HE
7/22/08
9:00 am

Free Distribution or Cost-Sharing?
Evidence from a Randomized Malaria Prevention Experiment

Jessica Cohen and Pascaline Dupas[1]

This Draft: January 2008

Abstract

It is often argued that cost-sharing—charging a subsidized, positive price—for a health product is necessary to avoid wasting resources on those who will not use or do not need the product. We explore this argument in the context of a field experiment in Kenya, in which we randomized the price at which prenatal clinics could sell long lasting anti-malarial insecticide-treated nets (ITNs) to pregnant women. We find no evidence that cost-sharing reduces wastage on those that will not use the product: women who received free ITNs are not less likely to use them than those who paid subsidized positive prices. We also find no evidence that cost-sharing induces selection of women who need the net more: those who pay higher prices appear no sicker than the prenatal clients in the control group in terms of measured anemia (an important indicator of malaria). Cost-sharing does, however, considerably dampen demand. We find that uptake drops by 75 percent when the price of ITNs increases from zero to $0.75, the price at which ITNs are currently sold to pregnant women in Kenya. We combine our estimates in a cost-effectiveness analysis of ITN prices on child mortality that incorporates both private and social returns to ITN usage. Overall, given the large positive externality associated with widespread usage of insecticide-treated nets, our results suggest that in some settings free distribution might be as cost-effective as cost-sharing, if not more.

[1] Jessica Cohen is at the Brookings Institution and Pascaline Dupas is at Dartmouth College. We thank the Mulago Foundation for its financial support. We also thank the donors to TAMTAM Africa, Inc. for providing the free nets distributed in this study. Jessica Cohen was funded by a National Science Foundation Graduate Research Fellowship. We are very grateful to the Kenya Ministry of Health and its staff for their collaboration. We thank Eva Kaplan, Nejla Liias, and especially Katharine Conn and Moses Barasa for the smooth implementation of the project and the excellent data collection. We also thank David Autor, Esther Duflo, Greg Fischer, Martin Fischer, Raymond Guiteras, Mead Over and Sendhil Mullainathan for helpful comments.
Comments welcome: jcohen@brookings.edu and pascaline.dupas@dartmouth.edu

1. Introduction

There is a general consensus that subsidizing health products with positive externalities can improve welfare. But this consensus coexists with a long-running debate on the extent to which the primary beneficiaries of those goods should contribute to their costs. One argument that has recently gained prominence is that charging non-zero prices for health goods is likely to improve the efficacy of public health interventions by reducing wastage from giving it to those who do not need it or will not use it. This argument rests on three possible effects of positive prices on usage intensity. First, a selection effect: charging a positive price could select out those who do not value the good and place it only in the hands of those who are likely to use it (PSI, 2003; Oster, 1995). Second, a psychological effect: Paying a positive price for a good could induce people to use it more if they exhibit "sunk cost" effects (Thaler, 1980; Arkes and Blumer, 1985). Third, higher prices may also encourage usage if they are interpreted as a signal of higher quality (Bagwell and Riordan, 1991; Riley, 2001).

While cost-sharing may lead to higher usage intensity than free distribution, it also reduces program coverage by dampening demand. A number of experimental and field studies indicate that there may be special psychological properties to zero financial price and that demand may drop precipitously when the price is raised slightly above zero (Ariely and Shampan'er, 2006; Kremer and Miguel, 2007). Beyond reducing demand, selection effects are not straightforward in the context of credit and cash constraints. That is, if people who cannot afford to pay a positive price are more likely to be sick and need the good, then charging a positive price would screen out the neediest and could significantly reduce the health benefits of the partial subsidy.

In the end, the relative benefits of various levels of subsidization of health products depend on a few key factors: 1) the elasticity of demand with respect to price, 2) the elasticity of usage with respect to price (which potentially includes selection, psychological, and signaling effects), 3) the impact of price variation on the vulnerability (i.e. need) of the marginal consumer and, finally, 4) the presence of non-linearities or externalities in the health production function.

This paper estimates the first three parameters simultaneously and explores the tradeoffs between free distribution and cost-sharing for a health product with a proven positive externality: insecticide-treated bed nets (ITNs). ITNs are used to prevent malaria infection and have been proven highly effective in reducing maternal anemia and infant mortality, both directly for users and indirectly for non-users with a large enough share of users in their vicinity. The manufacturing of ITNs is expensive and the question of how much to subsidize them is at the center of a very vivid debate in the international community, opposing proponents of free distribution (Sachs, 2005; WHO, 2007) to advocates of cost-sharing (PSI, 2003; Easterly, 2006).

In a field experiment in Kenya, we randomized the price at which 20 prenatal clinics could sell long-lasting ITNs to pregnant women. Four clinics served as a control group and four price levels were used among the other 16 clinics, ranging from 0 (free distribution) to 40 Kenyan Shillings ($0.60). ITNs were thus heavily-subsidized, with the highest price corresponding to a 90 percent subsidy, comparable to the subsidies offered by the major cost-sharing interventions operating in the area (in particular, the non-profit organization Population Services International (PSI) offers ITNs subsidized at 87.5 percent to pregnant women through prenatal clinics). To check whether women who need the ITN most are willing to pay more for it, we measured hemoglobin levels (a measure of anemia and an important indicator of malaria in pregnancy) at the time of the prenatal visit. To estimate the impact of price variation on usage, we visited a sub-sample of women at home a few months later to check whether they still had the net and whether they were using it.

The relationship between prices and usage that we estimate based on follow-up home visits is the combined effect of selection and sunk cost effects.[2] To isolate these separate channels, we follow Ashraf, et al. (2007) and implement a randomized, two-stage pricing design. In clinics charging a positive price, a sub-sample of women who decided to buy the net at the posted price could participate in a lottery for an additional discount; for women who participated in this second-stage lottery, the actual price ranged from 0 to the posted price. Among those women who agreed to pay a given posted price, any variation in usage with the actual price paid should be the result of psychological sunk cost effects. Taken together, both stages of this experimental design enable us to estimate the relative merits of free distribution and varying degrees of cost-sharing on uptake, selection, and usage intensity.

We find that the uptake of ITNs drops significantly at modest cost-sharing prices. While we do not find a large drop in demand when the price increases from zero to slightly above zero ($0.15), demand drops by 60 percent when the price is increased from zero to 40Ksh ($0.60). This latter

[2] The correlation between prices and usage is also potentially the product of signaling effects of prices, but it is unlikely in our context. Qualitative evidence suggests that the great majority of households in Kenya know that ITNs are subsidized heavily for pregnant women and young children and that the "true" price of ITNs (i.e. the signal of their value) is in the $4-$6 range. This is likely due to the fact that retail shops sell unsubsidized ITNs at these prices.

price is still 10Ksh ($0.15) below the prevailing cost-sharing price offered to pregnant women in this region through PSI. Our estimates suggest that of 100 pregnant women receiving an ITN under full-subsidy, 25 of them would purchase an ITN at the prevailing cost-sharing price.

We find no evidence that usage intensity is increasing with the price of ITNs. Women who paid the highest price were slightly (though insignificantly) more likely to be using the net than women who received the net for free, but at intermediate prices the opposite was true, showing no clear relationship between the price paid and probability of usage, as well as no discontinuity in usage rates between zero and positive prices. Further, when we look only at women coming for their first prenatal care visit (the relevant long-run group to consider) usage is highest among women receiving the fully-subsidized net. Women who received the net free were also no more likely to have re-sold it than women paying higher prices.

The finding that there is no overall effect of ITN prices on their usage suggests that any potential psychological effects of prices are minor and insignificant for this health product. The absence of sunk cost effects is supported by the results from our second-stage randomization, in which we find no significant effect of the actual price paid (holding the posted price constant) on usage. This result is consistent with other recent field work on the sunk cost effect of prices on usage of a water purification product (Ashraf et al. 2007).[3]

In order to explore whether higher prices induce selection of women who need the net more, we measured hemoglobin levels (anemia rates) for women buying/receiving nets at each price. Anemia is an important indicator of malaria and is a common symptom of the disease in pregnant women in particular. We find that prenatal clients who pay positive prices for an ITN are no sicker than the clients at the control clinics. Relative to the control group, women who receive free ITNs have lower rates of anemia, but so do women who pay the highest price for the net.

