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# Does Insecticide Treated Mosquito Nets (ITNs) Prevent Clinical Malaria in Children Aged Between 6 and 59 Months Under Program Setting?

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**Abstract** Inconsistent use of the mosquito nets and other social and technical factors were shown to influence efficacy of mosquito nets at field trials. But to date, experience with local factors influencing effectiveness of ITN programs remain very limited. The objective of this study was to assess the effectiveness of ITNs for preventing clinical malaria in under-five children of Omo Nada Woreda, Jimma Zone South West Ethiopia. Matched case-control study was conducted in the catchments population of Asendabo and Nada health centers, Omo Nada Woreda, South West Ethiopia on a sample of 273 under-five children. Each case of fever and parasitemia in a child was paired with two controls. Cases and controls were compared with regard to ITN ownership and other factors assessed by a pre-coded, pre-tested structured questionnaire. Data was analyzed using EPI-INFO version 3.3.2 software. To control the effect of confounding variables, conditional logistic regression model was used. Sleeping under the mosquito net the night (OR = 8.28 95% CI: 0.96, 71.1) and the week (OR = 2.41 95% CI: 0.41, 14.0) before the survey date were strongly, but not significantly associated with clinical malaria. Mosquito net possession and appropriate utilization of mosquito net were not associated with clinical malaria. In the comparison of cases with all the controls rolling out of mosquito net & corrugated iron roof were found to be independent predictors of clinical malaria. Knowledge about the sign and symptoms of malaria and its modes of transmission were also independent predictors of clinical malaria in comparison of cases with health center and community controls, respectively. With the presence of many programmatic deficiencies like poor ITN distribution and re-treatment services, ITNs were not significantly associated with clinical malaria in under-five children when used during low-transmission period. Further research using a large sample size is required. In line with ITN scale up, information Education Communication (IEC) about the preventive practices against malaria, causes of malaria, treatment and sign and symptoms of malaria should be given to the community.

**Keywords** Malaria · ITN · Prevention · Childhood · Effectiveness · Mosquito net

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## Introduction

Malaria is the world's most common parasitic infection, ranking among the major health and developmental challenges for the poor countries of the world particularly Sub-Saharan Africa (SSA) countries & mostly among children less than 5 years old [1–8].

In Ethiopia childhood malaria is the commonest cause of hospital attendance and admissions except for deliveries for women as well as deaths, with only 20% of children under 5 years of age that contract malaria treated at existing health facilities [9–11]. In Oromiya State, 95% of the area is prone to malaria with over 2 million people at risk of acquiring the infection every year [10]. Malaria is a major health problem in Jimma Zone with incidence of 56% at household level and most of the Kebeles labeled as malaria endemic [10, 12]. Malaria is the first cause of OPD

visits and inpatient cause of death in all ages and adult admission in Asendabo and Nada health centers [13, 14].

The Roll Back Malaria initiative aims to halve malaria mortality by 2010, with a strategy relying heavily on the use of Insecticide-Treated Nets (ITN), which has been shown to reduce all-cause mortality among children younger than 5 years by a mean of 17% in the first 2 years after their introduction [15]. Resistance of the vectors to insecticides is generally increasing. Moreover, even in areas where the benefits are substantial and mosquito nets have been deployed through national programs, community uptake has been disappointing. The effectiveness of ITNs varies with the rate of malaria transmission; the nets do not work well in many areas of low and unstable transmission, where malaria vectors bite in the early evening and morning [1].

The ITN studies conducted in the late 1970s demonstrated the safety of synthetic pyrethroids and the significant impact of ITNs on various entomological parameters [16]. Since the groundbreaking research of Bradley and Greenwood in the Gambia [17], and the 1991 report of Alonso and his colleagues [18], which showed a significant inverse correlation between ITN usage and mortality, much hope has been pinned on the use of ITNs in malaria control [19–22]. Despite the proven benefits and cost-effectiveness of ITNs, achievement of widespread use has proved difficult. In most SSA countries, only a small percentage of individuals who should be protected by nets actually use them. Free provision of ITNs, sometimes linked to other initiatives such as vaccination or attendance to antenatal clinics, has strong advocates and is gaining support, but this approach needs a major and sustained commitment from international donors [23].

Many ITN trials achieved their impact with close to 100% of households possessing nets and 50 to 75% of under-5s sleeping under them, a level of use similar to the Abuja target of 60%. Where lower coverage and use rates are achieved, the impact on mortality will be less [24, 25]. Subsequent programs have demonstrated the effectiveness of ITNs under field conditions [1, 24].

To date, however, experience with local factors influencing the effectiveness and sustainability of ITN programs remains very limited [19, 26–29] and it is not known whether the impact of treated nets in the context of well Randomized Control Trial (RCT) can be replicated under program conditions [27, 30–32].

