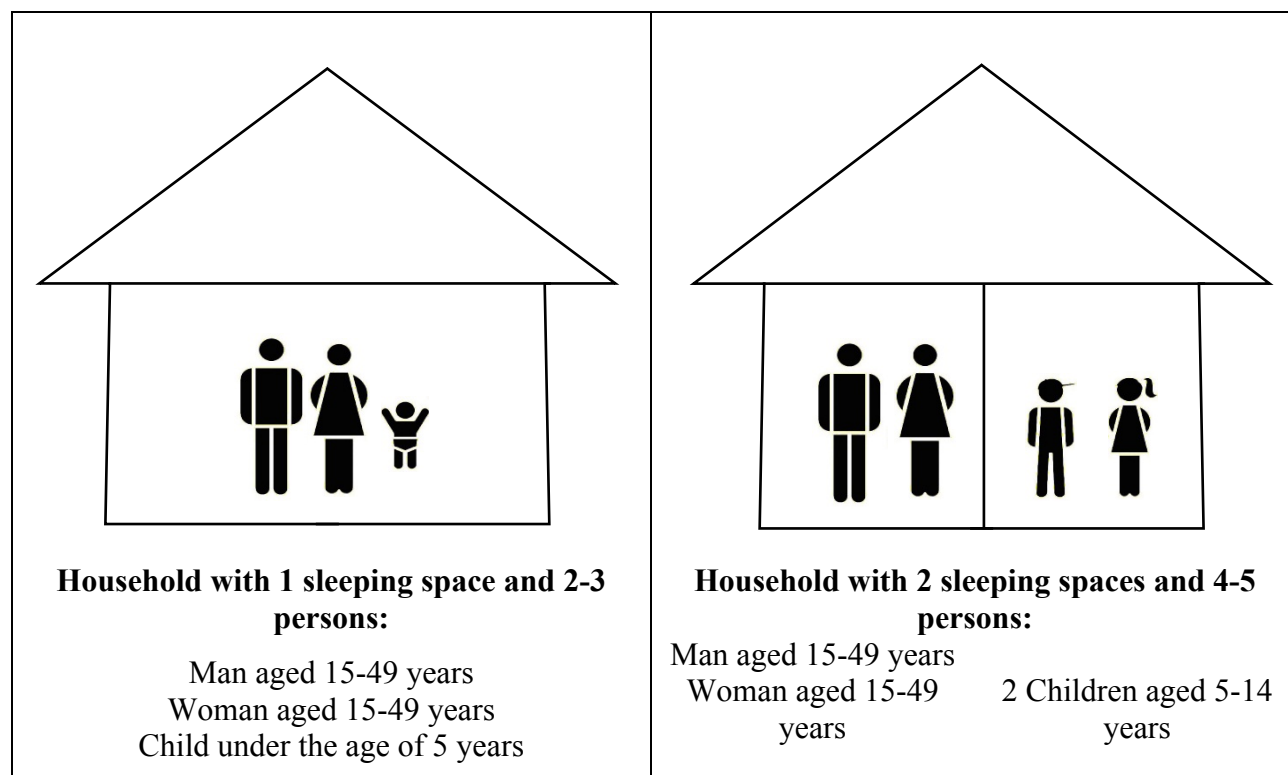


**Figure 7 Representation of the most commonly occurring household size, number of sleeping spaces and sleeping arrangements**

The analysis of the most common sleeping arrangements by person categories in the subgroup of households with one sleeping space and two or three persons, showed that the second most common pattern, occupying 15.2 percent of the sleeping spaces, was a combination of a man aged 15 to 49 years and a (not pregnant) woman aged 15 to 49 years. A man age 15 to 49 years sharing a sleeping space with a pregnant woman was also common, occupying 7.3 percent of the sleeping spaces in the subgroup. Additionally, sleeping arrangements of women aged 15 to 49

with children under the age of 5 years occupied 8 percent of the sleeping spaces, while women

aged 15 to 49 with children aged 5 to 14 years occupied 7.3 percent (Table 9).

**Table 9 Most common sleeping patterns where at least one person for each category is present in households with 1 sleeping space and 2-3 persons.**

| In households with 1 sleeping space and 2 – 3 persons n=546 households | n | % | Weighted % (CI) |
|---|---|---|---|
| At least one of each: Man (15-49yrs) Not pregnant, woman (15-49yrs) Child under the age of 5 years | 96 | 17.6 | 17.5 (12.4 – 22.5) |
| At least one of each: Man (15-49yrs) Not pregnant, woman (15-49yrs) | 82 | 15.0 | 15.2 (12.6 – 17.9) |
| At least one of each Man (15-49yrs) Pregnant woman | 46 | 8.4 | 7.3 (3.8 – 10.8) |
| At least one of each: Child under the age of 5 years Not pregnant, woman (15-49yrs) | 40 | 7.3 | 8.0 (4.3 – 11.8) |
| At least one of each: Adult over the age of 50 years Child aged 5-14 years | 38 | 7.0 | 6.6 (3.9 – 9.2) |
| At least one of each: Child aged 5-14 years Not pregnant, woman (15-49yrs) | 33 | 6.0 | 7.3 (4.3 – 10.3) |
| At least one of each: Man (15-49yrs) Not pregnant, woman (15-49yrs) Child aged 5-14 years | 30 | 5.5 | 5.4 (1.4 – 9.4) |
| At least one of each: Man (15-49yrs) Pregnant woman Child under the age of 5 years | 29 | 5.3 | 4.1 (2.2 – 6.0) |

Among the sub-group of households with two sleeping spaces and four or five people, the two

spaces were also analyzed by only whether or not a person category is present, rather than by

counts of each person. Patterns of the intra-household division of sleeping spaces became

apparent. In the first sleeping space, often a man aged 15 to 49 years and a woman age 15-49

years slept either with the youngest child category in the household or alone. Commonly

occupying the second sleeping space were one or more children aged 5-14 years, or a

combination of children aged 5-14 years and children under the age of 5 years. A second pattern observed was an unoccupied sleeping space with all men, women, and children in the household occupying the secondary space (Table 10).

**Table 10 Most commonly occurring sleeping arrangements by sleeping space in households with 2 sleeping spaces and 4-5 persons**

**At least one of following person categories are present per sleeping space**
**n=428 households**

| Household with 2 sleeping spaces | | N | % | Weighted % (CI) |
|---|---|---|---|---|
| **Sleeping Space 1** | **Sleeping Space 2** | | | |
| Child aged 5-14 years | Man (15-49yrs)<br>Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | 31 | 7.3 | 7.0 (4.0 – 10.0) |
| Child aged 5-14 years | Man (15-49yrs)<br>Not pregnant, woman (15-49yrs) | 20 | 4.7 | 6.0 (0.1 – 11.9) |
| Empty sleeping space | Man (15-49yrs)<br>Child aged 5-14 years<br>Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | 20 | 4.7 | 7.37 (0 – 16.8) |
| Empty sleeping space | Man (15-49yrs)<br>Child aged 5-14 years<br>Not pregnant, woman (15-49yrs) | 14 | 3.3 | 3.7 (0 – 9.0) |
| Child aged 5-14 years<br>Child under the age of 5 years | Man (15-49yrs)<br>Not pregnant, woman (15-49yrs) | 11 | 2.6 | 2.7 (0.5 – 4.9) |
| Child aged 5-14 years<br>Child under the age of 5 years | Man (15-49yrs)<br>Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | 10 | 2.3 | 2.9 (0.2 – 5.6) |
| Child aged 5-14 years<br>Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | Man of reproductive age (15-49yrs) | 8 | 1.9 | 1.8 (0.7 – 2.9) |
| Child aged 5-14 years | Man (15-49yrs)<br>Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | 8 | 1.9 | 2.3 (0.4 – 4.3) |
| Empty sleeping space | Man (15-49yrs)<br>Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | 7 | 1.6 | 1.7 (0-3.7) |
| Child aged 5-14 years<br>Not pregnant, woman (15-49yrs) | Man (15-49yrs)<br>Not pregnant, woman (15-49yrs) | 7 | 1.6 | 1.1 (0 – 2.4) |
| Child aged 5-14 years<br>Not pregnant, woman (15-49yrs) | Adult over 50 years | 6 | 1.4 | 1.5 (0.7 – 2.6) |
| Child aged 5-14 years | Child under the age of 5 years<br>Not pregnant, woman (15-49yrs) | 8 | 1.9 | 2.0 (0 - 4.5) |
| Man (15-49yrs)<br>Child aged 5-14 years | Man (15-49yrs)<br>Not pregnant, woman (15-49yrs) | 9 | 2.1 | 1.6 (0.3 – 2.9) |

