



Impact of Population Services International (PSI) Insecticide-treated Net (ITNs) Distribution on Malaria Prevalence in Pregnancy: A Case of Kimilili-Bungoma Sub-County, Kenya

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Insecticide-treated net (ITN) use is one of the most promising tools which have been shown to reduce the number of mosquito bites. Pregnant women and children less than five years have been specifically designated as high-risk groups, therefore need to be protected by effective personal protection. An intensive effort by Population Services International (PSI) to prevent malaria among vulnerable groups in Kenya by creating a mosquito 'net culture' was launched in 2002 sells highly subsidized nets. During the second half of the project (2004-2007) Population service international (PSI) increased its focus on the rural population. Despite these efforts, there is inadequate knowledge about the efficacy of net use in controlling malaria in the high-risk groups in the study area. This research determined the effects of PSI efforts in rural areas by assessing malaria prevalence among the pregnant women attending antenatal clinics at Kimilili Sub-county (Bungoma County, Kenya) Hospital. The study used cross-sectional descriptive survey design. It was conducted between April to October 2017 and November 2017 to March 2018 which correspond to during rainy season and dry seasons respectively. The study recruited a total of 320 pregnant women were involved in the study. This was done before the rolling out of the whole family net coverage in twenty-three endemic counties. The information obtained should act as baseline data in

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the study area for future assessment of the impact of nationwide mass net distribution by the ministry of public health and sanitation. A structured questionnaire was administered to determine net use and a sample of blood was taken by finger prick method to determine the peripheral malaria parasitemia. Some fewer net users were malaria positive as compared to non-users suggesting that net uses were more protected. The course of malaria infection was noted depend on age and parity. This study demonstrates that net use reduce malaria and it's associated anaemia in pregnancy. Also, dry seasons should not be perceived as low transmission periods because the results revealed that there was still a very significant transmission. It was also concluded that the multigravidae had developed more immunity as compared to the primi- and secundigravidae. It was recommended that the focus for educational programs should shift from net re-treatment to augmenting adherence. Coverage of entire populations will be required to accomplish large reductions of malaria in endemic areas.

Keywords: Insecticide-treated net; malaria-endemic region; malaria prevalence; pregnancy; Bungoma Kenya.

1. INTRODUCTION

Malaria cases and deaths occur in higher numbers in Sub Saharan Africa [1]. Mostly, pregnant women and children less than five years have been specifically designated as a high-risk group [2,3]. Therefore there is an urgent need to explore malaria prevention and control strategy in the region. Subsequently, there have been resurgent efforts in Africa towards malaria control interventions such as insecticide-treated nets (ITNs) [4-8]. An intensive effort by Population Services International (PSI) to prevent malaria among vulnerable groups led to the creation of a mosquito 'net culture' in 2002, which led to the distribution of highly subsidized nets. During the second half of the project (2004-2007) PSI increased its focus on the rural population. The use of ITN is the most promising tools which have been shown to reduce the number of mosquito bites in a variety of ecological settings thus reducing mortality of children aged five years or less [9]. In areas of active use, there are reported of significantly reduced malaria parasitemia, maternal anaemia and increase birth weight [10]. There is, however, little research and documentation on the effectiveness of PSI led ITN 'net culture' mass adoption of ITN in areas of Africa especially in low endemic transmission regions.

Population Services Kenya through the Health Communication and Marketing program (HCM), supported by the United States Agency for International Development/President's Malaria Initiative (USAID/PMI), have assisted the Government of Kenya, through the National Malaria Control Program (NMCP), to implement the objectives of the Kenya Malaria Strategy 2009-2018. One of the key strategies is to

achieve universal coverage of long-lasting insecticidal nets in twenty-three endemic counties in Kenya [11]. The two-year campaign kicked off in March 2017. However, despite these efforts, there is inadequate knowledge about the efficacy of net use in controlling malaria in the high-risk groups in many areas including the study area. This research sought to find out if PSI and PMI efforts are bearing fruits in rural areas by assessing malaria prevalence among pregnant women in Kimilili-Bungoma Sub-County.