The National Malaria Prevention and Control approach in Ethiopia employs four main strategies: early diagnosis and prompt treatment, selective vector control including the use of ITN and Indoor Residual Spray (IRS), early detection and control of malaria epidemics and prevention of malaria during pregnancy. Although there is a very good experience in malaria vector control through IRS, historically the use of ITNs in Ethiopia has been limited. A total of 4 million ITNs are required to achieve the Abuja target. The National Strategic Plan for Scaling-up coverage and use of ITNs in Ethiopia is designed to guide national malaria prevention and control efforts to achieve coverage of 60% of target districts by the end of the year 2007 [33, 34]. According to the 2005 Ethiopian Demographic and Health Survey (EDHS) although one-fifth of Ethiopian households located at altitudes less than 1,500 m, report owning a mosquito net, only half of them owns an ITN. Just 4% of children under age 5 and 1% of pregnant women slept under an ITN the night before the survey [35]. Continuous monitoring of the ITN program is part of the National Strategic Plan for the Scaling-up Coverage and this study would help have some light on that line.

In Omo Nada Woreda as other parts of Oromiya Region, ITN distribution began in 2001, with conventional ITNs for a subsidized cost. In 2005, the conventional ITN and newly introduced Long Lasting Insecticide-treated Nets (LLINs) were distributed for free [12, 36] and have reached about 45% coverage [37], but their effectiveness and related factors are not known at the community level. Thus, this study aims to assess the program effectiveness of ITNs for preventing clinical malaria in under-five children in Omo Nada Woreda.

## Methods

This study was conducted in the catchment area of Asendabo Health Center and Nada Health Center in Omo Nada District (*Woreda*) of Jimma Zone, Southwest Ethiopia from December 21, 2006 to January 30, 2007. Asendabo Health Center is found in Asendabo Town and Nada Health Center is found in Nada Town which is the capital town for the Woreda. The two health facilities serve as training centers for Team Training Program of Jimma University. Most of the Catchment's population of Asendabo health center is located within Gilgel Gibe Field Research Center. Gilgel Gibe Field Research Center is located around Gilgel Gibe Hydroelectric dam with a total population of 42,290 [13, 14, 38].

A matched case-control study design was used where Children from 6 to 59 completed months sampled from under-five children within the catchment areas of Asendabo and Nada health centers, Omo Nada Woreda (for both the cases and controls) and who fulfill the inclusion criteria were included. The study employed matched case-control study where cases were matched with controls by age, sex and vicinity. Sample size was calculated with EPI-INFO version 3.3.2 software using prevalence of ITN use (main exposure variable) among the controls of 27%, odds ratio being detected of 0.34, [36] 80% power, 95% confidence

interval, and a control: case ratio of 2:1. This gave 83 cases and 166 controls (total 249 study children). Adding 10% for non-response rate, the total sample size was 273 (91 cases and 182 controls).

Cases were defined as children who had an axillary temperature of greater than 37.5°C or history of fever within the last 48 h and positive blood smear for plasmodium falciparum. Two types of controls were selected, one from the health facilities and the other from community. Health center controls were defined as children who came for growth monitoring or EPI, and those children who came to the health center for non-febrile illnesses and have a negative blood smear. Community controls were defined as children with a negative blood smear and an axillary temperature <37.5°C who had not been ill within the last 2 weeks. Community controls were randomly selected by escorting malaria cases to their homes, after which a random direction was chosen by spinning a coin. The next household in the chosen direction was selected. Subsequent households were approached if necessary, until a matching control is found. Children who were in the age group between 6 and 59 months and who lived in the study area for more than 1 month were included in the study. Children who had diarrhea and upper respiratory symptoms were excluded.

Data was collected by trained high school complete personnel using pre-tested structured questionnaire. The questionnaire was adopted from WHO and UNICEF. For ITN users, the condition of their nets including the size, shape, hanging place, holes, etc. was observed during the interview using a checklist prepared by the principal investigator. Blood sample was taken from cases and controls and examined by a laboratory technician for malaria parasites using Giemsa stained thick blood smears. Parasite density was calculated by counting the number of asexual parasites per 200 White Blood Cells (WBC's), assuming a WBC count of 8,000/μl of blood. Slides were considered negative if no parasites are found after examining 100 high-power fields [39]. Data was entered into computer and analyzed using SPSS 12.0.1 and EPI-INFO 3.3.2 statistical software. Univariate and multivariate analysis were done. To control the effect of confounding variables, conditional logistic regression model was used. Collinearity was also checked and Variance Inflation Factor (VIF) was calculated and variables with VIF of 10 and above were excluded from the model. Two-way and three-way interaction between the independent variables was checked for before entering them into the final models. Likelihood tests are used to assess the goodness of fit of the final models. The following definitions were used; Program setting, in this study, meant community setting where ITN is distributed freely by the government.

Use of ITN was defined as owning an ITN, keeping it in good condition and using it appropriately. Children using an untreated net or no net and children that live in households that own ITNs but are not using them were classified as non-users. Most researchers consider a child to be users when he/she had slept under an ITN the previous night [40]. In this study, the use in the previous night and 1 week are considered.

