The global usage rate of bed nets during the last ten years: a systematic review and meta-analysis

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Abstract

**Background:** Malaria is an endemic disease especially in tropical areas transmitted by Anopheles mosquito through their bites. Therefore, bednets are one of the best methods for protection against their bites. However, many regions have limited access to bednets and limited knowledge about their importance.

**Objectives:** Primary objectives were to estimate bednet possession and usage rate for last 10 years. Secondary objectives aimed to calculate the prevalence of specific bednets’ types.

**Methods:** We performed an electronic search on 12 databases, and 106 studies were included obeying the criteria.

**Results:** 106 studies included in our meta-analysis. Study participants were mostly from Africa while a few from Asia and southern America. Overall bednet ownership rate per households among countries was 72.1% (95% CI: 62.9-79.7) while per individuals was 52.5% (95% CI: 37-67.4). In addition, overall bednet usage rate per households among countries was 41.2% (95% CI: 25.1-59.3) same as bednet usage per individuals.

**Conclusion:** Our study suggests that the bednet ownership and usage rate among different countries are less satisfactory, hence not maximizing the potential benefit of the bed net. There is a crucial need to increase awareness towards the bednet usage across endemic areas and implement programs for free distribution of bednets.

Background

Malaria envelops about 90 countries all over the world, especially those located within tropical and subtropical regions where malaria blossoms with stagnant water and warm climate.[1] The principal causative organism of malaria in humans is a parasite called plasmodium which includes *P. falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, and, *P. knowlesi*, which is transported through insects, chiefly the anopheles genera.[2, 3] Notably, diagnosing malaria is too difficult even for experts which exacerbates its danger on humans.[3] Malaria with poverty is the key factor for about 438,000 causalities annually, most of them among African kids.[4] While there are numerous drugs to treat this plasmodium infection, the developing resistance is hindering success towards eradicating this dilemma. Consequently, a great portion of the success in eradicating malaria lies within developing an anti-malarial innovative treatment. However, bed nets are the main vector control intervention still used against malaria.[5]

Bed net is an open mesh which covers sleeping people as a physical barrier to limit insects and flies.[6] The perspective of a bed net was developed later to include nets which are treated with insecticides to provide both chemical and physical barriers against vectors resulting in further protection against vector-borne diseases. Interestingly, some of these treated bed nets can be effective for a few years, namely the Long-Lasting Insecticidal Net (LLIN). Clinically, the usage of bed nets had a considerable impact on
reducing infection with malaria.[7] A Cochrane review of 23 trials proved that using bed nets has cut down the prevalence of malaria and other vector-borne diseases by 17%.[8] Insecticide-treated nets (ITN) succeeded to save about 50% more lives as estimated by another study.[9]

The impact of such bed nets urged volunteers, NGOs and medical organizations to support endemic areas with nets; resulting in the spread of nets to reach unprecedented rates. However, more work is needed to cover all potential targets of vector-borne disease. Unfortunately, the coverage rate of bed nets in many countries is low, for different reasons including the unavailability in many areas.[10] Also, the reported prevalence of bed nets may be biased due to the difference between the possession rate and the usage rate which could result in different outcomes of the implementation of bed nets. Therefore, our study aims to evaluate the true possession and usage rate of bed nets globally to alert health organizations to take actions.

Methods

Study protocol registration

According to recommendations of Cochrane Handbook for Systematic Reviews of Interventions and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), our study was performed as shown in the PRISMA checklist (Supplementary Table 1).[11, 12] A pre-protocol of methods has been registered with the International prospective register of systematic reviews (PROSPERO) website (CRD42019122019) on April 2nd, 2019.

Search strategy

In October 2018, we conducted a systematic search of 12 electronic databases including PubMed, Scopus, Web of Science (ISI), EMBASE, Google Scholar, VHL, GHL, meta Register of Controlled Trials (mRCT), Cochrane, POPLINE, NYAM, and SIGLE. The search terms employed was: (bednet OR bednets OR "bed net" OR "bed nets" OR "insecticide-treated" OR ITNs OR ITN OR "pesticide-treated") AND (coverage OR use OR usage). Including only papers published from 2008; no human filter, nor restriction applied regarding age, gender, ethnicity, language, or country was used. The search results from the databases mentioned above are available in Supplementary Table 2.