Taken together, our results suggest that cost-sharing ITN programs may have difficulty reaching a large fraction of the populations most vulnerable to malaria. Since the drop in demand induced by higher prices is not offset by increases in usage, the level of coverage induced by cost-sharing is

[3] Ashraf et al. (2007) find a positive but insignificant effect of the act of paying on usage of a water-treatment product, whereas we find a negative but insignificant effect of the act of paying on usage of a bednet. One difference in the studies is that Ashraf et al. (2007) examine a door-to-door marketing program, whereas the free nets in our study were distributed through health facilities. Another difference is that people in our study were particularly vulnerable in terms of health (pregnant women in a malaria-endemic region).

likely to be too low to achieve the strong social benefits that ITNs can confer. When we combine our estimates of demand elasticity and usage elasticity in a model of cost-effectiveness that incorporates both private and social benefits of ITNs on child mortality, we find that for reasonable parameters, free distribution is as cost-effective as partial-but-still-highly subsidized distribution such as the cost-sharing program for ITNs that is currently underway in Kenya. We also find that, for the full range of parameter values, the number of child lives saved is highest when ITNs are distributed free.

Anecdotally, we do not find that free distribution generates higher leakage of ITNs to non-intended beneficiaries. To the contrary, we observed more leakage and theft (by clinic staff) when ITNs were sold at a higher price. We also did not observe any second-hand market develop in areas with free distribution. Among both buyers and "recipients" of ITNs, the retention rate was above 90 percent.

The absence of a selection effect on valuation (i.e. usage) and need (i.e. health) for an ITN could result from two main factors. First, the distribution of ITNs in our experiment was targeted to the most vulnerable populations (pregnant women), who probably have a stronger need and valuation for ITNs than the general population. Second, willingness and ability to pay counteract each other. That is, it may be the sickest women who are willing to pay more for an ITN, but the sickest women are also likely to be the poorest and the least able to afford cost-sharing prices.

These results have to be considered in their context: ITNs have been advertised heavily for the past couple of years in Kenya, both by the Ministry of Health and the social-marketing NGO Populations Services International (PSI); pregnant women and parents of young children have been particularly targeted by the malaria prevention messages; and most people (even in rural areas) are aware that the unsubsidized price of ITNs is high, thus reducing the risk that low prices through large subsidies are taken as a signal of bad quality. These results thus do not speak to the debate on optimal pricing for health products that are unknown to the public. However, our findings are consistent with previous literature on the value of free products: in a series of lab experiments, both hypothetical and real, Ariely and Shampan'er (2006) find that when people have to choose between two products, one of which is free, charging zero price increases consumers' valuation of the product itself, in addition to reducing its cost. In a recent study in Uganda, Hoffmann (2007) finds that households who are told about the vulnerability of children to malaria on the day they acquire an ITN are more likely to use the ITN to protect their children when they receive it for free than when they have to pay for it.[4]

The remainder of the paper proceeds as follows. Section 2 presents the conceptual framework. Section 3 provides background information on ITNs and describes the experiment and the data. Section 4 describes the results on price elasticity of demand, price elasticity of usage, and selection effects on health. Section 5 presents a cost-effectiveness analysis, and Section 6 concludes.

2. Conceptual Framework

Let's consider a social planner whose objective is to minimize the presence of some poor health outcome *Y* (e.g. malaria episodes, HIV infants, etc.) through the distribution of a health tool (*X*). The social planner has to choose the price *P* at which to sell the good. Define effective coverage as:

$$C = \frac{O \times I}{N}$$

where *O* is the number of people owning the good, *I* is the fraction of those who own the good using it and *N* is the total population.

Suppose the structural relationship between health outcomes (*Y*), coverage (*C*) and prices (*P*) is given by: $Y = F[C(P)]$. We can rewrite this as: $Y = F[C\{O(P), I(P)\}]$, and we can derive:

$$\frac{\partial Y}{\partial P} = \frac{\partial F}{\partial C} \cdot \frac{\partial C}{\partial P} = \frac{\partial F}{\partial C} \cdot [\frac{\partial C}{\partial O} \cdot \frac{\partial O}{\partial P} + \frac{\partial C}{\partial I} \cdot \frac{\partial I}{\partial P}] = \frac{\partial F}{\partial C} \cdot \frac{\partial C}{\partial O} \cdot \frac{\partial O}{\partial P} + \frac{\partial F}{\partial C} \cdot \frac{\partial C}{\partial I} \cdot \frac{\partial I}{\partial P} \quad (1)$$

The first component in (1) corresponds to the "demand" effect of price, or the extensive margin. The second component corresponds to the "intensity of usage" effect of price. Let's consider each component of (1) separately.

Demand effect: Extensive margin

We know that $\partial F / \partial C < 0$ (i.e. using the good *X* reduces the prevalence of some disease *Y*). We also know that $\partial C / \partial O \geq 0$ (i.e. if more people own the good, effective coverage increases) and

[4] A possible interpretation of this result is that recipients of free ITNs may feel that they "owe" it to the donor to use the ITN as intended, whereas buyers do not feel guilty to allocate the ITN among household members as per their own choice.

$\partial O / \partial P \leq 0$ (i.e. if the price of a good increases the number of people using it decreases). Therefore, if there is no impact of price on the intensive margin (e.g. if everyone who owns the good uses it, so that: $\partial I / \partial P = 0$) then moving to cost-sharing from free-distribution unambiguously reduces coverage and thus is worse for health outcomes.

Intensive Margin

We know that $\partial C / \partial I \geq 0$ (i.e. if a higher fraction of the people owning the good are using it, overall usage increases). However the sign of $\partial I / \partial P$ is unknown. As mentioned above, there are two potential reasons why $\partial I / \partial P$ may be positive in our context.[5] First is the selection effect—a higher price generates a pool of owners who are more likely to use the good. Second is the sunk cost effect—paying a higher price for the good may induce usage for psychological reasons. It is also possible that $\partial I / \partial P$ is negative. For example, this may be the case if higher prices screen out poor people and poor people value the good more (e.g. because they are sicker). Since all of these mechanisms could be present, the sign of $\partial I / \partial P$ could also depend on the price level at which we are evaluating it.

The field experiment we conducted sought to estimate $\partial I / \partial P$ and the resulting net effect of prices ($\partial Y / \partial P$) in the case of anti-malarial bed nets in a highly malaria-endemic area.

3. Background on ITNs and Experimental Set-Up

3.1. Background on Insecticide-Treated Nets (ITNs)

ITNs have been shown to reduce overall child mortality by up to 38 percent in regions of Africa where malaria is the leading cause of death among children under 5.[6] ITN coverage protects pregnant women and their children from the serious detrimental effects of maternal malaria. Sleeping under an ITN has been shown to reduce severe maternal anemia (the morbidity measure most sensitive to changes in malaria transmission levels) by up to 47 percent during pregnancy (Marchant et al., 2002; Ter Kuile et al., 2003). In addition, ITN use can help avert some of the substantial direct costs of treatment and the indirect costs of malaria infection on impaired

[5] We ignore the effect of higher prices as signals of quality, as discussed in footnote 3 on page 3.

[6] D'Alessandro et al. (1995), Nevill et al. (1996), Binka et al. (1996), Phillips-Howard et al. (2003). Earlier estimates of ITN use on reductions in child mortality from a randomized trial in Gambia were as high as 60 percent (Alonso, et al. 1991), but most estimates from randomized trials in Africa are closer to 20 percent.

learning and lost income.[7] Lucas (2007) estimates that, alone, the gains to education of a malaria-free environment more than compensate for the cost of an ITN.

Despite the proven efficacy and increasing availability of ITNs on the retail market, the great majority of pregnant women and children in sub-Saharan Africa do not use an ITN.[8] At $5 - $7 a net (US$ in PPP), they are unaffordable to most families, and so governments and NGOs distribute ITNs at heavily subsidized prices.[9] However, the price that is charged for the net varies greatly by the distributing organization, country and consumer.

