Psychology, Gender, and the Intrahousehold Allocation of Free and Purchased Mosquito Nets

by

Vivivan Hoffmann

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Department of Agricultural and Resource Economics

The University of Maryland, College Park

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Abstract: This paper reports results from a field experiment in Uganda. The proportion of children five years and younger who slept under a mosquito net was 20 percent higher when nets were distributed for free compared to when an equivalent cash transfer could be used to purchase nets. This effect is attributable to the endowment effect (more nets were retained when received for free than offered for sale), and to differences in how purchased and free nets are allocated within the household. Nets received for free were more likely to be used by young children. Purchased nets, on the other hand, were used by those members of the household, often adults, perceived by participants to suffer from malaria most frequently. When a married woman acquired nets, the probability that her children used these increased with the educational attainment of her husband.

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1. Introduction

For some health goods, intra-household allocation may be more important in determining outcomes than household-level consumption. An important example is the use of mosquito nets to prevent malaria. Malaria kills over one million people annually, 90 percent of them children under the age of five (World Health Organization, 2004). Despite public health messages emphasizing the importance of using mosquito nets to protect young children from malaria, scarce nets are often used by adults when a household does not have enough nets to cover all members (Korenromp et al., 2003; Mugisha and Arinaitwe, 2003). This paper investigates the determinants of intrahousehold mosquito net usage, including the gender of the member who obtained the net and whether the net was purchased or received in kind.

Experimental evidence suggests that whether a good is endowed or offered for sale affects the salience of particular features, in particular public good or moral attributes (Boyce et al., 1992; Irwin et al. 1994). Whether mosquito nets are given for free or offered for sale may thus influence the way in which a household decision-maker thinks about how a net, once acquired, ought to be used, particularly if the gift or sale is accompanied by a message about child health.

The possibility that mode of delivery affects intrahousehold allocation adds a new dimension to the debate over cost-recovery for health-related goods. It is often argued that charging a positive price for health goods results in higher usage rates (PSI, 2006). This argument rests on three possible effects of positive prices: screening out those who will not use the good (Oster, 1995), serving as an indicator of quality (Milgrom and Roberts, 1986), and creating a psychological sunk cost effect (Thaler, 1980; Arkes and Blumer, 1985). While recent studies test both screening and sunk cost effects on usage of health goods (Ashraf et al. 2007, Cohen and Dupas, 2007), the effect of paying on intrahousehold allocation of goods has not been investigated.

The way in which mosquito nets are distributed varies across and even within countries. However, comparing the intrahousehold allocation of nets across program boundaries is problematic because of spatial variation in both malaria endemicity (which affects adult immunity to malaria) and cultural norms. Using an experimental approach, it is possible to randomize the mode of distribution within one locality and thus to cleanly identify the effect of the distribution policy.

I conducted a field experiment in an area of seasonal malaria transmission in western Uganda. Parents or guardians of young children were randomly assigned to receive either cash or ITNs, and then had the opportunity to trade the ITNs for cash or vice versa. Usage of nets was observed during nighttime checks three weeks later. Almost all (97 percent) of the individuals who acquired one or more nets were sleeping under a net, as were 93 percent of those who had at baseline shared a sleeping place with this person. Nets that had been received in kind were more likely to be used by young children in accordance with information given to all participants that children are more vulnerable to malaria. Purchased nets were more likely to be used by those household members perceived to experience at least one malaria episode each year. Educational attainment of the participant had no effect on child usage, however the husband's education was associated with children's usage when a married woman received or purchased nets. This suggests that women may not be able to implement health related knowledge without the cooperation of their husbands, and that men should be included in education efforts to promote child health.

In the following section I describe the problem and review the existing literature on intrahousehold usage of mosquito nets. Possible explanations for a difference in the usage of free and purchased nets, and in the usage of nets acquired by men and women, are outlined in Section 3. Section 4 discusses the conceptual framework. I describe the setting and baseline data collection in Section 5. Section 6 presents the experimental design and Section 7 describes results. Discussion and concluding remarks follow in the final two sections.

1. Malaria and insecticidal nets

Malaria is caused by a parasite that requires both human and mosquito hosts to complete its life cycle. If not treated properly, malaria parasites can remain in the human body long after symptoms subside, causing repeated episodes of illness. With treatment and avoidance of re-exposure, malaria can be cleared from the system completely. In East Africa, the most common species of malaria-transmitting mosquito bites primarily late at night, so that sleeping under a mesh mosquito net is a highly effective means of avoiding infection. The use of insecticide treated mosquito nets (ITNs) has been shown to reduce all-cause child mortality by one-fifth and reduce malaria episodes by half (Lengeler, 2004) and is considered the most cost-effective available strategy for control of the disease (Breman et al., 2006). In 2000, 44 of the 50 malaria affected countries in Africa committed themselves to increasing the use of ITNs by vulnerable populations, in particular children under five years of age and pregnant women (Roll Back Malaria, 2000).

The appropriate mechanism of ITN delivery—free distribution versus some degree of cost recovery—is hotly debated (Curtis et al., 2003; Lines et al., 2003; Lengeler et al., 2007). Mass distributions of free nets to families with young children have recently been undertaken in a number of African countries, and have achieved high coverage rates in rural areas where marketing of nets has mostly failed. Widespread ITN use reduces the mosquito population and thus the risk of contracting malaria even for those in the community not using nets. In recent years a consensus has emerged that this positive externality of ITN use justifies some degree of public subsidy. However, ongoing free distribution of nets is widely considered fiscally unsustainable (Lengeler, 2007)[1].

While adults in malarious regions have typically acquired some immunity to the disease through repeated exposure over the course of their lives, they may still suffer symptoms and even death due to malaria. Adults' symptoms are more serious in regions where malaria transmission is seasonal, since immunity diminishes after several months without an infective bite. However the risk of severe malaria resulting in lifelong disability or death is highest for young children and pregnant women across transmission environments (Snow et al., 2003, pp. 11-12). On the other hand, lost labor time often accounts for the largest portion of the private cost of the disease (Cropper et al., 2004). This implies a tradeoff between minimizing the income lost to malaria and minimizing the risk that a household member dies or is permanently disabled, particularly in areas of lower transmission intensity.

Lack of knowledge about the particular vulnerability of young children and pregnant women, as well as non-unitary preferences within the household, imply that an observed allocation of mosquito nets may not maximize household welfare. Determining the welfare-maximizing allocation of nets is beyond the scope of this paper. Rather, I take as given the stated public

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[1] Interviews with Connie Balayo, National Malaria Control Program, Uganda (August 2006); Ali Abdullah Suleiman, Zanzibar Malaria Control Division (April 2007).

health priority of covering young children and compare the effects of two net distribution policies on this outcome.

Studies of particular programs in which nets were given for free to expectant mothers suggest that this is an effective way of targeting nets to infants. Guyatt and Ochola (2003) and Dupas (2005) both found that 85 percent of nets given to pregnant women were used by their intended recipients. Guyatt and Ochola, studying two districts in Kenya, noted a lower rate of net use among newborns in the district with lower malaria transmission intensity (80 vs. 91%), where adults tend to suffer more serious symptoms.

In contrast, studies using a broader sample of households, among which many nets are likely to have been purchased through market channels, give inconsistent results on children's net use. Using data from the 2000-2001 Demographic and Health Survey (DHS) in Uganda, where there had been no widespread distribution of free nets, Mugisha and Arinaitwe (2003) showed that the coverage of young children in that country was largely incidental to sharing a bed with an adult: children who slept in the same bed as an adult were 22 times more likely to be sleeping under a net than other children. A cross-country study using DHS data from 12 African countries revealed that children were no more or less likely than adults to use nets (Korenromp et al. 2003). However more recent work conducted in five African countries after widespread free distribution of nets found that young children were prioritized for net use (Baume et al 2005).

