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DETERMINANTS OF BED NET USE IN THE GAMBIA: IMPLICATIONS FOR MALARIA CONTROL

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Abstract. Malaria is still one of the biggest health threats in the developing world, with an estimated 300 million episodes per year and one million deaths, most of which are in sub-Saharan Africa. Although the efficacy and cost-effectiveness of treated bed nets has been widely reported, little is known about the range, strength, or interaction between different factors that influence their demand at the household level. This study modeled the determinants of bed net ownership as well as the factors that influence the number of bed nets purchased. Data was collected from 1,700 randomly selected households in the Farafenni region of The Gambia. Interviews were also held with 129 community spokespersons to explore the extent to which community level factors such as the quality of roads and access to market centers also influence demand for bed nets. The results of each model of demand and their policy implications are discussed.

INTRODUCTION

One million people die of malaria each year, mostly in sub-Saharan Africa.[1] Malaria also has a significant impact on the productivity and wealth of households[2–4] and on economic growth.[5] Although insecticide-treated nets (ITNs) remain one of the most widely advocated strategies for preventing malaria in African communities, the mechanisms by which household decision-making affect malaria prevention are not well understood. Gaining a better understanding of the factors affecting consumption and expenditure decisions at the household level is crucial to the success of malaria prevention interventions.

This study makes a number of specific contributions to the existing literature on malaria prevention. Many of the existing studies of prevention-seeking behavior give an indication of use patterns and the key determinants of those patterns. However, one cannot assess the relative importance of those differences in the demand for malaria prevention or the magnitude of their marginal impact. In this study, we test for the statistical significance of each determinant of demand while controlling for other factors. Second, this demand analysis is based on revealed preferences rather than stated preferences and as such it will provide a more objective basis for analyzing demand determinants than relying exclusively on a consumer's subjective assessments of the key influences on demand. In this sense, it is more akin to estimating actual responses to policy changes than hypothetical responses. The study also includes data from a parallel community infrastructure survey. This enables us to examine a wider range of factors such as the quality of roads and seasonal effects and their influence on the demand for bed nets. Finally, the results of this study inform key policy questions. For example, predicting the effect on demand of changes in price setting practices can inform the subsidization of bed nets by public and commercial sectors. Moreover, isolating the effect of individual, household and community level factors on the demand for bed nets provides a strong basis for re-designing education programs and public infrastructure to promote the use of bed nets.

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BACKGROUND

Much effort is currently being directed towards stimulating the demand for ITNs in African communities.[6,7] One of the key reasons cited for this is that when used properly, intact ITNs provide almost complete protection from mosquito bites.[8] Several studies have also demonstrated the efficacy of ITNs with an overall reduction in all-cause mortality by 19%.[9–12] The cost-effectiveness of ITNs relative to other forms of malaria prevention and treatment has also been widely reported.[9,13–17] Despite their clearly demonstrated effectiveness, the current rates of net coverage remain disappointingly low in many African countries, especially among the poorest households.[18]

There has been much debate over the extent to which the price of a bed net acts as a barrier to use. A study by Simons and others explored the extent to which reform of tariff and tax policy can be expected to increase ITN purchases.[19] The authors predict that reducing tariffs on insecticides on ITNs from 42% to 0% and the tariff on netting materials from 40% to 5% would lead to an increase in the demand for ITNs by 9–27%. Although there are limited studies measuring the extent to which the retail price of ITNs acts as a barrier to their use, we do know that in many African settings the upfront cost of protecting an entire household with ITNs typically exceeds ability to pay.[20]

Gender also plays an important role in the demand for bed nets.[21–23] It has been argued that when women are pregnant, they fall into a high-risk malaria group. In turn, they receive greater exposure to health services and gain a higher level of awareness of the disease and ways of preventing it.[21] It is also commonplace for women to be the main caregiver in a household and to take responsibility for looking after family members with malaria.[22,23] Moreover, the amount of money available for treatment during the malaria episode has been shown to be a function of the income of women.[24] There is no reason to doubt that this would also apply to malaria prevention. The extent to which women can make decisions over the consumption of health care depends on their access to financial resources and their position of power within the household,

which is in turn influenced by factors such as the sex of the household head. For example, it has been argued that women have greater control over resource allocation decisions in female-headed households.[25]

