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Source and use of insecticide treated net and malaria prevalence in Ghana

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Abstract

This study contends that the achievement of Global objective of reducing malaria prevalence through the scaling up of Insecticide Treated Nets (ITNs) is largely dependent on the extent of education incorporated into its distribution by the sources (distributors). 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 in Ghana. Method: 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). Results: 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 centres, 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. Conclusion: Scaling up ITN distribution is not enough to ensure utilisation and 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

Malaria threatens the lives and livelihoods of about 3.2 billion people worldwide and causes over one million deaths annually (WHO & UNICEF, 2005). WHO (2013) estimated that 6.9 million children died in 2011 giving an average of 19,000 deaths daily from mostly preventable diseases including malaria. Majority of these deaths occurred in the poorest regions and countries of the world, and in the most 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).

As of 2010, malaria accounted for 44 percent of ambulatory care, 13 percent of all hospital deaths and 22 percent of mortality among children less than five years in Ghana It is hyper-endemic in all parts of the country, with the entire population at risk (Nketiah-Amponsah, 2010). Malaria is the number one cause of morbidity, accounting for about 38 percent of all outpatient illnesses, 36 percent of all admissions, and 33 percent of all deaths in children under-five years. 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 who constitute 4 percent of the general population (GHS, 2011).

Although there was a reduction in under-five Malaria Case Fatality Rate from 2.2 percent in 2006 to 1.32 in 2010, the general incidence as well as deaths associated with malaria increased sharply from 79.7 per 1000 and 3378 deaths in 2009 to 108.3 per 1000 and 3859 deaths in 2010 respectively. Compared to some selected African countries, presumed and confirmed malaria a case in Ghana from 1999 to 2011 is an issue of public concern.

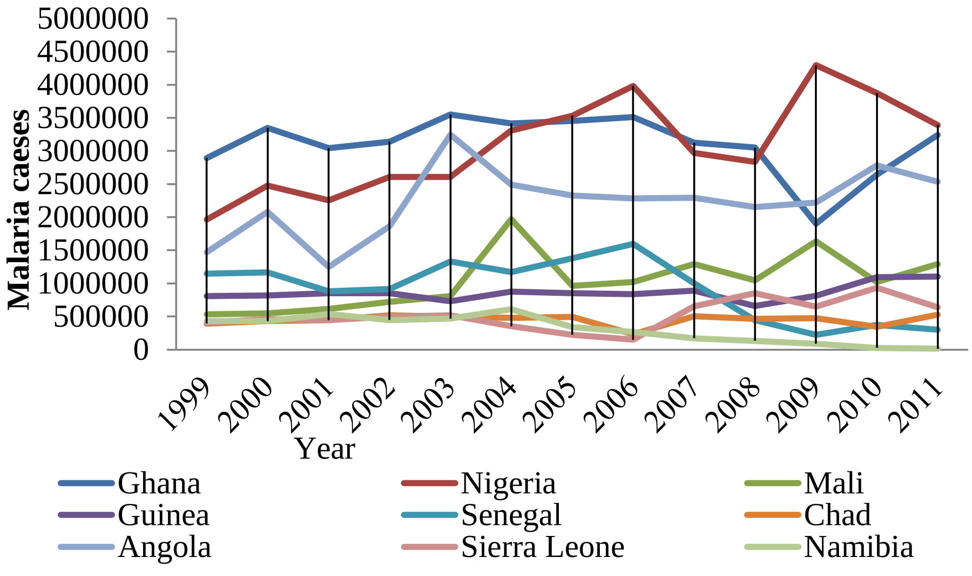

Figure 1: Presumed and confirmed malaria cases in some selected African countries. Source: Derived from WHO (2013).

The Figure shows that compared to the selected African countries, presumed and confirmed malaria cases in Ghana between 1999 and 2005 were relatively higher than the cases in the selected countries. Ghana, Nigeria and Angola had more cases of malaria than the remaining selected countries. However, since 2009, the cases of malaria have shown a sharp upward trend in Ghana than even Nigeria and the rest of the selected West African countries. 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. This malaria prevalence varied across the regions and national ecological zones. 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).

