Comparing Insecticide-Treated Nets Access-Use Based On Universal Household and Population Indicators Vis-A-Vis Measures Adapted to Sleeping Spaces in Ethiopia

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Abstract

Background: Insecticide treated nets (ITNs) access-use has been pivotal monitoring indicator for malaria prevention and control, particularly in resource limited settings.

Objectives: To compare ITN access-use based on universal household and population indicators and measures adapted to sleeping spaces

Methods: A cross-sectional study was conducted in five districts of Jimma Zone, Ethiopia, March, 2019. 762 HHs were sampled for the survey. We used multi-stage followed by simple random sampling. Monitoring and evaluation reference group's (MERG's) indicators were used for measuring ITN access-use. MERG's indicators are each adapted ITN access-use to sleeping spaces. The data were analyzed using Statistical Package for Social Sciences (SPSS) version 20.0. Differences of estimates of ITN access-use based on the two methods reported as magnitude of over/under estimations, at p-value <0.05.

Results: Based on MERG's approach, the study revealed household (HH) based indicators as such: HH ownership of at least 1 ITN (92.6%), sufficiency of ITN for every two people in HH (50.3%), and saturation of ITN for every 2 people in HHs with any ITN (54.6%). Moreover, population based indicators were: population with ITN access (P3=78.6%), people who slept under ITN previous night (63.0%), people who slept under ITN among who accessed it (73.1%), ITN use-gap (26.9%). Equivalent indicators of HH ownership, sufficiency, saturation, people accessed at where they actually slept, and people slept under ITN among those who accessed where they slept estimated at 71.3%, 49.4%, 69.3%, 66.3%, and 92.1%, respectively. MERG's approach over-estimated ownership, people's access, and behavior-failures by 21.3%, 12.3%, 19.0%, respectively. Over-estimation occurred for reasons such as many sleeping spaces lack ITN and > 2 people actually sleep in one space.

Conclusions: MERG's universal indicators over estimated households and populations ITN access-use as a result of absence of measures capturing access-use values at spaces where people actually slept. Consequently, measures adapted to sleeping contexts revealed potential misdistributions practiced when the existing indicators are in use. Insertion of sleeping spaces into existing approach will be worthwhile and needs to be promoted as it improves curiosity in ITN distribution, produces closer estimates and prevents malaria prevention and control programs from overlooking access-use challenges.

Introduction

Despite absurd achievements over the last decades, malaria remains an important public health problem (1-4). Nineteen countries in sub-Saharan Africa and India carried almost 85% of the global malaria burden of malaria (5,6). Nowadays, global malaria program aspires to achieve malaria elimination by 2035 and global eradication by 2040-2050 (6-10). Ethiopia has set national goal of eliminating malaria by 2020 (sub-national) and 2030 (national) (11-12). Ethiopian national malaria indicator survey (ENMIS) 2015 revealed that 65% of districts in the country were malarious (13).Global technical strategy has been committed in rendering supports and commodities required to meet malaria prevention, control and elimination efforts in resource limited settings (7). In 2018, 197million Insecticide Treated Nets (ITNs) were delivered globally, of which 87% were gone to sub-Saharan Africa (5).

ITN is one of the most effective malaria preventive tools especially in population at high risk (7-11). Consequently, the Roll Back Malaria (RBM) recommends every member of household should sleep under ITN every night. The minimum population based utilization that could provide sufficient leverage to malaria prevention and control conventionally has been 80% (14-18). Although behavioral factors were significant, many studies also indicated that access to ITN is a crucial factor (19-25). Keeping other factors constant, there has been strong conviction that addressing access is presumptive to ITN use (14-18). Ethiopian national strategic malaria prevention (NSMP) III plans to achieve 80% ITN use through 100% population access (11). Given that access to nets has to precede usage, multiple approaches such as mass distribution campaigns, antenatal care facilities and immunization programs were utilized to increase access in malaria affected communities particularly in resource limited settings (5, 26-28).

The RBM's Household Survey Indicators (HIS) recommended seven indicators to measure proportions of household (HH) and population who have access to and use ITN (14-18). Few studies were conducted based on the HSI estimates of HH and population coverage and use of ITN in resource limited settings (26-31). At HH level, the HSI recommended the bottom-line access through ownership of at least 1 ITN per HH. Another HSI is sufficiency of the ITN in HHs owning at least 1, assuming that 1 ITN is sufficient for every two people in the HH. (18, 32-34). Mere presences of ITN in HHs do not necessary indicate individual access and use. Therefore, to further assure every person in the community utilizes ITN, RBM-HSI recommended indicators that could embrace access at population level beyond the proportion of HHs with ITN. This requires to be sure if all the ITNs available in the HHs were enough for every two persons in the HH. This is expected to meet the requirement that every member in a HH should use ITN at every night. When access is a challenge, pregnant women and children under-five years old should receive priority for sleeping under ITN (18, 33-34).