Other demographic variables shown to influence bed net use include age, education, size of household, and ethnicity. Some studies indicate that children are less likely to use nets,[26,27] especially those living in rural areas,[18] while others have failed to detect any significant effect of age on bed net use.[21] The number of very young children in the household is also a determinant of bed net use with studies showing that women with many young children are more likely to participate in malaria prevention programs than women with only one child or where the children are older and less vulnerable to malaria.[22,23] Although there is limited evidence to suggest that education has a direct effect on bed net use, it does influence the type of work a person does and subsequent income generated.[28] The attitudes of individuals and households towards malaria prevention also vary according to ethnicity and location of residence.[21,29–32] For example, certain ethnic groups may live and work in rural areas where malaria is often more prevalent. There may also be an income-related effect whereby particular ethnic groups engage in occupations that are poorly paid, which in turn restricts their ability to pay for malaria prevention products.

Finally, access to markets where ITNs and re-treatments are sold can also influence use patterns.[30,33,34] It has been shown that expenditure on health care[35] and on all forms of malaria prevention[36] often depends on the type of infrastructure available at the community level, including the quality of roads and proximity to market centers.

Estimating demand has an important role to play in the area of malaria prevention where coverage rates are influenced by a variety of complex and interacting factors. Failing to tease apart these factors will mean that we will be left with major gaps in any strategy to control this disease.

METHODS

Study site and sample. Data collection for this study was carried out between January 2003 and December 2003 in the Farafenni region of The Gambia, where malaria occurs throughout the year but is most common during the rainy season (i.e., September to November). The average annual rainfall for the Farafenni area is 693 mm.[37] The main ethnic groups are Mandinka, Wollof, and Fula. Most residents are Muslim. A detailed demographic profile of the area as well as a summary of recent studies conducted in Farafenni can be found in the *Farafenni Demographic Surveillance Report.*[37]

For this study, 1,700 households were selected using stratified cluster sampling. All households in the selected clusters were listed and equal numbers were randomly selected from each. Clusters were stratified by geographic location (i.e., rural and peri-urban villages and urban blocs). In the study population, families typically lived in compounds, made up of one or more households. A household was defined as a group of people who ate from the same food bowl.

Interviews. Trained fieldworkers from the study area conducted structured interviews with household heads. Interviews were staggered over a 12-month period to capture the effects of seasonality on expenditure. First, respondents were asked how many bed nets they currently owned and how old the nets were. Second, they were asked how much they paid for these nets and how much they had spent on the treatment and repair of bed nets over the previous six months. Detailed demographic and socioeconomic information was also collected. The interview questions built on the principles of the World Bank's Living Standards Measurement Surveys.[38] Questions were translated into Fula, Mandinka, and Wollof and piloted on men and women who spoke different dialects, had varying levels of education, and were from both rural and urban areas.

Interviews were also held with 129 community spokespersons between January and March 2004. Respondents were purposively sampled and interviewed about community level factors such as the quality of roads and access to commercial outlets that were likely to influence demand for bed nets. Data from the household survey and the community infrastructure survey were used to construct the econometric models of demand for bed nets.

Interviews were double entered by two data entry clerks using Access 7.0 (Microsoft, Redmond, WA). All financial estimates are expressed in the local currency (Dalasis) and in U.S. Dollars. Clearance for this research was obtained from the ethics committees of the Medical Research Council (Fajara, The Gambia) and the London School of Hygiene and Tropical Medicine. Written informed consent was obtained from all participants.