The failure to achieve higher ITN coverage rates despite repeated pledges by governments and the international community (such as the Abuja Declaration of 2000) has put ITNs at the center of a lively debate over how to price vital public health products in developing countries (Lengeler et al, 2007). Proponents of cost-sharing ITN distribution programs argue that charging a positive price is needed to screen out people who will not use the net, and thus avoid wasting the subsidy on non-users. Cost-sharing programs often have a "social marketing" component, which uses mass media communication strategies and branding to increase the consumer's willingness to pay (PSI, 2003; Schellenberg, et al. 1999 and 2001). The goal is to shore up demand and usage by making the value of ITN use salient to consumers. Proponents of cost-sharing programs also point out that positive prices are necessary to ensure the development of a commercial market, a key to ensuring a sustainable supply of ITNs.

Proponents of full-subsidization argue that, while the private benefits of ITN use can be substantial, ITNs also have important positive health externalities deriving from reduced disease transmission.[10,11] In a randomized trial of an ITN distribution program at the village level in Western Kenya, the positive impacts of ITN distribution on child mortality, anemia and malaria

---

7 In a study conducted in Kenya, Chuma, et al. (2006) estimate that 7.1 and 5.4 percent of monthly expenditures are devoted to the direct and indirect costs of malaria infection, respectively. Among the poorest households, these figures were 11 and 8.1 percent, respectively. Ettling et al. (1994) find that poor households in a malaria-endemic area of Malawi spend roughly 28 percent of their cash income treating malaria episodes.

8 The most recent household data available (from the World Health Organization's World Malaria Report (2005)) indicates that less than 10 percent of children in Kenya, where this evaluation takes place, sleep under an ITN.

9 Guyatt et al. (2002), Cham et al. (1997), Okrah, et al. (2002), Holtz, et al. (2002) and Winch, et al. (1997).

10 The external effects of ITN use derive primarily from three sources: (1) fewer mosquitoes due to contact with insecticide, (2) reduction in the infective mosquito population due to the decline in the available blood supply, and (3) fewer malaria parasites to be passed on to others.

11 The case for fully-subsidizing ITNs has also been made on the basis of the substantial costs to the government of hospital admissions and outpatient consultations due to malaria (Evans, et al., 1997).

infection were as strong in control villages within 300 meters of intervention villages as they were in the intervention villages themselves (Gimnig et al., 2003; Hawley et al., 2003).[12] While ITNs may have positive externalities at low levels of coverage (e.g. for unprotected children in the same household), it is estimated that at least 50 percent coverage is required to achieve strong community effects on mortality and morbidity (Hawley et al., 2003). To date, no cost-sharing distribution program is known to have reached this threshold (WHO, 2007).

3.2. Experimental Set-up

The experiment was conducted in 20 communities in Western Kenya, spread across four districts: Busia, Bungoma, Butere and Mumias. Malaria is endemic in this region of Kenya: transmission occurs throughout the year with two peaks corresponding to periods of heavy rain, in May/June/July and October/November. In two nearby districts, a study by the CDC and the Kenyan Medical Research Institute found that pregnant women may receive as many as 230 infective bites during their 40 weeks of gestation (Ter Kuile et al., 2003). Malaria and anemia are common during pregnancy in Western Kenya and up to a third of all infants are born either premature, small-for-gestational age or with low birth weight (Ter Kuile et al., 2003).

The latest published data on net ownership and usage available for the region come from the Kenya Demographic and Health Survey of 2003. It estimated that 19.8 percent of households in western Kenya had at least one net and 6.7 percent had a treated net (an ITN); 12.4 percent of children under 5 slept under a net and 4.8 percent under an ITN; 6 percent of pregnant women slept under a net the night before and 3 percent under an ITN. Net ownership is likely to have gone up since, however. In July 2006, the Measles Initiative ran a one-week campaign throughout Western Kenya to vaccinate children between 9 months and 5 years of age, distributing free long-lasting ITNs to mothers who would bring their children as an incentive mechanism to achieve high coverage with the vaccine. A 2007 survey conducted (for a separate project) in the area of study among 622 households with school-age children found a rate of long-lasting ITN ownership around 30%.

[12] In a similar study in Ghana, Binka et al. (1998) find that child mortality increases by 6.7 percent with each 100 meter shift away from the nearest household with an ITN.

Our experiment targeted ITN distribution to pregnant women visiting health clinics for prenatal care.[13] Distribution was targeted in this way since pregnant women and newborns are very vulnerable to acquiring and suffering severe consequences from malaria. We worked with 20 rural, public health centers chosen from a total of 70 health centers in the region, 17 of whom were private and 53 were public. The 20 health centers we sampled were chosen based on their public status, their size, services offered and distance from each other. We then randomly assigned them to one of five groups: 4 clinics formed the "control group"; 5 clinics were provided with ITNs and instructed to give them free of charge to all expectant mothers coming for prenatal care; 5 clinics were provided with ITNs to be sold at 10Ksh (corresponding to a 97.5 percent subsidy); 3 clinics were provided with ITNs to be sold at 20Ksh (95.0 percent subsidy); and the last 3 clinics were provided with ITNs to be sold at 40Ksh (90 percent subsidy). The highest price is 10Ksh below the prevailing subsidized price of ITNs in this region, offered through PSI to pregnant women at prenatal clinics.[14] Table 1 presents summary statistics on the main characteristics of health centers in each group.

Clinics were provided with financial incentives to carry out the program as designed. For each month of implementation, clinics received a cash bonus (or a piece of equipment of their choice) worth 5,000Ksh (approximately $75) if no evidence of "leakage" or mismanagement of the ITNs or funds was observed.[15] Clinics were informed that random spot checks of their record books would be conducted, as well as visits to a random sub-sample of beneficiaries to confirm the price at which the ITNs had been sold and to confirm that they had indeed purchased an ITN (if the clinic's records indicated so). Despite this, we observed leakages and mismanagement of the ITNs in 4 of the 11 clinics that were asked to sell ITNs for a positive price (one at 10Ksh, two at 20Ksh, and one at 40Ksh). We did not observe any evidence of mismanagement in the five clinics instructed to give out the ITNs for free. Out of the four clinics that mismanaged the ITNs, none of them altered the price at which ITNs were made available to prenatal clients, but three clinics

---

[13] The nets distributed through our program were PermaNets, sold by Vestergaard Frandsen. They are circular, polyester bed nets, treated with the insecticide Deltamethrin and maintain efficacy without retreatment for about 3 – 5 years (or about 20 washes).

[14] Results from a pre-program clinic survey suggest that it is perhaps not appropriate to interpret our results in the context of widely available ITNs to pregnant women at 50Ksh, as many of the clinics reported the supply of PSI nets to be erratic and frequently out of stock.

[15] Clinics that implemented the program for three months without incident thus received a $225 gift, a substantial amount for rural clinics in Kenya.

sold some of the program ITNs to ineligible recipients (i.e. non prenatal clients).[16] In addition, the stock of ITNs stored by clinics depleted and was unaccounted for in three clinics.[17]

The ITN distribution program was phased into all clinics between March and May 2007, and was kept in place for at least 3 months in each clinic, throughout the peak "long rains" malaria season and subsequent months. Posters were put up in clinics to inform prenatal clients of the price at which the ITNs were sold. Other than offering a free hemoglobin test to each woman on survey days, we did not interfere with the normal procedures these clinics use at prenatal care visits, which often include a discussion of the importance of bed net use.

