The Effectiveness of Malaria Prevention Methods for Migrant Population: A Systematic Review of Published Results

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Received 9 April 2007; accepted 27 December 2007

Abstract

Malaria remains a major public health problem in the world especially in the developing countries. Migrant populations are an especially vulnerable group for the malaria prevention. This systematic review has been performed to estimate the effectiveness of malaria prevention methods. Five past field trials comparing various prevention methods to placebo or untreated controls for migrant populations were included to assess the effectiveness of each method. The calculated pooled relative risk for those field trials using the insecticide-treated bed net prevention method was 0.34 (95% confidence interval (CI) between 0.29 and 0.41). The calculated pooled relative risk for studies using insecticide-treated cloths, bed-sheets, or top-sheets was 0.62 (95% CI 0.52 to 0.74). Taken together for all field trials, the pooled relative risk was 0.38 (95% CI 0.34 to 0.42). Thus, result suggests that the aforementioned malaria prevention methods decreased the risk of contracting malaria by approximately 62%.

Keywords: Malaria prevention; Migrant; Systematic review; Relative risk

Introduction

Malaria remains a major public health problem in certain areas of the world. The World Health Organization (WHO) estimates that people living in 107 countries are at risk of malaria transmission. Approximately 350 to 500 million clinical cases occur each year (WHO, 2005). Within a country, the transmission of malaria varies considerably between regions. Factors that affect these differences amongst the regions include: the type of malaria parasites, ecological conditions, and socioeconomic factors such as poverty and inaccessibility to effective health care and preventive services (Krissanakriangkrai & Hengboriboonpong, 2007).

The migration of infected people from areas where malaria is an endemic to areas where the disease had been eradicated can lead to a resurgence of the disease (Martens & Hall, 2000). The migration of malaria carriers was a key factor in drug resistance dynamics (Wernsdorfer, 1994). Southeast Asia has the highest rate of malaria drug resistance in the world, and the multidrug-resistance has contributed to a re-emergence of malaria in many areas, especially along international borders (WHO, 2005). Migratory laborers who work in forested areas are especially at high risk (Chaveepojnkamjorn & Pichainarong, 2004). In Thailand, malaria cases are found the highest in the border areas, particularly along the Thai-Myanmar border (Ministry of Public Health, 2004).

Numerous methods for malaria prevention are used by migrants such as bed net, mosquito repellent, clothes, etc. A number of field trial studies have evaluated those prevention strategies; however, there is no systemic review for those prevention strategies in the migrant population. This systemic review consolidates available data and compares the effectiveness of the prevention strategies from previous field trials. The results of this systemic review will help national and international decision makers to determine which malaria prevention methods will most effectively curtail the spread of malaria in the migrant population, finally resulting in reduction of malaria reservoirs, especially

in the moving population.

Materials and Methods

Literature search

A systematic review was conducted to determine the effectiveness of prevention strategies for migrants. A search of the malaria literature (written in English) published between 1992 and 2006 was performed using the following online database: PubMed, Cochrane Infectious Disease Group and Joannabrigg Institution. In addition, a search was performed on the research databases at the following universities and organizations: Naresuan University, Mahidol University, Chulalongkorn University, Chiangmai University, and WHO. The titles of abstracts were searched in the databases using one of the three phrases: *malaria prevention and migrants, malaria interventions, and refugees*. We also hand-searched some of the tropical medicine journals such as *The Southeast Asian Journal of Tropical Medicine & Public Health, The American Journal of Tropical Medicine & Public Health, Bulletin of the World Health Organization (BLT)*, and the *Malaria Journal* for the period between 1992 and 2006. Many researchers known to be actively involved in the field of malaria preventive interventions of migrants were contacted and inquired for any unpublished works. Reference lists of all trials identified by the above methods were also investigated. Articles were examined in detail by both authors. Any disagreement was resolved by consensus with a third party.

Selection of studies

Studies were selected for further analysis according to the following inclusion criteria: (1) the field trials used malaria prevention strategies for the migrant population; (2) the studies had concurrent control groups to be compared with the experimental groups; (3) the studies had to quantify new incidences of malaria which were verified based on both the malaria symptomatic records obtained by a physician and the parasitemia results (positive diagnosis of malaria through the use of blood smears).

Statistical method for systematic review

The outcome of interest in each study was the relative risk of malaria episodes between the experimental group and the control group with 95% confidence interval (CI). The prevented fraction among the exposed (PFe) was also calculated. The Mantel-Haenszel risk ratio (RR_{MH}) (Rothman & Greenland, 1998) was used to calculate the pooled measures of effect with 95% CI. Two subset analyses were performed: the first analysis by pooling studies that used insecticide-treated bed nets, and the second analysis by pooling studies that used insecticide-treated cloth, bed-sheet, and top-sheet.

