The Demand for Malaria Prevention in The Gambia

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Abstract
The use of bednets is an important, cost-effective element in malaria control strategies. Little is known, however, on the extent of bednet ownership in sub-Saharan Africa or the factors that influence the number of bednets owned. This study collected data on bednet ownership as well as a range of socio-economic and demographic indicators from 966 households in The Gambia. We found that the average household had 3.2 bednets as against 9.2 household members. We found that the principal determinants of the demand for bednets included household wealth (as measured by a wealth index which is one of the paper's innovations), demographic composition of the household and characteristics of the household head including age, marital status, ethnicity and occupation. Considerable inequality in wealth in The Gambia was identified, which as implications for public policy decisions about the universal provision of free bednets or their targeting at specific groups.

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1. Introduction

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, the vast majority in sub-Saharan Africa (WHO 2001). In addition to health outcomes, malaria has been shown to have a significant impact on the productivity and wealth of households (Sauerborn et al, 1991; Shepard et al, 1991; Gilson et al, 1994) and on economic growth (Gallup & Sachs, 2001).

One of the most widely advocated strategies for preventing malaria in African communities is through the use of Insecticide Treated Nets (ITNs). There is a growing literature highlighting the cost-effectiveness of ITNs in the African setting (Goodman et al 1999; Goodman et al 2000; Lengeler 2001; Wiseman et al 2003). In contrast, 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.

The aim of this study is to provide quantifiable estimates of the relative impact of different factors on the demand for ITNs in The Gambia. This information is important for a number of reasons. Firstly, it is based on revealed preferences rather than stated preferences and as such it will provide a more 'objective' basis for analysing 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. Secondly, many of the existing studies of prevention seeking behaviour provide an indication of utilisation patterns and the key determinants of those patterns, one cannot assess the relative importance of those differences in the demand for malaria prevention or the magnitude of their marginal impact. Consequently, in this study we test for the statistical significance of each determinant of demand while controlling for other factors. Quantitative estimates of the impact of marginal changes in explanatory variables of demand will also be generated. This analysis can then be used to predict the effect on demand of changes in price setting practices in the commercial sector for ITNs. Finally, from a policy perspective, there has been and continues to be considerable demand for ITNs from the public sector in many African countries. This analysis can also provide some insights into the potential constraints facing such initiatives.

2. Background

Very few studies have attempted to estimate the relative influence of the different determinants of treatment and prevention for malaria and febrile illness (Bartolome and Vosti, 1995; Asenso Okyere et al, 1997; Mensah, 2000). Even fewer have been conducted in the area of malaria prevention (Simon et al 2002). In relation to malaria treatment, studies have tended to focus on explaining patients' choice of provider. For example, Asenso Okyere et al (1997) found that the choice of malaria care providers is influenced by facility price, travel time, waiting time for treatment, a range of demographic factors (including education, age and sex) and finally, the quality of care measured in terms of drug availability. Cost of treatment was the major determinant of where a person chooses to seek malaria care. They also reported that as income rises, individuals lean more towards self-medication when they get malaria. The authors conclude from this that as user charges are raised at government facilities more people are likely to turn to private or mission facilities where quality is perceived to be relatively higher.

In Brazil, Bartolome and Vosti (1995) investigated the responsiveness of demand to changes in price and wealth for the purposes of informing the implementation of a subsidy for treatment in private clinics. They found that individuals suffering from malaria were more likely to choose treatment at a better but more expensive clinic as household wealth increases and as price decreases. Mensah (2000) found that in Benin a patient's age, total expenditure, ethnicity, treatment costs and participating in a local credit scheme significantly affected the choice of treatment.

In terms of prevention, only one study predicting the responsiveness of demand for ITNs to a change in price was identified. This study predicted that reducing tariffs on insecticides on ITNs from 42% to zero and the tariff on netting materials from 40% to 5% would lead to an increase in the demand for ITNs by between 9 and 27% (Simon et al 2002). Other factors *predicted* to influence demand for ITNs include historical patterns of use, household knowledge of the benefits of ITNs, access to markets where ITNs and retreatments are sold and access to savings or credit (Agyepong and Manderson, 1999; Reed and Viswanathan, 1997; Mills, 1998).