Studies have shown that decreases in malaria parasites prevalence correspond with increases in Insecticide Treated Net (ITN) use (Magalhães & Clements 2011). An ITN is a mosquito net that repels disables and/or kills mosquitoes coming into contact with insecticide on the netting material. It has been found to be one of the most cost-effective means of minimizing malaria and its related diseases such as fever and anaemia which cause most deaths among children and pregnant women. Extensive studies on the protective efficacy of ITN show 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 (UNICEF, 2013). Results 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).

As a result, increased ITN coverage has been advocated globally by WHO and other corporate organisations as a major means to encourage increased ownership, its effective use and subsequent reduction in malaria prevalence, morbidities and mortalities. In line with this global effort, the National Malaria Control Program (NMCP) and its partners, including the President's Malaria Initiative (PMI) as well as some None Governmental Organizations (NGOs) have intensified the campaign for increased ITN ownership especially between 2010 and 2012 with volunteers going door to door to distribute and hang Long-Lasting insecticide-treated bed nets (LLINs) either for free or at highly subsidised cost. As of 2012, 5,789,023 ITNs had been distributed since 2007 with the view to meeting the requirement of the Abuja declaration as well as the targets of the MDG4 and MDG6 by 2015 (PMI, 2013). Since the free ITN coverage is not nationwide, members of some households obtained their ITNs from markets, shops and street vendors all in an attempt to avoid malaria infection (MoH, 2013).

Most studies on ITN use and malaria prevalence conclude with a caveat that protective efficacy of ITNs depends on its full coverage and consistent use. However, evidences have shown that the spate of ITNs use, both in Ghana and Sub-Saharan Africa has lagged behind the spate of coverage and distribution due to some socioeconomic barriers. This has subsequently resulted in low rate of reduction in the burden of malaria. From demand and supply chain perspectives, this study contributes to the discourse by arguing that translating increased coverage and ownership of ITN into use by households is largely influenced by the sources from which ITNs are obtained. Eisele et al. (2009), Afolabi et al. (2009) and Krezanoski et al. (2010) found that from demand side, financial constraints have been identified as the main reasons given by households for not acquiring health products such as ITNs. Dupas (2011) found that in Kenya, pregnant women universally take up an antimalarial bed net when it is given for free during a prenatal visit, but only 40 percent buy one at a highly subsidized price of US$0.60 These evidences suggest that free or high subsidisation of ITNs has the potential to induce high ownership and use in Ghana.

On the supply side, Berthélemy and Thuilliez (2014) argue that lack of availability and failure in ITN distribution systems have been identified by RBM as the main limitations (other than cost) of large-scale implementation of ITN use. The second aspect of the supply side is the education component expected to be incorporated into the ITN distribution process by the distributors or suppliers. Increasing education on how to hang the nets and their potential health benefits can induce increase in use among recipients. In Ghana, households obtain their ITNs mainly from public and private health agencies (agents) as well as None Governmental Organizations (NGOs). Others obtain theirs from Community Based Agents (CBAs), market and street vendors. ITNs obtained from government agencies, NGOs and CBAs are known to be either free or highly subsidised than those obtained from other private sources.

In addition to the source, extant literature shows that authors differ in opinion on the direction of causality between malaria prevalence and ITN use. While one school of thought is of the view that ITN use is a predictor of malaria prevalence, other school of thought holds the contrary view. For instance, Oresenya etal (2008) and Picone, Kibler and Apouey (2013) have explored malaria prevalence as a predictor of ITN use. On the contrary, Yusuf, Adeoye, Oladepo, Peters and Bishal (2010), Settumba (2010), Temu, Coleman, Abilio, Kleinschmidt (2012) and Novignon and Novignon (2012) argue that ITN use is rather a predictor of malaria prevalence. This suggests that there is an unaddressed element of endogeneity arising from simultaneity between malaria prevalence and ITN use. There is also an element of self-selection since ITN usage is a choice variable. This means that using either probit or logit estimation techniques as usually used in most studies will bias the result. There is the need for an 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 many of such factors that influence ITN use have been explored in several studies, few if any have considered the influence of the sources from which households obtain their ITNs. 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 of self-selection and endogeneity. Specifically, the study examines the association between sources of ITN ownership and use and the impact of ITN use via sources of ownership on malaria prevalence among children under-five in Ghana. From our opinion, the conduct of this study is timely especially as Ghana aspires to meeting 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 role of the source of ITN ownership in the distribution process and add to the current discourse on malaria- ITN use nexus. 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 considered were public or government agents, NGO/CBAs, market, shops, street vendors and private health centres. We re-categorised these sources into a dummy variable taking on the value 1 if the net was obtained from government health centres, agencies or NGO/CBAs which is classified as either free or highly subsidised source and 0 if they were obtained from private health centres, shops, markets and street vendors labelled as the none-free (paid for) sources.