Within clinics where the posted price was positive, a second stage randomization was conducted on unannounced, random days. On those days, women who had expressed their willingness and showed their ability to purchase an ITN at the posted price (by putting the required amount of money on the counter) were given the opportunity to participate in a lottery for an additional promotion by picking an envelope from a basket. The final price paid by women participating in the lottery could be the initial offer price if they picked an empty envelope; zero if they picked a "free net" envelope; or a positive price below the initial offer price if the initial price was 40Ksh.[18]

3.3. Data

Three types of survey data were collected. First, administrative records kept by the clinic on ITN sales were collected. Second, each clinic was visited three or four times on random days, and on those days enumerators surveyed all pregnant women who came for a prenatal visit. Women were asked basic background questions and whether they purchased a net, and their hemoglobin level was recorded. In total, these measures were collected from 545 pregnant women. Third, a random sample of 246 prenatal clients who had purchased/received a net through the program was selected to be visited at their home 3 to 10 weeks after their net purchase. All home visits were conducted within three weeks in July 2007 to ensure that all respondents faced the same

[16] They forged the receipts to pretend that prenatal clients had bought the nets, but spot checks with the supposed "buyers" proved that the ITNs had been sold to others. These cases were observed in 2 clinics in the 20 Ksh group and 1 clinic in the 40 Ksh group.
[17] 15 ITNs were stolen in one of the five clinics selling the ITNs at 10Ksh; 42 ITNs were stolen from one of the clinics selling the ITNs at 20Ksh; and 22 ITNs were stolen in one of the clinics selling the ITNs at 40Ksh. In all three cases, it is likely that a staff member of the clinic stole the ITNs from the storage room.
[18] This second-stage randomization started at least five weeks after the program had started in a given clinic, and took place no more than once a week, on varying week days, to avoid biasing the women's decisions to purchase the ITN based on the expectation of a discount.

environment (especially in terms of malaria seasonality) at the time of the follow-up. Of this sub-sample, 92 percent (226 women) were found and consented to be interviewed. During the home visit, respondents were asked to show the net, whether they had started using it, and who was sleeping under it. Surveyors checked to see whether the net was taken out of the packaging, whether it was hanging, and the condition of the net.[19]

3.4. Randomization at the Clinic Level

The price at which ITNs were sold was randomized at the clinic level, but our outcomes of interest are individual-level behavioral choices: take-up and usage rates. When regressing individual-level dependent variables on clinic-level characteristics we are likely to overstate the precision of our estimators if we ignore the fact that observations within the same clinic (cluster) are not independent (Moulton, 1990; Donald and Lang, 2007). We compute cluster-robust standard errors by using the cluster-correlated Huber-White covariance matrix method (the STATA "cluster" command). In addition, since the number of clinics (clusters) is small (16 treatment clinics), the critical values for the tests of significance are drawn from a t-distribution with 14 (= 16 - 2) degrees of freedom (Cameron, Miller and Gelbach, 2007). The critical values for the 1 percent, 5 percent and 10 percent significance levels are thus 2.98, 2.14 and 1.76, respectively.

4. Results

4.1. Price-Elasticity of Demand for ITNs

Figure 1a plots average sales during the first month of the program by ITN price. Demand appears to be decreasing monotonically in price, with only a modest drop between 0 and 10Ksh, and the largest drop occurring between 20 and 40Ksh. The quantity of ITNs sold at the highest price is 79 percent lower than the quantity distributed for free (0Ksh).

Table 2 presents coefficient estimates from OLS regressions of weekly ITN sales on price with district fixed effects. The coefficient estimate on ITN price from the most basic specification in Column 1 is -0.797. This estimate implies that weekly ITN sales drop by about 8 nets for each 10Ksh increase in price. Since clinics distributing ITNs for free to their clients distribute an average of 41 ITNs per week, these estimates imply that a 10Ksh increase in ITN price leads to a

[19] The nets that were distributed through the program were easily recognizable through their tag. Enumerators were instructed to check the tag to confirm the origin of the net.

20 percent decline in weekly ITN sales. The specification in Column 2 regresses weekly ITN sales on indicator variables for each ITN price (0Ksh is excluded). Though noisy, since observations are at the clinic-level, these estimates suggest that the impact of price on demand is non-linear. Contrary to Kremer and Miguel (2007), we find no evidence that a small increase in price above zero reduces demand for ITNs sharply. The elasticity of demand is lowest between 0 and 10Ksh. Raising the price from 0 to 40Ksh reduces demand by 80 percent (from 41 ITNs per week to 9)—a substantial decline in demand, a bit smaller than the decline implied by the linear estimate in Column 1.

Columns 3 and 4 present results of robustness checks conducted by including various characteristics of the clinics as controls. Since net sales are conditional on enrollment at prenatal clinics, one concern is that our demand estimates are confounded by variation in the level of prenatal attendance across clinics. Subsidized ITNs may provide an incentive to receive prenatal care, and therefore the level of prenatal enrollment after the introduction of the program is an endogenous variable of interest (Dupas, 2005). Any impact of ITN price on total enrollment should be captured by total ITN sales (which reflect the change in the number of patients and in the fraction of patients willing to buy ITNs at each price). However, our demand estimates could be biased if total attendance prior to program introduction is correlated with the assigned ITN price. To check whether this is the case, the specification in Column 3 controls for monthly prenatal attendance at each clinic in 2006. The specification in Column 4 controls for additional clinic characteristics that could potentially influence attendance such as any fee for prenatal care, whether the clinic offers counseling and/or testing for HIV, the distance to the closest other clinic/hospital in our sample and the distance to the closest other clinic/hospital in the area. The coefficient estimates on ITN price are basically unchanged when clinic controls are included, but their precision is improved. However, the inclusion of clinic controls changes the coefficient of the price dummies, especially for the 10Ksh price group: the specification in Column 6 suggests that take-up is higher when ITNs are sold for 10Ksh rather than handed out for free. This is not confirmed by the individual data we analyzed below.

One might be concerned that our net sales data is biased due to (a moderate amount of) mismanagement, theft and misreporting by clinics. Further, since the number of observations in Table 2 is so small, demand estimates are not precisely estimated. For these reasons, it is important to check that the demand estimates based on net sales are consistent with those based on our survey data. Table 3 presents additional estimates of demand based on individual-level data from surveys conducted among all prenatal clients who visited the clinics on the days random checks were conducted. These specifications correspond to linear probability models where the dependent variable is a dummy equal to one if the patient bought or received an ITN; the independent variables are the price at which ITNs were sold, or dummies for each price. The coefficient estimate of -.015 on ITN price in Column 1 implies that a 10Ksh increase in the price of ITNs reduces demand by 15 percentage points. This is very consistent with the results based on net sales; they suggest that demand for ITNs is 75 percent lower at the current cost-sharing price in Kenya (50Ksh or $0.75) than it would be under a free distribution scheme.

Robustness checks are presented in Columns 2 and 3 of Table 3. Column 2 controls for when the survey was administered, including day of the week fixed effects and the time elapsed since program introduction. Column 3 controls for the same clinic characteristics used in Table 2, Column 4. These coefficient estimates are still very close to the basic specification.

Estimates in Column 4 confirm that demand decreases increasingly rapidly with price. The decrease in demand for an increase in price from 0 to 10Ksh is estimated at 7 percentage points (larger than suggested by the clinic-level ITN sales in Table 2), but an increase in price from 20 to 40Ksh leads to a 43 percentage point drop in demand. That is, demand drops at a rate three times faster between 20 and 40Ksh than between 0 and 10Ksh.

Column 5 presents demand estimates for the restricted sample of women who are making their first prenatal care visit for their current pregnancy. This is the relevant long-run population to consider when estimating the impact of a permanent distribution scheme at a given price *P* through prenatal clinics; indeed, once the stock of women who are pregnant when the program begins runs out, every woman would have access to an ITN at price *P* at their first visit. It is also important to separate first visits from revisits because the latter may be returning because they are sick. Alternatively, women who are coming for a second or third visit may be healthier, since they have already received the benefits of the earlier visit(s), some of which can directly affect their immediate need for an ITN (such as malaria prophylaxis and iron supplementation). The coefficient estimate in Column 5 is larger than that for the entire sample, implying that women coming for the first time are more sensitive to price than women coming for a revisit. This could be because women who return are sicker, but it also could be that women learn about the subsidized ITN program at their first visit and bring the cash to purchase the net at their second visit.

Access to free ITNs from other sources could have dampened demand for ITNs distributed through the program. This is a real concern, since the Measles Initiative ran a campaign in July 2006 (9 months before the start of our experiment) throughout Kenya to vaccinate children between 9 months and 5 years of age, distributing free ITNs to mothers of these children in Western Kenya. To examine the demand response among women who are less likely to have had access to free ITNs in the past, Column (6) estimates the impact of ITN price on demand for women in their first pregnancy only. When we restrict the sample in this way, the coefficient on ITN price drops to -.011. This implies that women in their first pregnancy are indeed less sensitive to ITN price differences, but their demand still drops by 55 percentage points when the ITN price is raised from 0 to 50Ksh.

