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Research Articles

Barriers in access to insecticide-treated bednets for malaria prevention: An analysis of Cambodian DHS data

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ABSTRACT

Background & objectives: The distribution of insecticide-treated bednets (ITNs), as an alternative to untreated bednets or no bednet at all, not only directly prevents the mosquito from biting an individual, but kills the mosquito as well. This reduces the mosquito infestation at the household and community levels. However, barriers may exist limiting the effectiveness of malaria prevention by these tactics. Objectives of the study were to assess current disparities in access to ITNs, what factors may be associated with disparities in access and the progress of antimalaria interventions.

Methods: This study examined disparities in access to intervention resources between rural and urban locations by assessing the percentage of households in each area that has at least one ITN. Demographic Health Survey (DHS) 2005 data from 16,823 survey respondents from Cambodia were explored, examining the ratio of households with at least one ITN according to various socioeconomic determinants. Statistical analysis was done using Chi-square and logistic regression with SPSS.

Results: Problematic distance from ITN distributors, rural location, and poverty were all associated with greater unlikelihood of possession of least one household ITN.

Conclusion: In order to effectively combat high malaria prevalence, interventions need to be refocused on increasing accessibility to ITNs. The limitations of this study require further investigation into alternative socioeconomic determinants.

Key words Cambodia; community effect; insecticide-treated bednets; malaria

INTRODUCTION

Malaria is one of the deadliest preventable diseases, and a major public health concern in developing countries. Inadequate access to information, healthcare and antimalarial resources results in the inability to properly implement malaria interventions, and disparities in access exist between rural and urban locations. Improperly treated malaria causes widespread morbidity and mortality in tropical and subtropical parts of the world, occurring mostly in Asia, central America, South America and sub-Saharan Africa. According to the World Health Organization (WHO), malaria is responsible for almost one million deaths with an estimated 247 million cases annually[1].

The disease causing agent of malaria is the eukaryotic parasite from the *Plasmodium* genus, the parasite is primarily *Plasmodium falciparum* (86% of malaria cases in Cambodia), which is more virulent than *P. vivax* (12% of malaria cases)[2].

The vector of malaria is the mosquito; and the transmission to a human occurs with anterior station transfer when a mosquito with malaria sporozoites (the infectious stage of the parasite) in its salivary glands bites a human. Sporozoites are then transferred into the human blood stream, migrate to the liver and become malaria merozoites, which enter red blood cells and circulate through the body; as the merozoites replicate in the red blood cell and cell lysis occurs, the red blood cells burst, allowing the newly free parasites to enter nearby uninfected cells. While the parasite resides in the liver, it is not exposed to the body's immune system. This allows for multiple relapses over the time span of 6 months to 3 yr making diagnoses complicated[3].

Upon the first signs of malaria infection, alternating stages of fever and coldness occur, as well as joint pain, vomiting, anemia, convulsions, and intracranial pressure, eventually leading to coma, neurological damage and death. Children and pregnant women are particularly susceptible to severe cases of malaria. Children <5 yr of age do not have effective resistance against the disease and infants do not have fully developed immune systems. Infections during pregnancy are more likely to result in stillbirth,

low birth weight or prematurity; this has devastating health consequences for both maternal and infant health[4].

In 2006, the malaria mortality rate in Cambodia was approximately 400 deaths per 100,000 individuals[5]. This accounts for a massive economic and social burden due to the disease being prevalent in many countries that are already economically disadvantaged. In Cambodia, 30.1% of the population is below the poverty line, 34.5% being in rural areas and only 11.8% in urban areas. With 79% of the population living in rural areas, a significant portion of the rural population is impoverished and has only limited or no access to healthcare facilities, insecticide-treated bednets, and antimalarial medication due to transportation and/or cost issues. The issue is not only bottom-up, but top-down as well: with only US $30 per capita for total public and private health expenditures in 2007[6], the Ministry of Health has limited capabilities to implement sustainable malaria interventions.

Improper dosage and inadequate usage of antimalarial medications have resulted in Cambodia hosting the most drug resistant strain of malaria in the world. Cambodia experiences monsoon seasonality and due to the majority of the population living in moist, dense forests, the mosquito niche overlaps with human settlement. The mosquito thrives in Cambodia due to the moist climate which allows for maximum breeding. The temperatures are prime for an expedited larval stage and lengthy adult phase, and with the mosquito biting approximately once every 48 h, humans have increased exposure to the parasite without proper prevention[7].