Studies suggest people should access ITN at their own sleeping spaces (SS) and that was supposed to improve accuracy of ITN access-use (25-29, 35-36). NSMP-III also specifies access to ITN at sleeping spaces (11). Sleeping space (SS), in this case, refers to any space or room that is arranged for sleeping in the surveyed HHs. Nonetheless, limited studies considered SS to understand determinants of ITN use (35-36). Therefore, the authors have strong conviction that the actual SS should be considered to enhance access-use of ITN at household level. This premises led to the need to compare ITN access-use based on existing HSI and those adapted to the context of SS. The authors intended to consider SS concurrent to the HSI, not to replace. To the best of the authors' knowledge, limited studies focused on measuring access to ITN using contexts of sleeping spaces, and compared the estimates with the existing. Therefore, it is appropriate to examine ITN access-use based on the HSI and the indicators adapted to SS, interpret the estimates and potential concurrence, and provide recommendation toward improved ITN access-use in resource limited settings like Ethiopia.

Methods And Materials

Study Setting and period

The data were collected during March-April, 2019 from HHs in five districts of Jimma zone namely; Limmu-Kossa, Botor-Tolay, Gera, Shebe-Sombo and Nono-Benja. Jimma zone has been one of malaria endemic settings in Ethiopia. The districts are in the range of 70-229 km from Jimma town (the capital of the zone). They also have high to medium risk of malaria. Moreover, 20 gandas (the lowest administrative of the government structure of the study setting) from each district were involved in the study. Across the districts, there are malaria programs rendering services and commodities for prevention and control (ITN, IRS and treatments).

Study design

The study used cross-sectional HH survey. In fact, the data was a portion of end line assessment of a school based social and behavior change communication (SBCC) interventions which was aimed to advance community malaria preventive practices. .

Population and Sample size

The survey was conducted among heads of the HHs. Given the study was merged with the SBCC project's end line survey; we used the same sample that was used for evaluating the project. Initially, the project's sample size was determined using two population proportion formula [(n= $(Z_{\alpha/2}+Z_{\beta})^2 * (P_1(1-P_1)+P_2(1-P_2)) / (P_1-P_2)^2$]; where $Z_{\alpha/2}$ is the critical value of the normal distribution at α/2, at confidence level of 95% which gives a critical value of 1.96), Z_β is the critical value of the normal distribution at β (for a power of 80%, β is 0.2 and the critical value is 0.84) and to detect minimum difference (P_1-P_2) of 7.5% between the two proportions (baseline and end line) in ITN usage (P_1=38.0%). This yielded 762 HHs.

Sampling technique

We used multi-stage sampling. First, based on probability proportional to size of population, the sample size was allocated to each study district and Ganda. Twenty Gandas were randomly selected; 4 from each district. In each Ganda, three subdivisions (zoni) were represented in the study based on probability proportional to sizes of total HHs in selected Gandas. The HHs lists were obtained from family folders owned by respective Gandas. Finally, the HHs were selected using computer generated random numbers. The homes of the selected HHs were traced through local guiders.

Expected outcome variables

This study was mainly intended to examine access-use of ITN by target community based on HSI first, and then adapted with sleeping space. We hypothesized ownership-access-use of ITN would be more enhanced when ITN is accessed at actual sleeping space rather than mere availability in the HH. Obviously, ITN prevents malaria when HH members slept under it at actual sleeping space. Therefore, we intend to investigate how close the access-use of ITN based on HSI and SS.

Measurements and operational definitions

Instruments

Ownership-access-use of ITN was measured by standard tools adopted mainly from a 2018 RBM guidelines for household survey indicators (HIS) for malaria control (18). The HSI include seven HH and population based proportions (P1-P7). The same proportions were estimated after adjustment to sleeping space- the alternative approach (SSP1-SSP7).

Operational definitions

1. **HSI based estimates: household and population coverage and use of ITN**

Indicator 1: Proportion of households (HHs) with at least one ITN (P1): measures HH ITN ownership i.e. the extent to which ITN programs have reached all households or, conversely, the not yet reached. It is calculated from the number of HHs surveyed with at least one ITN as a numerator, and the total number of HHs surveyed as a denominator.

Indicator 2: Proportion of HHs with at least one ITN for every two people (P2): measures the proportion of HHs that have a sufficient number of ITNs to cover all individuals who spent the previous night in surveyed HHs, assuming each ITN is shared by two people. It is calculated from the number of HHs with at least one ITN for every two people (HHs with people to ITN ratio of 2 or less) as a numerator, and the total number of HHs surveyed as a denominator. HHs with full coverage (enough nets) are indicated by value 1, the rest of HHs are assigned a value of 0. In connection with P1, P2 can be used to determine what proportion of HHs already reached with at least one ITN have a sufficient number of ITNs (saturation) to protect all members in the HH (this can be labeled as P5, in order to pick difference in denominator with P2) or conversely it describes the intra-HH ownership gap (1-P5) (i.e., HHs that own at least one ITN but do not have full coverage). If the difference between these indicators is substantial, programs need to assess whether current ITN distribution strategies should be revised to fill the saturation gap.

