Impact of insecticide-treated bednet use on malaria prevalence in Benishangul-Gumuz regional state, Ethiopia

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ABSTRACT

Background & objectives: In Ethiopia, nearly 10 million insecticide-treated bednets (ITNs) were distributed between 2004 and 2005; which touched 56 million in 2012. The study was aimed to determine the impact of these bednets on malaria prevalence, in Yaso district of Benishangul-Gumuz region, western Ethiopia.

Methods: A cross-sectional study was conducted during the peak malaria transmission season (October–November, 2014) in the Yaso district, Benishangul-Gumuz region. Data on demographic variables, ITN ownership and malaria infection rates were collected using structured questionnaires and blood film tests and analyzed using SAS for windows software. The probability of getting infected (questionnaire and the blood film results) was regressed against groups of explanatory variables, like age, sex, bednet use etc. using multiple logistic regressions.

Results: The results revealed that about 40% of the study subjects (384) were positive for Plasmodium falciparum; while P. vivax, P. falciparum and mixed infections accounted for 74.5% of the study subjects. All the 384 study subjects possessed insecticide-treated bednets; 50.5% possessed one, 39.3% two and 10.2% more than two. According to the logistic regression, there was significant association between illness due to malaria and at least one of the explanatory variables ($\chi^2 = 271.9, p<0.0001$). For all Plasmodium species, education level, and age appeared to be significant beneficial factors (OR<1 and negative $\beta$-values). Occupation was a significant risk factor. Proper ITN utilization improved with increasing educational status.

Interpretation & conclusion: Schools may be appropriate for creating awareness and distribution of ITN instead of the current mass campaign, which is less effective. Efforts of stakeholders (schools, community health workers, and the government) should be integrated.

Key words Benishangul-Gumuz region; Ethiopia; insecticide-treated bednets; malaria; utilization

INTRODUCTION

Ethiopia is among the top five malaria riddled countries in Africa. Despite the long history of malaria eradication and control since the 1950s, this disease is still a major challenge in the country\(^1\). In Ethiopia, malaria is seasonal, unstable and focal, depending largely on rainfall and altitude. The unstable nature of the malaria makes the population unable to develop a semblance of immunity, and therefore, people become prone to focal and cyclical epidemics\(^2\). September to December and April to May are the two transmission seasons. About 75% region of Ethiopia is at risk of malaria infection (areas with altitude of < 2000 m above sea level)\(^3\) and two-thirds of the population lies/lives in areas prone to malaria epidemics\(^5\). It is a leading cause of morbidity and mortality in the country. Plasmodium falciparum accounts for 65–75% of malaria infections, P. vivax for 25–35%, while P. ovale and P. malariae are rare\(^4,6\).

Areas/regions lying below 2000 m altitude are ‘malaria-endemic’ where control interventions are primarily targeted. Interventions include the supply of long-lasting insecticidal nets (LLINs), indoor residual sprays (IRS), prompt diagnosis using microscopic examination of blood smears and rapid diagnostic tests (RDTs) coupled with prompt and effective case management with artemisinin-based combination therapy (ACT)\(^3,7\).

According to IDA Foundation, 40% of the world’s population is at risk of malaria, and prevention is an important weapon. Prevention blocks the contact between the host and the vector mosquito. Insecticide treatment dramatically improves the effectiveness of bednets. Long-lasting insecticide-treated net (LLIN) is factory pre-treated and remains not only effective but also cost-effective during its entire life span\(^8\). According to a report from the African Leaders Malaria Alliance, in 2006 the estimated number of malaria cases in Ethiopia was 12,405,124, with an estimated 49,963 deaths. Ethiopia uses LLINs and IRS for vector control and has scaled up RDTs and ACTs country wide. The country is making good progress towards achieving universal coverage of malaria control interventions since...
December 2010. Based on a rapid impact assessment, inpatient malaria mortality in children <5 yr-old declined by 62% immediately after the mass distribution of LLINs. Since 2000, transmission intensity in malaria endemic areas has declined, probably as a result of interventions, and the number of people living in the highest endemicity class (PIPR2-10 ≥ 10%) has declined from 630,000 persons in 2000 to 381,000 persons in 2010. Combined with different partners (donors), it is estimated that between 2005 and 2012 approximately 56 million LLINs have been distributed in Ethiopia.