Knowledge of malaria was evaluated by asking close-ended questions about different attributes of malaria with choices. We calculated a knowledge index by giving a score of 1 for correct answer and 0 for incorrect answer then adding the score (one for each) given for each question then divide by the number of the questions and take the mean as cut off point, above which was knowledgeable and below which otherwise.

Economic status of the household was evaluated by using an index which comprises monthly income, household possessions, source of fuel, presence of toilet in the house, source of water. The index was calculated by giving a score of 1 for correct answer and 0 for incorrect answer then by adding the score (one for each) given for each question then divide by the number of the questions and take the percentiles to divide between the lowest, second, middle, fourth and highest quintiles..

## Results

The response rate was 90% of whom 82 were cases, 82 health center and 82 community controls). Rural residents were 56% and around 44% of the respondents were from Nada kebele. The mean age of the mothers was 27.23 years ± 0.34. More than 74% of mothers/caretakers were in the age range of 21–30 years. Males headed around 95% of the houses. Majority of the mothers were Muslim (87.7%) and married (96.3%). Around 60% of the mothers and more than 33% of the fathers of the children were illiterate. Most (85.4%) mothers were housewives and majority of fathers were either farmers (60.9%) or merchants (21.0%). Most (81.4%) of the families earn between 200 and 499 Ethiopian Birr. Considering some of the household possessions, monthly income and other household assets 24.9% were in the lowest wealth quintile and 23.7% of them in the highest quintile. The average family size was 5.71 persons per household. The average number of under-five children per household was 1.74 ± 0.717. The mean walking distance from a health institution was 60.95 min ± 2.79. The mean age of the children was 29.23 months ± 0.84. Nearly a third of them were in the age group 24–35 months. The age group 24–35 months included 35.4% of case, 30.5% of the health center controls and 29.3% of the community controls. Males constituted 63.4% of the total children (Table 1).

**Table 1** Socio-demographic characteristics of respondents (246), Omo Nada Woreda Jimma Zone, Oromiya Region, South West Ethiopia Feb 2007

| Socio-demographic characteristics | Case (%) | HC[#] (%) | CC* (%) | *N* (%) |
|---|---|---|---|---|
| Educational status of the mother/care-giver | | | | |
| Illiterate (can't read or write) | 44 (30.1) | 52 (35.6) | 50 (34.2) | 146 (59.3) |
| Can read and write only | 8 (22.2) | 12 (33.3) | 16 (44.4) | 36 (14.6) |
| Primary education | 20 (46.5) | 12 (27.9) | 11 (25.6) | 43 (17.5) |
| Secondary education | 9 (52.9) | 4 (23.5) | 4 (23.5) | 17 (6.9) |
| More than secondary education | 1 (25.0) | 2 (50.0) | 1 (25.0) | 4 (1.6) |
| Work of the mother/care-giver | | | | |
| Farmer | 7 (53.8) | 2 (15.4) | 4 (30.8) | 13 (5.3) |
| House wife | 65 (31.0) | 73 (34.8) | 72 (34.3) | 10 (85.4) |
| Daily laborer | 1 (20.0) | 2 (40.0) | 2 (40.0) | 5 (2.0) |
| Government worker | 7 (63.6) | 3 (27.3) | 1 (9.1) | 11(4.5) |
| Merchant | 2 (33.3) | 2 (33.3) | 2 (33.3) | 6 (2.4) |
| Others | | 2 (15.4) | 1 (100) | 1 (0.4) |
| Overall economical status (wealth quintile) ($n = 245$) | | | | |
| Lowest | 16 (26.2) | 21 (34.4) | 24 (39.3) | 61 (24.9) |
| Second | 18 (26.9) | 20 (29.9) | 29 (43.3) | 25 (10.2) |
| Middle | 23 (39.0) | 18 (30.5) | 18 (30.5) | 42 (17.1) |
| Fourth | 22 (44.0) | 18 (36.0) | 10 (20.0) | 59 (24.1) |
| Highest | 2 (25.0) | 5 (62.5) | 1 (12.5) | 58 (23.7) |
| Housing characteristics | Case (%) | HC (%) | CC (%) | *N* (%) |
| Roof of the house | | | | |
| Corrugated Iron sheet | 48 (39.0) | 42 (34.1) | 33 (26.8) | 123 (50.0) |
| Thatched | 34 (27.6) | 40 (32.5) | 49 (39.8) | 123 (50.0) |
| Kitchen in the house ($n = 245$) | | | | |
| Yes | 34 (38.2) | 32 (36.0) | 23 (25.8) | 89 (36.2) |
| No we cook inside the living room | 35 (26.7) | 41 (31.3) | 55 (42.0) | 131 (53.3) |
| No we cook outside the house | 12 (48.0) | 9 (36.0) | 4 (16.0) | 25 (10.2) |
| Functional radio in the house | | | | |
| No | 63 (37.3) | 60 (35.5) | 46 (27.2) | 169 (68.7) |
| Yes | 19 (24.7) | 22 (28.6) | 36 (46.8) | 77 (31.3) |

[#] HC: Health Center, * CC: Community Control

A total of 135 (54.9%) households (56.1% for cases, 42.7% for health center control and 48.8% for community control) owned mosquito net. Almost half (44.9%) of the mosquito nets (37.0% for cases, 55.3% for health center control and 40.5% for community control) were dirty but placed appropriately. The mean age of the ITNs was 7.25 months ± 0.52 (minimum 2 months, maximum 30 months). Thirty-seven (27.0%) mothers/caretakers who had mosquito nets said that their children sometimes rolled out of the ITN during night time.