ITN use was captured as whether somebody slept under a net (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. As far as children under-five were concerned, the line numbers of either their mothers or care givers were used to identify whether the child slept under the net or otherwise. Following this, a dummy variable was created 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 captured as Positive falciparum only (PF), Positive, Other species (O,M,V),Positive, both falciparum and OMV and Negative. Following this categorization, all the positive results were re-categorised to take on the value 1 if the child tested positive for any of the positive observations 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 the 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:

$$U = u(H, L, C;\ X_h) \quad (1)$$

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:

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

Where Y is a vector of health inputs such as nutrient intake, health care practices such as child immunization, time spent by parents taking care of the child and use of ITN. 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 child health while u is a vector of all unobservable characteristics of the child, parents, household, and the community that affect child's health.

The household is assumed to be limited by its full income constraint in making choices. This income constraint function is specified as:

$$P_C C + WL + P_Y Y = FI \quad (3)$$

Where $P_{C,} W$, and P_Y are the price vectors of consumption goods (C), leisure (L) and health inputs (Y) correspondingly, and FI is the full income including the value of the time endowment of the household and non-labor income. Through constrained maximization of household welfare, the reduced-form demand function for child health can be written as:

$$H_i = \varphi(X_i, X_h, X_c\ FI\ , P_C, W, P_Y\ \mu) \quad (4)$$

where the particular functional form of the function $\varphi(.)$ depends on the underlying functions that describe the household preferences, the health production function and all other relevant production functions. Since the study is constrained by non-availability of prices of the various inputs in the dataset that used, the study strictly assumes that prices on the average are the same for all households. The reduced-form demand function for child health can be specified as:

$$H_i = \alpha + \beta X_i + \delta X_h + \theta X_C + \varepsilon_i \quad (5)$$

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

Empirical model specification

Following the simultaneity between ITN use and malaria prevalence, and the issue of self-selection, using probit or logit to regress ITN use on malaria prevalence will produce bias estimates. We use recursive bivariate estimation technique to address the presence of endogeneity that can bias the result. With this estimation technique, we use source of ITN ownership as an instrument for ITN us 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:

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

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. From the MICS report, members of households obtain their ITNs from different sources. These are government or public agents, None Governmental Organizations and Community Based Agents (NGD/CBAs), private health centres and agents as well as shops, markets and street vendors. Compared to the other private sources of ITN ownership, those obtained from government, NGOs and CBAs come with some form education. In addition, they are either free or highly subsidised. On this bases, we re-categorise sources of ITN ownership into public and NGOs/CBAs on one hand and those obtained from shops/markets and street vendors on the other hand. We assign the value 1 to those obtained from public agencies and 0

The reduced-form equation can be specified as:

$$\Pr(ITN_i = 1|Y_i) = b_0 + b_1 Source_c + b_2 IRS_c + b_3 Male_i + b_4 Urban_c + b_5 HHsize_h + b_6 Moedu_p + b_7 Wealth_h + b_8 Wealth_h + b_9 Age_i + b_{10} Agesq_i + b_{11} Reg_c + \varepsilon_2 \quad (7)$$

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:

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

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

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 proof of the correlation matrix showing that these conditions have been satisfied is presented in appendix B. In appendix C, 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 2 below illustrates the process through which the final sample was obtained.