Study eligibility criteria and study selection

After removing duplicates using Endnote X8.1, studies were included according to the following criteria: community-based studies that investigated the rate of bed net usage in the population from 2008 to 2018. Case reports, abstracts only, reviews, letters, editorials, books, conferences, studies with unextractable data or those with insufficient data were excluded. Also, we excluded studies that involve specific subgroups including pregnant women, children of any specific age group, school-based, or hospital-based, infected population, specific ethnicity, etc. Also, studies with a duplicated data set and any studies that report data after bed net distribution were excluded. Three independents reviewers
included or excluded the studies based on the title and the abstract first, followed by the full-text screening.

**Data extraction**

Three independent reviewers were responsible for data extraction from the included studies, and in case of conflict, consultation was supported. The extraction sheet was composed of three parts: baseline characteristics section, outcomes section and quality assessment. The first part included reference ID, study design, age and gender. The second part was outcomes of the study including usage rates of bed nets per each country and prevalence of specific bed net types. The last third part for NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

**Outcome measures**

Bed net ownership was defined as the number of individuals or households that own at least one bed net of any type but not necessarily using it. While bed net usage is defined as the number of households or individuals that use bed nets during sleep regardless of frequency of usage. Sometimes, sleeping under a bed net at the night before the survey is considered bed net usage. Our primary outcome was the prevalence of bed net ownership and usage rate globally. The secondary outcome was the prevalence of insecticide-treated nets or any special types of bed nets. Outcomes taken at any time before intervention or trial was included.

**Quality assessment**

Using NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies we assessed the quality of all included studies independently by three reviewers. The assessment of each domain was categorized as Yes (1), No (0), Other (CD, NR, NA) * "*CD, cannot determine; NA, not applicable; NR, not reported". A score of 10-14 indicated a good quality article, 5-9 for fair, and 1-4 for a poor-quality article. Any differences between our three independent reviewers were resolved by discussion and by consultation with a supervisor to reach a concordance if needed.

**Statistical analysis**

Analysis was carried out using Comprehensive Meta-analysis software. Heterogeneity was evaluated between the included studies by using the Q statistic and I² test. A p-value of less than 0.05 is considered statistically significant for heterogeneity. Pooled OR with the corresponding 95% confidence intervals (95%CI) was also to be calculated. Regarding weighting of the studies, we used a fixed-effects model when there was a lack of significant heterogeneity and used a random-effects model when there was heterogeneity between studies. Dichotomous data are presented as prevalence event rate with a 95% confidence interval (CI). The qualitative synthesis was performed to describe the clinical and methodological characteristics of the included studies. Data synthesis was done by three independent reviewers. The discrepancies between the reviewers were resolved by discussion with senior reviewers.
Using the funnel plot and Egger’s regression test we evaluated publication bias. If detected publication bias, we would add studies that may be missed by using the fill method.

**Results**

**Systematic search and its results**

The initial search resulted in 7036 articles from 12 databases. Of these, 2475 duplicated articles were excluded by endnote X8. After the title and abstract screening stage, 2431 articles were excluded because they did not meet inclusion criteria, and 2130 full-text articles were screened to determine eligibility. Of these, we excluded 2045 articles for reasons shown in Figure 1. After adding 21 articles after the manual search stage, a total of 106 articles underwent full data extraction and were included for the final qualitative and quantitative analysis.

**Studies characteristics**

A total of 106 studies [10, 13-116] have been included in the systematic review and meta-analysis. Regarding study design, mainly cross-sectional studies were conducted and a representative population of all ages and gender were recruited to represent their communities or districts. Furthermore, most of the study population are from the African continent due to the high malaria state while the rest are from Asia and rarely southern America. Regarding quality assessment, there were 79 papers with fair quality, 16 papers with good quality whereas 13 papers had poor quality. All details are provided in Supplementary Table 3.

All 106 studies were included in the meta-analysis. The data firstly were divided into the household level and individual level as not all studies reported data in the same unit. Besides, each group underwent subgroup analysis, one according to different countries and the other according to the type of bed net used. Finally, a crude map was constructed with the above-mentioned data, reporting the prevalence of ownership and usage of bed nets among countries and a broad view among continents.

**Bed net household ownership**

In household level ownership, the overall ownership rate of bed net households was (event rate=72.1%, 95% CI: 62.9-79.7). Random effect model was used due to high heterogeneity: I²=99.907, P-value<0.001. The highest bed net household ownership rate was in Bangladesh (event rate=98.4%, 95% CI: 89.4-99.8). On the other hand, the lowest ownership rate of bed net households was reported in Saudi Arabia (event rate=22.1%, 95% CI: 3.7-67.5) (Figure 2). The household ownership rate of each country illustrated in Supplementary Figure 1, showed that all studies were conducted in only Africa and Asia.