Ethiopia remains a country with a very different malaria ecology compared to its southern regional neighbours. The country’s population is exposed to either traditionally low stable endemic risk zones represented by a predicted mean parasite prevalence of < 1% (39%), or to areas of unstable, epidemic transmission in the highlands (17%); both areas do not support transmission of either P. falciparum or P. vivax because of low temperatures (27%) since 2000. So far the beneficial impact of ITNs has been achieved only from areas of stable malaria transmission where the prevalence of P. falciparum is over 40%.

In Ethiopia, past malaria prevalence studies show mixed findings with respect to sex and age of patients. Also possession of ITNs does not mean it is appropriately utilized. The study area (Kamashi zone, Ethiopia) is characterized by high illiteracy rate (82%) and malaria prevalence (85%)

In rural areas, illiteracy might lead to low awareness about malaria and ITNs might be used improperly contributing for high disease prevalence. Data from the health office of Yaso district of Benishangul-Gumuz regional state, Ethiopia, show that no study has been conducted on the coverage and consistent use of ITN in the district. Therefore, this study was conducted to investigate the use and subsequent impact of bednets on the prevalence of malaria in the district.

**MATERIAL & METHODS**

**Study area**

Benishangul-Gumuz regional state is located in the western Ethiopia between 09.17°–12.06° North latitude and 34.10°–37.04° East longitude. The regional capital, Assosa, is located 687 km west of Addis Ababa, the capital city of Ethiopia. About 75% of the region is lowland [<1500 m above sea level (asl)], 24% is intermediate (1500–2500 m asl) and 1% is highland (> 2500 m asl). The study was conducted in Yaso district, Kemashi zone, Benishangul-Gumuz regional state, western Ethiopia. The district is situated 318 km east of Assosa town and 599 km west of Addis Ababa. Altitudes range from 1200 to 2000 m asl, i.e., Yaso district is considered as semi-arid, where mean annual temperature rises to 35°C. Average annual rainfall ranges from 1700 to 1800 mm.

**Sampling design**

In 2014, the total population of the district was 26,012 (12,746 males and 13,266 females) (Yaso district health office, unpublished data). In order to determine the impact of bednets on malaria prevalence, a cross-sectional study was conducted during the peak malaria transmission season (October–November 2014) in the Yaso district of Ethiopia.

Villages in the district were categorized as hotspots or non-hotspots in terms of malaria incidence/prevalence. Then accessible villages were included in the study from both groups. Once villages were identified, simple random sampling procedure was adopted to select representative families. A total of 384 families were studied. The malaria history of all members in the family was recorded.
Sample size

Sample size was determined by using the formula\( ^{20} \)

\[ n = \frac{Z^2 \times P(1 - P)}{D^2} \]  \( \ldots (1) \)

Where, \( n = \) Sample size of the study; \( Z = \) Standard number for the level of confidence (95%); \( P = \) Expected prevalence; \( D = \) Marginal error.

The prevalence of malaria was not known in the study area. Therefore, an expected prevalence (\( P = 50\% \)) was taken. This prevalence yielded a sample size of 384 at 5\% margin of error. The study group was stratified once and the design effect was taken to be one. Therefore, sample size was \( 1 \times 384 = 384 \), plus 10\% contingency, \( i.e. \) 38 subjects, giving a total of 422 study subjects. Prompt diagnosis using microscopic examination of blood smears and rapid diagnostic tests (RDTs) was carried out at the Health Center of Yaso district. Appropriate treatment or referral was provided to persons testing positive.