*Only 13 most frequently occurring patterns displayed in table

**Associations Between Person Type Categories Sharing Sleeping Spaces and LLIN Coverage**

Of particular interest in this analysis were the sleeping arrangements of vulnerable groups—

pregnant women and children under the age of 5 years—as knowledge on their sleeping patterns

is essential to ensuring they are under LLINs within a household. Children under the age of 5

years most frequently shared sleeping spaces with women of reproductive age (including

pregnant and not pregnant women aged 15-49 years). A total of 81.1 percent of all sleeping

spaces that were occupied by at least one child under the age of 5 years also included at least one

woman of reproductive age. The second person category most often accompanying children

under the age of 5 years was men aged 15 to 49 years, present in 54.5 percent of all sleeping

spaces occupied by at least one child under the age of 5 years (Table 11). There were significant

associations found between children under the age of 5 years sharing sleeping spaces with

pregnant women, (not pregnant) women aged 15 to 49 years, men aged 15 to 49 years, and adults

over the age of 50 years  (Table 11). After stratifying the sleeping spaces by those that are and

are not covered by LLINs, the person categories significantly associated with children under the

age of 5 years are different among those in sleeping spaces not covered with an LLIN. There is

no longer a significant association between children under the age of 5 years and adults over the

age of 50 years, and a new significant association exists with children aged 5 to 15 years (Table

12).

**Table 11 Frequency that a sleeping space with at least one child under 5 years of age is shared with other person categories**

| Sleeping spaces with at least one child under the age of 5 years | | | | |
|---|---|---|---|---|
| n=1101 sleeping spaces | N | % | Weighted % (CI) | P value |
| Slept alone | 36 | 4.32 | 3.38 (2.14 – 4.63) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age* | 888 | 80.7 | 81.1 (77.6 – 84.6) | <0.01 |
| Pregnant woman * | 110 | 10.0 | 8.2 (5.6 – 10.8) | 0.01 |
| Woman aged 15-49 years* | 784 | 71.2 | 73.2 (70.8 – 75.7) | <0.01 |
| Man age 15-49 years* | 608 | 55.3 | 54.5 (48.8 – 60.1) | 0.01 |
| Adult over the age of 50 years* | 143 | 13.0 | 12.7 (10.0 – 15.3) | 0.01 |
| Child aged 5 to 14 years | 469 | 42.6 | 42.8 (37.4 – 48.2) | 0.40 |
| Another child under the age of 5 years | 243 | 22.1 | 22.7 (18.1 – 27.3) | -- |

*Significant association

**Table 12 Frequency that a sleeping space with at least one child under 5 years of age is shared with other person categories in sleeping spaces not covered with an LLIN**

| Sleeping spaces not covered with an LLIN with at least one child under the age of 5 years | | | | |
|---|---|---|---|---|
| n=130 sleeping spaces | N | % | Weighted % (CI) | P value |
| Slept alone | 7 | 5.38 | 6.09 (0.21 – 11.97) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age* | 100 | 76.9 | 75.7 (67.8 – 83.7) | 0.01 |
| Pregnant woman | 13 | 10 | 7.5 (0.8 – 14.2) | 0.13 |
| Woman aged 15-49 years* | 87 | 66.9 | 68.3 (57.6 – 78.9) | 0.02 |
| Man aged 15-49 years* | 76 | 58.5 | 53.8 (44.7 – 62.9) | 0.01 |
| Adults over the age of 50 years | 12 | 9.2 | 11.9 (8.2 – 15.6) | 0.58 |
| Child aged 5 to 14 years* | 60 | 46.2 | 45.3 (30.8 – 59.7) | 0.03 |
| Another child under age of 5 years | 37 | 28.5 | 26.4 (16.9 – 35.8) | -- |

*Significant association

Pregnant women were most frequently sharing a sleeping space with men aged 15 to 49 years old. Among sleeping spaces with at least one pregnant woman 176/243 (71.5%) were also occupied by at least one man aged 15 to 49 years. The second person category most frequently sharing sleeping spaces with pregnant women was children under the age of 5 years. Among all sleeping spaces occupied by pregnant women, 45.3 percent were shared with at least one child under the age of 5 years (Table 13). There were significant associations between pregnant women sharing a sleeping space with: (not pregnant) women aged 15 to 49 years, men aged 15 to

49 years, children aged 5 to 14 years, and children under the age of 5 years. The number of

pregnant women sleeping in spaces not covered by LLINs was small (n=37). After stratifying for

sleeping spaces covered and not-covered with LLINs, among sleeping spaces not covered with

LLINs there were no longer most of the significant associations between any of the person

categories and pregnant women, except children aged 5 to 14 years (Table 14).

**Table 13 Frequency that a sleeping space with at least one pregnant woman (aged 15-49 years) is shared with other person categories**

| Sleeping spaces with at least one pregnant woman n=243 sleeping spaces | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 10 | 4.1 | 4.2 (0.4 – 8.1) | -- |
| Shared a sleeping space with at least one | | | | |
| Not pregnant, women aged 15-49* | 20 | 8.2 | 8.3 (3.4 – 13.1) | <0.01 |
| Man aged 15 to 49 years* | 176 | 72.4 | 71.5 (63.9 – 79.0) | <0.01 |
| Adult over the age of 50 years | 25 | 10.3 | 14.3 (7.0 – 21.6) | 0.37 |
| Child under the age of 5 years* | 110 | 45.3 | 41.1 (26.9 – 55.2) | 0.01 |
| Child aged 5 to 14 years* | 82 | 33.7 | 32.4 (24.9 – 39.8) | <0.01 |
| Another pregnant woman | 1 | 0.4 | 0.2 (0 – 0.7) | -- |

*Significant association

**Table 14 Frequency that a sleeping space not covered by an LLIN with at least one pregnant woman (aged 15-49 years) is shared with other person categories in sleeping spaces**

| Sleeping spaces with at least one pregnant woman, in sleeping spaces not covered with an LLIN n=37 sleeping spaces | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 3 | 8.1 | 5.7 (0 – 13.4) | -- |
| Shared a sleeping space with at least one | | | | |
| Not pregnant, women of reproductive age | 2 | 5.4 | 11.9 (0 – 33.0) | 0.17 |
| Man of reproductive age* | 29 | 78.4 | 75.6 (56.4 – 94.7) | <0.01 |
| Adult over the age of 50 years | 4 | 10.8 | 9.88 (0.2 – 19.6) | 0.82 |
| Child under the age of 5 years | 13 | 35.1 | 29.4 (7.9 – 51.7) | 0.13 |
| Child aged 5 to 14 years | 15 | 40.5 | 32.7 (0 – 66.4) | 0.95 |
| Another pregnant woman | 0 | | | |

*Significant association

Lastly, children aged 5 to 14 years, sharing a sleeping space with no other person categories,

composed the most common sleeping arrangement in sleeping spaces among all households. As

they were not significantly associated with children under the age of 5 years in all sleeping

spaces (Table 13), a separate analysis was completed for this group. Children aged 5 to 14 years

were most frequently with women of reproductive age or another child aged 5 to 14 years. There

was only one person-category with which children age 5 to 14 years had a statistically significant

association for sharing a sleeping space: pregnant women (Table 15). After stratifying for LLIN

coverage by sleeping space, the only statistically significant association exists with children aged

5 to 14 years sharing a sleeping space with children under the age of 5 years (Table 16).