Results

Description of studies

A total of 63 field trials were identified by the literature search. Fifty-eight field trials were excluded because the target population did not pertain to migrants. Therefore, five studies were included for the systematic review (Table 1).

Table 1. Characteristics of studies included for analysis

First author and study location	Study design	Study duration	Frequency of intervention	Intervention group (n)	Control group (n)	Relative risk (95% CI)	PFe (%)	Crude rate	
								Ex [a]	Control [b]
Kamolratanakul (1992), Thailand	R	35 wks	1	Permethrin (0.5 g/m^2)-impregnated bed nets (n = 126)	Untreated bed nets (n = 135)	0.58 (0.39 – 0.86)	42%	0.22	0.38
Rowland (1999), Pakistan	R	32 wks	4	Permethrin (1 g/m^2)-impregnated chaddars and top-sheets(n = 438)	Placebo EC formulation (n = 387)	0.64 (0.52 – 0.79)	36%	0.25	0.38
Kamolratanakul (2001), Thailand	Q	44 wks	1	Lambdacylothrin (20 mg/m^2) - impregnated bed nets (n = 1,034)	Malaria surveillance (n = 757)	0.31 (0.25 – 0.38)	69%	0.11	0.36
Macintyre (2003), Kenya	Q	32 wks	2	Permethrin- impregnated bed-sheets (n = 234)	Untreated bed-sheets (n = 238)	0.47 (0.18 – 1.21)	53%	0.03	0.06
Kimani (2006), Kenya	Q	24 wks	8	Permethrin (15 ml/4000 ml)-impregnated cloth & sheets (n = 90)	Plain water-impregnated cloth & sheets (n = 91)	0.57 (0.41 – 0.77)	43%	0.38	0.66
Kamolratanakul (2001), Thailand	Q	44 wks	1	DDT (2 g a.i./m^2) spraying (n = 1,423)	Malaria surveillance (n = 757)	0.26 (0.22 – 0.31)	74%	0.10	0.36

[a] malaria episodes in experimental group

[b] malaria episodes in control group

Abbreviations: a.i. = active ingredient; EC formulation = Emulsifiable concentrate formulation -impregnated chaddars and top-sheets; PFe = Prevented fraction among the exposed; Q =quasi- experimental study; R = randomized control trial; wks = weeks

The level of evidence was assessed using the criteria developed by the National Health Service (NHS) Centre for Reviews and Dissemination, University of York (Centre for Reviews and Dissemination, 2001). Two of the five studies were in level 1 (randomized control trial) and the other three studies were in level 2 (quasi-experimental trials).

The first randomized control trial (RCT) compared the effectiveness between the permethrin (0.5 g/m^2)-impregnated bed nets and the untreated bed nets (Kamolratanakul & Prasittisuk, 1992). It was a randomized, double-blind, field trial conducted on workers who had migrated in the Bothong District, Chonburi Province, Thailand. A thick blood smear was obtained for diagnosis of all subjects. Twenty-eight cases were diagnosed in the treatment group, and 51 cases were diagnosed in the control group. The second RCT studied the effectiveness of permethrin (1 g/m^2)-impregnated chaddars and top-sheets for protection against malaria in an Afghan refugee camp in north-western Pakistan. The chaddars and the top-sheets used by the control group were treated with a placebo emulsifiable concentrate (EC) formulation. This study confirmed malaria cases using both malaria symptomatic records obtained by a physician and parasitemia (Rowland et al., 1999). In this study, 108 malaria cases were confirmed in the treatment group, whereas 148 cases were confirmed in the control group.

The three quasi-experimental research included in this study can be summarized as follows. The first quasi-experimental study was used to compare the difference in effectiveness of insecticide-impregnated bed nets or insecticide spraying to the control group with only malaria surveillance method amongst migrants and Karen hill tribes in six villages in the Mae-Ramard District, Tak Province, Thailand (Kamolratanakul et al., 2001). Thick blood smears were obtained from all subjects and were tested for malaria. This study used two malaria prevention methods: 1) lambdacyhalothrin (20 mg active ingredient (a.i)/m^2)-treated mosquito nets (115 cases reported in the treatment group and 275 cases were reported in the control group) and 2) DDT (2 g a.i./m^2) spraying (136 cases reported in the treatment group and 275 cases were reported in the control group).