For the subgroup of the type of bed net, the commonest type of owned nets was reported as long-lasting insecticides treated nets (LLINs), (event rate=78.3%, 95% CI: 71.5-83.8), whereas insecticide-treated nets (ITNs) was the lowest reported, (event rate=62.9%, 95% CI: 55.8-69.5) (Supplementary Figure 2)
Bed net individual ownership

As regard to individual-level ownership rate, Meta-analyses of country subgroups showed that the highest bed net individual ownership rate was in Kenya (event rate=72.9%, 95% CI: 64.7-79.9). On the other hand, the lowest ownership rate of bed net individual was reported in Uganda (event rate=14.7%, 95% CI: 9.2-22.8). The overall ownership rate of bed net individual was 52.5% (95% CI: 37.0-67.4) (Figure 3).

For net-type subgroup, the analysis revealed that the most common individual owned type of bed net according to studies was bed net of non-specified type (event rate = 70.3%, 95% CI: 39.6-89.6), and the insecticide-treated nets (ITNs) was the most commonly owned bed net-type, especially in Kenya, (event rate=74.0%, 95% CI: 71.4-76.4) (Supplementary Figure 3).

Bed net household usage

The analysis results for household usage rate revealed the highest bed net household usage rate was in Vietnam (event rate=90.3%, 95% CI: 70.3-97.3). On the other hand, the lowest bed net household usage rate was reported in be Ghana (event rate=5.9%, 95% CI: 0.8-31.9). And the overall usage rate of bed net households was 41.2% (95% CI: 25.1-59.3). The total households among all countries that use bed net are 13481 out of 35,224 with an event rate of about 41.2% which is almost half the ownership rate of 72.2% (Figure 4). The household usage rate of each country was further illustrated in (Supplementary Figure 4).

For the type of bed net subgroups as shown in the Supplementary Figure 5, the highest rate found for household usage was of LLIN (event rate=52.6%, 95% CI: 37.5-67.3), followed by any type (event rate=41.3%, 95% CI: 25-59.7), and ITN (event rate=38.8%, 95% CI: 23.8-56.2).

Bed net individual usage

Individual usage rate meta-analyses of relevant studies showed the highest rate in Vietnam (event rate=90.3%, 95% CI: 70.3-97.3) and the lowest rate in Ghana (event rate=5.9%, 95% CI: 0.8-31.9). Moreover, the overall usage rate of bed net individual was 41.2% (95% CI: 25.1-59.3), which was lower than that of the individual ownership 58.2% (Figure 5).

In the subgroup meta-analysis done for net types of individual usage, we saw the magnificent rise of usage of LLINs among people in various countries with the overall rate of 52.6% (95% CI: 37.5 -67.3), especially highest in Vietnam (event rate=90.4%, 95% CI: 88.1-92.2) and lowest in India (Ntuku’2017) (event rate=11.7%, 95% CI: 11-12.5) (Supplementary Figure 6).

We detected publication bias (Supplementary Figure 7) by Egger's test with significant results (p-value=0.02536) among 106 studies included in our meta-analysis. There were 20 studies with the risk of publication bias and this issue was resolved by the fill method.

Discussion
Our systematic review and meta-analysis explained that the low prevalence rate of bed net usage may undermine the clinical effectiveness of bed nets as the usage of bed nets is significantly lower than the ownership rates in households.

Notably, Eng et al. found that children, who are occupants of houses with an unhanged bed net, were about 5.1–16.1%, while children, who were occupants of houses with hanged bed nets but did not sleep under it, were about 4.3–16.4%.\(^{117}\) Therefore, researchers should take the reported rates with much caution as these results may misguide them. The reason behind non-use nets may be a result of different social factors including, for instance, the number of family members in the household. Therefore, we need to understand human behavior before the optimization of medical intervention to eliminate endemic diseases like malaria.\(^{118}\)

Regarding household’s ownership, we found that Saudi Arabia was the lowest country owning bed nets while Bangladesh reported the highest ownership of bed nets. This result is raising a question about the reason behind having a rich country like Saudi Arabia in the tail of countries having bed nets. A study figured out that Saudi households have good knowledge about malaria and prevention measures, however, they recommended improvement for the practices.\(^{61}\) For an explanation for this low percentage, we need to consider the low burden of malaria in SA compared to the burden of Malaria in Bangladesh.\(^{119}\) Also, a study found that there is a significant difference between Saudi/Non-Saudi households in obtaining nets.\(^{61}\) Simply, we cannot neglect the socio-economic factors when trying to explain human behavior towards protective measures like bed nets. Additionally, we need to know that the household as a word may cause a bias; as the house may hold a family, two families or even three. Then the household rates will not explain the availability of bed nets for usage.

