Source and Use of Insecticide Treated Net and Malaria Prevalence

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30 June 2014

ABSTRACT

This study argues that different practices of sources from which households obtain their Insecticide Treated Nets (ITNs) determine the effect of ITN use on malaria prevalence. The study categorises the sources into those that include some sort of education about how to use the nets and those that do not and examines the effect of these sources on the relationship between ITN use and malaria prevalence among children under-five in Ghana. A recursive bivariate probit estimation technique that addresses endogeneity between ITN use and malaria prevalence was used to analyse data on 2,908 under-five children from the 2011 Multiple Indicator Cluster Survey (MICS). The descriptive results revealed that the proportion of ITN usage among children in households who acquired their ITNs from government, NGOs and Community Based Agents (CBAs) was higher than the proportion of usage among those who acquired their ITNs from private health centers, market, shops and street vendors that do not include education. The estimation shows that controlling for other socio-demographic factors, sleeping under ITN reduces the likelihood of experiencing malaria by 22 percent. Owners of ITNs will not use them to bring the expected reduction in malaria prevalence, unless the source includes education.

Key words: *Insecticide Treated Net, Malaria prevalence, children under-five, endogeneity, recursive bivariate probit.*

JEL: I12 I15 I18

Introduction

WHO (2013) estimated that 6.9 million children died in 2011 giving an average of 19,000 deaths daily from preventable diseases including malaria. Majority of these deaths occurred in the poorest regions and underprivileged areas within countries in Sub-Saharan Africa. Malaria contributes directly to poverty, low productivity, reduced school attendance and poor performance among children (WHO, 2008). Studies on malaria control interventions have established that malaria manifests itself in the form of fever and in some instances results in severe anaemia among children under-five (D'Acremont, Lengeler & Genton, 2010).

Malaria is hyper-endemic in all parts of Ghana, with the entire population at risk (Nketiah-Amponsah, 2010). It is estimated that between 3.1 and 3.5 million cases of clinical malaria are reported in public health facilities each year, of which 900,000 cases involve children under-five years. National malaria microscopy-based prevalence rate based on the report of the 2011 Multiple Indicator Cluster Survey shows that 28 percent of children aged 6-59 months were suffering from malaria. Malaria is a vector-born infectious disease caused by protozoan parasites from the Plasmodium family that is transmittable by the bite of Anopheles mosquito, a contaminated needle or transfusion (GSS, 2011).

Magalhães and Clements (2011) have indicated that decreases in malaria prevalence correspond with increases in Insecticide Treated Net (ITN) use. An ITN is a mosquito net that repels, disables and or kills mosquitoes coming into contact with insecticide on the netting material. UNICEF (2013) has estimated that generally, 5.5 lives could be saved per year for every 1000 children under-five years of age given that they are fully protected with ITN. Findings of community-randomised control trials postulate that at a full coverage, ITNs reduce all-cause child mortality by an average of 18 percent, Plasmodium falciparum and P. vivax infections by 50 percent (Lengeler, 2009; WHO, 2011).

In line with the global objective to reduce malaria prevalence, Ghana National Malaria Control Program (NMCP) and its partners, including some Non-Governmental Organizations (NGOs) have scaled up ITN coverage especially between 2010 and 2012 with volunteers going door to door to distribute and hang Long-Lasting Insecticide-Treated Nets (LLINs) for households. As of 2012, 5,789,023 ITNs had been distributed since 2007 with the view to meeting the MDG4 and MDG6 targets by 2015 (PMI, 2013). Apart from these sources, some households obtained their ITNs from private health centres, markets, shops and street vendors. However, compared to the ITNs obtained from private health centres, street vendors and markets, those obtained from government agencies, NGOs and CBAs are known to be either free or highly subsidised and include education on how to use the nets (MoH, 2013). On these bases, this study asserts that households' translation of increased ITN coverage into use is not only influenced by availability of the nets but also the education that is included in the distribution process. Dupas (2011) and Berthélemy & Thuilliez (2014) assert that inadequate education and affordability have been some of the main barriers to the use of ITNs by households. Making the nets more affordable, increasing education on how to hang them and explaining their potential health benefits can induce increase in use among recipients.

Econometrically, extant literature shows that there is a bicausal relationship (endogeneity) between the use of ITN and malaria prevalence. While one school of thought (Oresanya, Hoshen & Sofola, 2008; Picone, Kibler & Apouey, 2013) argues that ITN use is a predictor of malaria prevalence, other school of thought (Yusuf, Adeoye, Oladepo, Peters & Bishai, 2010; Temu, Coleman, Abilio & Kleinschmidt, 2012; Novignon & Novignon, 2012) holds the contrary view that ITN use rather predicts malaria prevalence. This means that failing to address the issue endogineity will bias the result. This study therefore employs a recursive bivariate probit estimation technique that takes into consideration the effect of other factors that influence ITN use and the subsequent effect of ITN use on malaria prevalence.