The second quasi-experiment compared the effectiveness of permethrin-impregnated bed-sheets to the control group with the untreated bed-sheets (Macintyre et al., 2003). This study was conducted in the nomadic pastoralists who migrated to the village of Ngilai located in Samburu District, northern Kenya. The malaria diagnosis was confirmed by parasitemia, 6 and 13 cases reported in the experimental and control groups, respectively.

The last quasi-experimental compared the effectiveness of permethrin (15 ml/4,000 ml of water)-treated clothes (experimental group) to plain water-impregnated cloth and bed-sheets (control group) (Kimani et al., 2006). This trial was done in Dadaab refugee camps, north-eastern province, Kenya. This study used malaria parasite smear to identify for malaria infections, 34 and 60 cases identified in the experimental and control groups, respectively.

Summary measures of quantitative review

Table 1 illustrates the comparison of the relative risk for each malaria prevention method. The reduction in risk per malaria episode due to permethrin-treated nets was 0.16. This calculation is based on malaria episodes in the group with untreated nets (51 of 135 [0.38]) deducted with malaria infections in the group with treated nets (28 of 126 [0.22]). When compared with untreated nets, the relative risk was 0.58 (95% CI, 0.39 to 0.86). This vector control method is appropriate in terms of acceptability and affordability

in eastern Thailand because the average cost of a bed net is only US$ 3.50 and the average cost of impregnation is only 0.83 US$ per net (Kamolratanakul & Prasittisuk, 1992).

To more effectively prevent the spread of malaria in the poorer populations, cheaper malaria prevention methods in lieu of insecticide-treated nets need to be developed. Chaddars are used by all refugees and serve a variety of functions during the day and night. Permethrin-treated chaddars gave 64% protection against falciparum malaria and 38% protection against vivax malaria among refugees younger than 20 years old (Rowland et al., 1999). The malaria incidence risk in the group with permethrin-treated chaddars compared to the placebo group was 0.64 (95% CI, 0.52 to 0.79) (Rowland et al., 1999).

The comparison of lambdacyhalothrin-treated mosquito nets and DDT spraying to the malaria surveillance group showed that the relative risk of lambdacyhalothrin-treated mosquito nets was 0.31 (95% CI, 0.25 to 0.38) and the relative risk of DDT spraying was 0.26 (95% CI, 0.22 to 0.31) (Kamolratanakul et al., 2001).

A shuka is a 6-foot by 4-foot sheet made of varying material, used on smaller children, doubling as a wrap during the day and as a bed sheet at night. The relative risk of the permethrin-treated bed-sheets for small children (shuka) to the control group was 0.47 (95% CI, 0.18 to 1.21) (Macintyre et al., 2003). In this study, it was found that the impregnated bed-sheets were effective against the spread of malaria in older children and adults but not as effective in younger children and infants. The use of insecticide-treated clothes for protection against malaria infection showed that the proportion of those who got infected with malaria after intervention in the comparison group was 66% while those who got infected in the treatment group was 38%. The relative risk was 0.57 (95% CI, 0.41 to 0.77) (Kimani et al., 2006).

As shown in Figure 1, the pooled relative risk of those studies was calculated using Mantel-Haenszel risk ratio (RR_{MH}). The pooled relative risk for those studies using insecticide-treated bed nets (Kamolratanakul et al., 2001; Kamolratanakul & Prasittisuk, 1992) was 0.34 (95% CI, 0.29 to 0.41). The pooled relative risk for those studies using insecticide-treated clothing, bed-sheets or top-sheets (Kimani et al., 2006; Macintyre et al., 2003; Rowland et al, 1999) was 0.62 (95% CI, 0.52 to 0.74). The pooled relative risk for all of field trials in this study including those studies using insecticide-treated bed nets, insecticide-treated clothing, bed-sheets or top-sheets, and insecticide spraying was 0.38 (95% CI, 0.34 to 0.42).

Discussion

Malaria places an enormous economic burden on affected countries and has a highly detrimental effect on economic and social development. One of the factors contributing to the reemergence of malaria is human migration (Martens & Hall, 2000). The situation is particularly critical among the high-risk groups of migrants along international borders. This can result in multidrug-resistant *Plasmodium falciparum*, and an eventual spread through most parts of the country (Kamolratanakul et al., 2001).