Unlike households, we have found that Kenya ranked first place in owning bed nets per individual. This may be a result of the governmental efforts made in Kenya to distribute free ITNs to pregnant women and kids.\(^{22}\) The lowest country was Uganda, however, more than half of the Ugandians sample reported holding bed nets. The difference between the percent of Uganda and Kenya is not significant enough to be justified.

For the usage rate, our meta-analysis proved that the Ethiopian households were the first ranking, while the Ugandians were the highest country in the level of individuals. Generally, the usage rate for both households and individuals were low compared to the possession rates. Some countries may show a high rate of usage due to the spread of the malarial concern, for example in Ethiopia 75% of its lands are a target for malarial infection.\(^{120}\) While the respondents were not providing realistic answers well, this percentage may reflect a more accurate answer compared to the ownership rate. The lowest rates in net usage were for India and Yemen, which may be due to poverty and low socio-economic factors. Despite high rates for households, individuals may not find the cash to pay for nets purchasing per person. For Yemen, we can stem this rate to the instability and political/racial conflict that has existed for years there.\(^{24}\) Several reasons also can work for this justification like using other tools for controlling malaria,
favoring not to sleep under nets, allergy to insecticides or unavailability of a bed net.[40, 121][40, 121].

Regarding the type of bed net used, the overall rate is in favour of the LLINs over the ITNs and un-treated nets. This may be attributed to the fact that LLIN is a breakthrough for the preventive measures of Malaria. While other insecticidal nets should be treated with insecticides at least once a year, this type of nets only need to be treated once while at the factory.[122] Another reason that may support the prevalence of LLINs is them being freely distributed or its economic costs, which is considered a low cost. Because of its efficacy, the national programs for controlling Malaria prefer using LLIN which can explain its spread.[123]

The low percentage of bed net usage is urging the medical organizations to push the awareness campaigns for humans across endemic areas to change their behavior towards bed nets. Also, there is a crucial need to enhance the programs that freely distribute bed nets.

Though our study included 106 articles, it possibly had several limitations. First, we used only search terms in English so we could miss studies in non-English articles. Second, most of the studies included were only from African and Asian countries that cannot present the whole global mapping. Third, there were only one or few studies in the subgroups resulting in a limitation of some pooled results. Four, the high heterogeneity could affect the strength of the evidence. Finally, it was not possible to analyze confounders that affect the pooled results.

Conclusion

Our study suggests that the bed net ownership and usage rates among different countries are not enough in several countries. While numerous factors are controlling the spread of bed nets globally, the proper intervention for preventive measures should include the study of human behaviors as well as the socio-economic factors. Also, health organizations should work on improving awareness of preventive measures for this serious disease; to support the rural places and poor countries with the needed materials to stand against those diseases. For policymakers, we urge them to reconsider their regulations and plans for combating vector-borne diseases and to push social studies regularly as a tool to optimize their action plans for the betterment for their communities.

Abbreviations

ITNs=Insecticide-treated nets

LLINs=long lasting insecticides treated nets

ND=not determined.

PRISMA= Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Declarations

Ethics approval and consent to participate
Not applicable

Consent for publication
Not applicable

Availability of data and materials
All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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HSM: She has participated in title and abstract screening, full text screening, data extraction, manuscript writing and final versions approval.

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SMS: He has participated in manuscript writing and final versions approval.

KM: He has participated in idea construction, manuscript writing and final versions approval.

NTH: He has participated in idea construction, supervision for all the PRISMA steps, manuscript writing and final versions approval.

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**Supplementary Data**
Supplementary Table 1. PRISMA checklist.

Supplementary Table 2. Details of search terms in each database.

Supplementary Table 3. Characteristics of included studies.

Supplementary Figure 1. Global mapping of household ownership rate.

Supplementary Figure 2. Meta-analysis for bed net household owner: subgroup for bed net used.

Supplementary Figure 3. Meta-analysis for bed net individual owner: subgroup for bed net used.

Supplementary Figure 4. Global mapping of household usage rate of bed net. Supplementary Figure 5. Meta-analysis for bed net individual owner rate: subgroup bed net used.