Although a number of studies have explored most of these factors, none of them has considered the influence of the sources from which households obtain their ITN on the relationship between ITN use and malaria prevalence. This study therefore examines the impact of ITN use on malaria prevalence among children under-five in Ghana using 2011 MICS data and employing recursive bivariate probit, an instrumental variable estimation technique that addresses the issue endogeneity between the two variables. Specifically, the study seeks to answer two main questions: (1) does the source of ITN influence use? (2) controlling for other socio-demographic factors, is ITN use associated with malaria prevalence? The conduct of this study is timely especially as Ghana aspires to meet target 6C (have halted by 2015 and begun to reverse the incidence of malaria and other major diseases) of the MDG 6 by 2015. The outcome of the study will provide policy makers with relevant evidence on the effect of the source of ITN ownership on the relationship between ITN use and malaria prevalence. The rest of the paper is organized as follows: The next section presents the method of the study followed by the results and discussions. The final section concludes with some policy recommendations.

Method of study

Source of ITN ownership, ITN use and malaria prevalence measures

In the MICS data set, sources of ITN ownership captured were public health centre or agents, NGO/CBAs, market, shops, street vendors and private health centers. Compared to the private health ceters, shops, markets and street vendors, government, NGOs and CBAs include some sort of education in the distribution. On this basis, we re-categorised the sources of ITN ownership into a dummy variable taking on the value 1 if the ITN was obtained from public health centers, or NGO/CBAs and 0 if it was obtained from private health centers, shops, markets and street vendors.

ITN use was measured as whether somebody slept under a treated net in a house during the night preceding the survey making reference to specific line number of the person who slept under the net. Following this, we created a dummy variable taking on the value 1 if a child under-five in the household slept under an ITN during the night before the survey and 0 otherwise. The dependent variable in this study is prevalence of malaria among children under-five which is based on the results of the malaria RDT test as captured in the survey report. In the report, malaria prevalence was measured as Positive falciparum only (PF), Positive, Other species (O,M,V),Positive, both falciparum and OMV and Negative. Based on this categorisation, all the positive results were re-categorised to take on the value 1 and 0 if the test result was negative. Appendix C provides further description of measurement of the other explanatory variables considered in this study and their respective a'priori signs.

Theoretical framework

Theoretically, the study adopts the household production model of Behrman and Skoufias (2004) which captures individual, household and community level characteristics. In this model, a household is assumed to choose between a child's health (H) and leisure L, as well as consumption of goods and services C. The household is further assumed to maximize welfare function subject to the health of the production function and budget constraints. The preferences of the household are assumed to be described by the utility function:

$$U = u(H, L, C;\ X_h) \tag{1}$$

Where X_h represent the household characteristics including education of the mother of the child. The production function of the health of the child can then be specified as:

$H = F(Y, X_i, X_h,\ X_c,\ u)$ (2)

Where Y is a vector of health inputs including the use of ITN by the child. X_i is a vector of child characteristics such as age and gender, X_c is a vector of environmental factors that may have a direct impact on the health of the child while u is a vector of all unobservable characteristics of the child, parents, household, and the community that affect child's health. Through constrained maximization of household welfare, the reduced-form demand function for child health can be written as:

$H_i = \alpha + \beta X_i + \delta X_h + \theta X_C + \varepsilon_i$ (3)

Where H_i is a vector of the health outcome of the child. X_i, X_h and X_c are respectively, the vectors of covariate at the individual, household (parental) and community levels and ε_i is the error term.

Empirical model specification

Following the presence of endogeneity between ITN use and malaria prevalence, using probit or logit to assert association between the two variables will produce bias estimates. From the theoretical model, we use recursive bivariate estimation technique to address this endongeneity. We use source of ITN ownership as an instrument for ITN use to determine the impact of ITN use on malaria prevalence. Supposed that malaria is a linear function of ITN usage plus other control variables, the empirical and structural functions of the recursive bivariate probit model for the determinants of malaria prevalence among children under-five can be specified as:

$\Pr(Mal_i = 1|X_i) = a_0 + a_1 ITN_i + a_2 IRS_c + a_3 Male_i + a_4 Urban_c + a_5 HHsize_h + a_6 Moedu_p + a_7 Wealth_h + a_8 HHsex_p + a_9 Age_i + a_{10} Agesq_i + a_{11} Reg_c + \varepsilon_1$ (6)

Where a_1 is the direct effect of ITN use on malaria prevalence conditional on the other covariates given that ITN utilization by children under five is the main explanatory variable of interest. The control variables are Indoor Residual Spraying (IRS), sex of the child, age of the child, wealth of the household, area of residence, the education level of the mother of the child, size of the household, mother's age at birth and health insurance status of the child. With the endogenous nature of the use of ITN, there is the need for an external instrument to moderate its relationship with malaria prevalence.