When cases were compared with both health center and community controls, children who did not sleep under the mosquito net the night before the survey date were more than 8 times at risk of clinical malaria compared to those who slept under the mosquito net (OR = 8.28 95% CI: 0.96, 71.1). Children who slept under the mosquito net the week previous to the survey date were more than two times likely to acquire clinical malaria as compared with those who did sleep under it (OR = 2.41 95% CI: 0.41, 14.0). But these associations were not statistically significant. Presence of mosquito net was not significantly associated with the occurrence of clinical malaria (OR = 0.88 95% CI: 0.44, 2.19). Status of the mosquito net mainly according to the retreatment status, frequency of washing and other mosquito net attributes, was not significantly associated with the occurrence of clinical malaria (OR = 0.67 95% CI: 0.36, 1.24). The major exposure variable, appropriate mosquito net utilization which is dependant on the status of the mosquito net as well as on the child's sleeping under it the previous night and week

was not significantly associated with the occurrence of clinical malaria (OR = 0.90 95% CI: 0.37, 1.77). As with the other matched bivariate analysis, higher socioeconomic status and quintile of families, poor knowledge (non-probed) of mothers about the treatment of malaria, rolling out of bed of children during sleep, higher educational level of mother/care-giver, larger number of rooms per house, and cooking in the living room were seen to be associated with higher risk of getting clinical malaria in the children. Children whose family possessed radio, who lived in thatched roof, who had knowledgeable mothers on modes of transmission of malaria were less likely to have clinical malaria (Table 2). On further analysis using multivariate conditional logistic regression, children who roll out of bed during sleep were 4 times higher risk of getting malaria compared to those who do not roll out of bed during sleep (OR = 4.33, 95% CI: 1.59, 11.80) and children who lived in a house with thatched roof were at 34% lower risk of getting malaria compared with children living in a house with corrugated iron sheet (OR = 0.34, 95% CI: 0.13, 0.88) (Table 3).

In our analysis of cases and health center controls, children who did not sleep under the mosquito net the night before the survey date were 6 times at risk of clinical malaria compared to those who slept under it (OR = 6.00 95% CI: 0.72, 49.82) and children who slept under the mosquito net the week previous to the survey date were two times likely to acquire clinical malaria as compared with those who did sleep under it (OR = 2.00 95% CI: 0.37, 10.92). But these associations were not significant. Presence of mosquito net was not significantly associated with the occurrence of clinical malaria (OR = 1.10 95%

**Table 2** Factors associated with clinical malaria in children aged 5–59 months (case versus all the controls), Omo Nada Woreda, Jimma Zone, Oromiya Region, South West Ethiopia Feb 2007*

| Variables | Cases | Controls | |
|---|---|---|---|
| | No. (%) | No. (%) | #COR (95% CI) |
| Child slept under the mosquito net the previous night | | | |
| Yes | 40 (87.0) | 86 (98.6) | 1 |
| No | 6 (13.0) | 3 (3.4) | 8.28 (0.96, 71.1) |
| Child slept under the mosquito net the previous week | | | |
| Yes | 42 (91.3) | 85 (95.5) | 1 |
| No | 4 (8.7) | 4 (4.5) | 2.41 (0.41,14.02) |
| Good knowledge (non-probed) about treatment of malaria | | | |
| Yes | 60 (77.9) | 138 (85.2) | 1 |
| No | 17 (22.1) | 24 (14.8) | **3.25 (1.01, 10.47)** |
| Rolling out of bed | | | |
| Yes | 17 (37.0) | 20 (22.0) | **2.95 (1.09, 8.02)** |
| No | 29 (63.0) | 71 (78.0) | 1 |
| Number of rooms per house | 82 (100) | 164 (100) | **1.47 (1.09, 1.97)** |
| Cooking inside the house | | | |
| Yes | 46 (56.8) | 68 (41.5) | 1 |
| No | 35 (43.2) | 96 (58.5) | **0.46 (0.25, 0.86)** |
| Roof of the house | | | |
| Thatched | 34 (41.5) | 89 (54.3) | **0.43 (0.21, 0.87)** |
| Corrugated iron sheet | 48 (58.5) | 75 (45.7) | 1 |
| Presence of radio | | | |
| Yes | 19 (23.2) | 58 (35.4) | **0.29 (0.13, 0.68)** |
| No | 63 (76.8) | 106 (64.6) | 1 |
| Good knowledge (non-probed) about mode of transmission of malaria | | | |
| No | 53 (85.5) | 88 (70.4) | 1 |
| Yes | 9 (14.5) | 37 (29.6) | **0.26 (0.08, 0.79)** |
| Good knowledge (probed) about mode of transmission of malaria | | | |
| No | 54 (87.1) | 88 (70.4) | 1 |
| Yes | 8 (12.9) | 37 (29.6) | **0.19 (0.05, 0.65)** |