Current interventions in Cambodia include stocking facilities with rapid diagnostic tests (RDTs) to diagnose malaria in rural locations, as well as providing timely and proper care with mixed medications that limit resistance. Opening communication channels to disseminate malaria prevention and treatment information is extremely important as well[8]. This study primarily looks at the use of insecticide-treated bednets as a community-level intervention. The distribution of insecticide-treated bednets, as an alternative to untreated bednets or no bednet at all, not only directly prevents the mosquito from biting an individual, but kills the mosquito as well. This reduces the mosquito infestation at the household and community levels. Pertaining to use of bednets, more protection is gained from one or more insecticide-treated bednets in each household[9]. Untreated bednets do not kill the mosquito; and bites are possible through the net or mosquitoes can enter through rips in the netting.

Interventions by community workers include distribution of at least one insecticide treated bednet to every household in a village; the corresponding decrease in malaria cases by eliminating mosquitoes from the village is described as the 'community effect'[9]. Coupled with intermittent preventative treatment (IPT) and indoor residual spraying (IRS), malaria has been successfully eradicated from entire areas with a simple, cost-effective and sustainable method. IPT is short-term community wide drug therapy for children and pregnant women to cure and prevent malaria; IRS is household spraying of insecticide that kills mosquitoes up to 6 months. The community effect has even been shown to decrease the caseload in neighbouring villages that have not had insecticide-treated bednets distributed to every household[9].

The phenomenon of the community effect is a valuable asset in reducing malaria prevalence in a cost-efficient and minimally intrusive manner. The cohort study "Evidence for a mass community effect of insecticide-treated bednets on the incidence of malaria on the Kenyan coast" by Howard *et al*[9] examined the far reaching benefits of the mass community effect in another malaria endemic country. It was found that the community-wide utilization of insecticide-treated bednets results in increased protection for community members not sleeping under any bednet at all. Also, the surrounding areas were found to have decreasing malaria prevalences. This effect was found to be significant up to 1.5 km from the proximity of the community using insecticide-treated bednets; malaria prevalence increased as distance from the community increased and coverage areas overlapped less.

Problem statement

This study examined disparities in access to intervention resources between rural and urban locations by assessing the percentage of households in each area that has at least one insecticide-treated bednet. Demographic Health Survey (DHS) data from Cambodia in 2005 were explored, examining the percentage of households with at least one insecticide-treated bednet in urban areas and in rural areas. With a significantly less percentage of rural households with at least one insecticide-treated bednet than in urban areas, access to interventions may be less in rural areas. Health facilities are less frequent in rural areas than in urban areas, and since ITNs are distributed from them, rural locations may be disadvantaged with less access to malaria interventions[10].

Access may be affected by many different factors, including whether or not distance to clinics where from insecticide-treated bednets distributed is problematic. Because the focal point of intervention strategies is generally at health facilities, distribution of insecticide-treated bednets will be more difficult as distance from the facility to the household becomes greater. Previous studies show

that up to two-third of the disease burden is lifted with adequate access to primary care facilities[11].

Objectives of the study

The objective of the study was to assess the social, economic and demographic determinants of household possession of at least one insecticide-treated bednet in Cambodia. Also, the study examined the underlying causes of barriers in access to malaria interventions. This information can provide relevant organizations and institutions, such as the Cambodian Ministry of Health, Roll Back Malaria, World Health Organization, USAID, and other operating organizations about: (i) progress of antimalaria interventions; (ii) current disparities in access to intervention; and (iii) what factors may be associated with disparities in access?

The utilization of the results from this study may allow stakeholders to better understand the complicated algorithms in successfully implementing an antimalarial intervention; thus, increasing efficiency and efficacy of such interventions. This is in pursuit of the Millennium Development Goal 6c, which is to halt and begin to reverse the incidence of malaria and other major diseases[12]. Ultimately, effective interventions will contribute to bolstering child and maternal health, which are Millennium Development Goals 4 and 5 as well.

METHODS

Ethical considerations

Ethical approval for access of Cambodia Demographic Health Survey (CDHS) 2005 data used in the study due to human subject protection issues in accordance with federal regulations was provided by the Institutional Review Board at Tufts Medical Center/Tufts University Health Sciences Campus. Subjects participating in CDHS 2005 were eligible to receive HIV testing, and certain participants were eligible for anemia testing and nutritional status determination by taking height and weight measurements. Certain participants were also eligible for the woman's status or domestic violence module.