**Table 15 Frequency that a sleeping space with at least one child aged 5-14 years is shared with other person categories**

| Sleeping spaces with at least one child aged 5-14 years<br>n=1546 sleeping spaces | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 151 | 4.5 | 11.46 (8.82 – 14.09) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age | 802 | 51.9 | 50.4 (46.8 – 53.9) | 0.13 |
| Pregnant woman* | 82 | 5.2 | 4.4 (2.6 -6.1) | <0.01 |
| Women aged 15-49 years | 734 | 47.5 | 46.6 (43.8 – 49.5) | 0.45 |
| Man of reproductive age | 579 | 37.5 | 37.3 (33.0 – 41.6) | 0.18 |
| Adult over the age of 50 years | 274 | 17.7 | 16.8 (12.6 – 21.1) | 0.27 |
| Child under the age of 5 years | 470 | 30.4 | 28.9 (24.0 – 33.8) | 0.40 |
| Another child aged 5-14 years | 684 | 44.2 | 43.3 (38.7 – 47.8) | -- |

*Significant association

**Table 16 Frequency that a sleeping space with at least one child aged 5-14 years is shared with other person categories in sleeping spaces not covered with an LLIN**

| Sleeping spaces with at least one child aged 5-14<br>Years, not covered by an LLIN<br>n=290 sleeping spaces | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 56 | 19.3 | 22.4 (14.6 – 30.2) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age | 105 | 36.2 | 34.6 (25.9 – 43.2) | 0.93 |
| Pregnant woman | 15 | 5.2 | 3.7 (0 – 7.8) | 0.95 |
| Women aged 15-49 years | 91 | 31.4 | 31.3 (23.8 – 38.8) | 0.89 |
| Man aged 15-49 years | 99 | 34.1 | 30.8 (21.7 – 39.9) | 0.92 |
| Adult over the age of 50 years | 32 | 11.0 | 9.6 (3.3 – 15.9) | 0.65 |
| Child under the age of 5 years* | 60 | 20.7 | 20.1 (8.9 – 31.3) | 0.03 |
| Another child aged 5-14 years | 140 | 37.9 | 46.3 (40.3 – 52.2) | -- |

*Significant association

**Models for Sleeping Arrangements**

In order to investigate the dynamics between women aged 15 to 49 years, men aged 15 to 49

years, and children under the age of 5 years and the combination of these groups were selected

for multivariable models. The combined group of pregnant and not pregnant women aged 15 to

49 years (women of reproductive age) and children under the age of 5 years were significantly

associated with sharing a sleeping space, and were present in many of the common sleeping

arrangements. The outcome of at least one woman of reproductive age and at least one child

under the age of 5 years sleeping together was modeled as a dependent variable in a logistic

regression, adjusting for other person categories possibly present in the sleeping space and other

household factors affecting sleeping spaces as independent variables. The odds of a woman of

reproductive age and a child under the age of 5 years sharing a sleeping space increased if a man

aged 15 to 49 years was present, if the sleeping space was permanent, or if there were fewer than

3 sleeping spaces in the household, after adjusting for all other variables. The odds of a woman

of reproductive age and a child under the age of 5 years sharing a sleeping space decreased if

there was an adult over the age of 50 years in the sleeping space, when adjusting for all other

variables. The odds of a woman of reproductive age and a child under the age of 5 years sharing

a sleeping space in the wealthiest quintile was 1/5 the odds of them sharing a sleeping space in

the poorest quintile, after adjusting for all other variables (Table 17).

**Table 17 Multivariable analysis model for the outcome that a woman aged 15 – 49 years is sharing a sleeping a sleeping space with a child under the age of 5 years**

| n=3720 sleeping spaces | Univariate analysis | | | Multivariable analysis | | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% Wald CI | P-value | Odds Ratio | 95% Wald CI | P-value |
| Men (15-49 years)* | 3.35 | (2.5 – 4.5) | <0.01 | 2.43 | (1.9 – 3.4) | <0.01 |
| Children 5-14 years | 0.96 | (0.7 – 1.4) | 0.83 | 0.89 | (0.6 – 1.2) | 0.57 |
| Adult over 50 years* | 0.45 | (0.3 – 0.7) | <0.01 | 0.47 | (0.4 – 0.7) | <0.01 |
| Wealth Quintile * | | | <0.01 | | | <0.01 |
| 5 vs. 1 | 0.20 | (0.1 – 0.3) | <0.01 | 0.23 | (0.2 – 0.3) | <0.01 |
| 4 vs. 1 | 0.37 | (0.2 – 0.6) | 0.06 | 0.53 | (0.2 – 0.6) | 0.41 |
| 3 vs. 1 | 0.64 | (0.5 – 0.8) | 0.02 | 0.60 | (0.5 – 0.8) | 0.06 |
| 2 vs. 1 | 0.69 | (0.5 – 0.9) | 0.01 | 5.12 | (0.5- 0.7) | 0.06 |
| Permanent sleeping space* | 5.57 | (2.9 – 10.7) | <0.01 | 5.36 | (2.7 – 10.6) | <0.01 |
| Fewer than 3 sleeping spaces* | 3.53 | (2.6 – 4.8) | <0.01 | 2.26 | (1.6 – 3.1) | <0.01 |

*Statistically significant

The outcome of at least one man aged 15 to 49 and at least one woman of reproductive age sharing a sleeping space was modeled as a dependent variable in a logistic regression, adjusting for other person categories possibly present in the sleeping space and other household factors affecting sleeping spaces as independent variables. The odds of a man aged 15 to 49 sharing a sleeping space with a woman aged 15 to 49 increased if there was a child under the age of 5 years present, if the sleeping space was permanent, or if there were fewer than 3 sleeping spaces in the household, after adjusting for all other variables. The odds of a man aged 15 to 49 sharing a sleeping space with a woman aged 15 to 49 decreased if there was an adult over the age of 50 years present, or if there was a child aged 5 to 14 years present, after adjusting for all other variables (Table 18).

**Table 18 Multivariable analysis model for the outcome that a woman aged 15-49 years is sharing a sleeping space with a man aged 15-49 years**

| n=3720 sleeping spaces | Univariate analysis | | | Multivariable analysis | | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% Wald CI | P-value | Odds Ratio | 95% Wald CI | P-value |
| Children < 5 years* | 3.94 | (3.2 – 4.9) | <0.01 | 3.17 | (2.5 – 3.9) | <0.01 |
| Adults over 50 years* | 0.15 | (0.1 – 0.3) | <0.01 | 0.69 | (0.5 – 0.9) | <0.01 |
| Children 5-14 years* | 0.79 | (0.6 – 1.1) | <0.01 | 0.12 | (0.1 – 0.3) | 0.02 |
| Permanent sleeping space* | 4.09 | (2.6 – 6.5) | <0.01 | 3.13 | (2.4 – 4.1) | <0.01 |
| Fewer than 3 sleeping spaces* | 3.01 | (2.5 – 3.7) | <0.01 | 3.58 | (2.1 - 6.2) | <0.01 |

*Statistically significant

Lastly, at least one man aged 15 to 49 years and at least one child under the age of 5 years sharing a sleeping space was modeled as a dependent variable in a logistic regression, adjusting for other person categories possibly present in the sleeping space and other household factors affecting sleeping spaces as independent variables. The odds that a man aged 15 to 49 years old and a child under the age of 5 years were sharing a space, when a woman of reproductive age was also present was 15.91 times the odds that they would be sharing a space when a woman of reproductive age was not present, adjusting for all other variables. The odds of a man aged 15 to 49 and a child under the age of 5 sharing a sleeping space also increase if the sleeping space is permanent, or if there are fewer than 3 sleeping spaces in the household. The odds that they would share a sleeping space decrease with the presence of any other person group (adults over the age of 50 years or children aged 5 to 15 years) sharing the sleeping space.