Data collection

Several explanatory variables were chosen to determine if they contributed for the occurrence of malaria. A total of 384 people were requested to complete a questionnaire prepared for this purpose. The explanatory variables included age, sex, residence, religion, occupation, education level of the respondents, number of ITNs in the house, who in the house was using ITN, if ITN was used properly or not, and period of utilization (Table 1). The outcome variable was a dichotomous variable with two possibilities (infected or healthy). It was further differentiated in to \textit{Plasmodium} species when found positive for malaria infection.

Ethical consideration

The purpose and nature of the research was explained to participating households. They were informed that it was voluntary, their identities would be kept anonymous, and those found malaria positive would be treated free of charge in accordance with the National Malaria Control Treatment Guidelines. Households who gave informed verbal consent were included in the study. Research ethics clearance was obtained from Bahir Dar University, Ethiopia (Ethics Reference No: ERN/01/07, dated August 22, 2014).

Statistical analysis

Data collected through structured questionnaires and that of blood film tests were analyzed using SAS for windows software\(^{21} \). The probability of getting infected (outcome variable) was regressed against groups of explanatory variables using multiple logistic regressions. Because there were several explanatory variables associated with the outcome variable, odds ratios were calculated for each of them separately. The odds ratio was denoted as \( P/1-P \), \( i.e. \) the probability of an event occurring (infection due to malaria parasites), over the probability of the event not occurring (no infection).

<table>
<thead>
<tr>
<th>Explanatory variable/ Categories</th>
<th>Assigned dummy variables</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>5–14 1</td>
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<td>&gt;15 2</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
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<tr>
<td>Female 0</td>
<td></td>
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<tr>
<td>Male 1</td>
<td></td>
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<tr>
<td>Residence</td>
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<tr>
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<tr>
<td>Rural 1</td>
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<tr>
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</tr>
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<td>Muslim 1</td>
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<td>Farmer 3</td>
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<td>Other 4</td>
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<td>Elementary school 2</td>
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<td>Illiterate 4</td>
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<td>ITN users</td>
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<td>Mother 0</td>
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<tr>
<td>Mother and children 1</td>
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<tr>
<td>Wife and husband 2</td>
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</tr>
<tr>
<td>All family members 3</td>
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</tr>
<tr>
<td>Number of ITN in the house</td>
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<tr>
<td>&gt;Two 0</td>
<td></td>
</tr>
<tr>
<td>Two 1</td>
<td></td>
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<tr>
<td>One 2</td>
<td></td>
</tr>
<tr>
<td>Period of ITN usage</td>
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<tr>
<td>All year round 0</td>
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<tr>
<td>During rainy season 1</td>
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<tr>
<td>During dry season 2</td>
<td></td>
</tr>
<tr>
<td>Other 3</td>
<td></td>
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<tr>
<td>Proper use of ITN in the house</td>
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</tr>
<tr>
<td>Yes 0</td>
<td></td>
</tr>
<tr>
<td>No 1</td>
<td></td>
</tr>
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</table>

Table 1. List of explanatory variables and their categories denoted by dummy variables at Yaso district, Benishangul-Gumuz regional state, Ethiopia
The joint effect of all independent (explanatory) variables put together may be expressed mathematically as:

\[
\text{Odds} = \frac{P}{1-P} = e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p} \quad \ldots (2)
\]

Where, \( e = 2.718282 \), \( \alpha \) = Intercept, \( \beta_i \) = Coefficient of variable 1, \( \beta_2 \) = Coefficient of variable 2, and so on.

The independent contribution of each of several factors, i.e. \( X_1, X_2, \ldots, X_p \) in equation (1) can be determined by taking the logarithm of both sides of the equation:

\[
\log_e \left( \frac{P}{1-P} \right) = \log_e \left( \frac{e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p}}{1 - e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p}} \right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p \quad \ldots (3)
\]

The term \( \log_e \left( \frac{P}{1-P} \right) \) is referred to as logarithmic transformation of the probability \( P \), and is written as logit \( \left( \text{logit} (P) \right) \).