To inform malaria prevention programmes, we must gain a better understanding of why people make the choices they do. Estimating demand has an important role to play in the area of malaria prevention where user preferences 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.

3. Theoretical Model of Demand for Bednets

Households obtain utility from consumption c and health h. The health of household members depends on their probability of being infected with malaria and their innate resistance to malaria r. Denote the reduction in probability of infection from malaria by using a bednet as z such that the health benefits of using a bednet can be written as a function $h(z|r)$. The innate resistance of household members depends on demographic characteristics d, $r(d)$. The wealth of the household is w, the price of a bednet is p and the number of bednets invested in is x. Thus the household's utility function can be expressed as:

$$u(w - px) + h(z \mid r(d)) \qquad (1).$$

As we outline below, data on income or total expenditure was not collected for this study, so we cannot frame the demand for bednets in terms of a constrained maximisation problem. Nevertheless, (1) highlights that the household's decision on how many bednets to invest in depends on w, p, and d, if we assume that z and $r(.)$ do not vary across households.

4. Empirical Considerations

Data

Nine hundred and sixty six households were interviewed in urban and rural parts of the Farafenni district of The Gambia, from January 2003 to July 2003. Stratified clustered sampling was used to select these households. All households in the selected clusters were listed and equal numbers randomly selected from each cluster. In addition to geographic location, villages were also stratified according to the distance to formal health care facilities.

Face to face structured interviews were held, usually with the head of the household for this part of what was a more detailed questionnaire. As well as details of their expenditure on bednets, they were asked about demographic and socio-economic characteristics of the household. The survey design built on the principles of the World Bank's Living Standards Measurement Surveys (Deaton, 1997) and interview lasted approximately 30-40 minutes.

Table 1 defines all variables used.

Table 1 Variable Definitions

Variable	Definition
numbednets	No. of bednets owned by hh
wealth3	Index of hh wealth
unitvalue	'Price' of a bednet (=household expenditure on bednets / number of bednets)
age04	No. in hh aged 0 to 4
age59	No. in hh aged 5 to 9
age1014	No. in hh aged 10 to 14
age1519	No. in hh aged 15 to 19
age2029	No. in hh aged 20 to 29
age3039	No. in hh aged 30 to 39
age4054	No. in hh aged 40 to 54
age55	No. in hh aged 55 and over
male	No. in hh who are male
immediate	No. in hh who are immediately related to head
numhh	No. in hh
hage	Age of head
hmarried	Head is married =1, 0 otherwise
hmadinka	Head is Madinka = 1, 0 otherwise
Hfula	Head is Fula = 1, 0 otherwise
hwollof	Head is Wollof = 1, 0 otherwise
hothereth	Head is from another ethnic group = 1, 0 otherwise
Farmer	Head is a farmer = 1, 0 otherwise
business	Head is a businessman = 1, 0 otherwise
otherocc	Head has another occupation = 1, 0 otherwise

Wealth and Access to material resources:

We use an index of household wealth (wealth3) as a measure of access to material resources. While, for developing countries, consumption is considered as "the best measure of the economic component of living standards" (Deaton and Grosh, 2000:95), this survey collected information on each household's ownership of a number of assets and livestock as a measure of material living standards. Measurement based on asset ownership has a number of advantages. First, there is likely to be less recall bias and mis-measurement of ownership of assets by comparison with income and consumption in developing countries. This is especially so for farmers and self-employed workers, due to the effects of seasonality, measuring and valuing home-produced consumption and imputing rental values and service flows from housing and other durables. Second, 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. This may be especially the case for respondents who have little or no formal education, on whom survey data is especially valuable. Third, cross-country comparisons of asset ownership requires fewer assumptions about survey methodology and purchasing power parity than similar comparisons of consumption or income data.

A number of approaches have been suggested to aggregate across assets so that a composite figure for a household's access to material resources can be calculated. One approach is to simply add up the number of assets owned (Montgomery et al., 2000). However, this implies that ownership of a motorbike and a watch are valued equally, which is difficult to justify. A second approach is to weight each asset by its market value (Conteh et al., 2003), so that if a motorbike is worth twenty times what a watch is worth, it gets twenty times the weight in the aggregation process.