Supplementary Figure 6. Meta-analysis for bed net individual usage rate: subgroup bed net used.

Supplementary Figure 7. Funnel plot of standard error demonstrating publication bias.

**Figures**
Figure 1

PRISMA flow diagram of study selection. PRISMA flow diagram reveals 106 studies included in our meta-analysis. Electronic search 12 different databases showed a total of 7036 results. After title, abstract and full text screening, a total of 85 studies were eligible. Further 21 studies were added after manual search.

Meta-analysis for household owner rate: subgroup for countries

| Group by Country | Event rate | Lower limit | Upper limit | Events/Total |
|------------------|------------|-------------|-------------|--------------|
| Bangladesh       | 0.984      | 0.894       | 0.998       | 5236 / 5322  |
| Burkina Faso     | 0.774      | 0.660       | 0.932       | 14004 / 20872|
| Burundi          | 0.520      | 0.431       | 0.685       | 4470 / 8596  |
| Cambodia         | 0.964      | 0.695       | 0.995       | 53 / 87      |
| Cameroon         | 0.743      | 0.480       | 0.900       | 2947 / 4358  |
| China            | 0.446      | 0.165       | 0.765       | 314 / 704    |
| Congo            | 0.342      | 0.112       | 0.680       | 230 / 609    |
| Eritrea          | 0.500      | 0.555       | 0.985       | 1636 / 1818  |
| Ethiopia         | 0.580      | 0.585       | 0.761       | 13906 / 27399|
| Ghana            | 0.591      | 0.375       | 0.773       | 20404 / 32756|
| Guinea           | 0.850      | 0.371       | 0.854       | 434 / 662    |
| India            | 0.819      | 0.384       | 0.970       | 1063 / 1300  |
| Kenya            | 0.547      | 0.313       | 0.801       | 9861 / 13573 |
| Liberia          | 0.360      | 0.073       | 0.650       | 422 / 1200   |
| Madagascar       | 0.540      | 0.199       | 0.827       | 2236 / 3572  |
| Malawi           | 0.399      | 0.404       | 0.802       | 7216 / 10529 |
| Mozambique       | 0.540      | 0.199       | 0.827       | 2399 / 3749  |
| Myanmar          | 0.736      | 0.535       | 0.871       | 12956 / 16450|
| New Guinea       | 0.525      | 0.133       | 0.889       | 313 / 596    |
| Nigeria          | 0.521      | 0.375       | 0.664       | 12061 / 24042|
| Rwanda           | 0.983      | 0.738       | 0.953       | 19242 / 22636|
| Saudi Arabia     | 0.221      | 0.037       | 0.675       | 57 / 258     |
| Senegal          | 0.530      | 0.192       | 0.924       | 4902 / 7780  |
| Sri Lanka        | 0.940      | 0.474       | 0.992       | 292 / 300    |
| Tanzania         | 0.380      | 0.295       | 0.442       | 17088 / 16727|
| Thailand         | 0.750      | 0.424       | 0.924       | 404 / 1356   |
| Uganda           | 0.776      | 0.563       | 0.903       | 7730 / 10609 |
| Vietnam          | 0.966      | 0.838       | 0.989       | 10021 / 1048 |
| Zambia           | 0.700      | 0.245       | 0.944       | 2151 / 3071  |
| Zimbabwe         | 0.285      | 0.053       | 0.741       | 2699 / 9442  |
| Overall          | 0.721      | 0.629       | 0.787       | 168563 / 256977|

Figure 2

Meta-analysis for bed net household owner: subgroup for countries. This figure shows meta-analysis of ownership rate among different countries per household study unit. The analysis proved that Bangladesh has the highest prevalence of ownership regarding household bednets and on contrast Saudi Arabia has the lowest ownership. The overall ownership rate (event rate=72.1%, 95% CI: 62.9-79.7).
Meta-analysis for individual owner rate: subgroup for countries

| Group by Country | Event rate | Lower limit | Upper limit | Total       |
|------------------|------------|-------------|-------------|-------------|
| Ethiopia         | 0.672      | 0.584       | 0.749       | 30100 / 44938 |
| Guinea           | 0.400      | 0.281       | 0.532       | 2779 / 6947  |
| Haiti            | 0.662      | 0.547       | 0.792       | 257 / 377    |
| Kenya            | 0.729      | 0.647       | 0.799       | 1767 / 2425  |
| Liberia          | 0.351      | 0.241       | 0.460       | 2269 / 6463  |
| Nigeria          | 0.615      | 0.520       | 0.744       | 1493 / 2057  |
| Uganda           | 0.147      | 0.092       | 0.226       | 4789 / 29467 |
| Vietnam          | 0.553      | 0.410       | 0.686       | 166 / 300    |
| Overall          | 0.525      | 0.370       | 0.674       | 43201 / 53134|