Transforming the counted proportion \( P \) (number of successes out of many trials or subjects) to logit eliminated the drawback of probability which varied from 0 to 1, whereas the logit could vary from \(-\alpha\) to \(+\alpha\), therefore, the natural logarithm of:

\[
\frac{P}{1-P} = \text{log it} (P) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p \quad \ldots (4)
\]

In equation (3), with these two possible outcomes of presence (coded 1) and absence (coded 0) of malaria parasites in the subject under study, \( \alpha \) represented the overall disease risk, \( \beta_i \) denoted the fraction by which the risk increased (or decreased) by every unit change in \( X_i \), and \( \beta_2 \) was the fraction by which the disease risk was altered by a unit change in \( X_2 \), and so on. The independent variables were qualitative and quantitative for which dummy variables were assigned (Table 1). Using this regression, parameters were estimated such that the coefficients indicated the observed results, most likely, the method known as maximum likelihood. The logit of a proportion \( P \) is the logarithm of the corresponding odds. If an \( X \) variable had a coefficient \( \beta \), then a unit increase in \( X \) increased the log odds by an amount equal to \( \beta \). This meant that the odds themselves increased by a factor of \( e^\beta \). The independent variables were categorized into two groups; the first group included sociodemographic variables and the second included variables of ITN utilization. Logistic regression was invoked separately for the two groups.

RESULTS

Over 26,000 people resided in the study area at the time of the study. They were represented by 384 study subjects. The study revealed that about 40% of the study subjects were positive for *P. falciparum* (Fig. 2). The percentages were calculated based on 384 individuals.

![Fig. 2: Percentage infection caused by different *Plasmodium* species (n = 384).](image-url)
factor. A non-significant risk factor was sex (OR=1.7, \( p>0.05 \)) and non-significant beneficial factors included residence (\( p=0.28 \)) and religion (\( p=0.10 \)) (Table 2).

Although, there was no clear distinction between sexes in relation to infection rates by different \textit{Plasmodium} species, falciparum appeared to attack men more than women (Fig. 3a); vivax prevalence was slightly more in rural residents than urban dwellers (Fig. 3b); religion did not show discernible pattern (Fig. 3c); subjects older than 15 yr were slightly more susceptible than children younger than 5 yr and those between 5 and 15 yr of age were less prone to infection (Fig. 3d); better utilization of bednets was observed in people who were educated and that contributed for less malaria incidence (Fig. 3e). Malaria attack was lower on merchants than on daily labourers, farmers, government employees and others (Fig. 3f).

\textit{Insecticide treated bednet utilization:} Proper and regular utilization of ITNs tended to reduce malarial infections but both were not significant (\( p>0.05 \)) (Table 2). The bednet utilization improved with the increasing level of education (Fig. 4).

The number of people in each level was different and percentages were computed on that basis. Proper use slightly increased in illiterates and persons with elementary schooling, but dramatically improved with education level of high school onwards.

\textit{Mixed infection with \textit{Plasmodium} species (\textit{P. falciparum} and \textit{P. vivax}):

Sociodemographic variables:} When the sociodemographic variables were considered as explanatory variables, the residence and education level had significant beneficial roles in reducing malaria incidence (\( p<0.05 \)). Religion had the same beneficial role but it was not significant. Sex, occupation and age were non-significant risk factors (Table 3).

\textit{Insecticide treated nets utilization:} Proper utilization of nets had significant beneficial role against malaria incidence (OR=0.02, \( p<0.02 \)). Other variables except num-

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Fig. 3: Sociodemographic variables with respect to \textit{Plasmodium} species infection levels (\( n=384 \)) at Yaso district, Benishangul-Gumuz regional state, Ethiopia (October–November 2014)—(a) Sex; (b) Residence; (c) Religion; (d) Age; (e) Education level; (f) Occupation.
Infection by *P. falciparum* species

**Sociodemographic variables:** Looking at the contribution of individual explanatory variables for infection by *falciparum* species, only two of the explanatory variables, viz. residence and education level were found significantly associated ($p<0.05$) to the outcome variable (illness/malaria infection) (Table 4). Higher odds ratio was recorded for residence ($OR = 1.970$).