* Bolds are significant associations, # COR: Crude Odds Ratio

**Table 3** Factors associated independently with clinical malaria in children aged 5–59 months, Omo Nada Woreda Jimma Zone, Oromiya Region, South West Ethiopia Feb 2007*

| Variables | Cases | Health center controls | | | Cases | Community controls | | |
|---|---|---|---|---|---|---|---|---|
| | No. (%) | No. (%) | #COR (95% CI) | AOR (95% CI) | No. (%) | No. (%) | #COR (95%CI) | **AOR (95% CI) |
| Poor knowledge (spontaneous) about sign or symptoms of malaria | | | | | | | | |
| Yes | 38 (51.4) | 25 (32.9) | **6.50 (1.47, 28.79)** | **2.72 (1.23, 6.00)**[a] | 38 (51.4) | 36 (52.9) | **1.25 (0.34, 4.66)** | |
| No | 36 (48.6) | 51 (67.1) | 1 | 1 | 36 (48.6) | 32 (47.1) | 1 | |
| Good knowledge (probed) about mode of transmission of malaria | | | | | | | | |
| No | 54 (87.1) | 53 (77.9) | 1 | | 54 (87.1) | 35 (61.4) | 1 | 1 |
| Yes | 8 (12.9) | 15 (22.1) | 0.38 (0.10, 1.41) | | 8 (12.9) | 22 (38.6) | **0.07 (0.01, 0.54)** | **0.18 (0.06, 0.50)**[b] |

| Variables | Cases | All controls | | |
|---|---|---|---|---|
| | No. (%) | No. (%) | #COR (95% CI) | **AOR (95% CI) |
| Rolling out of bed | | | | |
| Yes | 17 (37.0) | 20 (22.0) | 2.95 (1.09, 8.02) | 4.33 (1.59, 11.80)[c] |
| No | 29 (63.0) | 71 (78.0) | 1 | 1 |
| Roof of the house | | | | |
| Thatched | 34 (41.5) | 89 (54.3) | **0.43 (0.21, 0.87)** | **0.34 (0.13, 0.88)**[d] |
| Corrugated iron sheet | 48 (58.5) | 75 (45.7) | 1 | 1 |

* Bolds are significant associations, [a] $P = 0.023$, [b] $P = 0.003$, [c] $P = 0.004$, [d] $P = 0.026$, # COR: Crude Odds Ratio, ** AOR: Adjusted Odds Ratio

CI: 0.47, 2.59) nor was the status of the mosquito net, (OR = 0.70 95% CI: 0.35, 1.39). The major exposure variable, appropriate mosquito net utilization was not significantly associated with the occurrence of clinical malaria (OR = 0.96 95% CI: 0.84, 1.10) (Table 4). In other matched bi-variate analyses comparing cases and health center controls poor knowledge (without probing) of mothers about the signs or symptoms of malaria and use of protected well/spring by the family as a main source of drinking water were found to be associated with higher risk of clinical malaria in the children. Risk of malaria in children decreases with suggested high price for mosquito net by mothers/care-givers. After controlling the effect of other confounding variables, only children of mothers with poor knowledge (spontaneous) about the signs or symptoms of malaria had a 2.7 times more risk of getting malaria (OR = 2.72 95% CI: 1.23, 6.00) as compared to those whose mother/care-giver had good knowledge (spontaneous) about the sign or symptoms of malaria (Table 3).

When cases were compared with community controls, children who did not sleep under the mosquito net the night before the survey date were 4 times at risk of clinical malaria as compared to those who slept under the mosquito net (OR = 4.00 95% CI: 0.45, 35.79) and children who slept under the mosquito net the week previous to the survey date were two times likely to acquire clinical malaria as compared with those who did sleep under it (OR = 2.00 95% CI: 0.18, 22.06). But these associations were not statistically significant. Neither presence of mosquito net (OR = 0.73, 95% CI: 0.34, 1.60) nor status of the mosquito net, was significantly associated with the occurrence of clinical malaria (OR = 0.67, 95% CI: 0.32, 1.38). The major exposure variable, appropriate mosquito net utilization was not significantly associated with the occurrence of clinical malaria (OR = 1.03 95% CI: 0.90, 1.18) (Table 3). As with the other matched bi-variate analysis higher socioeconomic status and quintile of families, higher educational of fathers, living far from health institutions, poor knowledge (probed) of mothers about the benefit of mosquito nets, larger number of rooms per house were associated with higher risk of malaria in children. Conversely, possession of functioning radio in the house, good knowledge (non-probed) of mother/care-giver on mode of transmission & sign or symptoms of sever malaria, good perception (non-probed) of mothers/care-givers about who is vulnerable to malaria & to death due to malaria, cooking outside the living room and living in houses with thatched roof were protective of clinical malaria in under 5 years old children. After controlling the effect of other confounding variables, only children whose mothers/care-givers had good knowledge (probed) of modes of transmission of malaria are at 18% more risk of getting clinical malaria (OR = 0.18, 95% CI: 0.06, 0.50) compared to those whose mothers/care-givers with poor knowledge (probed) of modes of transmission of malaria (Table 3).