Most of the above studies relied on questions about who slept under a net the previous night. To the degree that respondents believe survey staff have preferences about the allocation of nets, these recall responses may be biased. The only exception is a study by Alaii et al. (2003), who physically checked net usage during the night. This study also represents the only investigation of why young children do not use nets. Even though all study participants were given enough nets for their entire household, under-fives were 14 percent less likely to use a net than others. In this setting of year-round high transmission intensity (and resulting relatively strong immunity outside early childhood), primary reasons reported for lack of net use by under-fives were temperature and the disruption of usual sleeping arrangements. The present research was conducted in an area of low transmission intensity, where adults typically suffer the symptoms of malaria if infected and economic factors may therefore play a stronger role in the intrahousehold allocation decision.

3. Individual and household-level decision-making

The most basic microeconomic model assumes that the household behaves as a unitary decision-maker and pools income from all sources to maximize a single utility function. According to this model, the intrahousehold allocation of a good will not depend on who within the household acquires it, nor will the way in which a good is obtained determine its use. However, empirical studies of intrahousehold allocation routinely reject the unitary household model. The behavioral economics literature documents systematic ways in which the assumption of income pooling is violated at the level of the individual.

Psychological effects

Recent work in Zambia showed that those willing to pay more did in fact use a water purification system more consistently than those with lower willingness to pay (Ashraf et al., 2007). However, no such effect was found in a separate study that randomized the prices charged for bednets by health clinics in Tanzania (Cohen and Duflo, 2007). Neither the bednets nor the water treatment study found statistically significant evidence of a sunk cost effect on usage.

That income has limited fungibility runs counter to standard theory but is well established empirically (Thaler, 1990). People tend to organize financial transactions into separate mental accounts linked to different needs, so that how money is spent depends on how it was acquired. For example, child tax benefits increase expenditures on children's clothing even though there are no rules about how these transfers should be spent (Kooreman, 2000). In a rural African setting, Duflo and Udry (2004) showed that income derived from certain crops was associated with expenditures on children's education and food while the income from other crops was associated with private and adult goods, even when the two income streams were under the control of the same individual.

In the rural Ugandan villages where I conducted the present study, purchased items may be associated with adult use whereas children are more likely to use goods received for free or handed down from adults. Indeed, the average household in the sample spent less than a dollar on children's clothes and shoes over the past year compared with over $18 on adult clothing and footwear.

Another finding from behavioral economics is that utility is reference dependent and that losses relative to a reference point loom larger than gains. Tversky and Kahneman (1991) developed the theory of loss aversion to explain their experimental finding that people charge more to sell a good than they are willing to pay to acquire the same good, a phenomenon known as the endowment effect. Loss aversion has been shown to differ across both gender and goods, being more common among women than men (Brooks and Zank, 2006) and stronger for goods with a public good component or moral attribute (Boyce et al., 1992; Irwin, 1994).

Boyce et al. (1992) ran an experiment in which subjects were assigned the opportunity to either buy or sell a houseplant in a kill or a not-kill treatment. Buyers (sellers) were asked to state their maximum willingness to pay (minimum willingness to accept cash) for a plant. In the kill treatments, all plants left over after bidding (buying treatment) or sold back to experimenters (selling treatment) were killed. In the not-kill treatments, no plants were killed. Selling offers in the kill treatment were much higher than in the not kill treatment, but bids to buy plants were only slightly higher in the not kill treatment, suggesting that the responsibility for the life of the plants was more keenly felt when participants owned the plants.

Irwin (1994) elicited subjects' hypothetical willingness to pay and willingness to accept payment for changes in environmental states and private goods, as well as their rankings of the goods in terms of public benefit and moral value, and verbal accounts of the decision-making process. She concluded that moral and public good attributes were more salient in the decision to accept payment, whereas personal gain was the main consideration when deciding how much to pay.

One possible explanation for the greater salience of public good attributes in selling modes is guilt aversion, the idea that agents experience guilt if they believe they let others down (Charness and Dufwenberg, 2006). Charness and Dufwenberg's formulation of guilt aversion requires a second party who is materially affected by an agent's actions, and has expectations concerning those actions. However the Boyce et al. and Irwin experiments suggest that a desire to act morally may also influence decisions in the absence of such a second party, and that perceptions of moral obligation are highly sensitive to framing. If a mother receives a free mosquito net in conjunction with a message that sleeping under that net can save the life of her child, she may perceive that using the net for her child is the right thing to do. Selling the net, or using it for a different member of the household, would trigger feelings of guilt. Receiving the same information along with the resources to purchase a net may not trigger the same perception of obligation to buy the net and use it for the child.

Gender effects

Many programs aim to improve child health outcomes by targeting resources to women, based on the assumptions that mothers have particularly strong preferences for their children's health, and that they are able to exert control over income they receive. Indeed, stated preferences differ systematically by gender (Kusago and Barham, 2001), and the share of income earned by women is positively associated with expenditures on food (Hoddinott and Haddad, 1995), expenditures on childcare (Phipps and Burton, 1998), and child health outcomes (Thomas, 1990; Duflo, 2003). These empirical studies reject the unitary model of the household in favor of a bargaining model in which each adult member maximizes his or her individual utility function.

Except for Duflo (*ibid*.), who showed that old-age pensions received by women, but not by men, affect child health, previous work testing the effect of women's income on household expenditure patterns does control for how income is derived. If income streams associated with child consumption (for example, gifts or government child subsidies) are primarily received by women, such analyses may overstate the impact of gender-specific preferences. Thomas (1990) found that unearned income under the mother's control has a greater effect on child survival than father's income, but noted that the composition of unearned income differs markedly by gender, with women deriving a larger share from pensions and social security relative to men, who earn a greater portion from financial and physical assets. Hoddinott and Haddad's (1995) analysis relied on attributing certain crops to male and female control, leaving open the possibility that income from particular crops (perhaps those usually under female control) is associated with public goods expenditures as found by Duflo and Udry (2004).

Using an experimental approach, it is possible to empirically distinguish the effect of gender and the psychological effect of the form in which income is received. Doing so in this paper, I find that giving mosquito nets in kind rather than selling them has a significant effect on child usage, whereas targeting transfers of nets or cash to a female rather than a male guardian does not. The latter result suggests that either women's and men's preferences for child usage of nets do not differ significantly, or that the transfer of a net or cash does not change the bargaining power within the household.

4. Conceptual framework

Whether a child sleeps under a mosquito net requires first that one or more nets are acquired by the household and second that the child is given one of these to use. Denote the probability of purchasing *n* nets as $buy_n(W_i, X_i, Z_h, p)$, and the conditional probability of a child sleeping under one of these as $cu(n, X_i, Z_h \mid buy_n)$. Suppose one of the child's guardians, denoted *i*, has an opportunity to purchase between 0 and *N* nets, where *N* is the number of nets required to cover all household members, at a price of *p* per net. The overall probability of a child using a net can be written as:

$$CU_b^i = \sum_0^N buy_n(W_i, X_i, Z_h, p) \cdot cu(n, X_i, Z_h \mid buy_n). \qquad (1)$$

In this formulation, the decision to purchase a given number of nets depends upon i's cash on hand W_i, individual and household attributes X_i and Z_h, respectively, and the price p. The probability of the child using a net given that n nets have been purchased depends upon n as well as on the characteristics of the guardian who purchased the nets and of the household. The probability of a child gaining access to a net when guardian i receives a transfer of $\overline{N}_i$ nets can similarly be written as:

$$CU_f^i = \sum_0^{\overline{N}} retain_n\left(\overline{N}_i, X_i, Z_h, \overline{p}\right) \cdot cu\left(n, X_i, Z_h \mid retain_n\right), \tag{2}$$

where $retain_n$ is the probability that n of the nets that have been received are retained by the household. Retention depends upon how many nets were received, the resale price $\overline{p}$ that can be obtained for the nets, and the guardian's individual and household attributes. The endowment effect implies that buy_n and $retain_n$ may differ for given values of their arguments. Recent work on the use of a home chlorination treatment for drinking water finds weak evidence that the act of paying positively influences usage, but no evidence that that the price paid has any effect (Ashraf et al., 2007). Allowing cu to depend on whether nets were retained or purchased explicitly allows for the possibility that paying affects the usage of nets.