**Insecticide treated net (ITN) utilization.** Proper utilization of nets had significant beneficial role against malaria incidence because odds ratio was < 1 and $\beta$-value was negative ($OR = 0.36, p<0.001$) (Table 4). Other variables did not contribute significantly.

### Table 4. The results of logistic regression in malaria occurrences caused by *P. falciparum* against selected explanatory variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard error</th>
<th>Wald $\chi^2$</th>
<th>Prob&gt; ChiSq</th>
<th>Odds ratio</th>
</tr>
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<tbody>
<tr>
<td><strong>Sociodemographic variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept ($\alpha$)</td>
<td>1.88</td>
<td>0.38</td>
<td>24.97</td>
<td>&lt;0.0001</td>
<td>–</td>
</tr>
<tr>
<td>Sex</td>
<td>0.20</td>
<td>0.24</td>
<td>0.68</td>
<td>0.410</td>
<td>1.22</td>
</tr>
<tr>
<td>Residence</td>
<td>0.68</td>
<td>0.24</td>
<td>7.74</td>
<td>0.005</td>
<td>1.97</td>
</tr>
<tr>
<td>Religion</td>
<td>0.24</td>
<td>0.32</td>
<td>0.59</td>
<td>0.444</td>
<td>1.28</td>
</tr>
<tr>
<td>Occupation</td>
<td>0.03</td>
<td>0.08</td>
<td>0.15</td>
<td>0.695</td>
<td>1.14</td>
</tr>
<tr>
<td>Education level</td>
<td>-0.62</td>
<td>0.09</td>
<td>43.87</td>
<td>&lt;0.0001</td>
<td>0.09</td>
</tr>
<tr>
<td>Age</td>
<td>-0.24</td>
<td>0.15</td>
<td>2.66</td>
<td>0.103</td>
<td>0.62</td>
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<tr>
<td><strong>Insecticide-treated net (ITN) utilization</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept ($\alpha$)</td>
<td>0.63</td>
<td>0.32</td>
<td>3.99</td>
<td>0.0458</td>
<td>–</td>
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<tr>
<td>Number of ITN</td>
<td>0.11</td>
<td>0.16</td>
<td>0.48</td>
<td>0.4891</td>
<td>1.25</td>
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<tr>
<td>Users of ITN</td>
<td>0.07</td>
<td>0.09</td>
<td>0.69</td>
<td>0.4047</td>
<td>1.25</td>
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<tr>
<td>Proper utilization</td>
<td>-1.03</td>
<td>0.22</td>
<td>22.26</td>
<td>&lt;0.0001</td>
<td>0.36</td>
</tr>
<tr>
<td>Period of utilization</td>
<td>0.06</td>
<td>0.17</td>
<td>0.13</td>
<td>0.7160</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Infection by *P. vivax* species

**Sociodemographic variables:** Logistic regression analysis for *P. vivax* infection showed that, four variables were significantly ($p<0.05$) associated to the outcome variable, viz. education level, religion, age and sex (Table 5). Higher odds ratio was recorded for occupation ($OR=1.06$). Beneficial factors included sex, residence, religion, education and age, but not occupation.

**Insecticide treated net utilization.** Around 47.7% of the study individuals used nets all year round. According to the records, a little more than half (53.4%) of the study subjects used bed nets daily. Proper utilization and period of utilization were significant beneficial factors while...
the other two, i.e. number of ITN and use of ITN were risk factors, but non-significant.