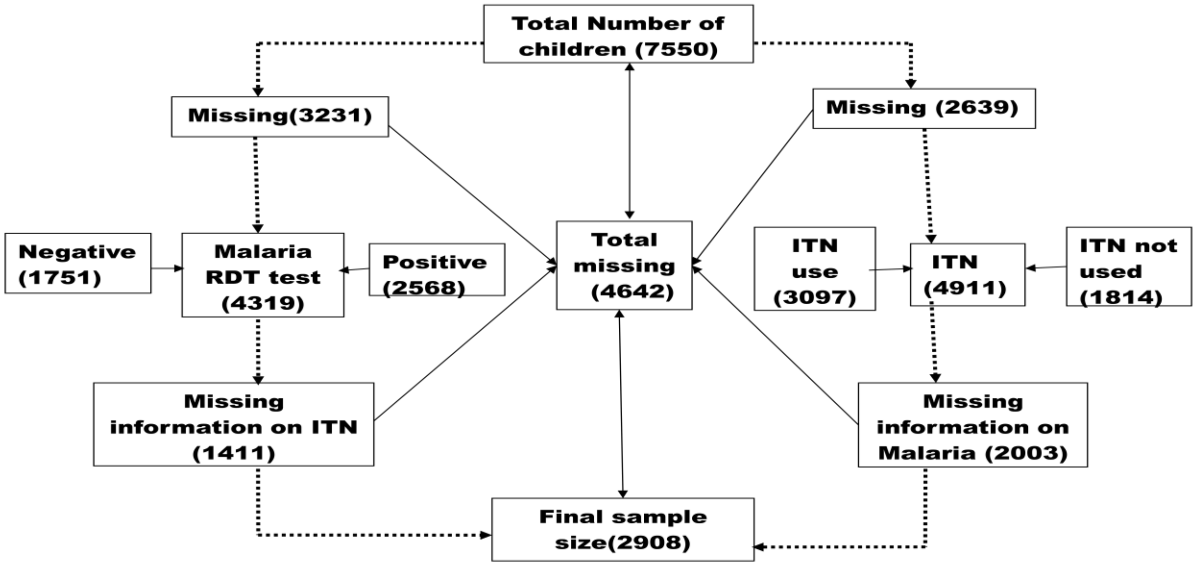

Figure 2: Data justification
Source: Author's own construct (2014)

Results and discussions

We begin the analysis with a description of the distribution of the various sources from which members of households obtain their ITNS. The distribution (as presented in Table 1) shows that members of households obtain their ITNs from four main categories of sources. These are government or public agents, None Governmental Organizations and Community Based Agents (NGD/CBAs), private health centres and agents as well as shops, markets and street vendors which are categorised under market and shops in this study. As indicated in Table 1, 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. The results clearly show government's dominance in the ITN distribution in the country. As stressed by Eislel eta l. (2009) and Krezanoski eta l. (2010) a major factor that could account for such a high reliance on government by households in Ghana for ITN is an issue of affordability. In most households in Ghana and Africa, high rate of poverty serves as a barrier to demand for health promoting goods and services hence their reliance on government and corporate institutions that can provide them such goods and services at affordable rate.

Table 1: Households' obtaining sources of ITN

Source	Percent
Public health centres or health professional	76
Private health centres and agents	3
NGO/CBA	5
Shop/Market/Street vender	16
Total	100
Observation (N)	2908

Source: Derived from MICS (2011)

The use of the ITNs by households after obtaining them is another issue of public discourse. Analysis of the distribution of usage of the ITN by children under-five shows that 63 percent of children under-five slept under ITNs during the night preceding the survey while the remaining 37 percent did not. This result is consistent with that of GSS (2011) as documented in the MICS report. Compared to the proportion in 2006 which was 41.7 percent, one would say that it is a sign of positive attitudinal change towards the campaign for the use of ITN as a means of preventing malaria in the country if only the ITNs were used properly as reported by caretakers and mothers of the children. A major issue regarding the use of ITN that requires more in-depth research for clearer understanding is the consistency and duration of use before disposing off the nets. Considering the fact that ITN use as measured in the 2011 MICS and subsequently used in this study was based on reports of parents of the children, assessing the consistency of use and the time that the nets are used by children each night is paramount. These factors largely determine the effectiveness of the nets in protecting users against malaria.