In a separate paper, coauthors and I use data from the experiment described here to show that, due to both liquidity and endowment effects, households are unlikely to purchase nets out of their own resources, and yet are unlikely to sell nets received for free (Hoffmann et al., forthcoming). The present paper focuses on usage of nets by young children under these two distribution mechanisms and in particular on the difference between $cu\left(n, X_i, Z_h \mid retain_n\right)$ and $cu\left(n, X_i, Z_h \mid buy_n\right)$. I also investigate whether the probability of a child using a net depends on the gender of the household member who acquired it.

5. Setting and baseline data collection

At the time data were collected in October and November of 2006 there had been no large-scale distribution of free or subsidized ITNs in Uganda. Conventional nets were available in weekly rural markets at a price of approximately $2.72 US, and higher-quality nets bundled with insecticide treatment kits were available in Mbarara, the nearest urban center, for twice this price.[2] The long-lasting insecticidal nets (LLINs) offered through the experiment described here were not commercially available in Uganda. These LLINs are much more durable than other nets, with an estimated 5-year lifespan compared to about one year for the highest quality conventional ITNs. LLINs do not need to be annually retreated with insecticide as do conventional ITNs and are recommended by both the World Health Organization and the Ugandan Ministry of Health.

Mbarara District was chosen for its seasonal transmission pattern of malaria and resultant low adult immunity, allowing identification of the income versus child health tradeoff. To ensure ease of tracking project nets, the sub-county with the lowest baseline net ownership per capita was chosen.[3] The experiment was conducted in Rubagano and Kimuli, villages 10 kilometers apart with populations of approximately 1300 and 900, respectively.

Households with children aged up to five years or a pregnant woman were eligible to participate in the study. A list of all households in each village meeting eligibility criteria was provided by the village chairmen. In order to separately identify the effects of gender-specific preferences

[2] Return transportation to Mbarara cost US $7.63.
[3] The number of nets per capita treated with insecticide in the government's 2005 retreatment campaign (according to district health center records) was used as a proxy for per capita net ownership.

and control over income, households were stratified by the marital status of the head. All 41 of the single-headed households identified, 38 of which were headed by women, were selected for inclusion in the sample. An additional 102 of the eligible dual-headed households were randomly selected. Respondents were not necessarily parents of the children under their care: 12 percent of the households interviewed contained at least one child aged five years or younger who was neither the son nor daughter of the head or spouse. All of these children were however relatives of the respondent.

A questionnaire covering demographic information, malaria history and income-generating activities of each member of the family as well as household consumption expenditures was administered during an initial household visit. Respondents were asked to recall food consumption over the past week, non-durables and services purchased over the past month, and less frequent but regular expenditures such as educational expenses and purchases of clothing and household items over the past year.

Average consumption value per capita among the sample was US $0.65 per day, excluding expenditures on health care. While values are not strictly comparable because of differences in data collection methods, this is close to the US $0.59 daily per capita private consumption expenditure reported by the World Bank for Uganda in 2005. Almost all households in the sample derived at least some of their living from farming, and home produced goods accounted for 43 percent of total consumption value on average.

Respondents were asked to state the hours worked by each member of the household on own farm, livestock, non-farm enterprises during the past week, how much it would cost to pay someone to do this work, and who in the household primarily controlled the income derived through this activity. The median reported hourly value for each activity was calculated and this activity-specific wage was multiplied by the number of hours worked.[4] Reported earnings from paid jobs during the past week were added to calculate individual incomes.

Respondents reported significant expenditures as a result of malaria: the mean and median costs incurred as a result of the most recent malaria episode, including transport, consultation fees and drugs, were $13.55 and $5.45, respectively. These figures are similar to the private costs of malaria reported in a recent review, which ranged from $15.26 in Congo to $20.56 in Rwanda (Cropper et al. 2004). Eighty-seven percent of individuals in the sample were reported to suffer from malaria at least once each year, and 79 percent of respondents claimed to know someone who had died of the disease. Admissions data obtained from the sub-county local health clinic showed that over the past year, 40 percent of visits by children younger than 5 years and 54 percent of visits by older patients were malaria-related. Only six of the 143 households interviewed owned any mosquito nets at the time of the initial household visit. Of the 15 individuals in these households using nets, three were five years or younger, and all three were sharing the net with at least one adult.

6. Experimental design

Treatment assignment

Either the husband or wife in each of the dual-headed households was randomly selected to represent the household in one of fourteen bidding sessions held over five days beginning one week after the last household interview. Approximately half of the participants in each category (married men, married women and single heads) were randomly assigned to receive a cash

[4] Wages for men and women did not differ significantly so a single wage was calculated for each activity.

transfer, the other half to receive mosquito nets. Bidding sessions were held separately for the two treatments, with seven sessions for each.

Table 1a shows the number of participants in each treatment by headship and gender. Participants who missed their assigned session were allowed to attend a later session. An effort was made to reassign the participants to a session of the same treatment, however this was not always possible. Staff and participants were unaware until a session began whether it would be an in-kind or cash transfer session. The reassignment of individuals between treatments is therefore unlikely to have introduced bias.

A number of households sent a representative other than the one randomly assigned. This person was asked to return home and send the assigned participant. If the representative insisted that the assigned participant was absent and would not be able to attend an alternative session, other community members were asked to verify this. In several instances, others contradicted the claim of the household representative and the intended respondent was eventually found. However for 9 of the 143 participating households, a non-randomly assigned individual participated. I retain these households in the analysis presented. The results are robust to their exclusion as well as to using an intent-to-treat approach in which assigned rather than actual gender is used.

Eleven households containing no children aged five years or younger were dropped from the analysis. Two of these had been included in the initial sample because they contained a woman who was or might soon become pregnant. Although an effort was made to replace households not meeting the eligibility criteria, lack of eligibility was not always discovered before the interview was initiated, resulting in the inclusion of nine ineligible households in the initial sample. As shown in Table 1c, the vast majority of these were single headed households. An additional household whose members could not be located for a follow-up visit to observe net usage is also excluded from the analysis.

Balance across treatments

Randomization implies that the characteristics of participating households are uncorrelated with the treatment in expectation. To test whether randomization was in fact successful, I compare the means of observed household and participant characteristics across treatments and gender categories in Table 2. Indeed, randomization on observables was successful, with none of these variables differing at the 10 percent level of significance.

The gender and headship categories reveal differences between men and married women, and between single and married women. The share of income controlled by men is significantly higher than that controlled by married women ($p<0.01$). Single women likewise control a greater proportion of household income than married women ($p<001$). Single female heads are significantly older and less educated than married women, and the demographic composition of single-headed households differs markedly from that of dual-headed households. Single headed households have fewer members overall, with fewer young children and adults aged 15 to 59, and a greater number of elderly members. Many of the children cared for by single female heads are grandchildren or other relatives. Notably, respondents perceived children aged 5 years and younger to suffer from malaria less frequently than adults ($p<0.1$).