DHS data and sample characteristics

Data were taken from the 2005 Cambodia Demographic and Health Survey[13]; which is a database of information taken from surveys of the sample, representing the national population. The survey consisted of an interview using questionnaires with men and women in the age group of 14–59 yr after providing consent. Data were extracted from the samples of the respondents education, age, distance to health facility, wealth, location and bednet usage[13].

In order to provide an accurate portrayal for all the 24 provinces in the country, samples from ten provinces were combined into five groups, and 14 provinces were looked at individually. For the 14 individual provinces and 5 groups, the domains of the data from each household provide accurate estimates of the indicators, while separating for urban and rural residences. The 19 reconstructed domains were designated into 38 stratifications that were either rural or urban depending on their designation in the 1998 Cambodia General Population Census[13].

The survey was taken using three questionnaires. The household questionnaire was used to collect information pertaining to each respondent listed on the questionnaire and mosquito net usage, the household wealth index, highest year of educational achievement, and a module about utilization of health services which included difficulty of access to healthcare facility due to distance[13].

Setting

This study setting was the Kingdom of Cambodia, a developing country in south-east Asia with a population of 14,783,000 in 2011. The population is primarily rural with 11,500,000 rural inhabitants and 3,283,000 urban inhabitants[6]. Data were collected from February to April in 2005[13]. Malaria is present in urban and rural areas throughout the entire country except Angkor Wat, Phnom Penh and Lake Tonle Sap[14]. Insecticide-treated bednets are generally distributed at health facilities which tend to be at central locations for easiest access by the surrounding inhabitants[10].

The total sample size was 16,823 respondents in 557 villages. The sample size used from the survey was controlled to ensure reliable indicator estimates; an accurate portrayal of results required weighing the total sample in regards to the number of rural and urban households. This was done by increased sample size for rural areas and weighing the smaller urban sample. In each enumerated area (which was one of the 557 villages, though larger villages were broken into smaller components), 24 households were surveyed in urban areas and 28 households were surveyed in rural areas[6].

Variable identification

Household possession of at least one insecticide-treated bednet was the dependent variable in this study. The variable was recoded. No household possession of at least one insecticide-treated bednet includes untreated bednets and no household possession of any bednet; this dichotomous variable was assigned a value of 0. Possession of at least one household insecticide-treated bednet included treated bednets and household possession of both treated and un-

treated bednets; this dichotomous variable was assigned a value of 1. Wealthindex was recoded into 3 categories: poor, which consisted of the bottom and second to last quintiles, middle (consisting of the middle quintile), and rich, which included the wealthiest and second wealthiest quintiles. Distance to health facility was recoded. Respondents who answered 'some problems' and 'big problems' were combined into the problematic category. 'No problem' remained the non-problematic category. Type of location of residence (rural or urban), was important in assessing whether malaria interventions were widespread and reach more distant locations. Age and educational attainments of the responder were important characteristics used to assess potential barriers in access to attaining insecticide-treated bednets.

Independent variables (covariates)

- Wealthindex: Wealth category (1 = Poor, 2 = Middle, 3 = Rich)
- Location: Location of residence (1 = Urban, 2 = Rural)
- Education: Years of educational attainment (continuous)
- Age: Age of respondent (continuous)
- Distance to health facility: Ease of access (1 = Problematic, 2 = Non-problematic) Dependent variable
- ITN use: Household possession of at least one insecticide-treated bednet (0 = No, 1 = Yes)

Statistical analysis

Quantifiable data were entered into SPSS statistical analysis software to test the hypothesis. A bivariate analysis was conducted and multivariate models for logistic regression were utilized. A chi-square test was utilized to test the dependent variable against several of the categorical independent variables for associations. To test predictor variables against the dependent variable, the logistical regression model was used to understand net effects. The following regression model was used:

ITN use = ß0+ß1+Wealth index ß2+ Location ß3+ Education ß4 +Age ß5 +Distance to health facility ß6+ u.

RESULTS

Social and demographic characteristics

Of the 16,823 respondents included in the survey, years of educational attainment ranged from no education to 12 yr. The average educational attainment was 3.27 yr with a standard deviation of 1.664 yr. The current age range of respondents was from 15 to 49 yr old. The average age was 29.67 yr with a standard deviation of 10.289 yr. The majority of the respondents (59.3%) were not located in a problematic distance from a health facility, though 6842 out of 16,823 respondents were located a problematic distance. Of the respondents, there is a small middle class (19.4% of respondents). The largest percentage of respondents pertains to the rich category (41.5%) and 39.1% of respondents pertains to the poor category. The vast majority of respondents (75.3%) live in rural areas of Cambodia. The majority of households (62.6%) do possess at least one insecticide-treated bednet (Table 1).