**Table 19 Multivariable analysis model for the outcome that a man aged 15 – 49 years is sharing a sleeping space with a child under the age of 5 years**

| n=3720 | Univariate analysis | | | Multivariable analysis | | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% Wald CI | P-value | Odds Ratio | 95% Wald CI | P-value |
| Women of Reproductive age (15-49 years)* | 21.74 | (15.2 – 31.0) | <0.01 | 15.91 | (11.1 - 22.7) | <0.01 |
| Adults over the age of 50 years* | 0.13 | (0.1 – 0.3) | <0.01 | 0.13 | (0.1 – 0.3) | <0.01 |
| Children aged 5-15 years | 0.94 | (0.6 – 1.6) | 0.80 | 0.93 | (0.5 – 1.5) | 0.78 |
| Wealth Quintile* | | | <0.01 | | | <0.01 |
| 5 vs. 1* | 0.29 | (0.2 – 0.4) | <0.01 | 0.35 | (0.2 – 0.6) | <0.01 |
| 4 vs. 1 | 0.48 | (0.3 – 0.7) | 0.03 | 0.56 | (0.5 – 0.7) | 0.06 |
| 3 vs. 1 | 0.87 | (0.7 – 1.1) | <0.01 | 0.86 | (0.6 – 1.2) | 0.01 |
| 2 vs. 1 | 0.85 | (0.5 – 1.4) | 0.10 | 0.82 | (0.5 – 1.4) | 0.23 |
| Permanent sleeping space* | 6.57 | (4.1 – 10.7) | <0.01 | 4.08 | (2.6 – 6.5) | <0.01 |
| Fewer than 3 sleeping spaces* | 3.17 | (2.3 – 4.3) | <0.01 | 1.55 | (1.2 – 1.9) | <0.01 |

*Statistically significant

# Discussion and Conclusions

## Discussion

For all sleeping spaces in the study population, as the number of household sleeping spaces increased, the average number of persons per sleeping space decreased. This is supported by previous sleeping space analyses, and is also apparent in the patterns for sleeping arrangements in this analysis. As the number of sleeping spaces per household increased, the proportion of sleeping spaces occupied by three or more person categories decreased in all instances. Similarly, sleeping spaces occupied by single person categories increased as the number of sleeping spaces per household increased. The only instance of this not occurring was among sleeping arrangements including only adults over the age of 50 years, which could be explained by the fact that both genders were included in that one person-category.

An important pattern observed in this exploratory analysis, which was not found in the literature, was that across varying conditions a man aged 15 to 49 years and a woman aged 15 to 49 years were frequently sharing a sleeping space. In both of the most commonly observed sleeping arrangements—households with one sleeping space and two to three persons, and households with two sleeping spaces and four to five people—a combination of these two person-categories were present. Previous studies in Africa highlight the sleeping arrangements of mothers and children under the age of 5 years, and while there is still an important association between those two person categories, this analysis shows that in Madagascar the men aged 15 to 49 years should be included in that relationship [27, 45]. The odds that a woman is sharing a sleeping space with either a child under the age of five years or a man aged 15 to 49 years both increase when the other person category is present in the sleeping space. Sleeping arrangements of a man

aged 15 to 49 years and a child under the age of five years—without a woman aged 15 to 49 years—are not common. The odds of a man aged 15 to 49 years and a child under the age of 5 years sharing a sleeping space with a woman of reproductive age present, are more than 15 times the odds of them sharing a sleeping space without a woman of reproductive age present, after adjusting for all other variables. This implies that the association hinges on the woman aged 15 to 49 years, and that she may be an important factor when addressing LLIN coverage and use for the household.

When aggregating all of the sleeping spaces, the most frequently occurring sleeping arrangement in the population was one or more children aged 5-14 years without any other person categories present. This sleeping arrangement is often a secondary sleeping space within a household, as it is not commonly observed in households with only one sleeping space. This sleeping arrangement was noted in other studies, often associated with temporary sleeping spaces and lower LLIN use than other person categories [33, 34, 36]. This analysis for children 5 to 14 years may also support those findings, as they were one of the most commonly occurring sleeping arrangements in both an analysis of temporary sleeping spaces, as well as in sleeping spaces that were not covered with LLINs. This could be in part explained by the fact that they also make up the largest proportion of the population in households. They were also the group least likely to be associated with sharing a sleeping space with other person categories, indicating they often slept in groups with other children of that age category, as was observed elsewhere [34]. Considering that men and women were commonly sharing sleeping spaces, with or without a child under the age of 5 years, it is logical that the secondary spaces in the household would include the older children.

While there were very few temporary sleeping spaces, the analysis of sleeping arrangements in temporary sleeping spaces is interesting because of its deviation from the patterns of sleeping spaces observed in all sleeping spaces. Single person-type category sleeping arrangements, except for children aged 5-14 years, all made up larger proportions of temporary sleeping spaces compared to the proportion of sleeping spaces they occupied in all sleeping spaces. The only increase in proportion of sleeping spaces occupied by a combination of person category groups found in temporary sleeping spaces was for men aged 5 to 14 years and children aged 5 to 14 years. This is supported by the literature, which demonstrated that men and older children's sleeping patterns were more variable than those of women and young children [26, 44]. It was, however, unusual that there was such a large proportion of women sleeping alone in temporary sleeping spaces, occupying 12.9 percent of all occupied temporary sleeping spaces, and this will be interesting to compare to intra-household LLIN use for those instances.

When stratifying all sleeping spaces by LLIN coverage for the most common sleeping arrangements, patterns similar to those of temporary sleeping spaces emerge. It was more common for single person-type category sleeping arrangement to occupy a greater proportion of sleeping spaces not covered with an LLIN, especially for sleeping arrangements including only children aged 5 to 14 years old. Again, all of the most frequently occurring sleeping arrangements with a combination of two or more person categories occurred for a smaller proportion of sleeping spaces among those not covered by an LLIN compared to those in the overall population, except for sleeping arrangements including both men aged 15 to 49 years and children aged 5 to 14 years. As both of these subsets experience similar patterns that deviate

from the most common combination of sleeping arrangements, it is possible that there is a

relationship between the person-types prioritized for permanent sleeping spaces and and those

prioritized for LLINs.

**Limitations**

A strong component of previous studies were the descriptions of prioritization of sleeping spaces

within a household. There were strong associations with certain household members sleeping in

temporary versus permanent sleeping spaces and these data could then be related to mosquito net

data on coverage and use. Previous studies defined these temporary sleeping spaces as multi-use

spaces, which accounted for areas of the household that were used as sleeping spaces at

nighttime, but had other purposes during the daytime [33-35]. With so few sleeping spaces being

classified as temporary, but with a relatively large amount of households containing only one

room or two rooms, it is likely the definition of a temporary sleeping space did not capture these

multi-use spaces in this survey.

A secondary limitation to the study is that relationships between individuals in a household were

not recorded at the time of the survey and therefore we do not know the true relationships

between household members. These relationships may have a an impact on the data, for example

sleeping arrangements composed of immediate family members may be separate from those

composed of extended family members, information that cannot be captured in this data.