In sum, our findings suggest that demand for ITNs is not very sensitive to small increases in price from zero, but that even a moderate degree of cost-sharing leads to large decreases in demand. At the mean, a 10Ksh ($0.15) increase in ITN price decreases demand by 20 percent. These estimates suggest that the majority of pregnant women are either unable or unwilling to pay the prevailing cost-sharing price, which is itself still far below the manufacturing cost of ITNs.

4.2 Price-Elasticity of the Usage of ITNs

Figure 2 shows the average usage rate of program-issued ITNs across price groups. Figure 2a shows self-reported usage rates, and Figure 2b shows the likelihood that the ITN was found hanging, both measured during an unannounced home visit by an enumerator. On average, 62 percent of women visited at home claimed to be using the ITN they acquired through the program, a usage rate that is very consistent with previous usage studies (Alaii et al., 2003; D'Alessandro et al., 1994). However, we find little variation in usage across price groups. This is confirmed by the regression estimates of selection effects on usage, presented in Table 4. Our coefficient estimate on ITN price in Column 1 is positive, but insignificant, suggesting that an increase of 10Ksh increases usage by a modest 4 percentage points, representing an increase of 6 percent at the mean. The confidence intervals are large, however, and the true coefficient could be on either side of zero. Adding controls in Column 2 does not improve precision.

Estimates using indicators for each price in Column 3 are also very imprecise, but show no pattern of increasing use with price. Women who pay 10 and 20Ksh are less likely to be using their ITN than women receiving it for free. In none of the cases, however, can we reject the hypothesis that price has no effect on intensity of usage.

The fact that higher prices do not seem to encourage selection of those more likely to use an ITN is more apparent when we restrict the sample to first visits and first pregnancies. Women who received a free ITN at their first visit appear more likely than all other price groups to be using the net (Column 5), but none of the coefficients on prices are significant. When restricting the sample to women in their first pregnancy we find overall usage rates are about 10 percent higher than for the sample as a whole (72 percent compared to 62 percent). The point estimate on usage is negative for this subgroup as well, but here again the sample size is very small and the estimates are insignificant.

Usage has traditionally been difficult to measure. In this case, checking usage of ITNs is fairly straightforward since the surveyor can see whether the net is hanging. Of course, we cannot observe whether the net is actually used at night, but it is reasonable to believe that, if the ITN is taken out of its packaging and has been hung on the ceiling, it is being used. Of those women who claimed to be using the ITN, 95 percent of them had the net hanging. It is not surprising, therefore, that results for whether or not the net is hanging (Columns 8 and 9) are very similar to those using self-reported usage (Columns 1 and 3).

Overall, the results so far suggest that, in this context, positive prices do not help generate higher usage intensity than free distribution.[20] The absence of a selection effect on usage could be due to the nature of the good studied, which is probably valued very highly in areas of endemic malaria, particularly among pregnant women who want to protect their babies. The context in which the evaluation took place also probably contributed to the high valuation among those who didn't have to pay. In particular, women had to travel to the health clinic for the prenatal visit and were told at the check-up about the importance of protection against malaria. In addition, PSI has been conducting a very intense advertising campaign for ITN use throughout Kenya over the past 5 years. Last, the evaluation took place in a very poor region of Kenya, in which many households do not have access to credit and have difficulty affording even modest prices for health goods.

[20] We also find no evidence that women receiving a free net are more likely to resell it. In fact, none of the women in our sample had sold the net at the time of our visit. Among those not using the net, the most common reasons given were that they were waiting for the birth of the child or for another net to wear out.

Thus, a large number of prenatal clients may value ITNs but be unable to pay higher prices for them.

Figure 3 combines our demand estimates from Table 3 with usage rates in Table 4 to estimate overall coverage rates across ITN prices. The share of prenatal clients that are protected by an ITN under the free distribution scheme is 63 percent, versus 14 percent when ITNs are sold for 40Ksh. These results imply that, at least in the Kenyan context, cost-sharing programs cannot offset through increased usage rates what is lost in dampened demand.

4.3. Are there Psychological Effects of Prices on Usage of ITNs?

In this section, we test whether the act of paying itself can stimulate higher product use by triggering a sunk cost effect, when willingness to pay is held constant. We use data from the ex-post price randomization conducted with a subset of women who had expressed their willingness to pay the posted price (in clinics charging a positive price). For those women, the transaction price ranged from "free" to the posted price they initially agreed to pay. Table 5 presents the coefficients of the effect of price levels (Columns 1 – 3) and of the act paying (Columns 4 – 8) on the likelihood of usage and likelihood that the ITN has been hung. These coefficients are from linear probability models with clinic fixed effects, estimated on the sample of women who visited a clinic where ITNs were sold at a positive price, decided to buy an ITN at the posted price, and were sampled to participate in the ex-post lottery determining the transaction price they eventually had to pay to take the net home.

We find no psychological effect of price or the act of paying on usage, as expected from the earlier result that there is no overall effect of prices on usage. In Column 1, the coefficient for price is negative, suggesting that higher prices could discourage usage, but the effect is not significant and cannot be distinguished from zero. Adding a control for having received a free ITN from the government in the previous year does not change this result (Column 2). In Column 4, the coefficient for the act of paying a positive price is also negative, suggesting that if the act of paying has any effect, it would decrease usage rather than increase it, but here again the coefficient cannot be confidently distinguished from zero. Overall, these results suggest that, in the case of ITNs marketed through health clinics, there is no psychological effect of price on usage. We do not have data on baseline time preferences to check (as done in Ashraf et al., 2007) whether certain subgroups are more likely to exhibit a "sunk cost" effect. We also do not have data on what women perceived *ex post* as the price they paid for the ITN; we thus cannot verify that those who received a discount mentally "integrated" the two events (payment and discount) to "cancel" the loss, in the terms of Thaler (1985), or whether they "segregated" the two events and perceived the payment as a cash loss and the discount as a cash gain.[21]

If usage does not increase with price, what about the private benefits to the users? Is it the case, as often assumed, that the users reached through the 40Ksh distribution system are those that really need the ITN, whereas the additional users obtained through the free distribution will not benefit from using the ITN because they don't need it as much (i.e. they are healthier, or can afford other means to protect themselves against malaria)? From a public health point of view, this issue might be irrelevant in the case of ITNs, given the important community-wide effects of ITN use documented in the medical literature cited earlier: It is likely that there will be large, positive social returns associated with the massive increase in effective coverage that can be obtained through free distribution (as shown in Figure 3). Nevertheless, it is interesting to test the validity of the argument advanced by cost-sharing programs with respect to the private returns of ITN use. This is what we attempt to do in the next section.

4.4 Selection Effects of ITN Prices

This section presents results on selection effects of positive prices on the health of patients who buy them. The argument that cost-sharing targets those who are more vulnerable by screening out women who appear to need the ITN less assumes that willingness to pay is the main factor in the decision to buy an ITN. In the presence of extreme poverty and weak credit markets, however, it is possible that ability to pay also plays a major role. The overall effect of price on the average "need" of ITN owners will thus depend on the relative importance of those two factors: willingness and ability to pay. The optimal subsidy level will have to be low enough to discourage women who do not need the product to buy it, while at the same time high enough to enable credit-constrained women to buy it if they need it. We focus our analysis on an objective measure of health among prenatal clients – their hemoglobin level. Women who are anemic (i.e. with a low hemoglobin level) are likely the women with the most exposure and least resistance to malaria, and are likely the consumers that a cost-sharing program would want to target.

[21] After having committed to purchase the ITN at the posted price, women could have mentally accounted the discount they received as a cash gain, and thus felt that they had paid for the ITN at its posted price despite the discount. If that's the case, even those who received the discount could have felt a "sunk cost", explaining why we do not see a difference across discount groups.

To judge whether higher prices encourage sicker women to purchase nets, we study the impact of price on the health of "takers" (i.e. buyers and recipients of free nets) relative to the health of the prenatal clients attending control clinics. Figure 4 plots the cumulative density functions (CDF) of hemoglobin levels for women buying/receiving a net at each price relative to women in the control group. For all positive prices, the CDF of hemoglobin levels of women who pay is either indistinguishable (10Ksh and 20Ksh) or to the right (40Ksh) of the CDF of women in the control clinics. The CDF for women receiving free nets is clearly to the right of the control group.