**Table 4** Factors associated with clinical malaria in children aged 5–59 months (case versus each controls), Omo Nada Woreda Jimma Zone, Oromiya Region, South West Ethiopia Feb 2007*

| Variables | Cases | Health center controls | | Cases | Community controls | |
|---|---|---|---|---|---|---|
| | No. (%) | No. (%) | #COR (95% CI) | No. (%) | No. (%) | #COR (95% CI) |
| Child Slept under the mosquito net the previous night | | | | | | |
| Yes | 40 (87.0) | 46 (97.9) | 1 | 40 (87.0) | 40 (95.2) | 1 |
| No | 6 (13.0) | 1 (2.1) | 6.00 (0.72,49.82) | 6 (13.0) | 2 (4.8) | 4.00 (0.45, 35.79) |
| Child Slept under the mosquito net the previous week | | | | | | |
| Yes | 42 (91.3) | 45 (95.7) | 1 | 42 (91.3) | 40 (95.2) | 1 |
| No | 4 (8.7) | 2 (4.3) | 2.00 (0.37, 10.92) | 4 (8.7) | 2 (4.8) | 2.00 (0.18, 22.06) |
| Poor knowledge (spontaneous) about sign or symptoms of malaria | | | | | | |
| Yes | 38 (51.4) | 25 (32.9) | **6.50 (1.47, 28.79)** | 38 (51.4) | 36 (52.9) | **1.25 (0.34, 4.66)** |
| No | 36 (48.6) | 51 (67.1) | 1 | 36 (48.6) | 32 (47.1) | 1 |
| High price of mosquito net suggested | 82 (100) | 82 (100) | **0.95 (0.90, 0.99)** | 82 (100) | 82 (100) | 1.00 (0.94, 1.05) |
| Walking distance from the nearby health institution | | | | | | |
| Less than 30 min | 28 (34.1) | 32 (39.0) | 1 | 28 (34.1) | 36 (43.9) | 1 |
| 30 min–1hrs | 21 (25.6) | 16 (19.5) | 1.85 (0.63, 5.49) | 21 (25.6) | 15 (18.3) | **4.79 (1.03, 22.37)** |
| 1–2 h | 27 (32.9) | 26 (31.7) | 1.23 (0.28, 5.38) | 27 (32.9) | 26 (31.7) | 6.31 (0.72, 55.12) |
| Good knowledge (probed) about the benefit of ITN | | | | | | |
| Yes | 19 (28.4) | 25 (33.3) | 1.2 (0.52, 2.78) | 19 (28.4) | 33 (50.8) | 1 |
| No | 48 (71.6) | 50 (66.7) | 1 | 48 (71.6) | 31 (49.2) | **2.33 (1.07, 5.09)** |
| Large Number of rooms per house | 82 (100) | 82 (100) | 1.16 (0.83, 1.63) | 82 (100) | 82 (100) | **1.97 (1.29, 3.01)** |
| Presence of radio | | | | | | |
| Yes | 19 (23.2) | 22 (26.8) | 0.84 (0.43, 1.64) | 19 (23.2) | 36 (43.9) | **0.29 (0.13, 0.68)** |
| No | 63 (76.8) | 60 (73.2) | 1 | 63 (76.8) | 46 (56.1) | 1 |
| Good knowledge (non-probed) about sign or symptoms of sever malaria | | | | | | |
| No | 40 (50.6) | 41 (50.0) | 1 | 40 (50.6) | 29 (36.7) | 1 |
| Yes | 39 (49.4) | 41 (50.0) | 1.09 (0.48, 2.47) | 39 (49.4) | 50 (63.3) | **0.27 (0.09, 0.80)** |
| Correct perception (non-probed) about vulnerability for death due to malaria | | | | | | |
| No | 36 (43.9) | 38 (46.3) | 1 | 36 (43.9) | 25 (30.9) | 1 |
| Yes | 46 (56.1) | 44 (53.7) | 1.17 (0.54, 2.52) | 46 (56.1) | 56 (69.1) | **0.27 (0.09, 0.80)** |
| Roof of the house | | | | | | |
| Thatched | 34 (41.5) | 40 (48.8) | 0.60 (0.26, 1.37) | 34 (41.5) | 49 (59.8) | **0.21 (0.07, 0.62)** |
| Corrugated iron sheet | 48 (58.5) | 42 (51.2) | 1 | 48 (58.5) | 33 (40.2) | 1 |
| Cooking inside the house | | | | | | |
| Yes | 46 (56.8) | 41 (50.0) | 1 | 46 (56.8) | 27 (32.9) | 1 |
| No | 35 (43.2) | 41 (50.0) | 0.72 (0.35, 1.47) | 35 (43.2) | 55 (67.1) | **0.21 (0.08, 0.55)** |
| Good knowledge (probed) about mode of transmission of malaria | | | | | | |
| No | 54 (87.1) | 53 (77.9) | 1 | 54 (87.1) | 35 (61.4) | 1 |
| Yes | 8 (12.9) | 15 (22.1) | 0.3 (0.10, 1.41) | 8 (12.9) | 22 (38.6) | **0.07 (0.01, 0.54)** |
| Good knowledge (non-probed) about mode of transmission of malaria | | | | | | |
| No | 53 (85.5) | 53 (77.9) | 1 | 53 (85.5) | 35 (61.4) | 1 |
| Yes | 9 (14.5) | 15 (22.1) | 0.57 (0.17, 1.95) | 9 (14.5) | 22 (38.6) | **0.13 (0.03, 0.58)** |