The synthesis of research findings from various studies has traditionally been accomplished with a thorough review of the research articles. A systematic review study provides another mechanism for synthesis that may reduce bias and allow quantitative estimation of the efficiency of the malaria prevention methods. In our study, the pooled relative risk for field trials using malaria interventions such as insecticide-impregnated bed nets, insecticide spraying, insecticide-impregnated bed-sheets and cloth is more effective than the relative risk that would be determined

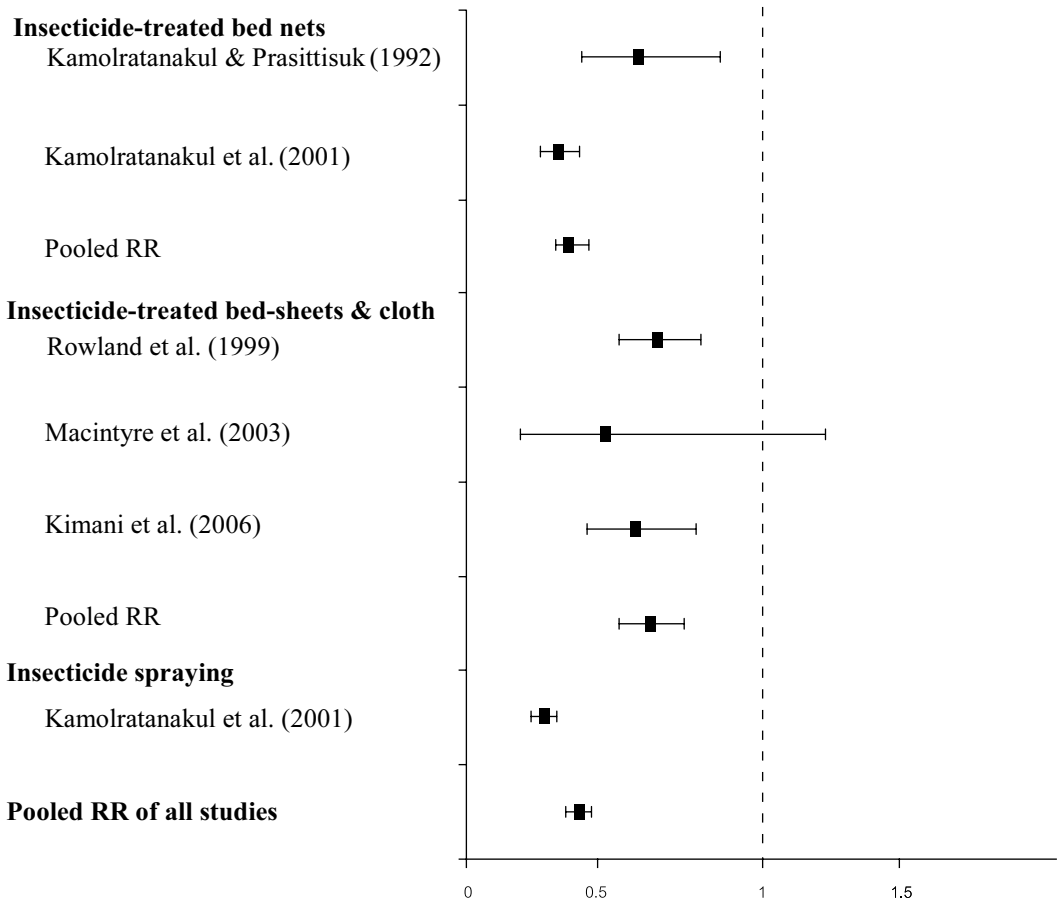

Figure 1. The relative risk and 95% confidence intervals of all studies.

in a single study since a systematic review of published data can often reduce the bias because of a large pooled sample size.

However, limitations can result from the pooled outcomes of several studies since the data collection methods used by each study can vary significantly. While mortality and severe illness would have been the most useful outcomes to evaluate the success of the various malaria prevention strategies, none of the studies have reported on either of these two metrics. Since only some of the studies used in our pooled evaluation of malaria prevention methods collected the mosquito density (Kimani et al., 2006), we were unable to calculate the effectiveness of insecticide-impregnated bed nets, chemical spraying, and insecticide-treated bed-sheets in terms of the reduction in mosquito density.

Previous systematic review studies have placed an emphasis on the effectiveness of insecticide-impregnated bed nets used in the rural population (Choi et al., 1995; Lengeler, 2004). When Choi and his coworkers (1995) reviewed 10 field trials and calculated the pooled relative risk for all insecticide-treated bed nets versus untreated bed nets, they found the relative risk to be 0.80 (95% CI, 0.69 to 0.93). This ratio suggests that insecticide-impregnated bed nets can decrease the risk by approximately 20% in the general population.