The reduced-form equation can be specified as:

$ITN_i = b_0 + b_1 Source_c + b_2 IRS_c + b_3 Male_i + b_4 Urban_c + b_5 HHsize_h + b_6 Moedu_p + b_7 Wealth_h + b_8 Wealth_h + b_9 Age_i + b_{10} Agesq_i + b_{11} Reg_c + \varepsilon_2$ (7)

The correlation between ε_1 and ε_2 is given by the ρ (Wooldridge, 2002) and the total effect of ITN use on malaria prevalence can be re-specified as:

$\Pr(Mal_i = 1|X_i) = c_0 + c_1 \widehat{ITN}_i + c_2 IRS_c + c_3 Male_i + c_4 Urban_c + c_5 HHsize_h + c_6 Moedu_p + c_7 Wealth_h + c_8 HHsex_p + c_9 Age_i + c_{10} Agesq_i + c_{11} Reg_c + \varepsilon_i$ (8)

ρ is the correlation between the error terms in the equations for ITN use and malaria prevalence once the explanatory variables have been factored out.

A likelihood ratio test of the significance of ρ is a direct test of the endogeneity of malaria prevalence and ITN use (Wooldridge, 2002 cited in Morris, 2004). If $\rho = 0$, then it is appropriate to use probit or logit model. If ρ is non-zero ($\rho \neq 0$), then ITN use and malaria prevalence are endogenous. This means that the probit or logit results are biased giving the need for preferring the recursive bivariate probit model to either probit or logit model. Controlling for endogeneity in a bivariate probit framework requires suitable instruments (in this case, source of ITN ownership) for ITN usage. The instruments should have the property of non-weakness, which means that source of ITN ownership should be strongly correlated with ITN use but uncorrelated with the error term in the malaria prevalence equation given that the other independent variables have been netted out ($\alpha \neq 0|X_i$). If this condition does not hold, then recursive bivariate probit model estimators will be inconsistent because the instrument itself is endogenous (Wooldridge, 2002; Cameron & Trivedi, 2005). A justification that these conditions have been satisfied is presented in appendix B. In appendix B, we present the definition, measurement and the a'prori expected signs of all the variables included in the study.

Data

The study relies on 2011 MICS data which is the fourth of its kind as a nationally representative sample survey of households conducted by the Ghana Statistical Service (GSS). The survey involved a collection of information on health and other socioeconomic factors on women between the ages of 15 and 49 years, children from 0 to 5 years of age and men between the ages of 15 and 59 years. Per the report of the survey, 12,150 households were selected for the sample but 11,970 were contacted for interviews. The report further indicates that 7,626 children under age 5 were identified for whom responses were obtained from their mothers or caregivers. Out of this figure, 7,550 were completely interviewed, giving a response rate of 99 percent. In order to obtain child specific and parental and household information, the household file was merged on to that of the child as one complete data file. After the merging, all the variables in the household data that did not match onto that of the child were dropped by default keeping the sample size at 7550 as indicated in the 2011 MICS report.

In the completely merged file for this study, the sample size of children who participated in the malaria RDT test was 4319. Out of this size, 2568 (59.46%) tested positive while the remaining 1751 (40.54%) tested negative. Children living in households with ITNs were 4911. Out of this, 3097 (63.06%) slept under ITNs the night preceding the survey but 1814 (36.94%) did not. It is however imperative to indicate that some of the variables included in the models had missing observations. As a result the sample size with consistent observations across both dependent and independent variables was 2908 and this was the actual sample size used in the analysis. Figure 1 below illustrates the process through which the final sample was obtained.