Experimental procedure

Households in the free nets treatment were assigned a transfer of one, two or three 190 by 180 centimeter Olyset brand nets. Those in the cash treatment received a transfer of the maximum possible price of one, two or three nets.[5] The transfer of nets or cash was intended to be sufficient to acquire nets for all household members. In calculating how many nets or how much cash to give to a family, I assumed that individuals already sleeping in the same bed would share a net. I also assumed that separate beds could be moved together in order to share nets if necessary. According to this logic, each household received nets or the cash equivalent equal to the minimum of the following: the number of distinct sleeping sites in the dwelling, the number of household members divided by two and rounded up to the next integer, and three. The maximum of three nets was due to a project budget constraint. Since nets were large enough to cover up to four children, even the largest households in the sample, which contained eleven members, would be able to cover all of their members. Separate sessions were held for households receiving one net, two nets, and three nets, and for those receiving a cash transfer of $7.63 (the maximum possible price of one net), $15.26, and $22.89.

At the beginning of each session, participants were given their transfer of nets or cash, according to the treatment. They were told that this gift of nets or cash was compensation for participation in the study, and that they could exchange or keep and use this compensation as they wished. Participants in all sessions were read the same statement about malaria. This included the following passage about the particular vulnerability of pregnant women and children (see the Appendix for the full script):

> Malaria is more likely to be serious for young children and pregnant women. In Uganda malaria is the number one killer of children under 5 years, and is responsible for 6 of every 10 miscarriages. Grown men and women who are not pregnant may

[5] Olyset nets are recommended by the World Health Organization and the Ugandan Ministry of Health. $7.63 US (14,000 Ugandan Shillings) is the approximate wholesale price of these nets in Kenya (they are not commercially available in Uganda); the manufacturing cost is approximately $5 US.

also become sick with malaria and may die, but they are less likely to die of malaria than young children and pregnant women. Severe malaria can also cause mental retardation, blindness, and deafness in children.[6]

Staff demonstrated how to hang a mosquito net and tuck it under the corners of the bed or sleeping mat. A villager who had received six of the same brand of LLIN through a UN project several months earlier told the group that these nets killed mosquitoes and had prevented malaria in her family during the time they had used them.

Participants then had the opportunity to exchange nets for cash or cash for nets using the Becker-deGroot-Marschak mechanism (Becker et al. 1964). This mechanism is commonly used in experimental economics because it is preference-revealing. The basic mechanism works as follows. Participants enter bids before the price of a good is revealed. The price is then randomly drawn from a distribution of possible prices. Participants in a buying treatment who bid at or above this randomly drawn price purchase the good at the drawn price and keep the remainder of any cash transfer they have received. Those who bid below the price do not purchase the good, keeping instead the entire cash transfer. The mechanism works because it is in the best interest of participants to bid according to their actual valuation of the good on offer. Those who bid less than their true value risk not buying the good when the price is low enough that they would in fact prefer to buy. Conversely, bidding above one's true value risks buying when the price is higher than one would actually be willing to pay.

Before bidding for mosquito nets, three non-confidential practice rounds were conducted in which food items and pencils were exchanged for cash. In the free net sessions, participants

[6] Information adapted from the Uganda Ministry of Health (2006).

were given food and pencils which they could keep or sell. In the cash transfer sessions participants were given cash which they could keep or use to purchase these goods. For each practice round, as well as the final ITN round, bidding proceeded as follows. One of the experimenters explained the bidding procedure, and for each item, told participants the possible prices that could be drawn as he placed one ping-pong ball representing each of these possible prices in a bucket. For all sessions, the possible prices were uniformly distributed from \$0.54 to \$7.63 in increments of \$0.54. Participants were given tokens representing currency, which they placed in envelopes to indicate their buying bids or selling offers. Those who had received cash indicated the maximum they were willing to pay and those who had received nets, the minimum they were willing to accept, for three items (in the three net sessions), two items (in the three net and two net sessions), and one item (in all the sessions). By requiring separate bids for the first, second and third nets, the marginal willingness to pay for each net was observed. Staff were available to assist with bids if needed, but participants were asked to keep their net bids as confidential as possible.

After all bids had been recorded (and in the practice rounds displayed), one of the participants drew a ball to select the price. In cash transfer sessions, participants who had bid at least as much as the drawn price for a given number of goods exchanged cash for that number of goods. For example, in a cash transfer session where the price drawn was p, if a participant bid at least $3p$ for three nets, he would buy all three nets at the total price of $3p$. If he bid less than $3p$ for three nets but at least $2p$ for two nets, he would buy two nets for $2p$, and if he bid less than $2p$ for two but more than p for one, he would buy one net at price p. Finally, if he bid less than $3p$, less than $2p$, and less than p for three, two and one net, respectively, he would keep all the cash and receive no nets. Transactions for the in-kind transfer sessions followed the same logic, with participants selling back the nets they had been given at the randomly drawn price.[7] The number of nets offered, number of participants, and price realizations for each session in the in-kind and cash transfer treatments are reported in Tables 3a and 3b.

Before consenting to participate, all participants were told that if they purchased or retained any nets, survey staff or village leaders would visit them at night to see how these were being used. Participants could request that either a fellow community member or member of the survey staff would perform this task. They were not informed of the date on which this the visit would occur. Home visits by community leaders were conducted between 9 pm and midnight on one night per village, three weeks after the bidding sessions. A few days later, again on a single night per village, survey staff visited the homes of those who had requested that an outsider conduct the net use check. During these visits, the net usage of each household member was recorded.

7. Results

Net purchase and retention

As respondents' willingness to pay for and sell nets received in kind is the subject of a separate paper (Hoffmann et al., forthcoming), the following discussion concerns primarily the intrahousehold allocation of nets. However, a brief summary of the bids and resulting distribution of nets across treatment groups is in order. Consistent with the endowment effect, those in the free nets treatment entered bids higher by $1.22 on average than those in the cash transfer treatment, resulting in a greater average number of nets per capita owned in the in-kind group (Table 4). Most of this difference is accounted for by those households in the cash group that did not buy any nets; conditional on acquiring at least one net, the number of nets per capita

[7] Two participants wished to change their bids after the price for nets was drawn. They were allowed to do so and their bids were altered accordingly.

is almost equal—and not statistically significantly different—across treatments, at 0.40 and 0.42 among the cash and net transfer groups, respectively. Some nets of the nets acquired through the experiment were observed but had not been hung at the time of the follow-up visit. Among the free nets group, 10 percent were not using at least one of the nets they had received; 13.5 percent of the cash transfer group had at least one unused net.

Individual usage

Looking first at the usage rates across age and gender categories (Table 5), the elderly, women of child-bearing age, and other adults are the most frequent users of nets. Children five years and younger follow, with older children the least likely to be covered. Usage is slightly higher overall among the group that received nets, even conditional on having acquired at least one net. The only group for which this is not the case is adults other than women aged 15 to 45, who have lower mean usage in the free nets group than the cash transfer group, conditional on acquiring at least one net. Children under 5 years of age are particularly advantaged when nets are received for free. The difference between children's usage in the free vs. purchased nets group is significant at the 1% level when all households are included, and remains significant at the 10% level when considering only those households who obtained at least one net.[8] Pregnant women are also more likely to be using a net when nets are received for free, however this effect is only significant at the 10% level when all households are included.