Therefore the objective of this study was to evaluate the insecticide-treated nets ownership in pregnant women in Kimilili -Bungoma Sub-County; determine malaria prevalence between net users and non-users among pregnant women in Kimilili -Bungoma Sub-County, and evaluate factors that hinder access to and use of ITNs among pregnant women in Kimilili -Bungoma Sub-County.

2. MATERIALS AND METHODS

2.1 Study Area and Study Sites

The study was carried out at Kimilili Sub County in Bungoma County between April 2017 and March 2018. The Sub-county covers about 133.6 km² with an estimated population of 132,822 [12]. Annual mean temperature range: 18°C to 21°C. Annual average rainfall: 1300 mm to 1800 mm, altitude range: 1500 m to 2000 m above sea level. The study sites were selected because they lie above 1500 m, an altitude defined as characterizing a highland area. They are also at risk of malaria [13] outbreaks although none has been reported therefore there was the need for malaria epidemic preparedness. The topography

of the study sites comprises of hills, valleys and plateaus. The residents of the region are mainly civil servants and business people. Malaria is endemic in the region with two intense transmission periods during the rainy seasons, April-August and October-November [14]. Data from the local health services indicate malaria as the principal cause of morbidity and mortality, accounting for 70% of hospital visits. Ministry of Health in conjunction with PSI, African Medical and Research Foundation (AMREF) and other non-governmental organizations have been distributing bed nets in the district, targeting pregnant women and children less than five years of age since 2002.

2.2 Sample Size Estimation

Participant recruited were pregnant women presenting at the health centre. Participant sampling from the study population was obtained by sampling a consecutive series of participants attending the clinic. Eligibility was open to consenting pregnant women who attended the antenatal clinic and lived in the study sites for more than 6 months of the year or if they were new to the area, who planned to live in the area for more than 6 to 12 months of the year. Signed informed consent for blood testing was sought from each pregnant woman. A malaria case was defined as an individual from the study sites who presented to the health centre with symptoms of malaria (fever, chills, severe malaise and headache, vomiting for children) and presence of *Plasmodium* parasites on microscopy testing of his/her blood smear.

During the study period, a total of 320 pregnant women attending the antenatal clinic, were recruited into the study (based on a statistically determined sample size of 384), using the sloven's formula: [15]

$$n = \frac{Z^2 pq}{d^2}$$

The sample sizes, for each target group, with a 95% confidence interval and precision level of 5% were arrived at using the formula: In this equation, n is the sample size, z is the critical value of the standard normal distribution at the 5% level (1.96), p is the malaria prevalence estimate since the prevalence of malaria in pregnancy in the area is not well known, a 50% estimate of individuals attending ANC at the district hospital was used, $q = 1 - p$ and d is the precision level at 0.05. This translated into a

sample size of 384 individuals. The response rate achieved (320/384) 83% and the non-response rate was (64/364) 17% of the subjects. A structured questionnaire was administered to those recruited to determine ITNs ownership and use. A sample of blood was taken by finger prick method to determine the peripheral malaria parasitemia.

2.3 Blood Collection and Processing for Malaria Parasitemia

Written informed consent for study participation was obtained from all consenting 1091 pregnant women. They voluntarily signed a consent form after being given an appropriate explanation of the purpose and nature of the study. For those under 18 years of age, consent was sought from parents or guardians accompanying them. A sample of blood was 0.5 to 1.0 ml taken by finger prick method (by a lab technologist working at the specimen collection bench) from each patient to determine the peripheral malaria parasitemia after preparation of site (finger) with alcohol, pricking of the fingertip with a lancet and obtaining the blood sample on a clean 25 × 75 mm slide in a 10 to 30 s period. The blood was spread out to make thick/thin films/smears, dried fixed in methanol and stained in 4% Giemsa for 30 minutes. All stained blood films were examined microscopically at 1000× objective under oil immersion to identify the malaria parasite species. Microscopic examination was done and the presence of malaria parasite species in sexual or asexual stages was considered a positive diagnosis. A second blood examination was done for quality assurance. The whole slide was carefully scanned before being declared negative. Slides were reported negative for parasites only after examining at least 50 fields.