Analysis. It was argued in the background section that the price of a bed net can be an important determinant of demand. If we are to include data on unit values, a two-part or hurdle model[39] needs to be applied because we do not have data on unit values for those households that do not own bed nets. We model the first part (bed net ownership) using a probit model and the second part (number of bed nets) using a negative binomial count model. The negative binomial model was favored over the Poisson because of overdispersion (probability $> \chi^2 = 0.00$). The two-part model is based on ownership of both treated and untreated bed nets. In this analysis, we have assumed that insecticide on bed nets lasts for six months.[40]

The models also include an index of household wealth (wealth3) to measure access to material resources. The first component from principal components analysis is used to assign weights to a group of assets.[41–43]‡ In this study, data on 14 assets were collected, 6 of which are related to livestock (cattle, donkeys, goats, horses, sheep, and none§) and 8 of

‡ Principal components analysis assumes that household long-run wealth, or access to material resources, explains the maximum variance in the asset variables. According to McKenzie (2003: 5), given an asset vector $x = (x_1, x_2, \ldots, x_p)'$, the first principal component of the observations, y, is the linear combination

$$y = a_1\left(\frac{x_1 - \bar{x}_1}{s_1}\right) + a_2\left(\frac{x_2 - \bar{x}_2}{s_2}\right) + \ldots + a_p\left(\frac{x_p - \bar{x}_p}{s_p}\right), \qquad (1)$$

whereby sample variance is maximized, subject to the restriction that $a'a = 1$, where a is the vector of coefficients, and $\bar{x}_k$ and s_k are the mean and standard deviation of variable x_k. The wealth index of household i with assets x_i is $y_i = a'\tilde{x}_i$, where $\tilde{x}_i$ is the vector of standardized variables above. The wealth index has zero mean and variance λ, where λ is the largest eigenvalue of the correlation matrix of the asset vector x.

§ Some respondents entered positive values in the 'none' category, which suggests they interpreted it as 'other'. On that basis we include it here.

which are related to durable assets (bicycles, carts, beds, motorbikes/cars, radios, TVs, tin roofs, and watches). The wealth index represents the maximum discrimination between households, whereby the assets that vary most across households get the greatest weight.

RESULTS

Table 1 shows the descriptive statistics of all independent variables. The average number of bed nets per household was 2.8 and the average household size was 8.8. Approximately 74% of households owned at least one net but only 28% of nets were treated. The wealth index has zero mean, varying from a low of –2.36 to a high of 12.93. The average unit value paid by the 1,104 households who had bed nets was 89.39 Dalasis or US $3.28. The maximum unit value was 200 Dalasis (US $7.35) and the minimum unit value was zero. The average household head was 49 years of age. Approximately 90% of heads were married and male. The three main ethnic groups of Wollof, Mandinka, and Fula were evenly represented. The road to 71% of households was impassable during certain times of the year. Approximately half of all households were from urban areas. Table 2 shows that affordability was the main reason for not owning a bed net (64%).

Table 3 shows that household size, expenditure on other malaria prevention products and practices, age, education, ethnicity, occupation of household head, and whether the road to a community was impassable at certain times of the year were all significant determinants of bed net ownership. Specifically, the likelihood of net ownership decreases with an increase in the number of household members in the 20–29-year-old age bracket and increases with the number between 5 and 9 years of age. The more a household spends on other forms of malaria prevention, the less likely they are to own a bed net. The older the household head and the more education he or she has had, the greater the likelihood of bed net ownership. Households where the head is a business person are also more likely to own a net. The more people in a household that are immediately related to the household head also increase the chances of bed net ownership (at the 10% level). Wollof and Fula households are less likely to own a bed net compared with the reference household headed by a Mandinka farmer. Lastly, households located in communities that are cut off from main roads at different times of the year because of flooding and other causes are less likely to own a net.

Table 3 also includes the results of the negative binomial model of the determinants of the number of bed nets owned.