Another limitation to the study is the assumption that the sleeping arrangements observed in this study are consistent over time. The survey was completed just after the rainy season, which corresponds to the high transmission season for the part of Madagascar surveyed. While this is the most ideal time for assessing LLIN use, if the study could have been repeated at different points in time, for example, during low transmission and high transmission seasons, the stability of sleeping arrangements and prioritization of person-types categories for LLIN coverage could have been assessed.

The age classification for children was chosen in order to make comparisons to the standard indicator for health programs, child under the age of 5 years. As adults are generally classified as anyone over the age of 15 years in Madagascar, children aged 5 to 15 years were included in a single category in this initial analysis. This categorization assumes homogenous sleeping arrangement behavior in this person-type category, which limits the interpretation. As the culturally appropriate sleeping arrangements of children under the age of 5 years and children aged 5 to 15 years has not been investigated, it should not be assumed that all ages within these person-type categories behave in the same way. For example, infants less than one year may have different sleeping space companions than their siblings of four years old. Such information was not included in this analysis, but could be performed in the future [23, 26]. Similarly, it may have been more appropriate to look at pre-pubescent versus pubescent children. It is a fairly large assumption that children aged 5 years have the same sleeping arrangement companions as children of 14 years. Since the most frequent sleeping arrangement among all sleeping spaces contained only children aged 5 to 14 years, and this person category was also frequent in uncommon groups—it was present in temporary sleeping spaces, in sleeping spaces not covered

by an LLIN, and in households with more than 3 sleeping spaces per household—it would be important to see how a different breakdown of the age category could affect the sleeping arrangements of this group.

The confidence level for statistical significance was set at 95 percent, for the entirety of the analysis for this thesis. As this was an exploratory analysis and many tests for association were completed, the significance level should have been set higher to account for type I error.

## Next Steps

The results of the sleeping arrangement patterns from this analysis will provide the foundation for a larger sleeping space analysis on intra-household prioritization of LLINs by sleeping space and how sleeping arrangements affect use of LLINs by person categories. While the patterns observed in this analysis will be beneficial to any health-related intervention targeted at the household level, especially because intra-household data on sleeping arrangements in Madagascar has not existed beyond anecdotal evidence.  In relation to malaria, the link of these sleeping arrangement patterns to LLIN ownership and use data will provide a clearer picture about what is occurring at the intra-household level for an intervention that has already been invested in on a very large scale in Madagascar and elsewhere.

Describing patterns of sleeping arrangements and household allocation of sleeping spaces, and relating it to LLIN coverage and use within households will be especially interesting. For example, with only sleeping arrangement data, it was not clear why multiple sleeping space

households would leave sleeping spaces unoccupied and have a large proportion of persons sleeping in another space together. When analyzed in the context of the data on LLIN ownership, coverage and use there could be factors associated with LLINs that would explain these sleeping arrangements.

Lastly, sleeping spaces in the population were largely homogeneous: at least three-fourths were covered with LLINs, were permanent sleeping spaces, and occurred in households that had fewer than three sleeping spaces. This caused patterns among the majority of subsets of both households and sleeping spaces to be similar. It will be important to further investigate some of these abnormal subsets—children aged 5 to 14 years, men aged 15 to 49 years who are not sleeping with a woman aged 15 to 49 years, and other person-categories occupying temporary and not covered sleeping spaces—to fully understand how intra-household dynamics for prioritization of LLIN allocation and use are occurring.

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# Supplemental Tables

**Table 1S Most common sleeping arrangements by sleeping space in all households**

| Sleeping arrangements in all households<br>    n=3,340 sleeping spaces<br>Person category arrangements by sleeping space | N | % | Weighted % (CI) |
|---|---|---|---|
| Only Children aged 5-14 years | 368 | 11.02 | 12.08 (9.99 – 14.16) |
| At least one of each:<br>    Man aged 15-49 years,<br>    Child under the age of 5 years,<br>    Not pregnant woman aged 15-49 years | 305 | 9.13 | 8.59 (5.20 – 11.98) |
| At least one of each:<br>    Man aged 15-49 years<br>    Not pregnant woman aged 15-49 years | 283 | 8.47 | 9.40 (5.92 - 12.89) |
| Only men of reproductive age | 249 | 7.46 | 6.75 (5.59 – 7.91) |
| Only adults over the age of 50 years | 205 | 6.14 | 6.33 (4.38 - 8.28) |
| Only women of reproductive age | 196 | 5.87 | 6.61 (3.62 – 9.60) |
| At least one of each:<br>    Child aged 5-14 years of age<br>    Not pregnant woman aged 15-49 years | 178 | 5.33 | 5.07 (4.05 – 6.08) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 175 | 5.24 | 5.28 (4.02 – 6.53) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years<br>    Not pregnant woman aged 15-49 years | 162 | 4.85 | 5.02 (3.79 – 6.25) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years | 134 | 4.01 | 3.82 (3.12 – 4.51) |
| At least one of each:<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 123 | 3.68 | 3.71 (2.26 – 5.17) |
| At least one of each:<br>    Adults over the age of 50 years<br>    Child aged 5-14 years | 97 | 2.90 | 2.84 (1.92 – 3.77) |
| At least one of each:<br>    Adults over the age of 50 years<br>    Not pregnant woman aged 15-49 years | 97 | 2.90 | 3.37 (2.84 – 3.90) |
| At least one of each:<br>    Child aged 5-14 years<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 94 | 2.81 | 2.74 (1.74 – 3.76) |
| At least one of each:<br>    Child aged 5-14 years<br>    Child under the age of 5 years | 84 | 2.51 | 2.48 (1.76 – 3.19) |

**Table 2S Most common sleeping arrangements by sleeping space in households with at least two sleeping spaces**

| Person categories by sleeping space | N | % | Weighted % (CI) |
|---|---|---|---|
| **Sleeping arrangements in households with at least 2 sleeping spaces** | | | |
| **n=2,296 sleeping spaces** | | | |
| Only Children aged 5-14 years | 367 | 15.98 | 16.71 (14.48 – 18.47) |
| At least one of each: Man aged 15-49 years, Child under the age of 5 years, Not pregnant woman aged 15-49 years | 168 | 7.32 | 6.71 (2.93 – 10.49) |
| At least one of each: Man aged 15-49 years Not pregnant woman aged 15-49 years | 194 | 8.45 | 9.74 (5.53 – 13.96) |
| Only men of reproductive age | 174 | 7.58 | 6.92 (5.47 – 8.38) |
| Only adults over the age of 50 years | 125 | 5.44 | 5.87 (3.96 – 7.78) |
| Only women of reproductive age | 136 | 5.92 | 6.67 (3.61 – 9.73) |
| At least one of each: Child aged 5-14 years of age Not pregnant woman aged 15-49 years | 136 | 5.92 | 5.33 (4.01 – 6.65) |
| At least one of each: Man aged 15-49 years Child aged 5-14 years Child under the age of 5 years Not pregnant woman aged 15-49 years | 77 | 3.35 | 3.76 (2.25 – 5.27) |
| At least one of each: Man aged 15-49 years Child aged 5-14 years Not pregnant woman aged 15-49 years | 98 | 4.27 | 4.42 (2.27 – 6.56) |
| At least one of each: Man aged 15-49 years Child aged 5-14 years | 125 | 5.44 | 4.99 (3.99 – 5.98) |
| At least one of each: Child under the age of 5 years Not pregnant woman aged 15-49 years | 80 | 5.92 | 3.44 (2.10 – 4.76) |
| At least one of each: Individual over the age of 50 years Child aged 5-14 years | 53 | 2.31 | 2.30 (1.19 – 3.40) |
| At least one of each: Individual over the age of 50 years Not pregnant woman aged 15-49 years | 76 | 3.31 | 3.71 (3.02 – 4.39) |
| At least one of each: Child aged 5-14 years Child under the age of 5 years Not pregnant woman aged 15-49 years | 49 | 2.13 | 2.10 (1.33 – 2.87) |
| At least one of each: Child aged 5-14 years Child under the age of 5 years | 84 | 3.66 | 3.40 (2.34 – 4.45) |