* Bolds are significant associations, # COR: Crude Odds Ratio

## Discussion

This health center based, case-control study represents one of the first evaluations of the effectiveness of ITNs in preventing malaria in Ethiopia, and is one of very few impact reports of an ongoing program. The study used sound study design and used a control to case ratio of 2:1 with health center and community controls. Case-control studies have been proposed as the most convenient and appropriate tools in the evaluation of ITN programs [32].

This was further advocated after the first ITN program evaluation in the Gambia [41]. Case-control studies are attractive because they can be performed relatively cheaply and quickly after the initiation of the intervention [42]. Despite these strengths this study had limitations such as recall bias from the cases about the use of mosquito nets and related issues more than the controls as they might relate it to the occurrence of their child's disease; interviewer bias could occur while collecting data by overstressing the sign and symptoms of malaria in cases, while underestimating these in controls. Misclassification bias was a threat for this study because the reported regular users might be irregular users. For these limitations extensive training and supervision of data collectors was carried out. The other limitations could be very short duration of study period which was a low-transmission period that might have undermined the effect of ITNs. Attendance bias was not addressed and it might have an undermining effect on the effectiveness of ITN. The data collection took more than 2 months and due to the budget constraint it was decided to stop the data collection when 90% of the planned study subjects have been included in the study.

In this study clinical malaria and sleeping under the mosquito net the previous night and week were seen to have big measures of association. However, the presence of ITN, status of the ITN, and history of sleeping under the ITN the night or week previous to the survey as well as the appropriate use of ITN were not significantly associated with clinical malaria. This is contrary to the studies done in Ethiopia [36, 43], in Africa as well as in other parts of the world [40, 42, 44–47]. These discrepancies could be due to difference in definition of appropriate mosquito net use. In our study we have used strict definition for appropriate use of mosquito net which might be different from other studies. The small sample size in our study might not also detect the difference. And it is known that presence of mosquito net does not guarantee appropriate utilization and hence effective protection from malaria. It is clear that some of the exposure attributes like sleeping under the mosquito nets the previous night and week had a large odds ratio and has a large 95% CI indicating smaller sample size. The other issues that should be noted are many ITN trials achieved their impact with close to 100% of households possessing nets and 50–75% of under-5 years old sleeping under them, a level of use similar to the Abuja target of 60% [24, 25] and extensive public education were given on continuous bases. Theses issues were not fulfilled in our study area where ITN coverage was not more than 50% by 2007 and no re-treatment service [36] was being given since 2 years. Additionally the study was done during a low-transmission season (December to February). There has been a study in South American study which involved four countries, where the protective efficacy of ITNs varied between 0% and 70% when looking only at the post intervention differences between intervention and control groups. In this Latin American study the average protection was 40.8% when considering a 4-month incidence of clinical malaria attacks and 28.3% when considering a 2-week malaria incidence. Important factors for the success of the mosquito net program seen in this South American study were insect susceptibility to pyrethroids, high coverage with impregnated mosquito nets, high malaria incidence, good community participation, high mosquito densities when people go to mosquito, and a high proportion of Plasmodium falciparum [48]. Despite the strength of the study low coverage of ITN and low-transmission season of our study might have undermined the effectiveness of ITN in preventing clinical malaria.

In this study, poor knowledge (without probing) of mothers of children on signs or symptoms of malaria was found to be statistically associated with more risk of getting clinical malaria even after controlling for other factors, which is similar to other study in Malawi [49]. Although more than 75% of the caregivers responded that they believed malaria to be transmitted by mosquito bites, more than half of the cases' parents or caregivers did not know one or more signs or symptoms of sever malaria, compared with approximately one-third of clinic control parents or caregivers. This finding could have important policy implications for ITN programs. Other studies had shown that effective malaria prevention and use of clinical services depends on people's ability to recognize the nature and severity of malaria illness [50, 51]. Given the low ITN coverage throughout much of sub-Saharan Africa [52], extensive health education programs on signs or symptoms of malaria and of the benefits of ITN use could lead to increased acceptance and use of these prevention methods.