Indicator 3: Proportion of population with access to an ITN in their HH (P3): estimates the proportion of the HH population that could have slept under an ITN, assuming each ITN is used by two people. It is calculated from the total number of individuals who could sleep under an ITN if each ITN in the HH were used by two people (potential ITN users) as numerator, and the total number of individuals who spent the previous night in surveyed HHs as denominator. A “potential ITN users” is an intermediate variable calculated by multiplying the number of ITN in each HHs by two. In HHs having more than one ITN for every two people, the potential users will be equal to the number of people who slept in that HH last night. Therefore, after dividing the sum of all potential ITN users in the sample by the total number of individuals who spent the previous night in surveyed HHs, P3 gives any value between 0 and 1, indicating the magnitude of people who access ITN. If the difference between P3 and proportion of population sleeping under ITN the previous night (P4) is substantial, the program may need to focus on identifying the main drivers or barriers to ITN use to design an appropriate intervention for behavior change.

Indicator 4: Proportion of the population that slept under an ITN the previous night (P4): measures the level of ITN use among all individuals who spent the previous night in surveyed HHs, regardless of whether those individuals had access to an ITN in their HH. It is calculated from the number of individuals who slept under an ITN the previous night as numerator, and the total number of individuals who spent the previous night in surveyed HHs as denominator. It can be separately calculated for the children under five years old and pregnant women as the two most vulnerable population segments that need priority to sleep under ITN when the access is limited. This indicator can be compared with P3 to describe the magnitude of the behavioral gap in use of ITNs (i.e., the population that has access to an ITN but is not using it). This analysis is useful for informing ITN programs whether they need to focus on achieving higher ITN coverage, promoting ITN use, or both. This value can be labeled as P6.

2. **Adapted to sleeping space (SS/SS) based estimates of ITN coverage and use**

In this case, sleeping space includes any room or space arranged for sleeping in the HH. The above HSI were all related with sleeping under ITN, indicating that where people sleep is worthy consideration.

Indicator 1: Proportion of HHs with ITN in at least any one of the sleeping spaces in the HHs (SSP1): measures sleeping space ITN ownership i.e. the extent to which ITN programs has reached SS in the HHs. It is calculated from the number of SS in HHs surveyed with ITN as a numerator, and the total number of SS in the HHs surveyed as a denominator.

Indicator 2: Proportion of HHs with ITN for every sleeping space in the HH (SSP2): measures the proportion of HHs having ITNs to cover all sleeping spaces in surveyed HHs, assuming each SS should have ITN. It is calculated from the number of HHs with ITN for every SS as a numerator, and the total number of SS in HHs surveyed as a denominator. This indicates the extent to which ITN can reach every SS of HHs in the community. If the denominator is limited to HHs with ITN for at least one SS, the value of saturation can be labeled SSP5, coverely the gap (1-SSP5)

Indicator 3: Proportion of population with access to an ITN in their SS in the HH (SSP3): estimates the proportion of the HH population that could have covered by ITN at SS. It is calculated from the total number of individuals who could sleep under an ITN given they are covered by ITN at SS as numerator, and the total number of individuals who spent the previous night in surveyed HHs as denominator. It is interpreted as proportion of people covered by ITN at their respective SS in that HH.

Indicator 4: Proportion of the population that slept under an ITN the previous night (SSP4=P4). It is calculated from the number of individuals who slept under an ITN the previous night as numerator, and the total number of individuals who spent the previous night in surveyed HHs as denominator. If P4 is limited to denominator of people with access to ITN at where they sleep, it is labeled SSP6. This can pick the seasonality or occasions when people covered by ITN at where they sleep also use it.

Data collection procedures

The data were collected through face to face interviewer administered method. The interview was conducted by trained experienced interviewers under supervision in Afaan Oromo language. Three days training about the purpose of the study, instruments and data collection procedures was given. The data were cleaned, checked for consistency on daily basis. The research team supervised overall data collection process.

Data analysis

The data were analyzed by using SPSS version 20.0. We referred to operational definitions set by 2018 RBM's HSI and adapted SS indicators to determine ownership-access-use of ITN. We used proportions with 95% confidence interval to describe the key indicators. Moreover, we determined discrepancies within and between, compared the closeness of the estimates, interpreted the implications and finally identified relevance of complementation of the two HIS and adapted SS indicators, particularly for ownership and access measures. Bivariate analysis (Chi-square) was performed to determine patterns of access-use of ITN along social-spatial variables. Odds ratio was executed between ITN use and sufficiency and access based on the two approaches. Moreover, we recommended malaria prevention and control programs an operational diagrammatic solution to improve access-use of ITN.