A third approach is to use the first component from principal components analysis to assign weights to each asset (Filmer and Pritchett, 2001; Minuijn and Bang, 2002; McKenzie, 2003). This approach 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 $x = (x_{1,} x_{2,} ..., x_{p,})'$, the first principal component of the observations, y, is the linear combination

$$y = a_1\left(\frac{x_1 - \bar{x}_1}{s_1}\right) + a_2\left(\frac{x_2 - \bar{x}_2}{s_2}\right) + ... + a_p\left(\frac{x_p - \bar{x}_p}{s_p}\right), \tag{2}$$

whereby sample variance is maximised, 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 standardised 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. The wealth index represents the maximum discrimination between households, whereby the assets that vary most across households get the greatest weight. An asset that doesn't vary across household gets a weight of zero for instance, as it explains none of the variation across households.

Data on fourteen assets were collected, six of which related to livestock (cattle, donkeys, goats, horses, sheep and none[1]) and eight of which related to durable assets

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

(bicycles, carts, beds, motorbikes/cars, radios, TVs, tin roofs and watches). Table 2 exhibits the summary statistics and main statistics relating to the principal components analysis.

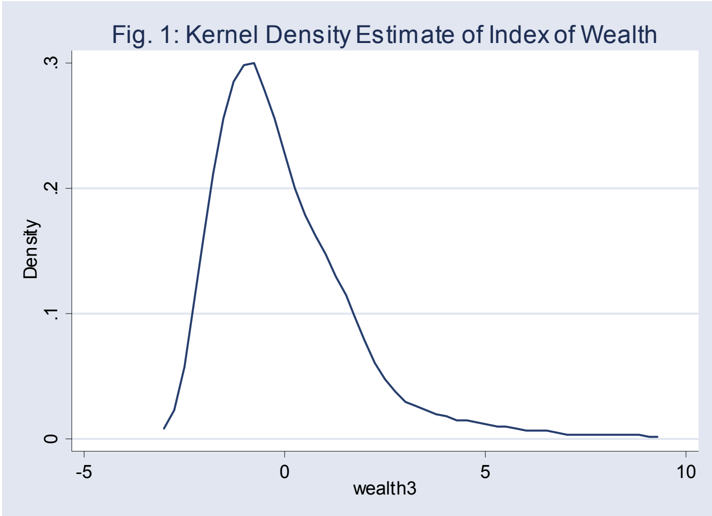
Table 2: Principal Components Analysis and Summary Statistics for Wealth Indicators

Variable	Scoring Factor for 1st Principal Component			Summary Statistics			
	Livestock Only	Durable Assets Only	All Indicators	Mean	Std. Dev.	Min.	Max.
Livestock							
Cattle	0.516		0.284	1.989	7.095	0	90
Donkeys	0.219		0.171	0.296	0.654	0	6
Goats	0.492		0.306	2.145	3.420	0	28
Horses	0.447		0.269	0.239	0.611	0	5
None[1]	-0.030		0.013	0.009	0.236	0	7
Sheep	0.493		0.319	1.309	2.882	0	29
Durable Assets							
bike		0.307	0.218	0.371	0.738	0	9
cart		0.186	0.271	0.340	0.586	0	8
bed		0.430	0.417	4.938	3.218	0	21
motorbike		0.267	0.138	0.076	0.329	0	4
radio		0.429	0.315	1.249	0.990	0	7
TV		0.313	0.149	0.202	0.506	0	6
tinroof		0.387	0.351	1.356	1.285	0	8
watch		0.428	0.253	1.194	1.429	0	13
Livestock Index				0.000	1.455	-1.700	11.137
Durable Asset Index				0.000	1.647	-2.282	9.064
All Indicators Index				0.000	1.844	-2.446	10.239
Eigenvalue[2]	2.116	2.711	3.399				
% variance[3]	35.3	33.9	24.3				
N	950	947	947				