2.4 Qualitative Data Collection

A structured questionnaire was administered to those recruited to determine those with ITNs and those without. Besides the routine information about patients, the questionnaire also sought information on; prior use of any antimalarial drugs, type of net owned, sources of nets, frequency of net usage, problems encountered when using nets and if they thought the nets were protecting them from malaria. For those without nets, the questionnaire sought to know if they felt they needed a net or not, the main constraints preventing them from acquiring nets and the possible assistance they would need to acquire.

2.5 Data Management and Statistical Analyses

The laboratory and field raw data were coded sorted and summarized using descriptive statistics. Data entry and presentation in the form of tables, graphs and other pictorial presentations was done using MS Excel software. Statistical operations were carried out using International Business Machines Statistical Package for Social Science Version 23.

3. RESULTS

3.1 Demographic and Socioeconomic Characteristics of Pregnant Women

A total of 320 pregnant women consented to fill the questionnaire and their responses were analyzed (Table 1). In terms of age, it was found out that 184 (57.5%) were aged between 15 to 30 years while 136 (42.5%) were between 31 to 45 years.

Table 1. Demographic and socio-economic characteristics of the study population

Characteristic	N	Percentage
Age(Years)		
15-30	184	57.5
31-45	136	42.5
Parity		
Primigravidae	103	32.3
Secundigravidae	80	25.1
Multigravidae	137	42.6
Marital status		
Married	297	93.0
Single	21	6.7
Widowed	2	0.3
Education level		
Primary or less	181	55.2
Secondary	116	36.2
Tertiary	27	8.6
Occupation		
Salaried or self-employed	929	30.9
Casual or unemployed	221	69.1
Total	320	100

3.2 Demographic Factors and Net Use in Pregnant Women

Out of the 320 pregnant women recruited in the study, 157 (49%) owned nets and admitted to using them, while 163 (51%) did not have nets. The overall prevalence of malaria was 23.75%

(76/320). Of the 76 malaria positive women, 31.6% (24/76) were net users, while 68.4% (52/76) were non-net users.

3.3 Relationship between Malaria Prevalence in Pregnancy and Net Use

Malaria was high in non-net users than in net users (Table 2). However, there was no statistically significant difference (Mann Whitney test, $p=0.871$) in terms of parasite positivity between net users and non-users. It should be noted that fewer net users (35% 21/60) had malaria as compared to non-net users (65%) 39 out of a total of 60 patients who had malaria.

Based on Table 2, the net use has no significant effect on malaria progression (Two-tailed Fisher's exact test, $p=0.355$)

3.4 Effectiveness of Long-lasting Nets Compared to Conventional Nets in Reducing Malaria Transmission

Table 3 shows malaria distribution about net type. A total of 39/157 (25%) net users were malaria positive, of which 10/157 (6.4%) were using long-lasting nets and 29/157 (18.6%) were using conventional nets. There was no significant difference in malaria positivity between those using long-lasting nets and those using conventional nets ($p = 0.177$).

Table 4 shows the effect of parity on malaria parasitemia levels. It should be noted that malaria parasitemia is higher in primigravidae and secundigravidae than in multigravidae.

3.5 Factors That Hinder Access to and Use of ITNs

The majority of those who had no nets expressed the wish to own one. However, when asked about the constraints preventing them from owning nets, most gave reasons, that at most were frivolous. Quite a number indicated that there was no reason for them not owning a net. The various responses given are summarized in Table 5. Although the majority mentioned the lack of money as the main constraint, they still agreed that the subsidized price of Kshs.50 (for pregnant women attending ANC and children under five) was affordable. Although nets have been substantially subsidized (about Kshs.50 for ANC attending women) majority still complained that money was a problem.