**Table 3S Most common sleeping arrangements by sleeping space in households with at least 3 sleeping spaces**

| Sleeping arrangements in households with at least 3 sleeping spaces n=682 sleeping spaces | | | |
|---|---|---|---|
| **Person categories by sleeping space** | **N** | **%** | **Weighted % (CI)** |
| Only Children aged 5-14 years | 124 | 18.18 | 18.65 (16.04 – 20.90) |
| At least one of each: Man aged 15-49 years, Child under the age of 5 years, Not pregnant woman aged 15-49 years | 26 | 3.81 | 3.01 (0.93 – 5.08) |
| At least one of each: Man aged 15-49 years Not pregnant woman aged 15-49 years | 58 | 8.50 | 9.94 (5.95 – 13.92) |
| Only men of reproductive age | 70 | 10.26 | 8.91 (6.48 – 11.33) |
| Only individuals over the age of 50 years | 32 | 4.69 | 5.64 (2.38 – 8.91) |
| Only women of reproductive age | 66 | 9.68 | 11.57 (6.54 – 16.60) |
| At least one of each: Child aged 5-14 years of age Not pregnant woman aged 15-49 years | 47 | 6.89 | 5.91 (4.12 – 7.72) |
| At least one of each: Man aged 15-49 years Child aged 5-14 years Child under the age of 5 years Not pregnant woman aged 15-49 years | 13 | 1.91 | 1.77 (0.94 – 2.60) |
| At least one of each: Man aged 15-49 years Child aged 5-14 years Not pregnant woman aged 15-49 years | 28 | 4.11 | 3.67 (2.88 – 4.47) |
| At least one of each: Man aged 15-49 years Child aged 5-14 years | 36 | 5.28 | 3.89 (2.54 – 5.24) |
| At least one of each: Child under the age of 5 years Not pregnant woman aged 15-49 years | 23 | 3.37 | 3.43 (1.47 – 5.38) |
| At least one of each: Individual over the age of 50 years Child aged 5-14 years | 11 | 1.61 | 1.68 (0.63 – 2.74) |
| At least one of each: Individual over the age of 50 years Not pregnant woman aged 15-49 years | 29 | 4.25 | 4.87 (3.88 – 5.85) |
| At least one of each: Child aged 5-14 years Child under the age of 5 years Not pregnant woman aged 15-49 years | 9 | 1.32 | 0.90 (0.30 – 1.51) |
| At least one of each: Child aged 5-14 years Child under the age of 5 years | 16 | 2.35 | 2.56 (1.40 – 3.72) |

**Table 4S Most common sleeping arrangements by sleeping space for sleeping spaces NOT covered by an LLIN**

| Sleeping arrangements in sleeping spaces not covered with LLIN<br>n=603* sleeping spaces | | | |
|---|---|---|---|
| Person categories by sleeping space | N | % | Weighted % (CI) |
| Only Children aged 5-14 years | 118 | 19.57 | 20.05 (17.02 – 23.08) |
| At least one of each:<br>Man aged 15-49 years,<br>Child under the age of 5 years,<br>Not pregnant woman aged 15-49 years | 34 | 5.64 | 4.82 (0.77 – 8.86) |
| At least one of each:<br>Man aged 15-49 years<br>Not pregnant woman aged 15-49 years | 38 | 6.30 | 8.07 (3.28 – 12.86) |
| Only men of reproductive age | 90 | 14.93 | 12.42 (9.2 – 15.62) |
| Only individuals over the age of 50 years | 31 | 5.14 | 5.98 (1.28 – 10.69) |
| Only women of reproductive age | 48 | 7.96 | 11.77 (3.43 – 20.11) |
| At least one of each:<br>Child aged 5-14 years of age<br>Not pregnant woman aged 15-49 years | 26 | 4.31 | 3.84 (1.80 – 5.88) |
| At least one of each:<br>Man aged 15-49 years<br>Child aged 5-14 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 24 | 3.98 | 3.54 (1.16 – 5.92) |
| At least one of each:<br>Man aged 15-49 years<br>Child aged 5-14 years<br>Not pregnant woman aged 15-49 years | 17 | 2.82 | 3.12 (1.87 – 4.37) |
| At least one of each:<br>Man aged 15-49 years<br>Child aged 5-14 years | 36 | 5.97 | 4.56 (1.69 – 7.42) |
| At least one of each:<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 13 | 2.16 | 2.16 (0.88 – 3.44) |
| At least one of each:<br>Individual over the age of 50 years<br>Child aged 5-14 years | 11 | 1.82 | 1.76 (0 – 3.74) |
| At least one of each:<br>Individual over the age of 50 years<br>Not pregnant woman aged 15-49 years | 12 | 1.99 | 2.39 (0.78 – 4.01) |
| At least one of each:<br>Child aged 5-14 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 9 | 1.49 | 0.73 (0 – 3.27) |
| At least one of each:<br>Child aged 5-14 years<br>Child under the age of 5 years | 14 | 2.32 | 0.98 (0.01 – 4.45) |

*203 sleeping spaces not covered by an LLIN were unoccupied

**Table 5S Most common sleeping arrangements by sleeping space for sleeping spaces covered by an LLIN**

**Sleeping arrangements in sleeping spaces covered with LLIN**
      **n=2,737\* sleeping spaces**

| Person categories by sleeping space | N | % | Weighted % (CI) |
|---|---|---|---|
| Only Children aged 5-14 years | 250 | 9.13 | 10.23 (7.71 – 12.75) |
| At least one of each:<br>    Man aged 15-49 years,<br>    Child under the age of 5 years,<br>    Not pregnant woman aged 15-49 years | 271 | 9.90 | 9.47 (6.04 – 12.90) |
| At least one of each:<br>    Man aged 15-49 years<br>    Not pregnant woman aged 15-49 years | 245 | 8.95 | 9.71 (6.27 – 13.16) |
| Only men of reproductive age | 159 | 5.81 | 5.44 (4.28 – 6.60) |
| Only individuals over the age of 50 years | 174 | 6.36 | 6.41 (4.97 – 7.86) |
| Only women of reproductive age | 148 | 5.41 | 5.41 (2.85 – 7.97) |
| At least one of each:<br>    Child aged 5-14 years of age<br>    Not pregnant woman aged 15-49 years | 152 | 5.55 | 5.35 (4.27 – 6.43) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 151 | 5.52 | 5.68 (4.51 – 6.85) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years<br>    Not pregnant woman aged 15-49 years | 145 | 5.30 | 5.46 (4.01 – 6.91) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years | 97 | 3.54 | 3.64 (3.02 – 4.27) |
| At least one of each:<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 110 | 4.02 | 4.07 (2.39 – 5.76) |
| At least one of each:<br>    Individual over the age of 50 years<br>    Child aged 5-14 years | 86 | 3.14 | 3.10 (2.28 – 3.92) |
| At least one of each:<br>    Individual over the age of 50 years<br>    Not pregnant woman aged 15-49 years | 85 | 3.11 | 3.60 (2.90 – 4.30) |
| At least one of each:<br>    Child aged 5-14 years<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 85 | 3.11 | 2.99 (1.84 – 4.14) |
| At least one of each:<br>    Child aged 5-14 years<br>    Child under the age of 5 years | 70 | 2.56 | 2.53 (1.90 – 3.16) |