Pregnant women and young children are the demographic group most vulnerable to severe malaria. Pregnancy is not reliably observed, and women of childbearing age are also income earners and often share a sleeping place with the household head, and so could be using nets for

[8] In order to account for correlation of the errors within the households, I test differences in means using a probit model in which the dependent variable is equal to one if the person is using a net and zero otherwise, with a treatment dummy as the only independent variable and standard errors clustered at the household level.

multiple reasons. In what follows I focus on the net usage of children aged five years and younger in order to more easily identify what leads households to protect those most at risk.

Table 6 presents results from a linear regression model in which the dependent variable is the household-level proportion of children aged five years and younger using nets in the free nets and cash transfer groups.[9] Households that did not acquire any nets through the experiment are assumed not to have changed their usage since the baseline survey. As described in Section 4, net allocation depends on two separate but related decisions. Participants decide both how many nets to purchase or retain and how to allocate any nets among household members. Both decisions clearly affect children's usage. The most basic and arguably most policy-relevant comparison across treatments does not separate the effect of these two decisions. The first column in Table 6 shows that child coverage in the free nets treatment is 20.5% higher on average than in the cash transfer treatment, unconditional on the number of nets obtained. This effect is significant at the one percent level, and is robust to including the number of children in the target age group and the educational attainment of the household head as controls (column 2).

Mode of receipt remains a significant predictor of child usage when controlling for the number of nets acquired (columns 3 and 4). However simply entering the number of nets on the right hand side is problematic since this also a choice variable and is clearly related to the decision of who will use the nets. I therefore use the number nets given or offered for sale to the household as an instrument for the number of nets acquired.

[9] Qualitatively similar results obtain using a probit specification in which the dependent variable is equal to one if all children are using nets and zero otherwise.

Recall that the number of nets or amount of cash given to a participant depended upon the number of people and distinct sleeping places in the participant's household according to the formula *min*{round(household size/2), number of distinct sleeping places, 3}. Due to the upper limit on the transfer and the discontinuous nature of this function, significant variation in the size of the transfer remains after controlling for household size, number of distinct sleeping places, and members per sleeping place, all of which may be directly correlated with children's net usage. Thus, the stepwise form of the ITN transfer function is the source of exogenous variation I exploit to identify the effect of the first-stage decision of how many nets to purchase or retain.[10] I use a limited information maximum likelihood (LIML) estimator due the superior small sample properties of this estimator compared with two-stage least squares (Anderson et al., 1982).

The excluded instrument is a highly significant predictor of nets acquired per member, with an F-statistic greater than 25 in both specifications. Controlling for the number of nets acquired in this way, receiving nets in kind has an independent effect on children's usage (columns 6 and 8). Conditional on household size and number of distinct sleeping places, households with more young children tend to acquire fewer nets. Education of the household head is positively associated with child net usage.

Table 7 presents results related to the gender of the (cash or net) transfer recipient. Only households headed by a married couple are included in this analysis. Across specifications, the gender of the net recipient has no effect on children's usage. Educational attainment of the participant likewise has no effect. However, for the sub-sample of households for which the

[10] A potential weakness of this identification strategy lies in the possibility that after controlling for household size, number of beds, and members per bed in a linear manner, correlation between the instrument and unobserved preference for child health (which may be reflected in the household size and number of beds) remains. To explore this concern I test a specification that includes squared terms of these control variables. This yields results identical to those presented (available from the author).

transfer recipient was a woman, the probability that all children will sleep under a net is affected by the education of the participant's husband. Spouse's education has no effect on the usage of nets obtained by men. This suggests that married women may not have sufficient power within the household to implement health-related behaviors even when they are provided with external resources. Educating fathers as well as mothers about child health may therefore be important.

Determinants of individual net usage

Next I explore the determinants of net usage with a probit regression of individual net usage on individual characteristics and household controls. The dependent variable is equal to one if the person was using a net at the time of the night-time visit and zero otherwise. As above, individuals in households that did not purchase any nets are assumed not to have changed their ITN usage since the time of the baseline survey.

Most households consist of a nuclear family in which a single guardian or couple cares for one or more children. The share of total household labor income earned by those sharing a bed with the recipient of the cash or nets transfer is 75 percent on average. This makes it difficult to separately identify the effects of individual income, headship, and net receipt on usage. I therefore control for these variables jointly with an indicator variable that is equal to one if the individual shares a sleeping place with the experimental participant. In 54 percent of sample households, no young children were sharing the bed of the individual who received the net or cash transfer.

The two other individual-level explanatory variables are indicators signifying whether the individual "usually gets malaria every year" according to the respondent in the baseline interview, and whether the individual is aged five years or younger and a child of the participant who received the transfer. As in the household-level model, I use the number of nets offered as an instrument for the number of nets acquired, controlling for the household size, number of distinct sleeping places, and people per sleeping place. Standard errors are clustered by household.

The results, given in Table 8, show that the strongest predictor of using a net is sharing a sleeping place with the individual who acquired the nets. Indeed, in all but four cases, those who had received or purchased nets were later found to be using a net (in two of these households the nets were not being used by anyone). When purchased with a cash transfer, nets were more likely to be used by those perceived to suffer from malaria most frequently, whereas young children were favored for use when nets were received in kind (column 2). Recall from the discussion of baseline characteristics that adults are perceived as suffering from malaria more frequently than young children.

Restricting the sample to dual-headed households, the way in which women and men allocate nets among household members does not differ significantly (column 4). This may be due to the fact that women do not control usage even when they are the ones to receive or purchase nets, as suggested by the effect of husband's education on the use of nets acquired by women.

8. Discussion

The results presented here show that the determinants of mosquito net usage are contingent on how nets are acquired. Young children, whose vulnerability to malaria is highlighted in a message accompanying net distribution, are more likely to use nets received for free.

The behavioral economics literature suggests several possible explanations for why nets received for free are more likely to be used for children. The effect could be due to mental accounting, with free goods more closely associated with children and purchased goods associated with adults. Alternatively, receiving enough nets for all family members may have led participants to perceive the status quo as all members using a net. If those who received cash had a different perception of the status quo, and if child health is subject to greater loss aversion than adult health, this could explain the observed difference in usage across treatments. Finally, if participants' perceptions of the researchers' beliefs—or their own beliefs—about who should use the nets varied across treatments, guilt aversion could underlie the differences in net usage. Even with identical verbal messages, the normative message implicit in giving a net versus giving cash could lead to such a difference in beliefs across treatments. This raises the question of whether knowledge of future monitoring affected usage differentially in the two groups. Future research could avoid this possible Hawthorne effect by monitoring which individuals' beds have nets hanging over them in an unannounced daytime follow-up visit. It is worth noting that many health interventions rely on some form of monitoring to increase compliance.

9. Conclusions

The experiment described here suggests that distributing nets for free leads to a greater number of children covered than offering nets for sale, even when caregivers are given adequate resources to purchase nets for the entire household. This result is partially due to the endowment effect: the number of free nets retained is higher than the number of nets purchased with a cash transfer of equal value. However, even controlling for the number of nets acquired, children are still more likely to use nets received for free.

Consistent with the findings of Cohen and Dupas (2007), almost universally, the person who received or purchased the nets used one of them him or herself. More than half of the time, there were no children sharing a sleeping place with this person. This result lends support to calls for nets to be targeted more broadly than to the vulnerable groups of young children and pregnant women (Teklehaimanot et al., 2007), since scarce nets appear to first be used by the household head, and young children who sleep separately may remain unprotected unless households own multiple nets.