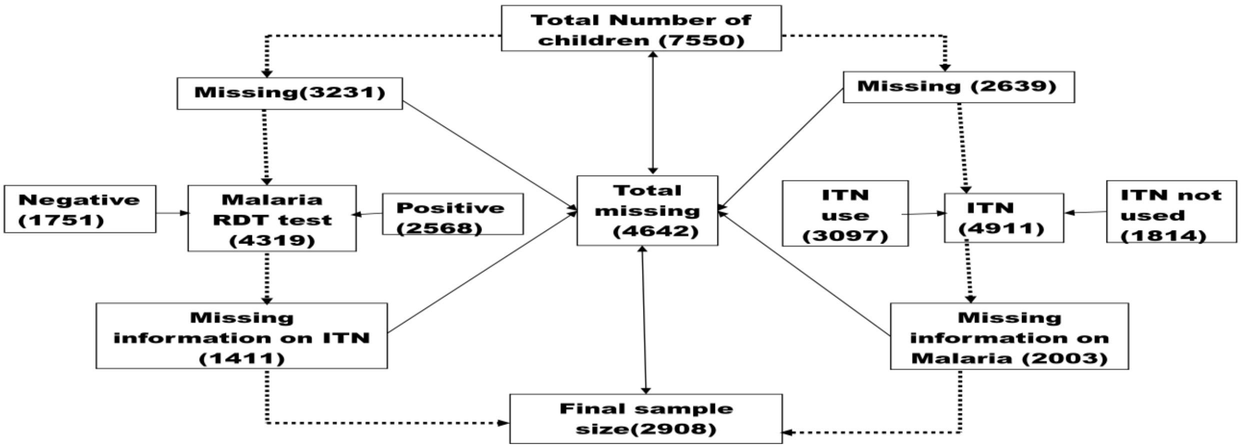

Figure 1: **Data justification**
Source: Author's own construct (2014)

Results

Given the influence of the various sources from which members of households obtain their ITNS on ITN usage, it is important to consider the proportion that each source contributed to the total ITN distribution in Ghana as of the time of the 2011 MICS. The distribution (as presented in Figure 2) shows that members of households obtain their ITNs from four main categories of sources. These are government or public agents, Non-Governmental Organizations (NGOs) and Community Based Agents (CBAs). Others obtain their nets from private health centres, shops, markets and street vendors which are all categorised under shops and markets in this study. As indicated in Figure 2, 76 percent of the ITNs were distributed by the public or government agencies, 16 percent of them were bought from shops, markets and street vendors. 5 percent were distributed to individuals by NGOs and CBAs while the remaining 3 percent were obtained from private hospital, clinics and health centres.

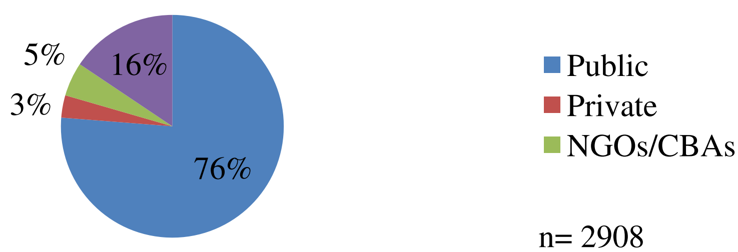

Figure 2: Sources of ITN
Source: Derived from MICS 2011

The use of ITNs by households after obtaining them is another issue of public discourse. In view of this the study sought to access the proportion of children under-five who slept under ITNs the night before the 2011 MICS. Figure 2 shows that 63 percent of children under-five slept under ITNs the night preceding the survey while the remaining 37 percent did not. With regards to malaria prevalence, Figure 4 shows that base on the sample size for this study, 59 percent of children under-five who participated in the malaria RDT test tested positive while 41 percent of them tested negative.

The first objective of this study is to examine the association between sources of ITN ownership and the use of ITN among children under-five in Ghana. To achieve this objective, we conducted a chi-square test on the relationship between the sources of ITN ownership and its use the night preceding the 2011 Multiple Indicator Cluster Survey. Figure 3 illustrates that 63 percent of ITNs were used while the remaining 37 percent were not used. Of the ITNs that were used, those obtained from NGOs/CBAs constituted the highest proportion (71%), followed by those obtained from public health centers and agents (66%), private health centers (60%) and shops/market (56%) respectively. The relationship between ITN use and source of ITN ownership is significant at 1 percent level.

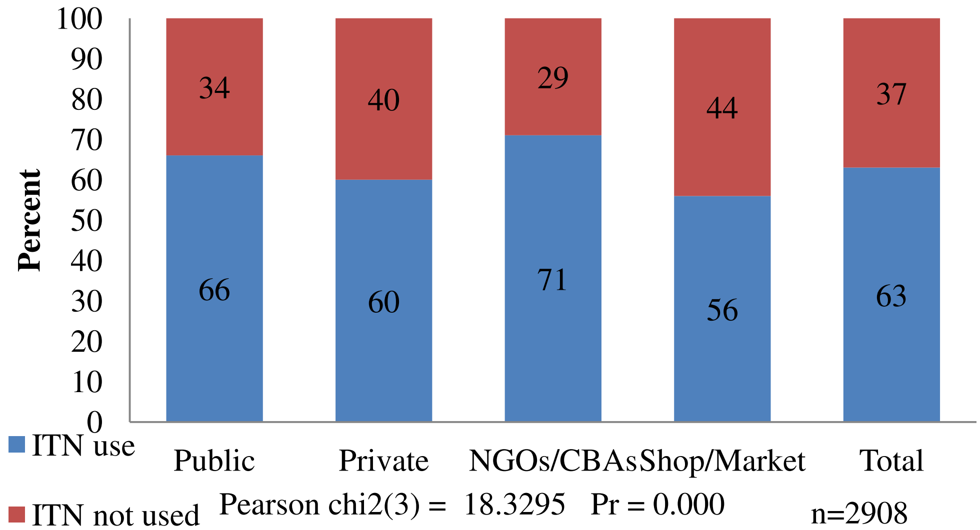

Figure 3: Sources of ITN ownership and its use a night before the survey
Source: Derived from MICS, 2011