With respect to the distribution of malaria prevalence among children under-five, the analysis shows that based 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. If this distribution obtained really reflects the reality on the ground, then it means that much effort will be required to address the issue of malaria prevalence among children under-five in the country. In order to achieve the reduction target of 75 percent by 2015 as stated in the objectives of the Roll Back Malaria initiative, government and corporate organisations engaged in malaria prevention campaigns in the country will have to double their effort to ensure further reduction.

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 centres and agents (66%), private health centres (60%) and shops/market (56%) respectively. The relationship between ITN use and source of ITN ownership is significant at 1 percent level.

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 form of education that has the potential to induce use among recipients. On this 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-categorisation, 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.

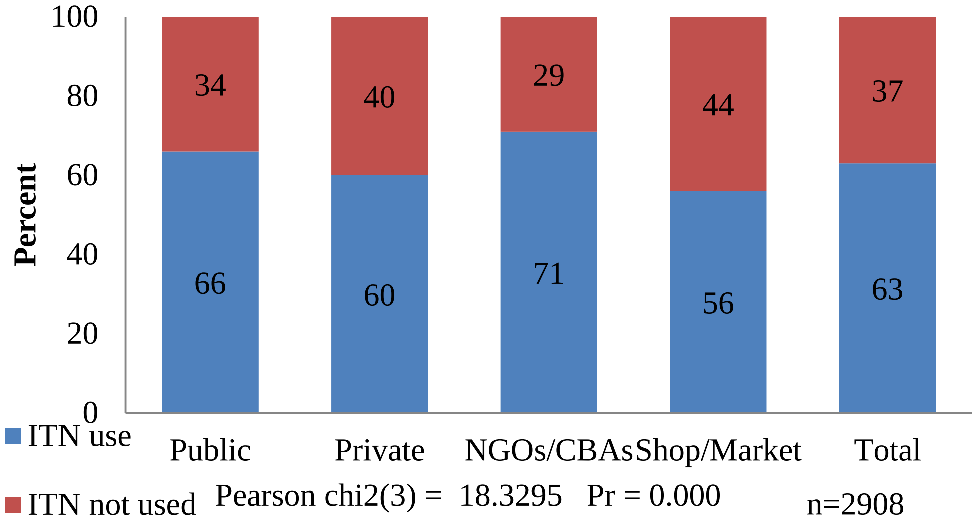

Figure 3: Sources of ITN ownership and its use a night before the survey
Source: Derived from MICS (2011)

This result confirms similar observation made by Eisele et al. (2009), Afolabi et al. (2009), Krezanoski et al. (2010), Dupas (2011) and Ruhago et al (2011) that free distribution of ITNs couple with education of the beneficiaries encourage proper and consistent use. Major inference that can be drawn from this result is that affordability, accessibility, and education are factors that should form core component of the campaign for increase in ITN coverage. Apart from the free distribution, effective oral and practical education on the health benefits and how to use the nets are essential factors that need to be given critical consideration in the ITN distribution process. This will induce behavioural change that will bring about consistent and appropriate use of the ITNs.

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 2 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 *a priori* 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.

In Randomised control Trials, it is estimated 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 obtained under Randomised Control Trials due to differences in the methodology and conditions under which the data for the two different studies were collected. However, the most important issue is that after addressing the endogeneity concerns, the findings of this study support the evidence based on Randomised Control Trials studies that the use of ITNs impact positively on malaria prevalence. With respect to cross sectional studies, the results obtained in this study and the intuition signs are all in line with similar observations made by Thomson et al (1996), Yusuf et al (2010) and Nahum et al (2010) who argue that ITN does predict incidence of malaria significantly although the estimation techniques used in those studies were chi-square and logit respectively. 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. This result is in contrast to the findings of Settumba (2010) and Temu et al (2012) who observed that IRS was not a significant predictor of malaria prevalence. 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 2 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 2 that a child who lives in a household located in the urban area is also 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. This finding could be due to the availability of alternative preventive measures such as fan, air conditioners and even differences in environmental conditions. Also, easy access to health facilities in the urban areas compared to the rural areas could largely explain why a child in the urban area has an advantage over his/her counterpart in the rural area as far as malaria infection is concerned. 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. This finding fails to validate most of the evidences gathered on the significant empirical and theoretical relationship between parental education and child health.