Another systematic review of insecticide-treated bed nets and curtains for preventing malaria (Lengeler, 2004) showed that insecticide-impregnated bed nets provided a 23% increase in protective efficiency for people living in rural

and urban malaria endemic areas compared to those using untreated nets (relative risk 0.77 and 95% CI, 0.63 to 0.95).

A large number of malaria prevention methods have been used all over the world. We identified 63 trials investigating the effectiveness of malaria prevention methods. A total of five trials spanning three different countries met the inclusion criteria. Two of the trials measured malaria incidence, and they showed that the use of insecticide-impregnated bed nets reduced malaria episodes in migrants by approximately 66%. The relative risk was found to be 0.34 with a 95% CI between 0.29 and 0.41. This systematic review also demonstrates that the insecticide-impregnated bed-sheets and clothing were more effective than untreated bed-sheets and clothing. The prevalence of malaria in the insecticide group was considerably lower than in the placebo group by 38%. The relative risk was found to be 0.62 with a 95% CI between 0.52 and 0.74.

In term of reducing malaria episodes in migrants, insecticide spraying is the most effective amongst all prevention methods. The use of insecticide spraying can reduce the malaria morbidity by 74% (Kamolratanakul et al., 2001). The study explained the reduction in malaria episodes due to DDT spraying when compared with only surveillance (Kamolratanakul et al., 2001). Kamolratanakul (2001) reported that the impregnated bed nets program was more cost-effective than DDT spraying in mitigating the spread of malaria. The cost per year of DDT spraying was US$ 1,199.18 while the cost per year of insecticide-impregnated bed nets was US$ 492.71 Insecticide impregnated bed nets also work well in protecting moving populations such as soldiers against vector-borne diseases (Curtis, 1991). The cost-effectiveness of impregnated bed nets has also been demonstrated (Goodman, 1999; Hanson et al., 2003).

Migrants often do their work in 3D characteristics (Difficulties, Dirty and Distance), making malaria prevention difficult (Bloland & Williams, 2003). In addition, many of the refugees have no source of income and rely almost completely on assistance from government support agencies working in the area (Kimani et al., 2006). Therefore, the malaria prevention methods used must be appropriate for a migrants' life style (economics, organization, and cultural manners). We recommend to the public health policy makers that the appropriate malaria prevention method to be used for the migrant population is insecticide-impregnated bed nets. This prevention method takes into account the effectiveness in reducing malaria episodes, the cost-effectiveness of insecticide-impregnated bed nets, and the appropriateness to the migrants' life style. In the endemic areas, wide-scale provision of insecticide-treated bed nets should not be considered as the sole element in malaria control, since migrants may spend time outside of their homes during the time that *Anopheles* mosquitoes bite. Therefore, insecticide spraying should be done in addition to insecticide-treated bed nets to effectively reduce the *Anopheles* mosquitoes. In addition, insecticide-treated clothing, bed sheets, top-sheets as well as personal protection should be provided when possible. Educational programs to promote personal protective behaviors should be conducted for the migrant population in order to control malaria for the long term.

Conclusions

This study synthesizes the available data from previous field trials and quantifies the overall effectiveness of the appropriate prevention methods in preventing malaria infection among migrant populations. The relative risks calculated in this study

suggest that a significant number of malaria cases could be prevented by the use of insecticide-treated bed nets, insecticide spraying, as well as insecticide-treated clothing, bed-sheets, and top-sheets. The pooled relative risk for all of field trials in this study was 0.38 (95% CI, 0.34 to 0.42) and the calculated pooled relative risk for studies using insecticide-treated bed net and insecticide-treated clothing, bed-sheets and top-sheets was found to be 0.34 (95% CI, 0.29 to 0.41) and 0.62 (95% CI, 0.52 to 0.74), respectively. The most cost-effective, feasible, and acceptable means for preventing malaria in the migrant population is insecticide-impregnated bed nets since bed nets are already available, affordable, and appropriate to the migrants' life style. However, insecticide spraying, insecticide-treated clothing, bed-sheets, top-sheets as well as personal protection should also be provided to help reduce malaria episodes.

Acknowledgements

We acknowledge Professor Dr.Supasit Pannarunothai, the Dean of Faculty of Medicine, and Assistant Professor Dr.Nathorn Chaiyakunapruk, Faculty of Pharmaceutical Sciences, Naresuan University, Phitsanulok, Thailand for the helpful suggestions during the process of the systematic review. We would also thank to the librarian of Naresuan University for the relevant documents. Our appreciation also goes out to Dr.Krongthong Thimasarn of RBM/Mekong for her constant help in providing technical resources. We acknowledge the expertise of our fellow researchers for their continuing research in the field of malaria.

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