Ethical approval and considerations

The study was approved by Jimma University, Institute of health institutional review board for Institute of Health. Official permissions to undertake the study were obtained from concerned bodies. Respondents were given detailed information about the purpose of the study. Informed written consent was obtained from all study participants.

Results

Socio-demographic characteristics of respondents

In this study, a total sample of 759 HHs and 3760 people were involved. The response rate was 99.6%. Average age of the respondents was 36.9 ±13.3 years old. Average family size per HH was 4.9±2.2 members. Table 1 contains detailed background information of the respondents

Description of sleeping spaces and their relevance for accessing people with ITN

Table 2 provides the details of sleeping spaces and ITN. The median sleeping spaces in the HHs was found to be 2. Averagely, 2.5 people slept in any sleeping space across HHs. In 75% of the sleeping spaces, there existed more than two persons slept in aggregate. People who slept in 6.6% of the spaces were the same sex. The probability of getting high risk group at any sleeping space was 55% for < 5 children and 42 per 1000 for pregnant women. The ratio of 1 ITN for median number of aggregates of persons per sleeping space (2.5) to RBM's access conversion factor (1 ITN for every 2 people) was 0.8. This means accessing ITN based on where people actually sleep can save 20% of ITN accessed to people through mere formula of 1 ITN per two people. This ratio only indicated relevance in terms of quantity of ITN, not the quality of size and form of its production. The relevance of approaching access to ITN based on sleeping space, concurrent to the RBM's existing approach, signals curiosity during ITN distribution and even manufacturing.

Availability and current status of ITN

Table 3 provides the details of ITN status. Each HH owned 2.1 ITNs, on average. The mean age of the ITNs was 13.6 months. In more than half of the HHs, 404 (53.3%), at least 1 ITN was kept folded/saved in cabinet. In those HHs, 672 (45.6%) of the ITNs were folded/saved. 186 (24.6%) of HHs had any ITN with repairable damage. About 252 (17.1%) of ITNs were washed across the observed HHs.

Household and population access and use of ITN: HSI and SS approaches.

Based on HSI approach (existing)

Proportion of HH ownership (P1), sufficiency (P2) and saturation (P5) of ITNs were 92.6% and 50.3%54.6% respectively. In the meanwhile, corresponding magnitudes of people who accessed and slept under ITN the previous night were 78.6% (P3) and 63.0 % (P4). The use-gap among people with access was 26.9% (1-P6) that indicated the amount of behavioral failure to use ITN, that is, due to reasons other than access (Table 4)

Based on SS approach (concurrent)

Proportions of ownership (SSP1), sufficiency (SSP2) and saturation (SSP5) of ITNs adjusted to the sleeping spaces in the HHs were 71.3%, 49.4% and 69.3%, respectively. People who accessed ITN where they actually slept in the HH was (SSP3=66.3%), people slept under ITN among those accessed where they slept (P6=92.1%). The ITN use-gap among people with access at sleeping space was 7.9% (1-SSP6) (Table 4).

Discrepancies between the approaches

The two models produced statistically significant differences on access-use indicators except sufficiency. The HSI approach over-estimated some indicators. For example, population access (by 12.3%) and ownership (by 21.3%) compared to the SS approach. Nonetheless, the SS model under-estimated the magnitude of people who slept under ITN among who accessed (by 19.0%) and saturation (14.7%). Inversely, it over-inflated intra-HH gaps and behavioral failures. Overall, the use to access ratio marked the highest discrimination between the models as the ratio adjusted with SS produced 27.5% excess odds of ITN use (Table 4).

Discussion

This study generated pertinent findings related to operational challenges of measuring ITN access-use in resource limited settings. Obviously, numerous programs are committed to provide ITN support as malaria preventive commodity to countries endeavoring to meet elimination plans (7-10). This study explored and recommended introduction of new supportive indicator into RBM's existing ones in order to improve access-use of ITN. For example, this study has found out HSI estimates of ITN access-use were relevant for detecting mis-distribution even though they over or under estimated some indicators compared to when adjusted with SS. Thereof, the complementation of the HSI with SS was discussed based on ITN-access indicators.