*177 sleeping spaces covered by an LLIN were unoccupied

**Table 6S Most common sleeping arrangements by sleeping space for temporary sleeping spaces**

| Sleeping arrangements in temporary sleeping spaces<br>n=117 sleeping spaces | | | |
|---|---|---|---|
| **Person categories by sleeping space** | **N** | **%** | **Weighted % (CI)** |
| Only Children aged 5-14 years | 15 | 12.82 | 11.58 (0 – 23.96) |
| At least one of each:<br>    Man aged 15-49 years<br>    Not pregnant woman aged 15-49 years | 8 | 6.84 | 5.08 (0 – 11.28) |
| Only men of reproductive age | 21 | 17.95 | 14.84 (5.34 – 24.34) |
| Only individuals over the age of 50 years | 9 | 7.69 | 9.89 (4.13– 15.65) |
| Only women of reproductive age | 13 | 11.11 | 12.92 (0 – 26.56) |
| At least one of each:<br>    Child aged 5-14 years of age<br>    Not pregnant woman aged 15-49 years | 6 | 5.13 | 3.84 (1.41 – 6.26) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years<br>    Not pregnant woman aged 15-49 years | 4 | 3.42 | 5.18 (2.87 – 7.50) |
| At least one of each:<br>    Man aged 15-49 years<br>    Child aged 5-14 years | 6 | 5.13 | 5.98 (3.09 – 8.86) |
| At least one of each:<br>    Child aged 5-14 years<br>    Child under the age of 5 years<br>    Not pregnant woman aged 15-49 years | 5 | 4.27 | 3.96 (0 – 11.23) |

**Table 7S Frequency of sleeping spaces per household**

| Number of sleeping spaces per household<br>n=2,211 sleeping spaces | N | % | Weighted % (CI) |
|---|---|---|---|
| **1 sleeping space** | **1044** | **47.22** | **42.21 (30.71 – 53.72)** |
| **2 sleeping spaces** | **910** | **41.16** | **42.03 (36.37 – 47.69)** |
| 3 sleeping spaces | 192 | 8.68 | 11.01 (5.53 – 16.50) |
| 4 or more sleeping spaces | 65 | 2.94 | 4.74 (1.24-8.24) |

**Table 8S Frequency of persons per households, in households with one sleeping space**

| Households with 1 sleeping space n=1,044 Persons per household | N | % | Weighted % (CI) |
|---|---|---|---|
| 1 | 176 | 16.86 | 16.40 (9.88 – 22.91) |
| **2** | **274** | **26.25** | **26.50 (20.52 – 32.47)** |
| **3** | **272** | **26.05** | **26.61 (21.65 – 31.57)** |
| 4 | 177 | 16.95 | 16.84 (11.67 – 22.03) |
| 5 | 88 | 8.43 | 8.31 (4.80 – 11.81) |
| 6 or more | 57 | 5.08 | 2.25 (0.81 – 3.69) |

**Table 9S Most commonly occurring number of persons per household, in households with two sleeping spaces**

| Households with 2 sleeping space n=910 households | N | % | Weighted % (CI) |
|---|---|---|---|
| Persons per household | | | |
| 1 | 15 | 1.65 | 1.60 (0.38 – 2.82) |
| 2 | 80 | 8.79 | 8.30 (4.54 – 12.06) |
| 3 | 151 | 16.59 | 16.29 (10.64 – 21.95) |
| **4** | **209** | **22.97** | **25.50 (20.16 – 30.85)** |
| **5** | **219** | **24.07** | **24.72 (20.60 – 28.84)** |
| 6 | 117 | 12.86 | 11.92 (6.01 – 17.31) |
| 7 | 56 | 6.15 | 4.66 (1.37 – 7.94) |
| 8 or more | 63 | 6.93 | 2.95 (0.99 – 4.91) |

**Table 10S Most common sleeping patterns accounting for every individual in households with 1 sleeping space and 2-3 people**

| In households with 1 sleeping space and 2 – 3 persons n=546 | N | % | Weighted % (CI) |
|---|---|---|---|
| Man aged 15-49 years<br>Not pregnant woman aged 15-49 years<br>Child under the age of 5 years | 96 | 17.58 | 17.47 (12.40 – 22.54) |
| Man aged 15-49 years<br>Not pregnant woman aged 15-49 years | 77 | 14.10 | 14.75 (11.98 – 17.53) |
| Man aged 15-49 years<br>Pregnant woman | 45 | 8.24 | 6.97 (3.78 – 10.17) |
| Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 30 | 5.49 | 5.38 (3.60 – 7.17) |
| Adult over the age of 50 years<br>Child aged 5-14 years | 22 | 4.03 | 2.98 (1.12 – 4.84) |
| Child aged 5-14 years<br>Not pregnant woman aged 15-49 years | 18 | 3.30 | 3.07 (1.38 – 4.57) |
| Man aged 15-49 years<br>Not pregnant woman aged 15-49 years<br>Child aged 5-14 years | 30 | 5.49 | 5.41 (1.38 – 9.44) |
| Man aged 15-49 years<br>Pregnant woman<br>Child under the age of 5 years | 29 | 5.31 | 4.09 (2.22 – 5.97) |
| Two adults over the age of 50 years | 23 | 4.21 | 4.28 (1.54 – 7.02) |
| Adult over the age of 50 years<br>Not pregnant woman aged 15-49 years | 19 | 3.48 | 4.38 (1.17 – 7.59) |
| Not pregnant woman aged 15-49 years<br>Child aged 5-14 years<br>Child under the age of 5 | 16 | 2.93 | 3.19 (2.01 – 4.36) |
| Two Men (15-49yrs) | 11 | 2.01 | 2.10 (0.49 – 3.70) |
| Two children aged 5-14 years<br>Not pregnant woman of reproductive age | 10 | 1.83 | 2.83 (0.70 – 4.96) |

**Table 11S Most commonly occurring sleeping arrangements by sleeping space accounting for every individual in households with 2 sleeping spaces and 4-5 persons**

**Any of the following person categories are present per sleeping space**
**n=428**

| Household with 2 sleeping spaces | | N | % | Weighted % (CI) |
|---|---|---|---|---|
| **Sleeping Space 1** | **Sleeping Space 2** | | | |
| Child aged 5-14 years | Man aged 15-49 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 31 | 7.24 | 7.01 (3.96 – 10.07) |
| Child aged 5-14 years | Man aged 15-49 years<br>Not pregnant woman aged 15-49 years | 20 | 4.67 | 6.04 (0.13 – 11.95) |
| Empty sleeping Space | Man aged 15-49 years<br>Child aged 5-14 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 20 | 4.67 | 7.37 (0 – 16.76) |
| Empty sleeping space | Man aged 15-49 years<br>Child aged 5-14 years<br>Not pregnant woman aged 15-49 years | 14 | 3.27 | 3.74 (0 - 8.96) |
| Child aged 5-14 years<br>Child under the age of 5 years | Man aged 15-49 years<br>Not pregnant woman aged 15-49 years | 11 | 2.57 | 2.67 (0.46 – 4.88) |
| Child aged 5-14 years<br>Child under the age of 5 years | Man aged 15-49 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 10 | 2.34 | 2.86 (0.16 – 5.56) |
| Child aged 5-14 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | Man aged 15-49 years | 8 | 1.87 | 1.81 (0.67 – 2.95) |
| Child aged 5-14 years | Man aged 15-49 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 8 | 1.87 | 2.32 (0.35 – 4.30) |
| Empty sleeping space | Man aged 15-49 years<br>Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 7 | 1.64 | 1.65 (0-3.72) |
| Child aged 5-14 years<br>Not pregnant woman aged 15-49 years | Man aged 15-49 years<br>Not pregnant woman aged 15-49 years | 7 | 1.64 | 1.11 (0 – 2.43) |
| Child aged 5-14 years<br>Not pregnant woman aged 15-49 years | Adult over 50 years | 6 | 1.40 | 1.46 (0.7.0130 – 2.64) |
| Child aged 5-14 years | Child under the age of 5 years<br>Not pregnant woman aged 15-49 years | 8 | 1.87 | 2.0 (0 -4.48) |
| Man aged 15-49 years<br>Child aged 5-14 years | Man aged 15-49 years<br>Not pregnant woman aged 15-49 years | 9 | 2.10 | 1.60 (0.27 – 2.92) |
| Man aged 15-49 years<br>Child aged 5-14 years | Adult over 50 years | 7 | 1.64 | 1.71 (0-3.71) |
| Child aged 5-14 years | Adult over 50 years<br>Not pregnant woman aged 15-49 years | 7 | 1.64 | 1.45 (0.31 – 2.59) |