Compared to the other private sources of ITN ownership, those obtained from government, NGOs and CBAs are either free or highly subsidised. In addition, those ITNs come with some sort of education that has the potential to induce use among recipients. On these bases, we re-categorise sources of ITN ownership into public and NGOs/CBAs on one hand and shops/markets and street vendors on the other hand. The result based on this re-categoriastion, shows that the average proportion of used ITNs which were obtained from public and NGOs/CBAs was 68.5 percent. This is about 10.5 percent higher than the proportion (58%) obtained from private health hospitals, markets/shops and street vendors. The result shows that although NGO/CBAs contribute just 5 percent of the total ITNs in possession of households, the proportion of the used ITNs that were obtained from this source is even higher than proportion obtained from public health centres and agencies as well as the private sources. This percentage difference can be ascribed to the education and affordability component as mentioned.

Econometric results

Econometrically the study seeks to assess the impact of ITN utilization on malaria prevalence among children under-five in Ghana. In addition to this objective, the study controls for the effects of some other socioeconomic factors that influence malaria prevalence. The main findings from the regression estimations are presented in Table 1. For comparison of the estimates and levels of significance, the results for both probit and recursive bivariate probit models have been presented. Table 1 depicts that controlling for other covariates in the probit model; ITN use by children under-five does not have significant effect on incidence of malaria even though it demonstrates the institutively expected negative relationship. However, in the recursive bivariate estimation model, ITN use significantly predicts malaria prevalence at 1 percent level. Specifically, the result indicates that holding other factors constant, a child who sleeps under an ITN is averagely 22 percent less likely to experience malaria compared to a child who does not sleep under an ITN. The apriori sign is also intuitively consistent.

The difference in the level of significance and marginal effects of the two estimation techniques clearly demonstrates the superiority of the latter to the former. The difference in the marginal effect explains the impact of the source of ITN ownership on malaria prevalence via the use of ITN and the essence of an estimation technique that addresses the element of self-selection and endogeneity between ITN use and malaria prevalence. The application of the instrumental variable estimation technique corrects for any possible bias that is likely to exist when logit and probit estimations were used.

Table 1: Econometric results on ITN use and malaria prevalence

	Probit (I)		**Bivariate probit (II)**	
Variable	Marginal Effect	P>z	Marginal Effect	P>z
ITN use	-0.009	0.586	-0.216	0.004***
	(0.017)		(0.075)	
IRS	-0.053	0.063*	-0.065	0.019**
	(0.028)		(0.028)	
Male	-0.021	0.174	-0.021	0.168
	(0.015)		(0.015)	
Urban	-0.092	0.000***	-0.090	0.000***
	(0.021)		(0.021)	
Household size	0.001	0.753	-0.005	0.169
	(0.003)		(0.003)	
Mother's Edu. (Base=None)				
Primary	-0.016	0.473	-0.022	0.338
	(0.023)		(0.023)	
Middle/JSS	-0.012	0.618	-0.008	0.737
	(0.024)		0.023	
Secondary+	-0.077	0.055*	-0.061	0.130
	(0.041)		(0.041)	

Table 1 continued.

Wealth (Base=Poorest)				
Second	-0.084	0.000***	-0.083	0.000***
	(0.023)		(0.023)	
Middle	-0.163	0.000***	-0.185	0.000***
	(0.032)		(0.031)	
Fourth	-0.320	0.000***	-0.335	0.000***
	(0.038)		(0.036)	
Richest	-0.507	0.000***	-0.533	0.000***
	(0.047)		(0.042)	
Child's age	0.091	0.000***	0.074	0.001***
	(0.022)		(0.023)	
Age square	-0.012	0.021**	-0.011	0.045**
	(0.005)		(0.005)	
Region (Base= Greater Accra)				
Western	0.327	0.000***	0.311	0.000***
	(0.058)		(0.057)	
Central	0.324	0.000***	0.304	0.000***
	(0.056)		(0.054)	
Volta	0.036	0.520	0.083	0.117
	(0.055)		(0.053)	
Eastern	0.228	0.000***	0.232	0.000***
	(0.057)		(0.052)	
Ashanti	0.285	0.000***	0.280	0.000***
	(0.057)		(0.054)	
Brong Ahafo	0.287	0.000***	0.286	0.000***
	(0.057)		(0.054)	
Northern	0.302	0.000***	0.279	0.000***
	(0.056)		(0.055)	
Upper East	0.291	0.000***	0.294	0.000***
	(0.058)		(0.054)	
Upper West	0.408	0.000***	0.399	0.000***
	(0.056)		(0.053)	
Sex of HH	-0.034	0.126	-0.041	0.061*
	(0.022)		(0.022)	
Sample size	2908		2908	
LR chi2(2)		851.71		
Prob> chi2		0.000		
Pseudo R2		0.2208		