According to this study, the HSI approach indicated high HH ownership of ITN (P1) i.e. proportion of HHs with at least 1 ITN=92.6%. EMIS 2015 reported 63% ownership in rural malarious settings (13). Many studies and evaluation of mass distribution programs revealed ownership to be high compared to other access indicators (26-30). The EMIS 2015 estimates national ownership at 63.7%, the lowest being 33.9% in Dire Dawa and the highest being 72.9 in Amahara and Tigray regions each (13). On the contrary, the SS adjusted ownership indicator showed moderate amount (SSP1=71.3%) i.e. availability of ITN in any SS in the HH. Noticeably, this huge gap between the existing and adapted model could be attributed to the assumptions of the two approaches: the later defines ITN ownership should be based on spaces where people actually sleep not just the HH that can potentially have several sleeping arrangements (P1 compares HHs with sleeping space in the HH). Clearly, ITN use behavior in itself is about "sleeping under it every night" i.e. impossible to use ITN unless actual sleeping spaces are considered. Ethiopian NMSP-III clearly strategized 100% sleeping spaces should own ITN (11). Therefore, the HSI indicator (P1) overestimated ownership/underestimated ownership-gap by 21.3%, indicating significant number of sleeping spaces that were considered 'owned ITN' did not actually own because people did not own them in spaces where they actually slept. Estimations based on HHs do not necessarily ensure people are sleeping under ITN. The study showed the HSI indicator-HHs with sufficient ITN i.e. proportion of HHs with at least 1 ITN for every 2 people in the HH, P2=50.3%. EMIS 2015 reported 33% ownership in rural malarious settings (13). Many studies showed closer estimate for HH ITN sufficiency (29, 30). Nonetheless, low magnitude of sufficiency at large estimate of ownership signifies abnormal allocation of ITN (discrepancy=42.3%HHs), either due to supply shortage, deprivation or unreported over concentration of ITN in certain HHs [there is ignorance of potential excess presence of ITN inherent to calculating P2] (32-34).On the other hand, equivalent indicator of SS approach quantified a very close estimate of ITN sufficiency (SSP2=49.4%) for aggregate people in every sleeping spaces in the HHs. In resource limited settings many people share living rooms (35). EMIS 2015 reported 1.7 mean number of sleeping spaces (13). Certainly, sleeping space is logical way to explore access worthy of consideration during ITN distribution.

In this study, saturation of ITN i.e. proportion of HHs with at least 1 ITN for every 2 people in HHs with any ITN, P5=54.6%. EMIS 2015 reports national estimate of ITN saturation at 31.7% (lowest, 13.8% in Harari, and highest, 41.4% in Tigray) (13). When compared to high ownership (P1=92.6%), this figure explains unfairness committed during ITN distribution in that 38.0% of all HHs claimed to own ITN did not have enough for every two people, causing substantial intra-household gaps (1-P5=45.4%]. Nonetheless, SS based equivalent (SSP5)=69.3%, yielded in sensible variation. Therefore, the HSI P5 underestimated saturation of ITN/overestimated intra-household gaps by 14.7% for couple of reasons: (1) the SS approach produced higher magnitude of saturation because more than 2 aggregate of people slept together in a given space in the HH, while HSI P5 utilizes conversion factor of 1 ITN for 2 people: indicating fewer number of ITNs are expected to meet saturation, (2) conceptually, 1-SSP5 underscores the question of accessing ITN at sleeping spaces while 1-P5 could unnecessarily report intra-HH gaps of accessing ITN in community wherein excess presence of ITN in some HHs could be observed (in fact, the formula hides this occasion) (32-34). This means an emphasis to sleeping spaces during distribution of ITN can improve HHs saturation by increasing curiosity to people at where they sleep in the HH.

Based on the HSI approach this study produced population access, P3=78.6% i.e. proportion of people in the HHs who accessed 1 ITN for every 2 people. This estimate is closer to previous similar studies (25-30). Nonetheless, in order to show key problems inherent to the calculation of P3 as it is currently defined by RBM, particularly in resource-limited settings, P3 was calculated without correcting higher access values to 1. For the section discussion this calculation is named as uncorrected P3. Not correcting higher access values to 1 has several indications, including misdistribution, over-accumulation and reasons behind those actions. Accordingly, the uncorrected P3 yielded 93.6%, the quantity that obviously looks overblown by 15% compared to the P3 of the current study. Studies that did not adjust excess presence/accumulation of ITN in some HHs during calculation yielded lesser values of P3 than they could have been had the distribution strategies and systems were carefully operated. This indirectly means that those studies were encouraging over-access in some HHs and supporting misdistribution of ITN, particularly when ITN sufficiency and saturation values are low (30).

High magnitude of incorrect P3 (i.e 93.6%) at high HH ownership (P1=92.6%) and low sufficiency (P2=50.3%) and saturation (P5=54.6%) implies: (1) excess accumulation of ITN in significant number of HHs, (2) inadequate availability of ITN in HHs with any ITN, (3) the ITN's accumulated in those HHs was as high as that could have covered the overall community's access challenge; (P3-P5) i.e. 39% of peoples in HHs with any ITN were claimed to have access while actually not, (4) the HSI P3 evenly distributed accumulation and inadequacy of ITN, that potentially misclassified access status. Concurrently, the SS approach's equivalent indicator (SSP3) revealed 66.3% i.e. proportion of people who accessed ITN in aggregates at their sleeping spaces. Compared to P3, the SSP3 produced more reliable estimate of population access. The comparison of SSP3 and P3 revealed the failure of the P3 to pick excess presence by 27.3% (when P3 is uncorrected P3) and even 12.3% (when P3 is corrected). This means that about 27.3% or 12.3% (uncorrected or corrected) of people who never accessed ITN at their sleeping spaces were claimed to have access to 1 ITN for two [i.e. P3-SSP3] in the HHs they have slept last night. The ITN saving and misuse status reported in the currect study also supports the idea that the corrected P3 leads to wrong estimation of access in settings with limited resource and system of distribution. For example, 48.1% of ITNs available across the HHs were saved or misused. Excess presence of ITN in the HHs was one of the potential factors for saving or misuse (37). Many studies report mis-use or multipurpose of ITN (21-26, 35-37).