Figure 3

Meta-analysis for bed net individual owner: subgroup for countries. The figure shows the results of meta-analysis of bed net ownership among different countries per individual unit. As regards ownership rate, Kenya is considered the highest country, but Uganda is the lowest. The overall rate is 52.5% (95% CI: 37.0-67.4)

Meta-analysis for household usage rate: subgroup for countries

| Group by Country | Event rate | Lower limit | Upper limit | Total       |
|------------------|------------|-------------|-------------|-------------|
| Cameroon         | 0.247      | 0.076       | 0.659       | 1013 / 3617 |
| Ethiopia         | 0.548      | 0.411       | 0.678       | 5596 / 11076|
| Ghana            | 0.059      | 0.008       | 0.319       | 10 / 170    |
| Guinea           | 0.495      | 0.125       | 0.871       | 99 / 200    |
| India            | 0.193      | 0.073       | 0.419       | 1475 / 9291 |
| Iran             | 0.596      | 0.176       | 0.909       | 294 / 494   |
| Malaysia         | 0.623      | 0.194       | 0.919       | 139 / 223   |
| Mozambique       | 0.370      | 0.080       | 0.736       | 1368 / 3749 |
| Nigeria          | 0.387      | 0.194       | 0.623       | 468 / 1369  |
| Saudi Arabia     | 0.156      | 0.026       | 0.560       | 40 / 258    |
| Tanzania         | 0.740      | 0.294       | 0.961       | 271 / 365   |
| Uganda           | 0.566      | 0.163       | 0.899       | 1731 / 3045 |
| Vietnam          | 0.903      | 0.703       | 0.973       | 945 / 1046  |
| Yemen            | 0.108      | 0.016       | 0.468       | 14 / 130    |
| Overall          | 0.412      | 0.251       | 0.593       | 13491 / 35224|

Figure 4
Meta-analysis for bed net household usage rate: subgroup for countries. The analysis reveals Vietnam recorded the highest prevalence of household bednet usage all over the world on contrast the lowest is Ghana. Unfortunately, the usage rate is very low comparing to the ownership rate.

**Meta-analysis for individual usage rate: subgroup for countries**

| Group by Country | Event rate | Lower limit | Upper limit | Total      |
|------------------|------------|-------------|-------------|------------|
| Cameroon         | 0.247      | 0.076       | 0.569       | 1013 / 3617|
| Ethiopia         | 0.548      | 0.411       | 0.678       | 5596 / 11076|
| Ghana            | 0.050      | 0.008       | 0.319       | 10 / 170   |
| Guinea           | 0.495      | 0.125       | 0.871       | 99 / 200   |
| India            | 0.193      | 0.073       | 0.419       | 1475 / 9291|
| Iran             | 0.595      | 0.178       | 0.909       | 294 / 494  |
| Malaysia         | 0.623      | 0.194       | 0.919       | 139 / 223  |
| Mozambique       | 0.370      | 0.089       | 0.708       | 1386 / 3749|
| Nigeria          | 0.367      | 0.194       | 0.623       | 468 / 1399 |
| Saudi Arabia     | 0.156      | 0.026       | 0.560       | 40 / 258   |
| Tanzania         | 0.740      | 0.294       | 0.951       | 271 / 306  |
| Uganda           | 0.568      | 0.163       | 0.899       | 1731 / 3046|
| Vietnam          | 0.903      | 0.703       | 0.973       | 945 / 1046 |
| Yemen            | 0.108      | 0.016       | 0.468       | 14 / 130   |
| Overall          | 0.412      | 0.251       | 0.593       | 13481 / 35224|

**Figure 5**

Meta-analysis for bed net individual usage rate: subgroup for countries. The analysis done among 14 countries that reported rates per individual study unit shows usage rate of bednets is highest in Vietnam but lowest in Ghana. The results are like household study unit which may indicate that the number of individuals using are same as numbers od household. Therefore, number of bed nets are equal to number of households, so each house owns one bed or amount of bed net distributed is one per household.

**Supplementary Files**

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- [Supplementary Tables.docx](#)
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