Variable	Observation	Mean	Std. Dev.	Min	Max
ATE	3097	-0.220	0.0601038	-0.2876099	-0.0169783

****p*<0.001, ***p*<0.05, **p*<0.01; Standard errors are in parentheses below the marginal effects. ATE is the average treatment effect of a child who used ITN.

With regard to the effect of the control variables on malaria prevalence, the results in Table 1 show that in both the probit and recursive bivariate probit models, malaria prevalence is significantly predicted by IRS, place of residence, household wealth, age of a child, region of residence and sex of household head. A child who lived in a house where the interior walls had been sprayed within the last twelve months before the survey was less likely to test positive for malaria RDT test. Thus, a child who lives in a household in which the interior wall had been sprayed within the previous twelve months preceding the 2011 MICS is 6.5 percent less likely to experience malaria as compared to a child who lives in a household with unsprayed interior walls.

Comparing the marginal effects in the two equations, it can be observed that there is a marked improvement in the marginal effect of IRS in the recursive bivariate probit estimation than that of the probit. It can however be observed from Table 4 that the marginal effect in both models are low. One can justify these low magnitudes of marginal effects on the grounds of low IRS coverage as of the time of the survey. In fact it was indicated in the 2011 MICS report that the national IRS coverage, as of the time of the survey was just 5 percent and the time was too limited for the full impact of IRS to be observed. This means that with time IRS could be both a reliable alternative and complement to ITN usage.

It can also be observed from Table 4 that a child who lives in a household located in the urban area is less likely to be malaria positive. The results indicate that compared to a child who lives in a rural area, a child who lives in the urban area stands a 9 percent chance of not testing positive for malaria. This marginal effect is significant at 1 percent level. On the relationship between mother's education and incidence of malaria among children under-five, mother's education did not prove to be significant in any of the models, although all of them were intuitively consistent. The results also indicate that household income (proxied by household wealth in this study) is a very significant predictor of incidence of malaria among children under-five. It can be seen from Table 4 that incidence of malaria reduces with an increase in household wealth. One observation is that the magnitude of the marginal effect of household wealth on incidence of malaria increases with increase in household wealth and all the categories are statistically significant at 1 percent value. Considering households in the poorest category as a reference, a child from a household that falls into the second category is 8.3 percent less likely to have malaria. In addition, a child from the middle category is 18.5 percent less likely to test positive for malaria.

In the same vein, a child who lives in a household in the fourth category of wealth stands 33.5 percent chance of not getting malaria as compared to a child who lives in the poorest category. Also a child in the richest category is 53.3 percent less likely to experience malaria compared to its counterpart in the poorest category. The result further shows that malaria prevalence among children under-five increases with the age of a child up to certain level, and then begins to decrease with an increase age. The result shows that a year increase in the age of a child is associated with 7.4 percent likelihood that the child will test positive for malaria at 1 percent level of significance. However, as the child ages up to a certain level, additional year increase in his/her age is associated with 1.1 percent less likelihood that it would test positive for malaria at 5 percent level of significance

The results also show that there are differences in malaria prevalence among children under-five across the ten regions of Ghana. With Greater Accra as the base category, a child in any of the remaining regions, apart from Volta region is more likely to experience malaria. The choice of Greater Accra is informed by the fact that, a child in this region has relative advantage over his/her counterparts in the other regions in terms of availability and access to health facilities and health care. A child in the Western region is 31.1 percent more likely to experience malaria at a significant level of 1 percent compared to a child in the Greater Accra region. Likewise, a child in the Central region is about 30 percent more likely to test positive for malaria compared to a child in the Greater Accra region. A child under-five who lives in the Eastern region is about 23 percent more likely to be malaria positive. The prevalence is high especially among children in the Northern and Upper West regions than the rest of the regions. As observed in Table 4, a child in the Upper West region is about 41 percent more likely to be malaria positive as compared to a child in the Greater Accra region.