Notes: 1. 'None' presumably refers to 'other livestock' as positive responses were collected.
2. Eigenvalue associated with the first component
3. Percentage of variance associated with the first component

We find considerable variation in the ownership of livestock, especially cattle, goats and sheep, with a little less variation in ownership of durable assets. Separate indices are calculated for livestock, durable assets and all wealth indicators. In the livestock index, all scores are positive except on 'none', while all scores are positive on the durable asset index. For the 'all indicators' index, all scores are positive. The results of the 'all indicators' index demonstrate, for instance, that if a weight of 0.284 is assigned to number of cattle owned by the household, then discrimination between households is maximised. The first component of the 'all indicators' index accounts for 24.3% of total variation in all indicators.

McKenzie (2003) highlights the importance of ensuring that there is a sufficiently broad class of asset indicators collected to discriminate adequately between households. Two potential problems are clumping and truncation. Clumping is where we cannot distinguish between households from the asset list collected and they are consequently clumped together on the same asset index value. Truncation is where the asset list does not allow us to distinguish between the poor and the very poor, for instance. Clumping and truncation are examined in Figure 1 by plotting the kernel density function of the asset index using the Epanechnikov kernel with Stata's default band-width.



The distribution of wealth is reasonably smooth. Given the absence of local peaks and troughs, there is little evidence of clumping. There may be some truncation at the bottom of the distribution, reducing its ability to distinguish poor households from very poor households. The positive skew and long right-hand tail indicate the degree of wealth inequality in The Gambia.

An alternative to generating a composite measure of wealth for each household is to model the effect of a household's access to material resources on their demand for bednets by including all assets as separate variables. While interpretation of each individual variable might be difficult, a more responsive model is possible. We present the results here for the composite index, wealth3, here and present those for the alternatives in the appendix.

Other variables

The survey collected data on expenditure on bednets and number of bednets owned. As such we can determine the unit value of each bednet purchased by the household. For a number of reasons, we cannot interpret unit values as prices. First, the household's choice of expenditure on bednets determines in part each bednet's the unit value. Thus unit value is, perhaps only partially, a choice variable, whereas prices are determined in the market and can be considered exogenous to the household. Second, measurement error in the expenditure variable or in the number of bednets variable will lead to measurement error in the unit value variable. Third, if a household chooses not to have any bednets, then we have no information on unit values. Nevertheless, unit values have been used as a noisy indicator of prices (for example Deaton, 1997). In this study, 20% of households do not have bednets, so no unit values can be calculated. We can either include these households, assume that they choose not to have bednets (that their choice of no bednets represents a corner solution) and exclude unit values as a variable. Alternatively, we can apply a two-part model, whereby the decision to acquire bednets is first modelled, followed by the decision on how many bednets to acquire. The unit value data can be included in the second part of the model. Since we have no prior expectation that those without bednets are structurally different from those who do (indeed we have information on reasons for not acquiring bednets, which included a preference for other forms of prevention, a reliance on medicine and a dislike of bednets but nothing that would mark them out as coming from a different 'type' of household) we apply the first alternative. The two part model is reported in the appendix.

Age and gender are included to model inter-household differences in the effect of infection with the malaria virus on health status. Malaria is very dangerous for young children and the elderly, less so for fit adults. Thus, we expect that the more young children and elderly in a household, with more bednets in the household, *ceteris paribus*.

The Gambia is a polygamous society, and Gambian households do not conform to Western notions of the nuclear family. It is common for men to have up to three wives, households can run over three or more generations, while step-children, in-laws and adopted children can also prevail. We test the effect of extensions to the head's family on demand for bednets by creating a variable called 'immediate'. This counts the number in the household who are wives, children (including adopted, foster and step-children), grandchildren and parents of the head. It excludes uncles and aunts, brothers and sisters, nieces and nephews, in-laws, wards, friends, students and other members of the household. We suggest that the greater the number in the household that are immediately related to the head, the greater the demand for bednets. However, our choice of who is immediate is arbitrary, and this variable needs to be discussed in detail with anthropologists who are working on the project.