This study observed 63.0% of people slept under ITN previous night of the survey. Many studies reported closer estimate (21-24, 35-37). World malaria report 2019 revealed ITN use was 50-80% in Sub-Saharan Africa (5). Moreover, this amount of ITN use was less than expected compared to national target (11). The finding from this study showed proportion of people who slept under ITN among those who accessed (P6)=73.1% indicating 26.9% use gaps. This designated the amount of people who failed to use ITN for reasons other than access. Concurrently, the SS equivalent (SSP6) was 92.1% producing only 7.9% behavioral failure to use ITN. The discrepancy (26.9%-7.9%) of 19% in estimates of behavior failure explained the HIS-based indicator over-estimated use of ITN among accessed ones by 19%. This implied: people tend to use ITN better when they were accessed exactly at their sleeping space than do just allocating 1 ITN for every 2 persons in the HH. Moreover, when fixed at sleeping spaces it involves sense of feeling accessed, prevents mis-use and unnecessary accumulation. Studies and national plans show accessing ITN at sleeping spaces worthwhile (11, 29, 35).

According to this study, the relevance factor of sleeping spaces was 0.8 of the HSI. For example, a total of 1600 ITNs counted across the sampled HHs in this study resulted in 78.6% population access. When adjusted to the SS, the same indicator will be 0.8*1600=1280, indicate 320 extra ITNs remain after covering 78.6% people at where they actually slept. In other words, given 2.5 average number of people slept in any sleeping space, in the current study, the 1600 ITNs would have served 98.3% people if properly distributed to people by considering where people actually sleep in the HH. This suggested improved curiosity of allocating and distributing ITN based on SS to policy makers and implementers in resource limited settings.

To sum up, this operational study was the first of its kind to compare SS with HSI approaches.. In fact, many studies commented on the need to consider sleeping spaces to measuring access. However, the study was not without limitation. The findings were not well discussed with other literatures and studies, given similar studies were limited. Furthermore, the study did not address about suitability of the ITNs' structural design and maps of sleeping spaces. In general, the study explored considerable discrepancy between the HSI and adjusted approaches in estimating access-use-gaps of ITN. Thereof, we designed framework that is believed to correct the distribution-access-use gaps of ITN in the study settings as presented in the following diagram by figure 5. The EMIS 2015 plainly reported about huge mismatches between coverage of ITN and administrative reports and observed gaps regarding the ITN distribution management. For example, the EMIS reported that the household level coverage of LLINs was 64 percent despite FMOH claim of delivery to almost all malarious districts visited. Still, the EMSI reported that there were undistributed ITNs in several district offices (13).

Conclusions

HSI approach underlined ITN misdistribution: unfairness and unacceptably excess presence in certain HHs. Nonetheless, it under estimated access-use gaps, evenly distributed abnormal accumulation and insufficiency-lack in community where overall access gaps were observed. Insertion of sleeping space into existing approach will be worthwhile and has to be promoted, as it: improves curiosity in ITN distribution, produces closer estimates and prevents malaria prevention and control programs from overlooking access-use challenges. Overall, we recommended local malaria prevention-control program to consider existing access-use indicators for ITN distribution. The operation of accessing ITN for supporting utilization should consider sleeping spaces concurrent to the existing indicators.

Abbreviations

AIM, Action and Investment to Defeat Malaria; GTS, Global Technical Strategy for malaria; IRS, Indoor Residual Spraying; ITN, Insecticide-Treated Net; ENMCP, Ethiopian National Malaria Control Programme; SBCC, Social and Behavioral Change Communication; PMI, President's Malaria Initiative; RBM, Roll Back Malaria; WHO: World Health Organization

Declarations

Ethics approval and consent to participate: Jimma University, institutional review board approved the study. Consent to participate is not-applicable.

Consent for publication: Not-applicable

Availability of data and materials: All relevant data are within the manuscript and its supporting information files.

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Authors' contributions: YK, MS, ZB conceived and designed the study. YK analyzed the data. YK drafted the manuscript. All authors critically reviewed the manuscript. All authors approved the manuscript version submitted to the journal.