Table 2. Distribution of confirmed malaria between net users and non- net users

Characteristic	Malaria status			
	Symptomatic		Asymptomatic	
	N	Per cent (%)	N	%
Net users	15	33	3	18.8
Non-users	31	67	13	81.2
Totals	46	100	16	100

Table 3. Malaria distribution concerning the net type

Characteristic	Malarial status (%)			
	Malaria negative		Malaria positive	
	N	%	N	%
Long-lasting net	44	37.3	10	25.6
Conventional net	74	62.7	29	74.4
Totals	118	100	39	100

Table 4. Gravidity distribution of malaria parasitemia levels

Variables	Mild (N %)	Moderate (N %)	Severe (N %)
Primigravidae (188)	21.5	16.6	7.4
Secundigravidae (102)	12.3	14.7	4.9
MultigravidaeGravidae (30)	8.0	2.5	1.8
Total	47.2	37.4	15.3

Table 5. Factors that hinder access to and use of ITNs

Problem	N	Per cent
Lack of money	6	3.6%
Gave to children	16	9.8%
Discomfort (heat and breathing difficulty)	118	72.5%
The only net used by the husband	17	10.4%
perceived low mosquito density	4	2.5%
Other priorities	2	1.2%
Total	163	100%

Determine malaria prevalence between net users and non-users among pregnant women in Kimilili -Bungoma Sub-County, and evaluate factors that hinder access to and use of ITNs among pregnant women in Kimilili -Bungoma Sub-County.

4. DISCUSSION

This study was evaluated the insecticide-treated nets ownership among pregnant women in Kimilili Bungoma Sub-County. The results show that out of the total 320 pregnant women recruited into the study, 49% had nets, either long-lasting or conventional ones. This is an indication that a fairly large number of women are aware of the importance of ITNs and are using it in preventing malaria. Insecticide-treated bed nets are issued free by the Ministry Health and at a subsidized price by NGOs such as PSI

to expectant mothers in malarious areas, who are also strongly advised to sleep under the nets and extend the same to their new-born. The result is an indicator that the PSI programme is yielding fruits. Rolling out of malaria control and prevention programmes where nets are distributed has resulted in a large number of net ownership in may countries of the Sub Saharan Africa including Kenya [16]. This could also be an indicator that effective barriers to net ownership including cost implication have been substantially minimized.

Concerning the malaria prevalence between net users and non-users among pregnant women, the study established that fewer net users who were malaria positive as compared to non-users. Results indicate that the transmission was low in net users than non-net users where 31.6% of malaria positive pregnant women were net users,

while 68.4% were non-net users. This implied that ITNs provided appreciable protection against malaria infection. Because of differences in malaria prevalence among net users and non-users, it can be suggested that net users were more protected. These results are consistent with results obtained under controlled trials in the Gambia [17], Tanzania [18] and other parts of Western Kenya [19]. For ITNs to work optimally, three outcomes must be maximized in the scale-up from efficacy to effectiveness: Adherence, insecticide treatment/re-treatment and coverage [20]. Maximization of adherence should involve the daily task of ITN storage at dawn and re-hanging at dusk. Coverage should ensure more vulnerable groups access the nets. To this end, the GOK along with NGOs like PSI have greatly assisted by providing subsidized nets in antenatal clinics. To augment this coverage, the government should not confine nets to ANC clinics. Instead, it should couple them with other programs such as the Expanded Program on Immunization (EPI). This integration could rapidly achieve household coverage approaching or exceeding the 60% target coverage suggested in Abuja Roll Back Malaria summit [12].

The fact that there was no significance between net use and malaria progression, underlines the importance of preventing malaria in pregnancy. This is regardless of whether one is using a net or not. As such, an integrated approach, involving other methods of malaria control, such as vector control and intermittent preventive treatment, should be implemented alongside net use. Emphasis should be put on preventive measures rather than curative measures, because, the findings suggest that, malaria infections, especially in multigravidae may be asymptomatic, but may still result in harmful effects such as anaemia and low birth weight of the newborns.