For each price level, we test the significance of the differences in CDFs (compared to the control group) with the Kolmogorov-Smirnov equality-of-distributions test. This non-parametric test rejects the null hypothesis of samples coming from the same populations if there is a point for which the cumulative empirical distributions of two independent samples are significantly different (Cassiman and Golovko, 2007). The results of the tests are presented in Table 6, Panel A. We can reject the null of hypothesis of equality of distributions between women who receive free nets and those attending control clinics at the 5 percent significance level (Panel A, Column 1). With p-values of .41 and .25, we cannot reject the equality of distributions for women in the control population and those paying 10 and 20Ksh for an ITN. Although the CDF of women paying 40Ksh appears shifted to the right of the control group in Figure 4, the p-value for the difference in distributions is not quite significant at .17.

Panel B in Table 6 presents the average characteristics of prenatal clients in control clinics (Column 1), and, for each price group, how the average buyer diverges from the average woman in the control group (Columns 2 to 5). These coefficient estimates reflect what can be seen in Figure 4: hemoglobin levels are .86 points higher among women who receive a free net than among women in the control group, while point estimates for higher prices are positive but not significant. Similarly, women paying positive prices are not more likely to be moderately or severely anemic than women in the control population, but women receiving free nets are substantially less likely to be sick.[22]

[22] While the characteristics of *buyers* is what is of interest in analyzing selection effects of cost-sharing, one might be concerned that it is inappropriate to compare characteristics of buyers at each price to the characteristics of the entire control group. We were not able to collect information on who bought nets at the control clinics, but when we compare the health and other characteristics of the total group of women attending clinics in each price group to the total control group, we find very similar results (tables available upon request).

Why would it be that women who receive free nets appear substantially healthier, even though higher prices do not appear to induce selection of women who are sicker than the general prenatal population? As illustrated in Figure 1b, enrollment at prenatal clinics is higher when ITNs are provided free of charge than when ITNs are sold for 20 or 40Ksh. This is consistent with a previous study illustrating a strong incentive effect of free ITNs on enrollment for prenatal care (Dupas 2005). As shown by the share of revisits in clinics providing free ITNs (Table 6, Panel B2), the free ITN distribution induced some women (who had come to the clinic before the introduction of the program) to come back for a revisit earlier than scheduled – in other words, before the health benefits of their first prenatal visit had worn out.[23] It also may have encouraged women who were enrolled for prenatal care in a neighboring clinic to walk an extra mile or pay additional transport fare in order to re-enroll at the prenatal clinic where they could get a free ITN. If the women who can afford to switch clinics are healthier and richer (able to pay higher transport costs and able to pay a second enrollment fee), then the pool of women attending the clinics offering free ITNs are likely to be less representative of the overall prenatal population than the women attending the clinics selling nets for higher prices. (The 20 clinics in our sample are sufficiently far away from each other that switches between clinics are highly unlikely in our sample, but there are, on average, 3 to 4 un-sampled prenatal clinics within 10 kilometers of a program clinic, as shown in Table 1).

The results in Panel B2 of Table 6 provide some evidence for the hypothesis that the incentive effect of free ITNs was strong: women who came for free nets were 12 percent more likely to be coming for a repeat visit, 14 percent more likely to have paid for transportation and paid about 3.5Ksh more to travel to the clinic than women in the control group. It is interesting to note that women who bought nets for 40Ksh were more likely to pay for transportation and paid more to come to the clinic than the control group as well, probably reflecting the fact that women who could afford 40Ksh are on average wealthier than women in the control group.[24]

In sum, the results in this section suggest that women who pay more for a net a no more likely to be sick than women in the general population. Due to the large decline in demand, this implies that ITNs are reaching fewer vulnerable women at 40Ksh. Figure 5 combines our estimates of

---

[23] In Kenya, pregnant women are typically given free iron supplements, as well as free presumptive malaria treatment, when they come for prenatal care. Both of these "treatments" have a positive impact on hemoglobin levels.

[24] This hypothesis is supported by the fact that, when we compare the average client at 40Ksh clinics (rather than the average buyer at these clinics) to the average control client, they are no more likely to have paid for transportation and paid no more for transportation than the control group (results not shown).

demand, usage and anemia rates to explore coverage of anemic women across ITN prices. It shows that, when the price is 40Ksh or higher, the number of anemic pregnant women gaining access to ITN coverage in the presence of a cost-sharing scheme is significantly lower than under a free distribution scheme.

5. Cost-Effectiveness Analysis

In this section we attempt to estimate the cost-effectiveness of each pricing strategy in terms of children's lives saved. As discussed in Section 3, there are many benefits to preventing malaria transmission in addition to saving children's lives, and restricting ourselves to child mortality will lead to conservative estimates of cost-effectiveness.

Quantifying Differences in Costs

In the analysis that follows, we assume that the only difference in cost per ITN between free distribution and cost-sharing is the difference in the subsidy. That is, we assume that an ITN given for free costs only 40Ksh more to the social planner than an ITN sold for 40Ksh. This assumption could be wrong for two reasons. First, given the demand effect, many more ITNs need to be delivered to clinics when they are distributed for free; this could increase the logistical cost (transportation and storage) of free distribution, unless there are economies of scale. On the other hand, cost-sharing introduces the need for additional supervision and accounting to ensure that the proceeds of the sales are not captured by clinic staff. This will tend to increase the logistical cost of cost-sharing. We do not have sufficient evidence on the importance of these two possible effects to quantify the differences in costs more precisely. For what it's worth, during the three months we implemented the various subsidy levels across 20 clinics, we experienced similar costs across subsidy levels.

Quantifying Differences in Benefits

An important dimension to keep in mind in the cost-effectiveness analysis is the non-linearity in the health benefits associated with ITN use: high-density ITN usage reduces overall transmission rates and thus positively affects the health of both non-users and users. The results of a recent medical trial of ITNs in Western Kenya imply that "in areas with intense malaria transmission with high ITN coverage, the primary effect of insecticide-treated nets is via area-wide effects on the mosquito population and not, as commonly supposed, by simple imposition of a physical barrier protecting individuals from biting" (Hawley et al, 2003). In this context, we propose the following methodology to measure the health impact of each ITN pricing scheme: we create a "protection index for non-users" (a logistic function of the share of users in the total population) and a "protection index for users" (a weighted sum of a "physical barrier" effect of the ITN and the externality effect, the weights depending on the share of users). This enables us to compute the health impact of each pricing scheme on both users and non-users and to (roughly) approximate the total number of child lives saved, as well as the cost per life saved.[25] Because the relative importance of the "physical barrier" effect and of the externality are unclear, we consider three possible values for the parameter of the logistic function predicting the protection index for non-users (we call it the "threshold externality parameter") and three possible values for the effectiveness of ITNs as physical barriers. This gives us a total of 3 x 3 = 9 different scenarios and 9 different cost-per-life-saved estimates for each of the 4 pricing strategies. Figure 6 illustrates how the protection indices vary with the share of users in the entire population, and shows the 3 options we consider for each parameter. Figure 6a shows that under the "low threshold" assumption the protection index for non-users reaches 0.7 for a share of users as low as 35 percent; whereas under the "medium" and "high" threshold assumption the protection index for non-users doesn't reach 0.5 until the share of users is 50 and 65 percent, respectively.[26]

Given the importance of the externality effect, another key parameter in the cost-effectiveness analysis is the share of ITN users in the total population. In Table 7, we assume that distribution programs would last for five years and estimate the share of ITN users in the entire population that would result under each price scenario at the end of the five years. This number depends on three factors: the share of ITN owners among households eligible for the program (i.e. households with a pregnancy), the share of users among owners, and the share of eligible households in the total population. While we estimated carefully the first two factors in our experiment, we do not know the last factor with certainty. We thus propose three possibilities (where the share of eligible households in a five year period is 65, 75 or 85 percent) and compute the resulting share of ITN users in the entire population. As discussed in the previous section, we find that cost-sharing considerably reduces the share of ITN users. With the conservative estimate of only 65

[25] Randomized controlled trials in different malaria transmission settings have shown insecticide-treated bed nets (ITNs) reduce all cause mortality in children less than five years old by 17 percent (Phillips-Howard et al., 2003). We follow these results, under the assumption that the baseline under-five mortality rate (in the absence of ITN coverage) is 50 deaths per 1000 child-years. To compute the number of lives saved in Table 8, we assume that for 1000 households with a newborn, 42.5 child lives will be saved if all 1000 households are fully protected (100 percent protection index) for five years, but only (42.5 x p/100) child lives will be saved if the protection index among those households is only p (p between 0 and 100). These figures might be too rough, but they don't affect the outcome of the cost-effectiveness comparisons. The costs per life saved in Table 8 are only provided to enable these comparisons, but their absolute values should be taken with caution.
[26] The latest literature suggests that the threshold is around 50 percent (Hawley et al, 2003). Therefore the "medium" case seems the most realistic.

percent of households experiencing a pregnancy, we see that none of the schemes manages to reach the 50 percent coverage threshold that has been discussed in the medical literature with respect to the importance of the externality effect.