If the wealth indicator is to measure marginal utility of consumption, it must be adjusted for household size. The inclusion of number in each age group may provide an adequate equivalence scale, but the total number in the household (numhh) is also included.

The characteristics of the head (age, marital status, ethnicity and occupation) are self-explanatory. Data on the education of the head was also collected. However, we wished to collect data on formal schooling only, while many respondents seem to have interpreted the question to include years of Koranic schooling. Since we were unable to distinguish between the presumed positive effect of formal schooling on demand for bednets and the unknown effect of Koranic schooling, we exclude the variable. In unreported work, we included schooling and found it to be insignificant.

Table 3 exhibits descriptive statistics.

Table 3 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
numbednets	952	3.20	2.96	0	19
wealth3	947	0.00	1.84	-2.45	10.24
unitvalue	741	86.08	48.96	0.00	1000.00
age04	964	1.38	1.48	0	10
age59	964	1.37	1.35	0	9
age1014	964	1.19	1.27	0	9
age1519	964	1.12	1.21	0	11
age2029	964	1.39	1.35	0	9
age3039	964	0.91	0.94	0	7
age4054	964	0.99	0.87	0	5
age55	964	0.75	0.87	0	5
male	964	4.38	2.87	0	20
immediate	964	7.78	4.48	0	26
numhh	964	9.27	5.41	1	33
hage	964	50.08	15.41	0	101
married	955	0.90	0.30	0	1
hmadinka	964	0.49	0.50	0	1
hfula	964	0.15	0.35	0	1
hwollof	964	0.30	0.46	0	1
hothereth	964	0.05	0.22	0	1
hfarmer	954	0.49	0.62	0	1
business	954	0.12	0.33	0	1
otherocc	954	0.39	0.49	0	1

The average number of bednets per household was 3.2, varying from zero to 19. As outlined above, the wealth index has zero mean and varying from a low of –2.45 to a high of 10.24. The average unit value paid by the 741 households who had bednets was 86.08 dalasis, or about €2.40. The maximum unit value of 1000 dalasis indicates a coding error, while the minimum value of zero is possible, since The Gambia has a free bed net programme, at least nominally.

Age categories were chosen such that a reasonably similar number of people were allocated to each age group, having account for important demographic considerations, such as the number of children under 4 and the number of elderly. As such, the average number in each age group ranged from 1.39 amongst those aged 20 to 29 to 0.75 amongst those aged over 55.

The average number of persons per household was 9.27, ranging from one to 33, which illustrates the difference between typical Gambian household structures and Western ones. The number of people per household classified as immediately related to the head was 7.78 on average, varying from none to 26. Caveats regarding this variable should be borne in mind. The average head was aged 50 and 90% of heads were married. The three main ethnic groups constituted 95% of the total sample. The composition of the other ethnic groups is reported in the appendix. Forty nine percent of heads were farmers, 12% were businessmen while the remainder were from disparate occupations, more details of which are available in the appendix.

A final note on imputation of missing values is required. According to King et al. (2001) "almost all" political science analysts fill in some survey responses with educated guesses. For the purposes of this paper, we are forced to do the same. Nine hundred and fifty two households responded to a question on their ownership of bednets, 758 of whom stated that they had bednets. Of this 758, 752 stated that they bought their bednets, and all other responses to this question were coded as missing, while 688 reported how much they paid for their bednets. If a respondent had answered the bednet ownership question but did not answer the questions on whether they paid for their bednets, or how much they paid, we chose to recode the missing values as zeroes. This assumption for the question on how much they paid may be particular controversial.

While 947 households responded to the question on ownership of durable assets, only 674 households answered the question on ownership of livestock. We suggest that the lower response rate was because households who had no livestock were coded as a 'no response'. Indeed, not one response by the 674 households who responded was zero, indicating that this is a reasonable conclusion to draw. Thus, if a household answered the question on ownership of assets but not the question on livestock, they were coded as having zero livestock.

An alternative approach would be to multiply impute missing values. Future work may consider this option.