DISCUSSION

In the present study, 75% of the study subjects were found infected with malarial parasites. About 40% of the study subjects were positive for *P. falciparum*. Only about 25% were found free of malaria infection. In 2003, i.e. 11 yr earlier, the prevalence was 85%, showing steady decline ever since19. This result was higher than similar studies carried out in other parts of Ethiopia22–25. This difference might be due to altitude variation and climatological difference that may contribute greatly in breeding of *Anopheles* vector. The predominant *Plasmodium* species detected was *P. falciparum*, followed by *P. vivax*. This was consistent with other previous studies4, 25–26. However, in studies carried out in other places, *P. vivax* was the most dominant, i.e. the most prevalent species, followed by *P. falciparum*. This indicates that prevalence can be location specific.

As education level increased, not only the knowledge of people towards risk factors improved but also their income increased which contributed for less prevalence of malaria. The government employees, merchants and others used bed nets in better way than illiterate people did27,29.

In the present study, majority of the study participants were rural residents (50.8%) and illiterate (40.6%) who increased the odds ratio for the occurrence of infection by the mixed species of *Plasmodium*. This might mean low malaria control intervention practice16 and improper handling of ITN. This study corroborates results of other studies regarding educational status and residence; illiterate participants and rural people who were prone to malaria parasites, respectively15. Improper utilization of bed net enhances the incidence of *Plasmodium* infection.

As age increases from childhood to adulthood, immunity improves helping the patient to overcome malarial infections. The overall malaria prevalence among the households with children under five years of age was 20.8%. This was lower than the reports of a study conducted in Nigeria (24.4%)13. ITN utilization was higher in Nigeria (57.7%)13 than in the present study (53.7%) but lower than the other reports from Oromia and Amhara regions of Ethiopia (63.4% and 62.4%, respectively)22.

Malaria is a major public health problem in Ethiopia; it contributes up to 20% of under-five deaths, with estimated 5–10 million clinical malaria cases each year and accounts for 12% of outpatient visit and 10% of health facility admissions30.

Reducing under-five child mortality rate remains a major concern for countries especially the developing countries. A lower under-five mortality rate is an indication of an improved child well-being as well as better coverage and success of child survival intervention programmes30. The millennium development goal 4 (MDG 4) specifically draws the world’s attention to the need of reducing the under-five mortality rate by two-third between 1990 and 2015. According to the World Health Organization (WHO), in 2013 about 6.3 million children under age five died across the world, i.e. about 17,000 every day30–31.

Furthermore, in this study, participants >15 yr (52.3%) and <5 yr were more susceptible to malaria compared to those aged between 5 and 15 yr. Adults often stay outdoors, while children <5 yr might naturally have lower immunity, increasing the probability of infection. Those between 5 and 15 yr-old may stay indoors and have better immunity. In Cameroon, as high as 87.6% infection rate was observed in people >15 yr32. This may be linked to the way people share sleeping rooms in the house. Similarly, a study in Dejen district, Ethiopia, revealed higher prevalence of malaria in individuals >15 yr-old15. When there are only a limited number of ITNs, it could be that the priority is given to the younger children. Family size also matters, whereby as the ratio of nets/family increases, the ratio of using mosquito nets improves33–34.

All the 384 study subjects had ITNs; 194 (50.5%) possessed one, 151 (39.3%) possessed two, and 39 (10.2%) possessed >2 ITNs. Therefore, the possession of ITNs was found to be highest as compared to other reports from Ethiopia26, 28, 35. This implies that the net distribution program is in progress and has attained the MDG target of 100% ITNs coverage4, 36.

In this study, all the nets were acquired through donation to address the MDGs. In a similar study in south-central Ethiopia, 98.7% of the study subjects possessed ITNs7, 26. In contrast, other reports claimed that 60.5% of the nets were endowed by the local health authorities free of cost and among the remainder only 24.6% nets were purchased from the market37–38.