**Table 12S Frequency that a sleeping space covered with an LLIN with at least one child under 5 years of age is shared with other person categories in sleeping spaces**

| Sleeping spaces covered with an LLIN with at least one child under the age of 5 years n=971 | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 29 | 2.99 | 3.01 (1.49 – 4.53) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age* | 788 | 81.15 | 81.83 (77.72 – 85.94) | 0.0009 |
| Pregnant woman of reproductive age* | 97 | 9.99 | 8.31 (5.66 – 10.96) | 0.0220 |
| Women aged 15-49* | 697 | 7.18 | 73.92 (70.60 – 77.24) | 0.0009 |
| Man aged 15-49 years* | 534 | 54.99 | 54.57 (48.62 -60.51) | 0.0089 |
| Adult over the age of 50 years* | 131 | 13.49 | 12.80 (9.91 – 15.69) | 0.0011 |
| Child aged 5 to 14 years | 410 | 42.22 | 42.49 (37.42 – 47.55) | 0.9196 |
| Another child under 5 years of age | 207 | 21.32 | 22.20 (17.65 – 26.74) | -- |

*Statistically significant

**Table 13S Frequency that a sleeping space with at least one pregnant woman (aged 15-49 years) is shared with other person categories in sleeping spaces covered by an LLIN**

| Sleeping spaces with at least one pregnant woman in sleeping spaces covered with an LLIN n=206 | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 7 | | 4.02 (0 – 8.67) | -- |
| Shared a sleeping space with at least one | | | | |
| Women aged 15-49* | 18 | | 7.59 (2.30 – 12.87) | <0.0001 |
| Man aged 15-49 years* | 147 | | 70.71 (61.60 – 79.83) | 0.0001 |
| Adult over the age of 50 years | 21 | | 15.06 (6.34 – 23.78) | 0.2812 |
| Child under the age of 5 years* | 97 | | 43.15 (28.39 – 57.90) | 0.0220 |
| Child aged 5 to 14 years * | 67 | | 32.29 (24.82 – 39.77) | 0.0058 |
| Another pregnant woman | 1 | | 0.26 (0 – 0.88) | -- |

*Statistically significant

**Table 14S Frequency that a sleeping space with at least one child aged 5-14 years is shared with other person categories in sleeping spaces covered with an LLIN**

| Sleeping spaces with at least one child aged 5-14 years covered by an LLIN n=1256 | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 95 | 7.64 | 9.00 (5.86 – 12.14) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age | 697 | 55.49 | 53.90 (49.30 – 58.51) | 0.0605 |
| Pregnant woman* | 67 | 5.33 | 4.52 (2.59 – 6.46) | 0.0058 |
| Women aged 15-49 years | 643 | 51.19 | 50.06 (45.83 – 54.30) | 0.2159 |
| Man aged 15-49 years | 480 | 38.22 | 38.73 (33.18 – 44.29) | 0.0948 |
| Adult over the age of 50 years | 242 | 19.27 | 18.48 (14.09 – 22.86) | 0.1035 |
| Child under the age of 5 years | 410 | 32.64 | 30.91 (26.58 - 35.23) | 0.9196 |
| Another child aged 5-14 years | 544 | 43.31 | 42.60 (36.81 – 48.39) | -- |

*Statistically significant

**Table 15S Frequency that a sleeping space with at least one adult over the age of 50 years is shared with other person categories**

| Sleeping spaces with at least one adult over the age of 50 years n=694 | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 123 | 17.72 | 17.50 (10.33 – 24.67) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age* | 249 | 35.89 | 42.88 (36.63 – 29.24) | 0.0031 |
| Pregnant woman | 25 | 3.60 | 4.20 (1.45 – 6.94) | 0.3665 |
| women aged 15-49 years* | 269 | 38.76 | 39.38 (34.19 – 44.58) | 0.0007 |
| Man aged 15-49 years* | 103 | 14.84 | 15.39 (8.90 – 21.88) | <0.0001 |
| Child aged 5-14 years | 274 | 39.48 | 36.69 (29.70 – 43.67) | 0.2739 |
| Child under the age of 5 years* | 143 | 20.61 | 18.67 (13.73 – 23.60) | 0.0037 |
| Another adult over the age of 50 years | 162 | 23.34 | 23.99 (18.15 – 29.83) | -- |

*Statistically significant

**Table 16S Frequency that a sleeping space with at least one adult over the age of 50 years is shared with other person categories for sleeping spaces NOT covered with an LLIN**

| Sleeping spaces with at least one adult over the age of 50 years n=90 | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 27 | 30 | 32.59 (13.96 – 51.20) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age | 34 | 37.78 | 36.73 (23.20 – 50.25) | 0.7290 |
| Pregnant woman | 4 | 6.67 | 3.27 (0 – 7.41) | 0.8150 |
| Women aged 15-49 years | 30 | 33.33 | 33.46 (20.25 – 46.67) | 0.7348 |
| Man of aged 15-49 years* | 21 | 23.33 | 18.69 (3.94 – 33.44) | 0.0396 |
| Child aged 5-14 years | 32 | 35.56 | 28.25 (7.16 – 49.33) | 0.6519 |
| Child under the age of 5 years | 12 | 13.33 | 15.54 (5.33 – 25.75) | 0.5792 |
| Another adult over the age of 50 years | 14 | 15.56 | 15.95 (6.28 – 25.80) | -- |

*Statistically significant

**Table 17S Frequency that a sleeping space with at least one adult over the age of 50 years is shared with other person categories for sleeping spaces covered with an LLIN**

| Sleeping spaces with at least one adult over the age of 50 years<br>n=604 | N | % | Weighted % (CI) | P value |
|---|---|---|---|---|
| Slept alone | 96 | 15.89 | 15.12 (9.43 – 20.81) | -- |
| Shared a sleeping space with at least one | | | | |
| Woman of reproductive age* | 255 | 42.22 | 43.86 (37.78 – 49.94) | 0.0008 |
| Pregnant woman | 21 | 3.48 | 4.34 (1.46 – 7.23) | 0.2812 |
| Women aged 15-49 years * | 239 | 39.57 | 40.32 (34.92 – 45.72) | 0.0004 |
| Man aged 15-49 years* | 82 | 13.58 | 14.88 (7.60 – 22.15) | <0.0001 |
| Child aged 5-14 years | 242 | 40.07 | 38.02 (32.15 – 43.89) | 0.1035 |
| Child under the age of 5 years* | 131 | 21.69 | 19.16 (14.22 – 24.10) | 0.0011 |
| Another adult over the age of 50 years | 148 | 24.50 | 25.24 (19.59 0 30.89) | -- |

*Statistically significant