Econometric Methods

Since the dependent variable, number of bednets owned by each household, is an integer count variable it can be modelled using count models such as the Poisson and negative binomial. The negative binomial model allows for overdispersion due to individual heterogeneity, whereas the Poisson requires that the mean and variance of outcomes are equal. Thus the Poisson is a special case of the negative binomial. Its appropriateness is tested below using a likelihood ratio test.

We interpret the negative binomial model in terms of a factor change in the rate, as described in Long and di Freese (1997). Denote $E(y \mid x, x_k)$ as the expected count y for a given vector of covariates x where we note the value of x_k, and denote $E(y \mid x, x_k + \delta)$ as the expected count after increasing x_k by δ units, then

$$\frac{E(y \mid x, x_k + \delta)}{E(y \mid x, x_k)} = e^{\beta_k \delta}.$$

Therefore, for a change δ in x_k, the expected count increases by a factor of $e^{\beta_k \delta}$.

If we are to include data on unit values, a two-part or hurdle model (Pohlmeier and Ulrich, 1995) needs to be applied, since we do not have data on unit values for those households that do not own bednets. We model the first part using a probit model and the second part using a negative binomial count model. Results are reported in the appendix.

5. Results:

Table 4 presents the determinants of demand for bednets.

Table 4 Determinants of Demand for Bednets

Variable	Coef.	P>|z|
wealth3	0.098	0.00
age04	0.008	0.71
age59	-0.022	0.37
age1014	-0.026	0.30
age1519	-0.047	0.07
age2029	-0.083	0.00
age3039	0.013	0.65
age4054	0.037	0.26
age55	0.025	0.52
male	0.007	0.63
numhh	0.069	0.00
hage	0.005	0.03
married	0.285	0.00
hfula	-0.480	0.00
hwollof	-0.644	0.00
hothereth	-0.266	0.02
business	0.036	0.62
otherocc	-0.236	0.00
_cons	0.352	0.01
McFadden's adj. R^2	10.6%	
Prob > χ^2	0.00	
N	939	

The negative binomial model was favoured over the Poisson due to the presence of overdispersion (Prob > χ^2 = 0.00). The reference household is one headed by a Madinka farmer. Significant variables include wealth, number aged between 15 and 19 (at the 10% level), number aged between 20 and 29, number in the household, the age of the head, their marital status, their ethnicity and whether or not they have an occupation other than farmer and businessman.

The coefficient on wealth implies that a one unit increase in a household's wealth index leads to an increase in their number of bednets by a factor of 1.103. This is a relatively modest economic effect given that 50% of the sample are within 2 index units of each other.

While the age variables are jointly significant, only the number in the household aged 20 to 29 is significant at the 5% level, although the number in the household aged 15 to 19 is significant at the 10% level. The negative signs on these variables is consistent with our hypothesis that the greater the effect of malaria infection on health status the greater the demand for bednets, since these age groups consist of fit adults who are least at risk of serious damage from infection. The gender variable is not significant, indicating no evidence of discrimination against women, for instance, in the household's demand for bednets.

The number of males and females in each age category was also modelled. This produced values for McFadden's adjusted R^2, the Akaike Information Criterion and the Bayes' Information Criterion of almost identical values to those reported here. Thus the simpler model where the age and gender elements of household composition are additively separable is favoured.

Over and above the effect of number in each age category, the number of people in the household had a significant effect, with each additional person in the household increasing the number of bednets by a factor of 1.071. When we experimented with the removal of numhh, the age effects became stronger. Those aged over thirty, and especially over fifty five, as well as those aged under five had a positive effect on number of bednets acquired. However, these effects were eliminated once the number in the household are included and explained variance improved. Thus the number in the household has an important positive effect on demand for bednets, over and above household composition.

Age of the household head and their marital status have significant effects on demand as does ethnicity. The number of bednets in the household increases by a factor of 1.33 if the head is married. If the head is a member of the Madinka ethnic group, the household's demand for bednets is considerably enhanced. These ethnic differences could be due to differences in tastes or differences in living standards not detected by the wealth variable. Finally, while households headed by a businessman do not differ in demand from households headed by farmers, heads with other occupations have lower demand. Many of these other occupations, including fisherman, herdsman, 'no occupation and domestic help, may have lower socio-economic status than that of farmer or businessman, meaning that this result is detecting income-related or education-related differences in demand. Further work on a socio-economic categorisation of all occupations may enlighten us further. A list of all occupations is provided in the appendix.