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Disclaimer statements

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Tables

Table 1: Socio-demographic characteristics of household respondents, Jimma Zone, March, 2019 (n=759 HHs)

Socio-demographic characteristics		Descriptive statistics	
		No	%
Sampled people (Districts)	Botor-Tolay [HH=120]	606	16.1
	Nono-Benja [HH=123]	651	17.3
	Limmu-Kossa [HH=132]	615	16.4
	Gera [HH=166]	759	20.2
	Shebe-Sombo[HH=218]	1129	30.0
	Total HH=759	3760	100
Sex of respondent	Male	439	57.9
	Female	320	42.1
Sex of HH head	Male	690	90.9
	Female	69	9.1
Marital status	Married	642	85.0
	Divorced	31	4.1
	Widowed	29	3.8
	* Others	53	7.2
Education	No read the write	313	41.2
	Read & write	80	10.6
	Primary school	251	33.1
	Secondary school	106	14.0
	College and above	5	1.1
Religion	Muslim	423	55.9
	Orthodox	230	30.4
	Protestant	104	13.7
Ethnicity	Oromo	576	76.0
	Amhara	138	18.2
	Others	54	7.0
Proportions of	<5 years population	584	15.5
	PW/15-49 years females)	31	3.4

HH: household, PW: Pregnant Women, *others: Gurage, Tigre, Dawro, Kaffa, Hadiya, and Kambata

Table 2: Description of sleeping spaces and people's availability in it, Jimma Zone, March 2019, Ethiopia (N=762 HHs)

Variables	Descriptive statistics	Estimates
Number of sleeping spaces in the HH		
	1	219 (28.7)
	2	365 (47.9)
	3	160 (21.0)
	4	18 (2.4)
	Mean	1.97
	Median	2.0
Aggregates of people per space		
Average measures	Mean	2.5
	Median	2.5
Quartiles	1st	2.0
	2rd	2.5
	3rd	3.0
Priority population's covered by ITN at where space they slept		
Pregant women slept	Mean	4.2 (3.4-5.2)
Under five children slept	Mean	55 (45-66)
Sex segregation per sleeping space		
	Same	50 (6.6%)
	Mixed	712 (93.4%)
Relevance factor of space-based access		
Median people actually accessed 1 ITN/SS	Space-based	1/2.5
Median people expected to access 1 ITN/ 2 people	RBM's-based	½
Relevance factor for space-based measure	Space/RBM	0.8

Table 3: Characteristics and perceptions about ITN and sleeping spaces in HHs, Jimma Zone, March 2019 (N=762 HHs)

Variables	Estimates	95% CI
ITN-characteristics		
Total number of functional ITNs in all HHs	1600 -	
Average number of ITN (HH)(mean)	2.1	2.0, 2.2
Age of ITN (in months)-mean	13.6	13.2,14.1
ITN observability rate	1475 (92.2)	90.2, 94.3
Observed status of ITN		
HHs as denominator (N=758)		
Any ITN tied on bed	575 (75.9)	72.9,78.9
Any ITN kept folded/saved	404 (53.3)	49.9,57.0
* Any ITN misused- other purpose	37 (4.9)	3.3, 6.7
ITN as denominator (N=1475)		
Tied on the bed	766 (51.9)	47.7, 56.9
Kept folded and saved	672 (45.6)	39.9,51.3
* Misused- other purpose	37 (2.5)	2.3, 2.7
ITN care status		
HHs as denominator (N=758)		
Any ITN damaged (has hole)	186 (24.6)	21.5,27.8
Any ITN washed (with last 3 months)	123 (16.3)	13.6,18.9
ITN as denominator (N=1475)		
Damaged (has hole) rate	246 (16.6)	13.5,17.8
ITN wash rate (with last 3 months)	252 (17.1)	13.4,18.9

*other purposes-used as sheet beneath bed, stored cereals in, and shield on toilet

Table 4: Comparison of HH and population's ownership-access-use of ITN based on HSI and SS approaches, Jimma Zone, March 2019 (N=762 HHs)

ITN ownership, access & use measures	Existing (1)	Concurrent (2)	Comparison (1-2)
Household based indicators	HIS	Adjusted (SS)	Discrepancy
Estimates (HSI, Sleeping space)	% (95% CI)	% (95% CI)	% (95 % CI)
Ownership (P1, SSP1)	92.6 (90.1, 94.1)	71.3 (67.7,74.4)	+21.3 (15.6, 26.3)*
Ownership gap (1-P1,1-SSP1)	7.4 (6.0,10.0)	28.7 (25.6,32.3)	-21.3 (-26.3,-15.6)*
Sufficiency (P2, SSP2)	50.3(46.5,53.6)	49.4 (45.5,53.0)	+0.9 (-7.5, 8.1)
Saturation (P5, SSP5)	54.6 (51.0,58.1)	69.3 (67.2,71.2)	-14.7 (-16.7, -13.1)*
Intra-household gaps (1-P5, 1-SSP5)	45.4(41.9,49.0)	30.7 (28.8,32.3)	+14.7 (13.1,16.7)*
Population based indicators	HIS	Adjusted (SS)	Discrepancy
Population access within-HH (P3, SSP3)	78.6 (74.6,81.7)	66.3 (62.3,70.5)	+12.3 (4.1, 19.4)*
Access gap (1-P3, 1-SSP3)	21.4 (2.3,10.4)	33.6 (36.3,42.9)	-12.3 (-19.4, -4.1)*
Slept under ITN previous night (P4=SSP4)	63.0 (61.0, 64.0)	63.0 (61.0, 64.0)	Not calculated
Slept under ITN among accessed (P6, SSP6)	73.1(68.5-77.5)	92.1 (89.2,94.6)	-19.0 (-26.1,-11.7c)*
Use-gap/behavior failure (1-P6, 1-SSP6)	26.9 (22.5,31.5)	7.9 (5.4,10.8)	+19.0 (11.7, 26.1)*
Use-access ratio-HH (P4/P3, SSP4/SSP3)	80.2 (78.3, 81.8)	95.0 (90.8,97.9)	-14.8 (-19.6, -9.0)*