Table 2: Econometric estimates

Dep. variable	**Probit**	**Bivaiate**	**Dep. variable**	**Probit**	**Bivariate**
(Malaria prevalence)	Marginal	Marginal	(Malaria prevalence)	Margin	Margin
ITN use	-0.009	-0.216***	*Region (Greater Accra)*		
	(0.017)	(0.075)	Western	0.327***	0.311***
IRS	-0.053*	-0.065**		(0.058)	(0.057)
	(0.028)	(0.028)	Central	0.324***	0.304***
Male	-0.021	-0.021		(0.056)	(0.054)
	(0.015)	(0.015)	Volta	0.036	0.083
Urban	-0.09***	-0.090***		(0.055)	(0.053)
	(0.021)	(0.021)	Eastern	0.228***	0.232***
Household size	0.001	-0.005		(0.057)	(0.052)
	(0.003)	(0.003)	Ashanti	0.285***	0.280***
Mother's Education (none)				(0.057)	(0.054)
Primary	-0.016	-0.022	Brong-Ahafo	0.287***	0.286***
	(0.023)	(0.023)		(0.057)	(0.054)
Middle/JSS	-0.012	-0.008	Northern	0.302***	0.279***
	(0.024)	0.023		(0.056)	(0.055)
Secondary+	-0.077**	-0.061	Upper East	0.291***	0.294***
	(0.041)	(0.041)		(0.058)	(0.054)
Wealth (poor)			Upper West	0.408***	0.399***
Second	-0.084***	-0.083***		(0.056)	(0.053)
	(0.023)	(0.023)	Sex of head	-0.034	-0.041*
Middle	-0.163***	-0.185***		(0.022)	(0.022)
	(0.032)	(0.031)	Child's age	0.091***	0.074***
Fourth	-0.320***	-0.335***		(0.022)	(0.023)
	(0.038)	(0.036)	Age square	-0.012***	-0.011***
Richest	-0.507***	-0.533***		(0.005)	(0.005)
	(0.047)	(0.042)	Sample size	2908	2908
LR chi2(2)	851.71	-----	Pseudo R2	0.2208	-----
Prob> chi2	0.000	------	Variable	(N=3097)	----
	------	-----	ATE	-----	-0.220

*** indicates significance at 1 percent level, ** at 5 percent level, and * at 10 percent level.
Standard errors are in parentheses rightly below the marginal effects. ATE is the average treatment effect of a child who used ITN compared to a child who did not use it.

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 2 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. This can be partly due to the fact 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 and IRS. 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.

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. In their analyses of the demographic and social determinants of febrile episodes in children, Yusuf et al (2010) came to similar conclusions. The result also confirms the theoretical explanation that as the child ages, it develops more immune that fight diseases.

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 especially, the three northern regions are more likely to experience malaria apart from Volta region. 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.

The possible reasons for the differences in the likelihood of a child in the Central and Western regions testing positive for malaria compared to a child in the Greater Accra could be due to differences in the socioeconomic status of their parents which 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 two regions. 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 region. 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. Holding other factors constant 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. It 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 manisfested when the parent (female household head) anticipates high future prospect of the child in question.

Conclusion

This paper investigated the empirical relationship between sources of ITN ownership and use and the impact of ITN use on 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 endogeneity emanating from simultaneity between ITN use and malaria prevalence. We found the probit model to be positively biased as far as malaria prevalence is concerned. In view of this, we maintain that using the bivariate probit model improves the efficiency of the estimates.

Based on the first objective, this study concludes that source of ITN ownership significantly influences its use. Particularly, ITNs obtained from the public or government and NGOs/CBAs are used more than those obtained from other sources such as private hospitals, shops/market and street vendors. As far as the second objective is concerned, we find that with the bivariate probit estimation technique, the tendency that a child under-five who sleeps under an ITN would have malaria reduces by 22 percent compared to a child who does not sleep under an ITN. The study also found that a child living in an urban area, household with more wealth, 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.