Who else in the household used a net depended on how nets were acquired. When nets were purchased, those perceived to suffer from malaria on a regular basis were more likely than others to use them. Nets received for free were more likely to be used by young children, in accordance with a message given to all participants about the particular vulnerability of this group. This finding suggests that mode of distribution can be used to influence the intrahousehold allocation of a good.

Giving or selling nets specifically to women, on the other hand, did not achieve higher child coverage. Husband's education level was a significant determinant of child usage when nets were received by married women, suggesting that these women do not fully control resources they bring into the household.

The health benefits of many goods, including mosquito nets, depend upon their allocation within the household. It is broadly recognized that parents may have heterogeneous preferences and keep separate accounts. The stylized fact that women value child health more than men is often used in the design of programs to promote child health. Less well understood is the link between how a good is obtained and how it is used, though this area is drawing increasing attention. The finding that the intrahousehold allocation of a good can be affected by the way in which it is obtained has implications for the design of programs targeting particular groups at the sub-household level. Such targeting may be appropriate if the preferences of household decision-makers are at odds with social preferences, or if decision-makers misperceive the relative vulnerability of household members.

Tables

Table 1a: Sample by headship, assigned treatment, and gender of assigned participant

		Received nets	Received cash	Total
Dual headed	Male	25	25	50
	Female	25	27	52
Single headed	Male	1	2	3
	Female	20	18	38
Total		71	72	143

Table 1b: Dual-headed households sending non-assigned participant, by assigned treatment and gender of assigned participant

		Received nets	Received cash	Total
Dual headed	Male	3	2	5
	Female	2	2	4
Total		5	4	9

Table 1c: Households with no children under 5 years, by headship, assigned treatment, and gender of assigned participant

		Received nets	Received cash	Total
Dual headed	Male	0	1	1
	Female	1	1	2
Single headed	Male	0	0	0
	Female	2	6	8
Total		3	8	11

Table 1d: Households absent during monitoring of net usage.

		Received nets	Received cash	Total
Dual headed	Male	1	0	1
	Female	0	0	0
Single headed	Male	0	0	0
	Female	0	0	0
Total		1	0	1

Table 1e: Final sample by actual treatment, headship and gender.

		Received nets	Received cash	Total
Dual headed	Male	24	24	49
	Female	27	23	50
Single headed	Male	1	2	3
	Female	18	12	30
Total		70	61	131

Table 2: Means of household and respondent characteristics, by treatment, gender and headship

	Treatment		Respondent gender and headship		
	Received nets	Received cash	Male	Female married	Female single
	(1)	(2)	(3)	(4)	(5)
Free nets treatment	1.00	0.00	0.48	0.55	0.60
	(0.00)	(0.00)	(0.07)	(0.07)	(0.09)
Female participant	0.64	0.57	0.00***	1.00	1.00*
	(0.06)	(0.06)	(0.00)	(0.00)	(0.00)
Single headed household	0.27	0.23	0.06*	0.00*	1.00
	(0.05)	(0.05)	(0.03)	(0.00)	(0.00)
Expenditures per capita (USD/week)	4.85	4.88	4.82	4.81	5.04
	(0.36)	(0.36)	(0.38)	(0.48)	(0.40)
Share of household income under respondent's control	0.40	0.36	0.39***	0.26	0.58***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.05)
Age of household head	38.64	41.41	37.94	35.51	51.17***
	(1.64)	(2.04)	(2.00)	(1.48)	(3.12)
Years education of male or single female head	3.73	4.23	5.04	4.73	0.87***
	(0.44)	(0.48)	(0.48)	(0.56)	(0.27)
Years education of spouse	2.81	2.87	2.97	2.71	.
	(0.48)	(0.46)	(0.43)	(0.50)	(.)
Proportion of household children 5 years or younger who "suffer from malaria every year"	0.81	0.86	0.87	0.78	0.87
	(0.04)	(0.04)	(0.04)	(0.05)	(0.06)
Proportion of household members aged 15-59 who "suffer from malaria every year"	0.89	0.94	0.92	0.88	0.94
	(0.03)	(0.02)	(0.03)	(0.03)	(0.04)
HH average expenditure on last malaria episode of child 5 or younger (USD)	9.75	6.62	8.22	9.17	7.00
	(1.54)	(1.44)	(1.27)	(2.06)	(2.32)
HH average expenditure on last malaria episode of member $\geq$ 6 years (USD)	17.07	15.71	18.12	14.33	17.23
	(2.26)	(2.07)	(2.43)	(1.93)	(4.34)
# of members aged 0-5 yrs	2.20	1.95	2.26	2.18	1.60***
	(0.13)	(0.10)	(0.16)	(0.12)	(0.15)
# of members aged 0-5 yrs who are not children of the participant	0.19	0.18	0.10	0.02	0.60***
	(0.07)	(0.06)	(0.06)	(0.02)	(0.15)
# of members aged 6-14 yrs	1.70	1.74	1.70	1.76	1.67
	(0.17)	(0.18)	(0.19)	(0.22)	(0.23)
# of members aged 15-59 yrs	2.11	2.13	2.44	2.27	1.33***
	(0.12)	(0.16)	(0.17)	(0.11)	(0.20)
# of members aged 60+ yrs	0.10	0.21	0.12	0.08	0.33***
	(0.04)	(0.06)	(0.05)	(0.05)	(0.09)
Household size	6.11	6.00	6.50	6.29	4.93***
	(0.26)	(0.26)	(0.29)	(0.31)	(0.32)

Standard errors are in parentheses. Tests of equality are between treatments (significance shown in column 1), between married men and women (significance shown in column 3), and between dual-headed and single-headed households (significance shown in column 5) * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3a: Number of participants, nets, and randomly drawn price, free net sessions.

Chronological session number	2	4	5	8	9	11	13	Mean
Number of nets or equivalent cash transfer	1	3	2	3	2	3	3	2.42
Number of participants in final sample	3	9	13	9	11	13	12	10
Randomly drawn price	2.72	5.46	1.09	6.54	4.35	4.90	5.44	4.35

Table 3b: Number of participants, nets, and randomly drawn price, cash transfer sessions.

Chronological session number	1	3	6	7	10	12	14	Mean
Number of nets or equivalent cash transfer	1	2	3	3	3	3	3	2.57
Number of participants in final sample	3	10	7	8	12	10	11	8.71
Randomly drawn price	3.81	5.99	5.99	5.45	3.81	6.54	7.08	5.58

Table 4: Bids, net purchases or retention, and usage by treatment

	Received nets	Received cash
Average buying bid or selling offer (up to 3 nets)	$7.16	$5.94***
Proportion keeping or buying at least one net	0.99	0.85***
Nets obtained per capita	0.42	0.33***
Nets obtained per capita, conditional on acquiring at least one net	0.42	0.40
Number of unused nets	0.19	0.14
Proportion with at least one net unused	0.10	0.14

* Difference in means is significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Proportion using net, by age and gender category.

	Whole sample[a]			Obtained at least one net		
	Pooled sample	Received cash	Received nets	Pooled sample	Received cash	Received nets
Age 0-5	0.69	0.56	0.79***	0.76	0.69	0.80*
Age 6-14	0.64	0.59	0.68	0.67	0.66	0.68
Female 15-45	0.85	0.79	0.91*	0.92	0.91	0.92
Other adults	0.84	0.80	0.87	0.89	0.90	0.88
Age 60+	0.89	0.82	1.00	0.94	0.90	1.00
Total	0.73	0.65	0.79	0.78	0.76	0.80

[a]Assumes no change from baseline net usage in households that did not acquire any nets through the experiment.
*Difference in means is significant at 10%; ** significant at 5%; *** significant at 1%. Differences in means are tested using a probit model of net usage within each subgroup with a treatment dummy as the only independent variable and standard errors clustered at the household level.