The 'immediate' variable, reported in Table 3, was included in earlier models, but was insignificant and seemed to be related to the number of people in the household. Thus it was excluded from the final model.

6. Conclusions

Most households in The Gambia own some bednets. However, the number of bednets per households is far less than the number of people per household, or indeed the number of beds per households (which is 4.9 on average, as against 3.2 bednets). Positive factors that influence the number of bednets in a household include socio-economic indicators like household wealth and occupation of the head, and demographic factors like the marital status of the head and the ethnicity of the head.

Since severity of a malaria infection depends on age, we expected demand for bednets to vary with households' demographic composition. We found that the number of people in their twenties in particular, had the expected negative effect on demand. In addition, there is evidence that males in this age group engage in high risk health behaviour, especially with respect to HIV/AIDS (Refs to be added). On the other hand, our results are not quite consistent with other findings from The Gambia where priority in terms of bednet use is given to pregnant women, the most economically productive and youngest children (Imoukheude, 2003; Lomas 2004; Jones personal communications; Clarke personal communications). The survey collected individual-level data on who in the household sleeps under a bednet, and future work will use these data to enrich our understanding of the effects of demography on demand for bednets.

Lomas (2004) showed that *unmarried* men in their twenties are less likely to use a bednet compared with married men in the same age group. One reason for this could be that married men are viewed to be economically responsible for their family and must provide at least some members of the household with a bednet as well as protect themselves. Unmarried men are often unmarried because they are of low socio-economic status, which reinforces the likelihood of them not owning a bednet. Another reason has to do with the distribution of bednets within households. As already mentioned, husbands are typically responsible for providing a bednet for themselves, their wives and their children. An unmarried male in his twenties is likely to still have the same bednet he had as a child which may be of very poor quality and no longer being used as a bednet. Lomas' (2004) findings accord with the results presented here that a household whose head is married have 33% more bednets than one whose head is unmarried, *ceteris paribus.*

The wealth index we employ has been used infrequently in developing country literature to measure access to material resources, and never in health economics literature as far as we are aware. We found that our list of assets and livestock was comprehensive enough to prevent clumping of households at particular points on the distribution, while truncation was low enough that one could discriminate between households in terms of wealth. The index illustrated considerable inequality in wealth in The Gambia. Future work should consider the effect of this material inequality on inequity in access to health care resources.

Three methodological issues need to be highlighted. First, this paper did not examine quality of bednets. The study collected data on whether or not the bednets were treated with mosquito repellent or mended in the past six months. Models of treated and mended bednets form part of the ongoing research. Second, while this paper considered only the effect of bednets as a malaria prevention strategy, the study also collected information on the use of other approaches to malaria prevention, including the use of smoke, coils, clearing vegetation, spraying and cleaning the house. It is unclear if these can be considered a complement to or a substitute for bednets. Further work will consider to appropriate way to model these data. Third, people who own bednets may not use them all the time. There is some evidence that they are used only in the rainy season when risk of infection is at its greatest (Imoukhuede, 2003). Despite this caveat, it is fair to assume the greater the number of bednets owned by the household, the greater the probability that household members will sleep under one. As such modelling ownership is worthwhile. Future work will examine seasonality in the use of bednets.