TABLE 1
Descriptive statistics for models

Variable	Mean/proportion	SD	Minimum	Maximum
Number of bed nets per household	2.84	2.84	0	19
Households that own at least one net	0.74	0.44	0	1
Number in household	8.81	5.22	1	33
Wealth index (wealth3)	-4.62×10^{-10}	1.83	–2.36298	12.93448
Price of a bed net (Dalasis)	89.39	32.62	0	200
Nets treated	0.28	0.45	0	1
Expenditure on other forms of malaria prevention	41.58	66.84	0	920
Number in household 0–4 years old	1.33	1.41	0	10
Number in household 5–9 years old	1.35	1.31	0	9
Number in household 10–14 years old	1.14	1.26	0	9
Number in household 15–19 years old	1.05	1.18	0	11
Number in household 20–29 years old	1.32	1.32	0	9
Number in household 30–39 years old	0.89	0.91	0	8
Number in household 40–54 years old	0.96	0.88	0	5
Number in household 55–59 years old	0.67	0.83	0	5
Number in household who are immediately related to head	6.43	4.36	0	25
Age of household head	48.90	14.65	0	101
Household head is male	0.88	0.33	0	1
Household head years of schooling	2.35	5.28	0	31
Household head is married	0.90	0.31	0	1
Household head is Fula	0.23	0.42	0	1
Household head is Wollof	0.37	0.48	0	1
Household head is a business person	0.18	0.38	0	1
Household head has other occupation (i.e., not business person)	0.01	0.08	0	1
Provisional shop in community	0.65	0.48	0	1
Household has access to piped water	0.49	0.50	0	1
Community's main road is impassable at different times of the year	0.71	0.45	0	1
Distance of community to motorable road (km)	1.14	1.46	0.002	8
Road quality (excellent = 1; good = 2; fair = 3; poor = 4; very poor = 5)	0.47	0.50	0	1
Distance to public transport (km)	1.27	1.59	0.005	8
Distance to public telephone (km)	3.70	5.94	0.01	25
Urban household	0.49	–	0	1
Peri-urban household	0.14	–	0	1
Rural household	0.37	–	0	1
January–March*	0.16	0.36	0	1
April–June	0.26	0.44	0	1
July–September	0.28	0.45	0	1

* Demand for bed nets is compared across different times of the year. These are defined in four quarters. Each quarter is compared to the rainy season (October–December). A typical rainy season for The Gambia is September to November but in 2003 the rains came late.

TABLE 2
Reasons for not owning any type of bed net

Reason	No.	%
Do not need one	54	11.79
Do not trust them	12	2.62
Not enough money	295	64.41
Not easily available to buy	5	1.10
Prefer to use medicine	23	5.02
Other	69	15.07
Total	458	100

Price was found to be a significant determinant of the number of nets owned at the 10% level. Curiously, this was a positive relationship; a 10% increase in price resulted in a 1% increase in net ownership. Wealthier households owned significantly more nets. The more household members 0–4 years of age and greater than 55 years of age, the greater the number of nets owned (at the 10% level). In contrast, the more household members between 5–9 years of age, the fewer nets owned. The number of household members immediately related to the head and households headed by a business person all had a positive influence on the number of nets owned. Wollof and Fula households owned fewer nets compared with Mandinka households.

TABLE 3
Two-part model of determinants of demand for treated and untreated bed nets

Variable	Coefficient	
	Probit	Negative binomial
Price of a bed net		0.10*
Number in household	0.54†	0.48†
Wealth index (wealth3)	0.03	0.08†
Expenditure on other forms of malaria prevention	–0.003†	–0.00
Number in household 0–4 years old	0.04	–0.03†
Number in household 5–9 years old	0.07†	–0.04†
Number in household 10–14 years old	–0.02	–0.00
Number in household 15–19 years old	–0.05	–0.01
Number in household 20–29 years old	–0.11†	–0.01
Number in household 30–39 years old	0.03	0.00
Number in household 40–54 years old	0.03	0.04
Number in household 55–59 years old	0.06	0.04*
Number in household who are immediately related to head	–0.03*	0.02†
Age of household head	0.01†	0.00
Household head is male	–0.09	0.12†
Household head years of schooling	0.02†	–0.00
Household head is married	0.20	–0.08
Household head is Fula	–0.74†	–0.26†
Household head is Wollof	–1.11†	–0.24†
Household head is a business person	0.20†	0.15†
Household head has other occupation (i.e., not business person)	–0.30	0.16†
Provisional shop in community	–0.05	0.03
Household has access to piped water	0.04	–0.13†
Community's main road is impassable at different times of the year	–0.46†	–0.07
Distance of community to motorable road (km)	0.07	–0.04
Road quality (excellent = 1; good = 2; fair = 3; poor = 4; very poor = 5)	–0.26	–0.13†
Distance to public transport (km)	–0.04	0.01
Distance to public telephone (km)	–0.00	0.00
January–March	0.34	0.05
April–June	0.22	0.07
July–September	–0.05	–0.06
Regression constant	0.38	–0.02
Log pseudolikelihood	–783.21	–2,066.59
Pseudo R^2	0.17	
Probit > χ^2	0	0
No.	1,630	1,104