Table 6: Proportion of children 5 years or younger using nets. Assumes no change from baseline usage in households that did not acquire any nets through the experiment.

Model	OLS				Limited Information Maximum Likelihood			
Dependent variable	Proportion of ≤5s using				# of nets acquired	Proportion of ≤5s using	# of nets acquired	Proportion of ≤5s using
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Received nets in kind	0.205***	0.226***	0.112*	0.125*	0.396***	0.158**	0.439***	0.171**
	(0.070)	(0.070)	(0.067)	(0.067)	(0.130)	(0.076)	(0.128)	(0.076)
Years education of head		0.018*		0.022**			-0.016	0.020**
		(0.010)		(0.009)			(0.017)	(0.009)
# children ≤ five years of age		-0.046		-0.025			-0.196***	-0.045
		(0.036)		(0.038)			(0.073)	(0.041)
Household size			0.008	0.008	-0.118	0.021	-0.084	0.023
			(0.061)	(0.060)	(0.129)	(0.062)	(0.126)	(0.061)
Number of distinct sleeping places			-0.052	-0.058	0.266	-0.032	0.289	-0.037
			(0.099)	(0.098)	(0.199)	(0.102)	(0.194)	(0.099)
Members per sleeping place			-0.097	-0.115	0.282	-0.104	0.348	-0.113
			(0.206)	(0.203)	(0.417)	(0.209)	(0.406)	(0.202)
# of nets acquired			0.214***	0.221***		0.090		0.111
			(0.041)	(0.041)		(0.101)		(0.099)
# of nets offered					0.777***		0.772***	
					(0.155)		(0.152)	
Constant	0.594***	0.609***	0.491	0.480	-0.782	0.598	-0.720	0.581
	(0.051)	(0.090)	(0.374)	(0.368)	(0.813)	(0.387)	(0.792)	(0.376)
							131	131
F-statistic on excluded instrument					25.08		25.84	
Observations	131	131	131	131	131	131	131	131
Adjusted R-squared	0.055	0.072	0.209	0.237	0.351	0.152	0.384	0.193

Marginal effects, Huber-White heteroskedasticity-consistent standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Proportion of children 5 years or younger using nets. Assumes no change from baseline usage in households that did not acquire any nets through the experiment.

	OLS				Limited Information Maximum Likelihood			
Sample	Two-Parent Households		Married Women	Married Men	Two-Parent Households			
Dependent Variable	Proportion of ≤5s using				# of nets acquired	Proportion of ≤5s using	# of nets acquired	Proportion of ≤5s using
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Participant was married woman	0.076	0.017			0.110	0.090	-0.008	0.037
	(0.079)	(0.098)			(0.160)	(0.075)	(0.191)	(0.090)
Years education of participant		-0.005	-0.002	-0.002			-0.041	-0.002
		(0.015)	(0.018)	(0.026)			(0.029)	(0.015)
Years education of participant's spouse		0.022	0.034**	0.001			0.005	0.023*
		(0.015)	(0.017)	(0.028)			(0.028)	(0.013)
# children ≤ five years of age		-0.034	0.069	-0.082			-0.170**	-0.057
		(0.041)	(0.063)	(0.054)			(0.085)	(0.045)
Household size					-0.096	0.074	-0.053	0.080
					(0.158)	(0.072)	(0.155)	(0.071)
Number of distinct sleeping places					0.228	-0.092	0.199	-0.085
					(0.246)	(0.117)	(0.242)	(0.113)
Members per sleeping place					0.107	-0.314	0.001	-0.294
					(0.497)	(0.236)	(0.490)	(0.231)
# of nets acquired						0.038		0.053
						(0.121)		(0.120)
# of nets offered					0.742***		0.724***	
					(0.187)		(0.183)	
Constant	0.686***	0.726***	0.451***	0.882***	-0.186	1.037**	0.470	0.978*
	(0.057)	(0.124)	(0.166)	(0.159)	(1.018)	(0.477)	(1.036)	(0.517)
F-statistic on excluded instrument					15.68		15.60	
Observations	97	97	50	47	97	97	97	97
Adjusted R-squared	-0.001	0.001	0.068	-0.012	0.275	0.070	0.309	0.109

Marginal effects, Huber-White heteroskedasticity-consistent standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8: Probit model of individual net use (=1 if individual was sleeping under net at time of follow-up visit; 0 otherwise), instrumenting for the number of nets acquired, by treatment; standard errors clustered by household; estimated coefficients shown. Assumes no change from baseline net usage in households that did not acquire any nets through the experiment.

	Effect of free receipt		Effect of female recipient	
	(1)	(2)	(3)	(4)
	nets acquired per member	using net at time of visit	nets acquired per member	using net at time of visit
Individual attributes				
shares bed with participant	-0.001	0.263***	-0.012	0.257***
	(0.012)	(0.043)	(0.009)	(0.045)
child of participant ≤ 5 years old	-0.034**	0.009	-0.023*	-0.011
	(0.015)	(0.040)	(0.013)	(0.042)
usually gets malaria each year	-0.054**	0.116**	-0.057**	0.198***
	(0.026)	(0.058)	(0.023)	(0.067)
Interactions				
free * shares bed with participant	-0.001	-0.021		
	(0.015)	(0.077)		
free * child of participant ≤ 5 years old	0.026	0.173**		
	(0.019)	(0.075)		
free * usually gets malaria each year	0.018	-0.214**		
	(0.030)	(0.107)		
female participant * shares bed with participant			0.009	-0.091
			(0.016)	(0.090)
female participant * child of participant ≤ 5 years old			0.003	0.011
			(0.018)	(0.075)
female participant * usually gets malaria each year			0.039	-0.078
			(0.031)	(0.125)
Household controls				
participant received nets free	0.046*	0.073		
	(0.027)	(0.063)		
participant is female			-0.020	0.149***
			(0.028)	(0.061)
household size	-0.055***	0.097**	-0.049***	0.131***
	(0.017)	(0.048)	(0.019)	(0.048)
members per bed	-0.032	-0.274*	-0.045	-0.423**
	(0.063)	(0.155)	(0.062)	(0.166)
beds	0.015	-0.130*	0.009	-0.185***
	(0.026)	(0.067)	(0.026)	(0.067)
number of nets available	0.119***		0.111***	
	(0.026)		(0.032)	
number of nets per member		0.762		0.992
		(0.645)		(0.742)
Number of observations	757		598	
probability > Chi-squared	0.000		0.000	
Number of households	129		95	

Marginal effects. Standard errors, clustered by household, in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

References

Alaii, Jane A., William A. Hawley, Margarette S. Kolczak, Feiko O. ter Kuile, John E. Gimnig, John M. Vulule, Amos Odhacha, Aggrey J. Oloo, Bernard L. Nahlen and Penelope A. Phillips-Howard. (2003) "Factors Affecting the Use of Permethrin-Treated Bed Nets During a Randomized Controlled Trial in Western Kenya", *American Journal of Tropical Medicine and Hygiene*. 68(Suppl 4), pp. 137-141.

Anderson, T. W., N. Kunitomo and T. Sawa (1982). Evaluation of the distribution function of the limited information maximum likelihood estimator, *Econometrica* 50, 1009–28.

Arkes, Hal R. and Catherin Blumer (1985). The Psychology of Sunk Cost. O*rganizational Behavior and Human Decision Processes*. 35, 124-140.