Table 1. Variables associated with ITN possession

Variable	Range	Mean	Std. Dev.
Highest year of education	0–12	3.27	1.664
Current age of respondent (yr)	15–49	29.67	10.289
Variable	**Frequency**		**Percent**
Distance to health facility			
Problematic	6842		40.7
Non-problematic	9977		59.3
Wealth index			
Poor	6584		39.1
Middle	3262		19.4
Rich	6977		41.5
Type of place of residence			
Urban	4152		24.7
Rural	12671		75.3
Household possession of ITN			
No	6293		37.4
Yes	10530		62.6

Differentials of possession of at least one ITN

The results of a chi-square test showed that more urban respondents are in possession of at least one household insecticide-treated bednet (78.1%) than rural respondents (61.2%). Also, it was found that fewer respondents who had problematic distance from a health facility were in possession of at least one household insecticide-treated bednet (56%) than respondents who were not at a problematic distance from a health facility (64.5%). Poor wealth category respondents were least likely to be in possession of at least one household insecticide-treated bednet (54.3%), followed by middle wealth category respondents (63.3%) and rich wealth category respondents (70.1%) (Table 2). The relationships between type of place of residence and household possession of at least one insecticide-treated bednet, as well as distance to health facility and household possession of at least one insecticide-treated bednet, were both found to be statistically significant.

Table 2. Chi-square test: variables associated with ITN possession

Characteristics	Possession of at least one ITN (%)	
	No	Yes
*Type of place of residence**		
Urban	21.9	78.1
Rural	38.8	61.2
*Distance to health facility**		
Problematic	44	56
Non-problematic	35.3	64.5
*Wealth category**		
Poor	45.7	54.3
Middle	36.7	63.3
Rich	29.9	70.1

Statistically significant at $p < 0.001$; $^{*}p < 0.001$.

Wealth category was also found to be statistically significant ($p < 0.001$).

Determinants of possession of at least one ITN

Social, economic and demographic information pertaining to the household possession of at least one insecticide-treated bednet is assessed using a multivariate analysis. Using this information, management tactics to distribute insecticide-treated bednets can be administered more effectively. This study is important because it assesses important variables alongside ITN possession, portraying disparities in access which ultimately inhibits the community effect, thus, mitigating the effectiveness of malaria prevention strategies.

When testing the logistic regression model with each variable individually, the respondents' highest year of educational attainment, current age, the distance to the health facility, the respondents' wealth category and the type of place of residence were all found to be significant predictors of household possession of at least one insecticide-treated bednet (Table 3). As education increased, likelihood of household possession of at least one insecticide-treated bednet increased as well (OR=1.037, 95%; CI=1.015, 1.060). As age increased, likelihood of possession of at least one household insecticide-treated bednet slightly decreased (OR=0.984, 95%; CI=0.981, 0.987). Living in an urban area resulted in the respondent to be 1.276 (95%; CI 1.185–1.375) times more likely to have at least one household insecticide-treated bednet and with the health facility located at a problematic distance, the respondent is 1.248 (95%; CI 1.171, 1.329) times as likely to have at least one household insecticide-treated bednet. In these cases, it is important to emphasize that in the crude model, each individual variable was examined for its effect on the outcome measure and other covariates were ignored.

Table 3. Determinants of possession of at least one ITN

Variables	Adjusted OR	Crude OR
Highest year of education	0.993	1.037*
Current age of respondent	0.975**	0.984**
Distance to health facility		
Problematic	1.040	1.248**
Non-problematic (ref)		
Wealth index		
Poor	0.554**	0.508**
Middle	0.774**	0.736**
Rich (ref)		
Type of place of residence		
Urban	1.050	1.276**
Rural (ref)		

$^{*}p < 0.05$; $^{**}p < 0.001$.

The logistic regression model portrayed two variables as significant predictors of household possession of at least one insecticide-treated bednet when covariates are considered: current age of the respondent and the wealth category of the respondent (Table 3). Distance to a health facility, highest year of educational attainment and type of place of residence do not have any statistically significant effect on household possession of at least one insecticide-treated bednet.

As current age increases by one year, the respondent is slightly less likely to have at least one household insecticide-treated bednet (OR=0.975, 95%; CI=0.972, 0.979). A poor wealth category respondent is less likely to have at least one household insecticide-treated bednet compared to a rich respondent (OR=0.554, 95%; CI=0.506, 0.605) and a middle wealth category respondent is also less likely to have atleast one household insecticide-treated bednet (OR=0.774, 95%; CI=0.699, 0.858) than a rich respondent, though more likely to have one than a poor wealth category respondent. The model accurately predicted 64.4% of the output.