Mechanically, in the presence of an ITN distribution program through prenatal clinics, the share of ITN users in the entire population increases as the share of households experiencing a pregnancy within five years increases. Since the share of users plays an important role in the cost-effectiveness estimates, we will restrict ourselves to the most conservative assumption (only 65 percent of households experiencing a pregnancy within five years). Making a less conservative assumption would increase the cost-effectiveness of distribution programs that generate a higher coverage rate (i.e. free distribution compared to cost-sharing).

Cost-Effectiveness Results

Table 8 presents the cost-effectiveness results for each of the 9 hypothetical scenarios for each of the 4 pricing schemes. In all 9 scenarios, the free distribution strategy saves the lives of more children than any cost-sharing strategy. This result is not surprising considering the large negative effect of cost-sharing on the share of ITN users in the entire population that we identified earlier. Under the low threshold assumption for the externality effect, in terms of cost per life saved, we find that charging 40Ksh is more cost-effective than free distribution if the physical barrier effect of ITNs is high (Panel D, Column 1). When the assumptions about the effectiveness of ITNs as physical barriers for their users are less optimistic, we find that free distribution becomes at least as cost-effective, if not more, than cost-sharing. Under the assumption of a "medium" externality threshold level, we find that free distribution could dominate cost-sharing in terms of cost-effectiveness (Panel D, Columns 4 – 6). Last, in the scenario where a large share of ITN users is necessary for a substantial externality to take place, we find that cost-sharing is again slightly cheaper than free distribution, unless the physical barrier effectiveness is very low. This is due to the fact that under the high threshold hypothesis, even free distribution to pregnant women is not enough to generate significant community-wide effects since not all households experience a pregnancy. It is worth noting, however, that under less conservative estimates regarding the number of households eligible for the free distribution program within five years, the free distribution strategy would become more effective than cost-sharing even for a high externality threshold level.

That said, given the very large standard errors on the usage estimates, the differences observed in cost per life saved cannot be distinguished from zero. The general conclusion of this cost-effectiveness exercise is thus that cost-sharing is at best marginally more cost-effective than free distribution, but free distribution leads to many more lives saved.

6. Conclusion

The argument that charging a positive price for a commodity is necessary to ensure that it is effectively used has recently gained prominence in the debate on the efficiency of foreign aid. In his 2006 book *The White Man's Burden*, William Easterly, discussing the rationale for the cost-sharing ITN program run by PSI in Malawi (p. 13), argues that ITNs distributed for free "are often diverted to the black market, become out of stock at health clinics, or wind up being used as fishing nets or wedding veils." This cost-sharing model of selling nets for $0.50 to mothers through prenatal clinics in Malawi is believed to reduce waste because "it gets the nets to those who both value them and need them." Our randomized pricing experiment in Western Kenya finds no evidence to support these assertions. We find no evidence that cost-sharing reduces wastage by sifting out those who would not use the net: pregnant women who receive free ITNs are no less likely to put them to intended use than pregnant women who pay for their nets. This suggests that cost-sharing does not increase usage intensity in this context. While it doesn't increase usage intensity, cost-sharing does considerably dampen demand: we find that the current cost-sharing scheme run by PSI in Kenya for this population results in a coverage rate 75 percentage points lower than with a full subsidy. In terms of getting nets to those who need them, our results on selection based on health imply that women who purchase nets at cost-sharing prices are no more likely to be anemic than women in the control group. Combining our results on demand, usage and health, we find that current levels of cost-sharing for ITNs achieve much lower coverage rates among anemic pregnant women than free distribution. Overall, our results suggest that cost-sharing is less effective and no more cost-effective than free distribution.

While our results speak to the ongoing debate regarding the optimal subsidization level for ITNs—one of the most promising health tools available in public health campaigns in sub-Saharan Africa—they may not be applicable to other public health goods that are important candidates for subsidization. In particular, it is important to keep in mind that this study was conducted when ITNs were already highly valued in Kenya, thanks to years of advertising by both the Ministry of Health and Population Services International. This high *ex-ante* valuation likely inoculated the risk that a zero or low price be perceived as a signal of bad quality.

Future research is needed to understand better the contexts in which a "sunk cost" effect emerges. In this study, we did not find evidence that either the act of paying or the amount paid for an ITN affects usage intensity. Previous research, however, suggests that the sunk cost fallacy does sometimes occur for certain products (Arkes and Blumer, 1985) or certain people (Ashraf et al., 2007). More research is needed to understand when sunk cost effects should be expected and when the magnitude of the effect is meaningful.

While ITN distribution programs that use cost-sharing do not appear more cost-effective than free distribution in terms of health impact, they might have other benefits. Indeed, they often have the explicit aim of promoting sustainability. The aim is to encourage a sustainable retail sector for ITNs by combining public and private sector distribution channels, e.g. by distributing vouchers for heavily-subsidized ITNs that can be purchased at private shops (Mushi et al., 2003). This method can increase demand for and knowledge about ITNs so that in the long-run, when income levels are higher and donor money goes elsewhere, the retail sector will have persisted and can sell ITNs profitably (PSI, 2003; Webster, 2007). Our experiment does not enable us to quantify the potentially negative impact of free distribution on the viability of the retail sector and therefore our analysis does not consider this externality. As with most randomized evaluations, we are unable to characterize or quantify the impact of these distribution schemes when they have been scaled up and general equilibrium effects have set in. This experiment should thus be seen as one piece in the puzzle of how to effectively use ITNs in the ongoing struggle against malaria.

References

Alaii Jane A., et al. 2003. “Factors Affecting Use of Permethrin-Treated Bed Nets During a Randomized Controlled Trial in Western Kenya.” *Am J Trop Med Hyg 68 (4 Suppl):* 137–141.

Alonso, P.L., et al. 1991. “The Effect of Insecticide-Treated Bednets on Mortality of Gambian Children.” *Lancet.* 1: 1499-502.

Arkes, Hal R. and Catherine Blumer. 1985. “The Psychology of Sunk Cost.” *Organizational Behavior and Human Decision Processes*. 35: 124-140.

Ariely, Dan and Krsitina Shampan’er. 2006. “How Small is Zero Price? The True Value of Free Products". FRB of Boston Working Paper No. 06-16 Available at SSRN: http://ssrn.com/abstract=951742

Ashraf, Nava, James Berry and Jesse Shapiro. 2007. “Can Higher Prices Stimulate Product Use? Evidence from a Field Experiment in Zambia.” *NBER Working Paper* #13247.

Bagwell, Kyle and Michael H. Riordan. 1991. "High and Declining Prices Signal Product Quality," *American Economic Review*, vol. 81(1): 224-39.

Bertrand, Marianne, Esther Duflo and Sendhil Mullainathan (2004), “How Much Should We Trust Differences-in-Differences Estimates?”, *Quarterly Journal of Economics*, 119, 249-275.

Binka, F. N. et al. 1996. “Impact of Permethrin Impregnated Bednets on Child Mortality in Kassena-Nankana District, Ghana: A Randomized-Controlled Trial.” *Tropical Medicine and International Health*. 1(2): 147-154.

Binka, F. N. et al. 1998. “Impact of Spatial Distribution of Permethrin-Impregnated Bed Nets on Child Mortality in Rural Northern Ghana.” *American Journal of Tropical Medicine and Hygiene.* 59(1): 80-85.

Browne, E. N. L. et al. 2001. “The Impact of Insecticide-Treated Bednets on Malaria and Anaemia in Pregnancy in Kassena-Nankana District, Ghana: A Randomized Controlled Trial.” *Tropical Medicine and International Health*. 6(9): 667-676.