The key findings of this study suggest that Government has to intensify the free distribution of ITNs to households coupled with intensive education that will induce continuous and regular use of the nets by recipients. There is the need for extensive and comprehensive education of the recipients/beneficiaries on how to hang the nets, make them available for re-impregnation or re-treatment and potential health benefits of using the ITNs. Given the greater influence of NGOs and Community Based Agents (CBAs) on the use of ITNs by households, government must deepen its collaboration with them in the ITN distribution process. Government should provide them with all the necessary support that they require to enable them to play active role in the ITN distribution process.

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. Since the effectiveness of ITN is only realised during sleeping hours, the distribution and use of other competing alternatives such as mosquito coils, sprays and ointments must be respectively considered by government and households.

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APPENDICES

Appendix A

First stage results of the recursive bivariate probit estimation

Dependent variable	(Malaria prevalence)		Dependent variable	(ITN utilisation)	
	Coef.	Std. Err.		Coef.	Std. Err
ITN use	-0.737***	0.255	Sources	0.206***	0.024
IRS	-0.222**	0.095	IRS	-0.215**	0.089
Male	-0.071	0.051	Male	-0.002	0.051
Urban	-0.309***	0.073	Urban	-0.013	0.073
Household size	-0.016	0.012	Household size	-0.113***	0.010
Mother's education (None)			*Mother's education (None)*		
Primary	-0.072	0.075	Primary/Middle	-0.091	0.074
Middle/JSS	-0.026	0.077	Middle	0.016	0.078
Secondary plus	-0.201	0.129	Secondary plus	0.171	0.121
Household wealth (Poorest)			*Household wealth (Poorest)*		
Second	-0.271***	0.072	Second	-0.096	0.072
Middle	-0.571***	0.094	Middle	-0.425***	0.094
Fourth	-1.005***	0.108	Fourth	-0.472***	0.108
Richest	-1.672***	0.158	Richest	-0.940***	0.142
Child's age	0.253***	0.079	Child's age	-0.179**	0.073
Chil's age square	-0.034***	0.017	Child's age square	0.017	0.016
Region (Greater Accra)			*Region (Greater Accra)*		
Western	0.955***	0.176	Western	0.05	0.151
Central	0.937***	0.171	Central	0.058	0.141
Volta	0.256***	0.167	Volta	0.351**	0.141
Eastern	0.706***	0.162	Eastern	0.126	0.139
Ashanti	0.858***	0.171	Ashanti	0.202*	0.144
BrongAhafo	0.877***	0.167	BrongAhafo	0.267	0.144
Northern	0.853***	0.167	Northern	-0.065	0.137
Upper East	0.903***	0.169	Upper East	0.287**	0.146
Upper West	1.277***	0.171	Upper west	0.164	0.138
Sex of head	-0.141**	0.075	Sex of head	-0.092	0.073
Cons	0.321	0.314	/athrho	0.479	0.211
Cons	1.098***	0.162	rho	0.445	0.161
N	2908		Prob> chi2	0.000	------
Wald chi2(48)	1106.01		-------	-----	------

Source: Derived from MICS (2011)

Appendix B

Correlation matrix for malaria prevalence, sources and use of ITN

	Malaria prevalence	ITN utilisation	Sources of ITN (Instrument)
Malaria prevalence	1.0000		
ITN utilisation	-0.0219 (0.2384)	1.0000	
Sources of ITN (Instrument)	0.0003 (0.9850)	0.8490* (0.0000)	1.0000

Numbers are Pearson correlation coefficients which go from -1 to 1. Closer to 1 implies a strong correlation. A negative value indicates an inverse relationship (when one goes up the other goes down).
Source: Derived from MICS (2011)

Appendix C

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 centre or NGOs/CBAs and 0 if obtained from either private health centre, shops, market or street vendors	Positive	2908	0	1

Source: Author's computation using MICS, 2011