* Significant at the 10% level ($P < 0.10$).
† Significant at the 5% level ($P < 0.05$).

DISCUSSION

This study shows that although 75% of Gambian households owned at least one bed net, less than one-fourth of these were treated. Although low retreatment rates with conventional insecticide nets has been reported as a problem in most African countries,[18] The Gambia has often been seen as something of an exception. In 1992, the Government of The Gambia was encouraged to initiate a National Impregnated Bednet Program as part of the National Malaria Control Program Strategy. An evaluation study conducted in 1996 showed that 83% of the bed nets surveyed had been impregnated and 77% of children less than five years of age and 78% of women of childbearing age were reported to be sleeping under impregnated bed nets.[44] Unfortunately, this study and others have shown that although Gambian households still have more nets than many other African households in areas at risk for malaria, the number of treated nets has decreased dramatically since the height of the national program.[45] However, there is potential to increase the use of ITNs by providing insecticide treatment of any untreated nets already in houses.[18] Based on the comparative coverage with untreated and treated nets reported in this study, this could result in a four-fold increase in the number of Gambian households with ITNs. Much depends however on the quality of the nets being re-treated.[45]

Particular attention also needs to be paid to cultural or ethnic related reasons for bed net ownership between the three main ethnic groups. This study showed that Mandinka households are more likely to own a bed net than the other ethnic groups. The reasons for this require further investigation. If this is the result of a lower value placed by certain ethnic groups on bed net use or greater geographic or financial barriers to access, then more attention must be paid to designing community interventions and education and awareness campaigns that target the needs of those groups less likely to own bed nets.

Another important result for malaria control policy concerns the relationship between expenditure on all types of bed nets versus other popular forms of malaria prevention. Expenditure on aerosols, coils, indoor spraying, smoke, and other prevention strategies such as drinking herbs and cleaning the outside environment was shown to be negatively associated with the ownership of bed nets. Under this model, bed nets and other malaria prevention activities/products are substitutes rather than complements. It suggests that activities designed to promote the consumption of bed nets may cause a shift away from other forms of malaria prevention. It is widely assumed by public health entomologists that many commercial and traditional products offer little or nothing in the way of protection. Consequently, this may be interpreted as an encouraging finding. However, much depends on the level of protection offered by these alternative products. Currently, we know little about this.

Most malaria control programs, including that of The Gambia, undertake a range of activities designed to promote the use of ITNs by those less than five years of age. This is justified on the grounds of the higher malaria burden in this group and the demonstrated effectiveness of bed net use in reducing childhood mortality.[46–48] In this study, we reported two key results relating to age and the demand for bed nets. First, we found that households with children less than five years of age were no more likely to own a bed net compared with households with persons more than five years of age. Other studies have also reported low levels of bed net ownership in those less than five years of age.[49,50] However, when we analyzed the determinants of the number of bed nets owned by a household, we found that this was positively associated with the number of children less than five years of age, as well as with the number of children 5–10 years of age. At first glance, these two results seem incompatible. One possible explanation is that although most households in this study (75%) owned about two nets, households with young children may own a greater number of nets because pregnant women tend to receive free nets from the government.

The results of this study also inform price setting practices, particularly in terms of calculating subsidies for bed nets in the public sector. In this analysis, price was found to be a significant determinant (at the 10% level) of the number of bed nets owned. Surprisingly, this was a positive relationship with the number of nets owned increasing with price. Other studies of health care demand in low-income countries have also shown a positive relationship between demand and price.[51–53] One of the key explanations put forward for this has been the role of quality with some households and patients willing to pay more for high quality treatment.[51] This explanation could be extended to bed nets. It is not inconceivable that some households may be willing to pay more for nets that are promoted as higher quality products (i.e., treated, more durable, allow for greater ventilation). This explanation is purely speculative. Further analyses are needed to test for the impact of price on net ownership.