The final objective of this study was to determine the factors that hinder access to and use of ITNs. The main reasons for not using a mosquito net varied among pregnant women in the study area. Nevertheless, discomfort (primarily heat and difficulty in breathing) was the predominant reason for non-use in 72.5% of pregnant women. Such reasons are significant especially in very hot and humid tropical areas as reported in Kisumu County in the same region with the study area [21]. The perceived low mosquito density, especially during the dry season, was cited as a reason for non-use (although not necessarily the predominant reason) in 2.5% of the cases

studied. This confirms perceived mosquito density and heat as the reasons why 80% of 875 respondents did not use mosquito nets during the dry season (as compared to 0.3% during the rainy season) [22]. It has also been reported that one-third of the surveyed respondents (female household heads) from mosquito net owning homes (73% of 260) "indicated that they did not use them regularly because of the heat" [23]. Lack of money was reported as a reason for not owning and using mosquito nets in 3.6% of the cases. In 9.8% of the households in which a net was owned, but not used, it was given to the children by the mother. Indeed, social marketing campaigns have even promoted ITNs as a means to minimize sleep disturbance [16]. However, if this discrepancy results in seasonal or irregular use (as the evidence presented in this study indicates) then the benefit of mosquito net utilization may not be fully realized. If a primary motivation to use a mosquito net is perceived mosquito density, then it also stands to reason that in areas where mosquito density falls as a result of increased ITN coverage the continued motivation to use an ITN may decrease. In other words, the very effectiveness of the ITN may render further ITN use undesirable. If such a scenario were to eventuate, then any programmatic gains in terms of reduced malaria-related morbidity and mortality, as well as the possibility of future malaria elimination, could be potentially threatened. The relationship between mosquito net use and mosquito density may, therefore, warrant careful and ongoing investigation in areas experiencing an increase in ITN coverage.

5. CONCLUSION

Based on study findings, it was concluded that the use of insecticide-treated nets was high among pregnant mothers and that this resulted in a reduced prevalence of malaria. Net use may reduce transmission of malaria infections in pregnant women. Moreover, conventional nets, once treated properly are as effective as the long-lasting nets, which do not require treatment during their life span of 3 years. Also, dry seasons should not be perceived as low transmission periods because the results revealed that there was still a very significant transmission. This was as a result of people not using nets because of warm weather and perceived absence of mosquitoes.

Although ITNs have a remarkable impact on malaria transmission in endemic areas, such as

the study area, they can not constitute a single/final solution to the problem of malaria in Kimilili-Bungoma Sub-county and, indeed, Kenya as a whole. Therefore, malaria control and prevention in the highlands of Kenya requires an appropriate selection of control strategy based on the local circumstances and the capability of the intervention to reduce malaria risk in the wider community. Also, it is important to continue to collect data on the effectiveness of these individual and/or combined interventions and its annual impact on endemic and epidemic malaria.

6. RECOMMENDATIONS

The following recommendations are made concerning the results obtained in this study:

1. Coverage of entire populations will be required to accomplish large reductions of the malaria burden in endemic areas. While coverage of vulnerable groups should still be prioritized, the equitable and communal benefits of wide-scale ITN use by children above 5 years and adults should be explicitly promoted and evaluated by national malaria control programmes.
2. To augment the ITN coverage, the government should not confine nets to ANC clinics. Instead, it should couple them with other programs such as the Expanded Program on Immunization (EPI). This integration could rapidly achieve household coverage approaching or exceeding the 60% target coverage suggested in Abuja Roll Back Malaria summit.
3. A related behavioural message that ITN users should re-treat their nets with appropriate insecticide should continue to be the focus of educational efforts in the context where users have conventional nets. Where long-lasting nets are being used, they have obviated the need for treatment. Here the focus for educational programs should shift from net re-treatment to augmenting adherence.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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