DISCUSSION

The results of this study support the hypothesis that in the crude model, rural areas may have less access health facilities for important malaria prevention tools, primarily insecticide-treated bednets. Since urban areas have a greater density of health facilities for resource distribution, this may be a reason as to why rural areas tend to have less households possessing at least one insecticide-treated bednet.

The findings of this study are consistent with other

studies that address similar issues. For example, it was found that the poorest populations are least likely to seek prompt and effective treatment of malaria in a study entitled ,"Barriers to prompt and effective malaria treatment among the poorest population in Kenya"[15]. Rural areas were found to have less access to malaria control interventions in a study entitled, "Do malaria control interventions reach the poor? A view through the equity lens"[16], as well as in a study entitled, "Geographical disparities in core population coverage indicators for malaria in Malawi"[17]. More research is required in the realm of current age of the respondent and household possession of at least one insecticide-treated bednet.

Limitations of this study are that not all socioeconomic determinants of possession of at least one ITN can be investigated, based on the available data. This requires further investigation into alternative determinants by expanding the data collection methods in future DHS studies. In addition, this study is a cross-sectional study, and inherently there are limitations. Though the sample size is large, Cambodia is a populous country and there is a definite possibility of sampling error. There are also possibilities of non-sampling errors depending on the interviewer, the questions and the respondents. Distance to health facility was an objective variable; more accurate results would be achieved if the distance is described by mileage, instead of whether or not it was problematic. Perceptions of risk and actual malaria prevalence vary geographically and seasonally, which will have an impact on whether or not a household is in possession of at least one insecticide-treated bednet. Also, the study uses insecticide-treated bednets as the sole indicator of access to control measures, though IPT and IRS are also very effective and the usage of these tactics was not assessed.

The results of this study can provide valuable information to the organizations and agencies managing the logistical aspects of malaria interventions to ensure significant portions of the population are not excluded due to being in rural areas. This also provides insight into the feasibility of healthcare access to the rural population of Cambodia, which should be taken into account by the Cambodian Ministry of Health. There may be more negative consequences on health of rural populations beyond the scope of this study due to disparities in access between rural and urban populations.

CONCLUSION

Recent socioeconomic and demographic data from 16,823 respondents living in Cambodia have provided the opportunity to analyze the distribution of household possession of at least one insecticide-treated bednet. A large sample size, appropriately standardized data collection and useful statistical analyses reflect that the results are valid and portray what barriers limit access to insecticide-treated bednets. This study aimed to assess the objectives by testing relevant social, economic and demographic variables that may decrease the access.

Urban respondents are more likely to have at least one household insecticide-treated bednet possibly due to a greater density of health facilities in urban areas. Efforts to distribute insecticide-treated bednets may be focused on locations where population density is higher in order to reach more people. It would be easier and more cost-efficient to distribute insecticide-treated bednets to people when they live closer together. In rural areas, health facilities are few and far between. Therefore, a problematic distance to a health facility may result in a household not being in possession of at least one insecticide-treated bednet due to the stress, cost and lost work time due to transportation from a distant location to the closest health facility.

The significant association between the current age of the respondent and household possession of at least one insecticide-treated bednet may be explained by increased knowledge as one gets older. As the respondent ages, they may become more wise in taking invested, long-term measures in malaria prevention such as installing screens on windows and doors, as well as sealing cracks to minimize exposure to the environment while indoors. In this case, use of insecticide-treated bednets would be redundant and not required. Also, as the average age of the household increases, the household ratio of respondents to insecticide-treated bednets will change as offspring move out of older-aged households. Therefore, there are fewer chances of at least one person sleeping under an insecticide-treated bednet.

The significant association between wealth category of the respondent and household possession of at least one insecticide-treated bednet may be explained by decreased financial resources reallocating priorities away from malaria prevention and treatment tools. For example, if a respondent had to choose between purchasing food or an insecticide-treated bednet, obviously food would be the responsible choice. An insecticide-treated bednet is an investment in preserving health, but clean water and food are staples of immediate survival requirements. Though insecticide-treated bednets are not relatively expensive, this is significant to the 34.1% of rural Cambodians living below the poverty line (Cambodia Data 2011). This creates an issue due to cost of the bednet, cost of transportation and cost due to lost work time while travelling to the health facilities.

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