Finally, sex of household head was also found to be negatively related to malaria prevalence. Holding other factors constant, a child in a household headed by a female is less likely to experience malaria compared to a child who lives in a male-headed household. In the recursive bivariate probit model, a child in a household headed by a female is 4.1 percent less likely to experience malaria compared to a child who lives in a male-headed household. This result is consistent with the a'priori sign of the sex of household in the empirical model.

Discussions

This paper investigated the effect of the sources of households' ITN ownership on the relationship between the use of ITN and malaria prevalence among children under-five in Ghana. Departing from most of the existing literature that use either probit or logit estimation, this study used both probit and recursive bivariate probit estimation technique in the analysis to allow for comparison of the estimates. The recursive bivariate probit estimation technique was used to correct for possible endogneity emanating from bicausal relationship between ITN use and malaria prevalence. We found the probit model to be positively biased as far as the effect of ITN on malaria prevalence is concerned. In view of this, we maintain that using the bivariate probit technique produces more efficient estimates.

Based on the first objective of this study, it is observed from the result that even though greater proportion of the ITNs owned by households was distributed by government, the proportion of usage among those who obtained their nets from NGOs and CBAs was higher than the proportion of usage among those who obtained theirs from government, street vendors, markets, shops and private health centres. This result confirms similar observation made by Krezanoski et al. (2010), Dupas (2011) and Ruhago et al (2011) that sources that include education encourage proper and consistent use of ITNs.

Major inference that can be drawn from this result is that probably, the NGOs and CBAs include education in the distribution and interact with beneficiaries in a way that the other sources do not do. It will be appropriate for government to deepen its collaboration with them and provide them with all the necessary support that they require to enable them play active role in the ITN distribution process. It can also be inferred that affordability, accessibility are factors that inform households' utilisation of ITNs from government, NGOs and CBAs more than the other sources. These factors have to be considered as the core component of the campaign for increase in ITN coverage.

As far as the second objective is concerned, we find that after addressing the endogeniety concerns using source of ITN ownership as an instrument to moderate the relationship between ITN use and malaria prevalence, ITN use reduces the tendency that a child under-five will have malaria by a significant percentage compared to a child who does not sleep under an ITN. Although Randomised Control Trials studies estimate that the use of ITN reduces malaria prevalence between 30 percent and 70 percent, it will be quite challenging to make direct comparison of the 22 percent obtained in this study to those figures due to differences in the methodology and conditions under which the data for the two different studies were collected. Nonetheless, the bottom line is that after addressing the endogeneity concerns, the finding of this study supports the evidence that the use of ITNs impact positively on malaria prevalence. Compared to the existing evidence on cross sectional studies, the result obtained in this study confirms the findings of Thomson et al (1996), Yusuf et al (2010) and Nahum et al (2010) who conclude that the use of ITN is effective in preventing malaria prevalence although the estimation techniques used in those studies were chi-square and logit respectively.

The study also found that a child living in an urban area, household with more wealth, household that had been sprayed within the last twelve months preceding the survey, and female headed household is less likely to experience malaria. Other factors found to influence malaria prevalence were the age, square of the age of the child (which shows a non-linear relationship between age of the child and malaria prevalence) and the regional dummies. With regard to household wealth status, it is possible that wealthy households may have the means to provide other malaria preventive measures such as fun, air conditioners, mosquito sprays and ointment apart from ITN. Even the nature of their buildings and the environment in which most of such buildings are located make them less prone to malaria infection compared to poor households who may not be able to afford those alternative preventive measures and who may live in unhealthy environments.

Several socioeconomic factors may also explain the differences in the likelihood of a chid in other regions testing positive for malaria compared to a child in the Greater Accra region. Differences in the socioeconomic status of their parents to some extent influence the access of the children to ITN use and other alternative preventive measures. It can also be due to differences in climatic and environmental conditions that influence the level of malaria endemicity in those regions. The results also show that IRS has significant effect on malaria prevalence. Considering the magnitude of the marginal effect of IRS in this study in spite of its low coverage, it is obvious that IRS is another potential means of protection against malaria. Government, NGO/CBAs and other institutions engaged in malaria prevention must expand the coverage of IRS to facilitate the malaria prevention effort. If possible, it should be considered as a complement and not a substitute for ITN as it is currently done in some part of the country.

The significant effect of a female household head on malaria prevalence confirms the theoretical and empirical expositions that a female household head is more likely to spend time and resources on a child than their male counterparts (Gary & Levine, 2000). This theoretical claim is empirically manifested when the parent (female household head) anticipates high future prospect of the child in question. As far as the age of the child is concerned, the result confirms similar conclusion of Yusuf et al (2010) and the theoretical explanation that as the child ages, it develops more immune that fight diseases.