Ashraf, Nava, Berry, James N. and Shapiro, Jesse M., "Can Higher Prices Stimulate Product Use? Evidence from a Field Experiment in Zambia" (July 2007). NBER Working Paper No. W13247

Baume, Carol A, Celeste M. Marin, Lonna Shafritz, Martin Alilio, Sheila Somashekhar and Roshelle Payes. (2005). "Awareness, Ownership, and Use of Mosquito Nets in Nigeria, Senegal, Zambia, Ghana and Ethiopia: Cross-country Results from the 2004 NetMark Surveys". Netmark.

Becker, G., M. DeGroot, and J. Marschak (1964), "Measuring Utility by a Single-Response Sequential Method", *Behavioral Science* 9: 226-36.

Bourguignon, F, Browmng, M., Chiappori, P. A. and Lechene, V. (1993). "Intrahousehold Allocation of Consumption: A Model and Some Evidence from French Data", *Annales d'Economie et de Statistiques*, Vol. 29, pp. 137-56.

Boyce, Rebecca R., T. C. Brown, G. H. McClelland, G. L. Peterson and William D. Schulze. *The American Economic Review*, Vol. 82, No. 5, 1366-1373.

Breman, Joel G., Anne Mills, Robert W. Snow, Jo-Ann Mulligan, Christian Lengeler, Kamini Mendis, Brian Sharp, Chantal Morel, Paola Marchesini, Nicholas J. White, Richard W. Steketee, and Ogobara K. Doumbo. (2006) "Conquering Malaria", in Disease Control Priorities in Developing Countries, 2nd ed., ed. D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove. 413–32. New York: Oxford University Press.

Brooks, Peter and Horst Zank (2005). "Loss Averse Behavior", *The Journal of Risk and Uncertainty*, 31(3); 301–325

Charness, Gary and Michael Dufwenberg. (2006) "Promises and Partnership", *Econometrica*, 74(6), 1579–1601

Cohen, J. & Dupas, P. (2007). *Free Distribution or Cost-Sharing? Evidence from a Randomized Malaria Prevention Experiment*. Brookings Global Economy and Development Working Paper No. 11

Cropper, Maureen L., Mitiku Haile, Julian Lampietti, Christine Poulos and Dale Whittington. (2004) "The demand for a malaria vaccine: evidence from Ethiopia". *Journal of Development Economics*. 75: 303-318.

Duflo, Esther. (2003). Grandmothers and Granddaughters: Old-Age Pensions and Intrahousehold Allocation in South Africa. *World Bank Economic Review*. *v17*(n1), 1-25.

Duflo, Esther and Christopher Udry. (2004) "Intrahousehold Resource Allocation in Cote d'Ivoire: Social Norms, Separate Accounts and Consumption Choices", National Bureau of Economic Research, Inc, NBER Working Papers: 10498

Dupas, Pascaline (2005) "The Impact of Conditional In-Kind Subsidies on Preventive Health Behaviors: Evidence from Western Kenya", Dartmouth University. Unpublished draft.

Global Fund to Fight AIDS, Tuberculosis and Malaria. (2007) "Partners in Impact - Results Report", http://www.theglobalfund.org/en/files/about/replenishment/oslo/Progress%20Report.pdf

Guyatt, H.L. and S.A. Ochola (2003). "Use of bednets given to pregnant women in Kenya", *The Lancet*, Vol. 362, pp. 1549-1550.

Hoddinott, J., and L. Haddad. (1995) "Does Female Income Share Influence Household Expenditures: Evidence from the Cote d' Ivoire", *Oxford Bulletin of Economics and Statistics*, vol.57, 1995, pp.77-96

Hoffmann, V., C.B. Barrett, D.R. Just (forthcoming) "Do free goods stick to poor households? Experimental evidence on insecticide treated bednets", *World Development*, in press.

Irwin, Julie R, et al, 1994. "Buying/selling price preference reversals: preference for environmental changes in buying versus selling modes", *Organizational behavior and human decision processes*, Vol. 60, 3, 1994, p. 431-457.

Kooreman, P. 2000 "The Labeling effect of a child benefit system", *The American Economic Review*, 90(3) p. 571

Korenromp E.L., J. Miller R.E. Cibulskis, Cham M. Kabir, D. Alnwick, C. Dye. (2003) "Monitoring mosquito net coverage for malaria control in Africa: possession vs. use by children under 5 years", *Tropical Medicine and International Health*. 8(8), pp. 693-703

Kusago, Takayoshi and Bradford L. Barham (2001) "Preference heterogeneity, power, and intrahousehold decision-making in rural Malaysia", World Development. 29(7) p. 1237-1256.

Lengeler C. (2004) Insecticide-treated bed nets and curtains for preventing malaria. *Cochrane Database of Systematic Reviews*, Issue 2. Art. No.: CD000363. DOI: 10.1002/14651858. CD000363 pub2

Milgrom, P. and J. Roberts. (1986) Price and advertising signals of product quality. *Journal of Political Economy*, 94(4):796—821.

Mugisha, F. and Arinaitwe, J. (2003). "Sleeping arrangements and mosquito net use among under-fives: results from the Uganda Demographic and Health Survey", Malaria Journal **2**(40)

Müller, Olaf and Albrecht Jahn (2003). "Expanding insecticide-treated mosquito net coverage in Africa: tradeoffs between public and commercial strategies", editorial, *Tropical Medicine & International Health* 8(10), 853–856.

Oster, Sharon M. *Strategic management for nonprofit organizations: Theory and cases*. Oxford University Press, Oxford, 1995.

Phipps, S, and Burton. P (1998). "What's Mine is Yours?: The Influence of Male and Female Incomes on Patterns of Household Expenditure", *Economica* 65(260): 599-613

PSI (Population Services International) "What is Social Marketing?" Available online: http://www.psi.org/resources/pubs/what_is_SM.html, accessed September 14, 2007

Roll Back Malaria (2000) "The Abuja Declaration and the Plan of Action: An Extract from The African Summit on Roll Back Malaria", Abuja, 25 April 2000 (WHO/CDS/RBM/2000.17) http://www.rbm.who.int/docs/abuja_declaration_final.htm, accessed August 16, 2007.

Snow, Robert W., Charles R.J.C. Newton, Marlies H. Craig, Richard W. Steketee (2003). "The public health burden of Plasmodium falciparum malaria in Africa: Deriving the numbers", Working Paper No. 11, Disease Control Priorities Project. Bethesda, Maryland: Fogarty International Center, National Institutes of Health

Teklehaimanot, Awash, Jeffrey Sachs and Chris Curits (2007) "Malaria control needs mass distribution of insecticidal bednets", *The Lancet*: Jun 30-Jul 6, 2007; 369, 9580;

Thaler, R. H. (1980) Toward a Positive Theory of Consumer Choice. *Journal of Behavioral Decision Making*, *1*(1), 39-60.

Thaler, Richard H. (1990). "Anomalies: Saving, Fungibility, and Mental Accounts" *The Journal of Economic Perspectives*, 4 (1): 193-205.

Thomas, D. (1990) "Intrahousehold Resource Allocation: An Inferential Approach", *Journal of Human Resources* 25: 635-664.

Tversky, A. & Kahneman, D. (1991). "Loss Aversion in Riskless Choice: A Reference Dependent Model", *Quarterly Journal of Economics* 106, 1039-1061.

Uganda Ministry of Health (2006) “The Burden of Malaria in Uganda”, available online: http://www.health.go.ug/malaria.htm, accessed June 23, 2007

WHO (World Health Organization) (2004) “Revised Global Burden of Disease 2002 Estimates”, http://www.who.int/healthinfo/bodgbd2002revised/en/index.html, accessed June 23, 2007