In the comparison of cases with health center control, suggestion of high price for Mosquito net by the mothers/care-givers of children was found to be significantly associated with lower risk of clinical malaria. This is obviously an implication of the relationship between affordability of mosquito nets and less risk of clinical malaria as the ones who can afford can protect their child from mosquito bite. In line with this it was also found that cost was the major factor for not owning ITNs in the study area similar to findings from other studies in Ethiopia [43] and across Africa [30, 38]. In countries like Tanzania, social marketing programs of ITNs were sustainable [53, 54]. In agreement with this, in Kilifi, Kenya, when charge was introduced following end of project of randomized trial, the use of ITNs and the retreatment rates were found to reduce abruptly [55].

In the comparison of cases with community controls, children who were living a walking distance of between 30

and 60 min to the nearby health institution were five times at risk of getting clinical malaria compared to those living a walking distance of less than half an hour. This could be due to better access to health institutions in terms of distance as it means better access to health education and good preventive practice. The access to health care has been shown to affect risk of malaria in a Tanzanian study [56]. Children of mothers with poor knowledge (probing) about the benefit of mosquito nets had a higher risk of getting malaria which is clearly an indication for a better education of mothers on the benefit of mosquito net which will help salvage more children from getting malaria. It has been clearly demonstrated in a study in Mali that the appropriate use of mosquito nets is dependant on educational programs that can increase the attitude of the mothers on its benefit [57].

Children whose family posses functioning radio in the house have less risk of getting clinical malaria compared to those whose family do not have functioning radio. This was seen in both comparisons of the cases with community controls as well as the collective controls. Owning radio will help mothers/caretakers to be informed about malaria and proper use of ITNs and hence their children would be well protected from malaria agreeing with a Zimbwabian study [58]. This association was not seen in other Ethiopian studies in Tigray and South Nations and Nationalities Peoples' Region (SNNPR) [43, 59].

Risk of malaria in children whose family had a house of thatched roof was low compared to corrugated iron sheet, in the comparison of cases with community controls and the collective controls. This was seen to be independent of other factors for the comparison between cases and collective controls. This might be explained by the absence of properly polished ceilings and presence of wooden structures, which could give a good resting plat form for the mosquitoes in the houses with corrugated iron sheet that could be found in the rural areas whereas the thatched roofs usually might have a good polished internal surface that might not give the former advantage for the mosquitoes. In a Burkina Faso study the risk of malaria was greater in houses with mud roof compared to those with iron sheet and thatched roof but no association was found between risk of malaria and houses with thatched roof [60].

Lower risk of getting clinical malaria was found in children whose family was not cooking in the living room and the influence of absence of kitchen and cooking inside living rooms were not statistically significant in the other study in SNNPR [43]. Cooking inside home in most rural and semi-urban areas of Ethiopia is common and this will lead to emission of smoke. It is not known whether this smoke could affect the efficacy of the insecticide and reduce the half-life of the ITN. But, from a study in northern Ethiopia, absence of separate kitchen was found to significantly increase the incidence of malaria [59]. The study also showed less risk of malaria in children of mothers/care-givers who have good knowledge of modes of transmission of malaria, in the comparison of cases with community controls (in which case it's independent of other factors) and all the controls. This knowledge about the mode of transmission might have helped them in taking measures to prevent transmission of malaria to their children. Taking mosquito control measures was related to knowledge of malaria transmission in a study in Zimbabwe [61].

In the comparison of case with all the controls, children whose mothers had poor knowledge (spontaneous) about the treatment of malaria were at a higher risk of getting clinical malaria. As the knowledge about treatment of malaria goes with other related knowledge about malaria, it might have helped them take measures to prevent malaria from getting their children. This relation has not been specifically reported in other studies. Children who roll out of mosquito during sleep were found to have a higher risk of getting clinical malaria than who don't, even after controlling for other factors when we compared cases with all controls. This may be due to increased exposure of the children for mosquito bite as they make their body out of the protection of the mosquito nets. This finding is in line with reports from other studies [43, 62, 63].

In this study ITNs were not found to significantly protect under-five children from malaria when used during low-transmission period. Knowledge on signs or symptoms and modes of transmission of malaria, rolling out of the ITN during night time and roof of the house were independent predictors of malaria. With these findings, the following recommendations are forwarded: The distributions of ITNs should be preceded by intensive health education on clear benefits of ITNs and issues related to its proper use. The community should be involved from the inception, planning and implementation of proper health education and it should include issues related to the preventive practices against malaria, causes of malaria, treatment and sign and symptoms of malaria. Further research assessing whether ITNs are effective for malaria prevention during high transmission period using a large sample size is required.

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