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APPENDICES

Appendix A

First stage results of the recursive bivariate probit estimation

Malaria	Coef.	Std. Err.	P>z
ITN use	-0.737	0.255	0.004***
IRS	-0.222	0.095	0.019**
Male	-0.071	0.051	0.168
Urban	-0.309	0.073	0.000**
Household size	-0.016	0.012	0.168
Mother's education	(Base=None)		
Primary	-0.072	0.075	0.335
Middle/JSS	-0.026	0.077	0.736
Secondary plus	-0.201	0.129	0.120
Household wealth	(Base=Poorest)		
Second	-0.271	0.072	0.000***
Middle	-0.571	0.094	0.000***
Fourth	-1.005	0.108	0.000***
Richest	-1.672	0.158	0.000***
Child's age	0.253	0.079	0.001***
Chil's age square	-0.034	0.017	0.046**
Region	(Base=Greater Accra)		
Western	0.955	0.176	0.000***
Central	0.937	0.171	0.000***
Volta	0.256	0.167	0.125
Eastern	0.706	0.162	0.000***
Ashanti	0.858	0.171	0.000***
Brong-Ahafo	0.877	0.167	0.000***
Northern	0.853	0.167	0.000***
Upper East	0.903	0.169	0.000***
Upper West	1.277	0.171	0.000***
Sex of household head	-0.141	0.075	0.061**
Cons	0.321	0.314	0.306
ITN use			
Sources	0.206	0.024	0.000***
IRS	-0.215	0.089	0.015**
Male	-0.002	0.051	0.977
Urban	-0.013	0.073	0.864
Household size	-0.113	0.010	0.000***
Mother's education	(Base=None)		
Primary/Middle	-0.091	0.074	0.226

Appendix A continued.

Middle	0.016	0.078	0.835
Secondary plus	0.171	0.121	0.157
Household wealth	(Base=Poorest)		
Second	-0.096	0.072	0.186
Middle	-0.425	0.094	0.000***
Fourth	-0.472	0.108	0.000***
Richest	-0.940	0.142	0.000***
Child's age	-0.179	0.073	0.014**
Child's age square	0.017	0.016	0.301
Region	(Base=Greater Accra)		
Western	0.05	0.151	0.729
Central	0.058	0.141	0.682
Volta	0.351	0.141	0.013**
Eastern	0.126	0.139	0.362
Ashanti	0.202	0.144	0.16
BrongAhafo	0.267	0.144	0.064*
Northern	-0.065	0.137	0.634
Upper East	0.287	0.146	0.048**
Upper west	0.164	0.138	0.235
Sex of household head	-0.092	0.073	0.207
Cons	1.098	0.162	0.000***
/athrho	0.479	0.211	0.016
Rho	0.445	0.161	
N	2908		
Wald chi2(48)	1106.01	Prob> chi2	0.000
Likelihood-ratio test of rho=0: chi2(1) = 5.86122 Prob> chi2 = 0.016			

***p<0.001, **p<0.05, *p<0.01;. Standard errors are in parentheses below the marginal effects.

Source: Derived from MICS, 2011

Appendix B

Description and summary statistics of variables included in the model

Variable	Definition	A priori sign	Sample	Min	Max
ITN	Insecticide Treated Net (1 if the child had slept under ITN for at least 2 years and 0 otherwise)	Negative	2908	0	1
IRS	Indoor Residual Spraying (1 if a household had been sprayed within the last 12 month preceding the MICS 2011 survey and 0 otherwise)	Negative	2908	0	1
Sex	Sex of the child (1= Male, 0=Female)	Negative	2908	0	1
Age	Age of the child (continuous)	Positive	2908	0	4
Age square	The square of the age of the child	Negative	2908	0	16
Wealth	Wealth of the household (categorical). With poorest as the base category, dummy variables take on the value 1 if the child is in a house that falls into second, middle, fourth and richest categories respectively and 0 otherwise.	Negative	2908	0	5
Area	Area of residence (1=Urban, 0=Rural)	Negative	2908	0	1
Moedu	Mother's education (Categorical). With None as a base category, dummy variables take on the value 1 if the mother attended Primary, Middle/JSS, secondary+ and 0 otherwise.	Negative	2908	0	4
Sex HH	The sex of the head of the household. Dummy variable takes on the value 1 if the head of the household if a female and 0 otherwise.	Negative	2908	0	1
HHS	Household size (continuous)	Negative	2908	2	26
Region	Regional dummy variable for each region	Ambiguous	2908	1	10
Sources of ITN	Sources of ITN ownership (1 if the ITN was obtained from public/government health center or NGOs/CBAs and 0 if obtained from either private health center, shops, market or street vendors	Positive	2908	0	1

Source: Author's computation using MICS, 2011