*P-value <0.05

Figures

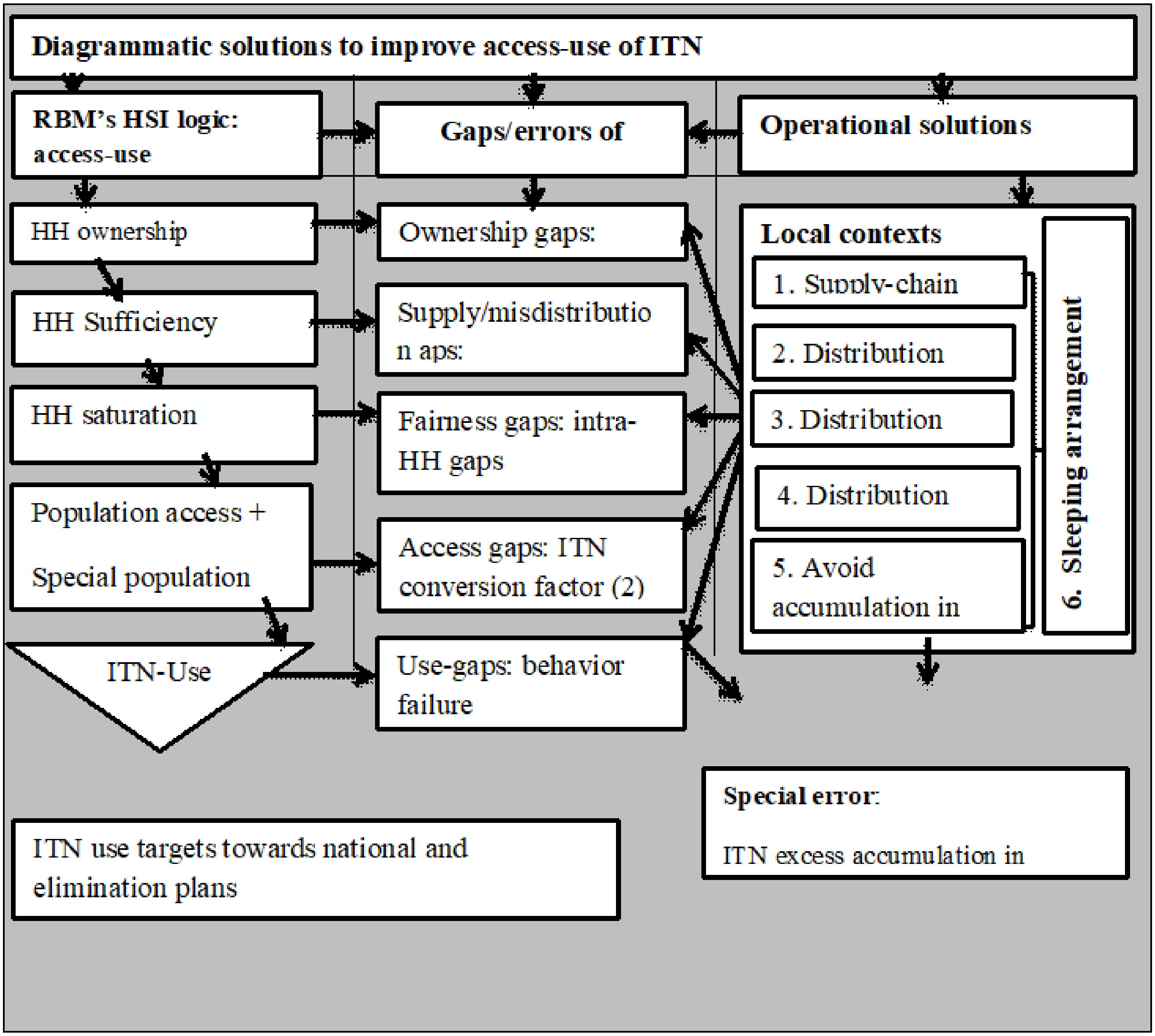

Figure 1

Diagram for operational framework for access-use of ITN involving sleeping space in resource limited setting, March 2019