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Simon et al

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APPENDICES

Table A1 Two Part Model of Determinants of Demand for Bednets

Variable	Probit		Negative Binomial	
	Coef.	P>|z|	Coef.	P>|z|
wealth3	0.034	0.39	0.090	0.00
unitvalue	-	-	0.000	0.37
age04	0.019	0.81	-0.005	0.78
age59	-0.027	0.74	-0.023	0.21
age1014	-0.139	0.09	0.015	0.41
age1519	-0.133	0.11	-0.021	0.27
age2029	-0.210	0.01	-0.036	0.04
age3039	-0.104	0.23	0.044	0.04
age4054	-0.139	0.16	0.067	0.01
age55	-0.149	0.19	0.060	0.04
male	0.021	0.58	-0.001	0.96
numhh	0.111	0.09	0.043	0.00
hage	0.011	0.02	0.002	0.20
married	0.462	0.01	0.126	0.12
hfula	-0.953	0.00	-0.180	0.00
hwollof	-1.140	0.00	-0.257	0.00
hothereth	-0.244	0.31	-0.223	0.02
business	-0.002	0.99	0.053	0.36
otherocc	-0.360	0.00	-0.124	0.00
_cons	0.467	0.09	0.708	0.00
Pseudo. R^2	17.5			15.2
Prob > χ^2	0.00			0.00
N	939			734

Table A2 Effect of Alternative Specifications of Wealth on Demand for Bednets

Variable	Model 1 Coef.	Model 2 Coef.	Model 3 Coef.	Model 4 Coef.	Model 5 Coef.	Model 6 Coef.
age04	0.015	-0.006	0.009	0.002	-0.005	-0.004
age59	-0.015	-0.029	-0.021	-0.024	-0.025	-0.031
age1014	-0.028	-0.042	-0.031	-0.029	-0.035	-0.037
age1519	-0.045	-0.047	-0.046	-0.048	-0.047	**-0.058**
age2029	**-0.085**	**-0.083**	**-0.086**	**-0.078**	**-0.079**	**-0.090**
age3039	0.013	0.006	0.012	0.007	0.005	-0.018
age4054	0.033	0.030	0.038	0.034	0.032	-0.009
age55	0.008	0.007	0.022	0.024	0.018	-0.049
male	0.006	0.009	0.007	0.009	0.010	0.018
numhh	**0.052**	**0.091**	**0.071**	**0.084**	**0.092**	**0.054**
hage	**0.004**	**0.006**	**0.005**	**0.005**	**0.005**	**0.004**
married	**0.275**	**0.295**	**0.290**	**0.293**	**0.293**	**0.254**
hfula	**-0.396**	**-0.461**	**-0.432**	**-0.502**	**-0.494**	**-0.417**
hwollof	**-0.604**	**-0.658**	**-0.624**	**-0.668**	**-0.672**	**-0.632**
hothereth	**-0.248**	**-0.321**	**-0.277**	**-0.298**	**-0.320**	**-0.302**
business	-0.075	-0.013	-0.061	0.054	0.026	0.053
otherocc	**-0.301**	**-0.294**	**-0.311**	**-0.237**	**-0.263**	**-0.203**
_cons	0.098	0.110	**0.353**	0.130	0.124	0.087
livestock1	0.000					
assets1	**0.046**					
livestock2		0.000				
assets2		**0.000**				
livestock3			0.015			
assets3			**0.100**			
wealth1				**0.006**		
wealth2					0.000	
cattle						**-0.008**
donkeys						-0.054
goats						0.008
horses						-0.002
none						0.061
sheep						0.001
bike						0.015
cart						0.051
bed						**0.104**
motorbike						-0.088
radio						0.006
TV						0.053
tinroof						**0.048**
watch						**-0.038**
Pseudo R^2	12.4	10.9	11.4	11.0	10.7	14.3
$Pr > \chi^2$	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. livestock1, assets1 and wealth1 refer to the simple aggregation of livestock and assets
2. livestock2, assets2 and wealth2 refer to the weighted aggregation of livestock and assets
3. livestock3 and assets3 refer to an index based on principal components
4. variables significant at the 5% level are in bold.

Table A3 Frequency Distribution of Ethnicity

Ethnicity	Freq.[1]
Bambara	31
Fula	1,283
Jola	44
Madinka	4,102
Manjago	124
Other	101
Sarahule	18
Serere	43
Wollof	3,092
Total	8,838

Note: 1. Refers to individuals, not households

Table A4 Frequency Distribution of Occupations

Occupation	Freq.
Business	118
Civil Servant	78
Domestic Help	6
Farmer	460
Fisherman	13
Herdsman	4
No Occupation	40
Nurse	4
Other (specify)	182
Shopkeeper/Retail	49
Total	954