Regarding the pattern of bednet utilization, 53.4% of the respondents reported correct use of ITNs (all year round and all family members slept under net). This is lower than the results reported in Pawe district of this region (69.9%)17 but was higher than the result reported in Assosa zone (44.4%) of the same region39. Yimer et al25 reported still higher bednet use (88.8%) in sleeping respondents/people. Variation may result due to differences in environmental factors like period of the study,
hot weather, absence of mosquito nuisance, and the local community sociocultural factors.

Another study conducted in Nigeria reported that net utilization was 58% in that region\(^{40}\). Proper use of bednets help to reduce malaria incidence. Malaria could be eliminated if 75% of the population starts using bednets\(^{41}\). Possession and appropriate utilization of ITNs do not necessarily go hand in hand\(^{40–41}\).

In the present study, bednets reduced malaria prevalence by 60.7% across age-groups. Given the relatively higher prevalence of infection in older children and adults, it is important to recognize the need of providing ITNs to all members of a community and not focus only on young children in areas of low transmission\(^{15, 42}\). This resounds with recent calls for high coverage among all community members across the range of transmission settings\(^{43}\) where it is also recognized that individuals older than five years contribute to transmission.

The evidence on the public health impact supporting the wide-scale use of ITNs in Africa is drawn from areas of stable malaria transmission where \(P. \text{falciparum} \) infection prevalence in the community is often over 40%\(^{10, 44}\). There is a scarcity of parasitological or health impact data on the benefits of ITNs in Africa that support low stable or unstable transmissions.

The current study showed all individuals had awareness of ITNs. Other researchers have reported 60% awareness of ITNs\(^{45–46}\). Elsewhere, over 80% of the respondents believed that ITN prevents mosquito bites while sleeping\(^{28}\). Some 77.3% of those owning ITN used their nets consistently throughout the year\(^{37}\).

Education level and knowledge about malaria transmission were some of the noteworthy reasons affecting usage of ITNs. Knowledge on transmission of malaria was different among educated and illiterate individuals. Educated individuals had knowledge about malaria and they used ITN more often than illiterates\(^{47}\). Formal education builds confidence in the adoption of a new technology. However, because all people can not be expected to attain higher education, therefore, regular training must be given to the local community.

High temperature and humidity, low altitude, high human population density, and deforestation speed up malaria transmission\(^{48}\). All of these factors are important in making an area malaria endemic. Furthermore, mosquitoes possess a highly developed set of host-detection organs that they use to sense colour, light, touch, and temperature, as well as the presence of \(\text{CO}_2\), all of which are used as sensory inputs to locate host\(^{48}\). More studies are required on these aspects.

CONCLUSION

In conclusion, the current study underpinned that ITN possession is important for preventing malaria occurrence. Sleeping under bednet was the common malaria prevention measure reported in the study. There was high awareness among the subjects about the significance of ITNs in preventing malaria infection. Despite the high awareness about bednets, there were still gaps in malaria prevention strategies, mainly in the utilization of bednets. Education had a significant role in using bednets properly for preventing mosquito bites while sleeping. Age and residence of the subjects also influenced bednet utilization directly or indirectly for reduction of the overall malaria burden.

According to this study 46% of the subjects >15 yr-old were susceptible to malaria infection. High malaria transmission often overlaps with the planting and harvesting season that increases malaria incidence among working age group and working adults in Agrarian communities. Falling ill due to malaria results in a heavy economic burden in the region as well as to the country. So the mode of ITNs distribution must be altered. The distribution of ITNs should be carried out in school while providing awareness about proper utilization instead of mass campaign. Efforts of stakeholders (schools, community health workers, and the government) should be integrated to achieve the goal of malaria elimination. Proper handling and utilization of ITNs in Agrarian communities must be promoted house-to-house.

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REFERENCES

2. Lemma H, Byass P, Desta A, Bosman A, Costanzo G, Toma L,


5. *Guideline for malaria epidemic prevention and control in Ethiopia*. Addis Ababa, Ethiopia: Malaria and Other Vector-Borne Disease Control Unit, Epidemiology and AIDS Control Department, Ministry of Health 1999; p. 31.


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