In terms of malaria control policy, the role of community infrastructure in the demand for bed nets should not be underestimated. The results of this study imply that the demand for bed nets can be significantly increased if certain aspects of public infrastructure, including road quality and access to piped water, are improved. There has been a tendency in past modeling exercises to focus on individual or household level determinants of demand. However, this analysis reinforces the need to take a broader perspective. Improving road quality, for example, may have as much impact on promoting the demand for bed nets as health education campaigns or financial subsidies. This reinforces the view that the task of malaria control cannot be left entirely to health services.

This study had three key methodologic challenges. Data was collected on bed net expenditure and number of bed nets owned. We were therefore able to determine the unit value of each bed net purchased by the household. Although it is not uncommon for unit values to be taken as a noisy indicator of prices,[38] caution is needed. For example, the household's choice of expenditure on bed nets determines in part the unit value of each bed net. Thus unit values are perhaps only partially, a choice variable, whereas prices are determined in the market and can be considered exogenous to the household. Measurement error in the expenditure variable or in the number of bed nets variable will lead to measurement error in the unit value variable. Lastly, if a household chooses not to have any bed nets, then we have no information on unit values.

In this study, because approximately 26% of households did not own a bed net, no unit values could be assigned. We chose to apply a two-part model, whereby the decision to acquire bed nets is first modeled, followed by the decision on how many bed nets are acquired. The unit value data was included in the second part of the model. However, if one was confident no marked differences existed between households with and those without bed nets, then it could be assumed that these households choose not to have bed nets (i.e., that their choice of no bed nets represents a corner solution). In turn, unit values as a variable could be excluded and a negative binomial or Poisson model run; the choice of model depending on the presence of overdispersion.¶ When analyzing the reasons why households did not own a bed net, we identified some factors that could indicate structural differences between these two sets of households. For example, approximately two-thirds of respondents said they did not own a net because they could not afford one. Consequently, we chose to use the two-part model. For the purposes of comparison we also ran the negative binomial model (Appendix 1), which generated different results to the two-part model. This highlights the importance of analysts giving careful consideration as to whether structural differences exist between households with and without nets.

Another challenge is the measurement of household income or total expenditure. This is difficult especially in low-income settings.[36,55] We chose instead to use an index of household wealth to measure access to material resources. Measurement based on asset ownership has a number of advantages.[43] For example, there is likely to be less recall bias and mismeasurement of ownership of assets by comparison with income and consumption in developing countries. This is especially problematic for farmers and self-employed workers because of the effects of seasonality, measuring and valuing home-produced consumption, and imputing rental values and service flows from housing and other durables. The time taken to collect data on asset ownership is less than that for consumption and income data, which is an important consideration for surveys that can place onerous demands on the respondents' time. From an economic point of view, a key limitation of asset based indices is that they cannot be used to model the demand for bed nets in terms of a constrained budget (i.e., consumers maximize utility subject to an income constraint). They also have some practical limitations such as focusing on ownership at the household level and thereby overlooking the fact that poor individuals often live in relatively wealthy households.[56] Detailed critiques of asset-based indices can be found elsewhere.[41,43]

Finally, this study assessed bed net ownership as opposed to use. These two concepts are not necessarily synonymous. People who own bed nets may not use them for the correct purpose or use them only at certain times of the year.[57,58] Modeling net ownership can provide useful insights into the factors influencing demand, which can be used to inform public policy decisions about the universal provision of free bed

¶ Overdispersion occurs when the variance is greater than the mean.

nets or their targeting towards specific groups. However, future efforts to model the determinants of bed net use may enable greater fine tuning of these policy initiatives.

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Note: Appendix Table 1, Determinants of demand for treated and untreated bed nets (full sample), appears online at www.ajtmh.org.

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