Cameron, A. Colin, Douglas Miller, and Jonah B. Gelbach. (2007). “Bootstrapped-Based Improvements for Inference with Clustered Errors.” NBER Technical Working Paper t0344.

Cassiman, Bruno and Elena Golovko. 2007. Innovation and the Export-Productivity Link. IESE Working Paper no 688.

Cham, M. K., et al. 1997. “The Impact of Charging for Insecticide on the Gambian National Impregnated Bednet Programme.” *Health Policy and Planning*. 12(3): 240-247.

Chuma, Jane et al. 2006. “Rethinking the economic costs of malaria at the household level: Evidence from applying a new analytical framework in rural Kenya”, *Malaria Journal* 5:76.

D’Alessandro, Umberto et al. 1995. “Mortality and Morbidity from Malaria in Gambian Children After Introduction of an Impregnated Bednet Programme.” *Lancet.* 345: 479-483.

D'Alessandro, Umberto 1994. "Nationwide Survey of Bednet Use in Rural Gambia." *Bulletin of the World Health Organization*. 72(3): 391-394.

Deaton, Angus. 1997. *The analysis of household surveys: a microeconometric approach to development policy.* The John Hopkins University Press.

Donald, Stephen, and Kevin Lang (2007): "Inference with Differences-in-Differences and Other Panel Data," *The Review of Economics and Statistics*, Vol. 89, No. 2: 221-233.

Dupas, Pascaline. 2005. "The Impact of Conditional In-Kind Subsidies on Preventive Health Behaviors: Evidence from Western Kenya." *Dartmouth College Department of Economics Working Paper.*

Easterly, William. 2006. *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good*. Penguin Press, 417 pp.

Ettling M, et al. 1994. "Economic Impact of Malaria in Malawian Households." *Tropical Medicine and Parasitology*. 45: 74-79.

Evans, D. B., et al. 1997. "Should Governments Subsidize the Use of Insecticide-Impregnated Mosquito Nets in Africa? Implications of a Cost-Effectiveness Analysis." *Health Policy and Planning*. 12(2): 107-114.

Gimnig, John E., et al. 2003. "Effect of Permethrin-Treated Bed Nets on the Spatial Distribution of Malaria Vectors in Western Kenya." *American Journal of Tropical Medicine and Hygiene*. 68 (Suppl. 4): 115-120.

Goodman, C. A and Mills, A. J. 1999. "The Evidence Base on the Cost-Effectiveness of Malaria Control Measures in Africa." *Health Policy and Planning*. 14(4): 301-312.

Grabowsky, M. et al. 2005. "Distributing Insecticide-Treated Bednets During Measles Vaccination: A Low-Cost Means of Achieving High and Equitable Coverage." *Bulletin of the World Health Organization*. 83(3): 195-201.

Guyatt, Helen L., Sam A. Ochola and Robert W. Snow. 2002. "Too Poor to Pay: Charging for Insecticide-Treated Bednets in Highland Kenya." *Tropical Medicine and International Health*. 7(10): 846-850.

Hanson, Kara, et al. 2003. "Cost-Effectiveness of Social Marketing of Insecticide-Treated Nets for Malaria Control in the United Republic of Tanzania." *Bulletin of the World Health Organization*. 81(4): 269-276.

Hawley, William A. et al. 2003. "Community-Wide Effects of Permethrin-Treated Bed Nets on Child Mortality and Malaria Morbidity in Western Kenya." *American Journal of Tropical Medicine and Hygiene*. 68(Suppl. 4): 121-127.

Hoffman, Vivian . 2007. "Psychology, gender, and the intrahousehold allocation of free and purchased mosquito nets". Mimeo, Cornell University.

Holtz Timothy H., et al. 2002. Insecticide-treated bednet use, anemia, and malaria parasitaemia in Blantyre District, Malawi. *Trop Med Int Health* 7: 220-230.

Kremer, Michael and Edward Miguel. 2007. “The Illusion of Sustainability”. *Quarterly Journal of Economics* 112(3), 1007-1065.

Lengeler, Christian, et al. 2007. “Quick Wins Versus Sustainability: Options for the Upscaling of Insecticide-Treated Nets”*Am. J. Trop. Med. Hyg*., 77(6_Suppl): 222-226.

Lucas, Adrienne. 2007. "Economic Effects of Malaria Eradication: Evidence from the Malarial Periphery". Mimeo, Wellesley College.

Marchant, Tanya, et al. 2002. “Socially Marketed Insecticide-Treated Nets Improve Malaria and Anaemia in Pregnancy in Southern Tanzania.” *Tropical Medicine and International Health*. 7(2): 149-158.

Maxwell, C. A. et al. 2002. “Effect of Community-Wide Use of Insecticide-Treated Nets for 3-4 Years on Malarial Morbidity in Tanzania.” *Tropical Medicine and International Health*. 7(12): 1003-1008.

Moulton, Brent R. 1986, “Random Group Effects and the Precision of Regression Estimates,” *Journal of Econometrics*, 32, 385-397.

Moulton, Brent R. 1990. “An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units, *Review of Economics and Statistics*, 72, 334-38.”

Mushi, Adiel K., et al. 2003. “Targeted subsidy for malaria control with treated nets using a discount voucher system in southern Tanzania.” *Health Policy and Planning*, 18(2), 163–171.

Nevill, C. G. et al. 1996. “Insecticide-Treated Bednets Reduce Mortality and Severe Morbidity from Malaria Among Children on the Kenyan Coast.” *Tropical Medicine and International Health.* 1(2): 139-146.

Okrah, Jane, et al. 2002. “Community Factors associated with malaria prevention by mosquito nets: an exploratory study in rural Burkina Faso.” *Trop Med Int Health* 7: 240-248.

Oster, Sharon. 1995. *Strategic Management for nonprofit organizations: Theory and Cases.* Oxford University Press, Oxford, 1995.

Riley, John G. 2001. “Silver Signals: Twenty-Five Years of Screening and Signaling”. *Journal of Economic Literature*, Vol. 39, No. 2, pp. 432-478.

Phillips-Howard, Penelope A., et al. 2003. “Efficacy of Permethrin-Treated Bed Nets in the Prevention of Mortality in Young Children in an Area of High Perennial Malaria Transmission in Western Kenya.” *American Journal of Tropical Medicine and Hygiene*. 68(Suppl. 4): 23-29.

Population Services International. 2003. “What is Social Marketing?” http://www.psi.org/resources/pubs/what_is_smEN.pdf

Sachs, Jeffrey. 2005. *The End of Poverty: Economic Possibilities for Our Time*, New York: Penguin Press.

Schellenberg, JRMA. et al. 1999. "KINET: a social marketing programme of treated nets and net treatment for malaria control in Tanzania, with evaluation of child health and long-term survival." *Transactions of the Royal Society of Tropical Medicine and Hygiene* 93, 225–231.

Schellenberg Joanna A., et al. 2001. "Effect of large-scale social marketing of insecticide-treated nets on child survival in rural Tanzania." *Lancet* 357, 1241–1247.

Ter Kuile, Feiko O., et al. 2003. "Reduction of Malaria During Pregnancy by Permethrin-Treated Bed Nets in an Area of Intense Perennial Malaria Transmission in Western Kenya." *American Journal of Tropical Medicine and Hygiene*. 68(Suppl. 4): 50 - 60.

Thaler, Richard. 1980. Toward a Positive Theory of Consumer Choice. *Journal of Economic Behavior and Organization*. 1(1): 39-60.

Thaler, Richard. 1985. "Mental Accounting and Consumer Choice". *Marketing Science*, Vol. 4, No. 3. pp. 199-214.

Thaler, Richard. 1999. "Mental Account Matters." *Journal of Behavioral Decision Making*, 12:183:206.

Webster, Jane, Jo Lines, and Lucy Smith. 2007. "Protecting all Pregnant Women and Children Under Five Years Living in Malaria Endemic Areas in Africa with Insecticide Treated Mosquito Nets." *World Health Organization Working Paper*. http://www.who.int/malaria/docs/VulnerableGroupsWP.pdf

WHO, 2005. *World Malaria Report 2005.* WHO, Geneva.

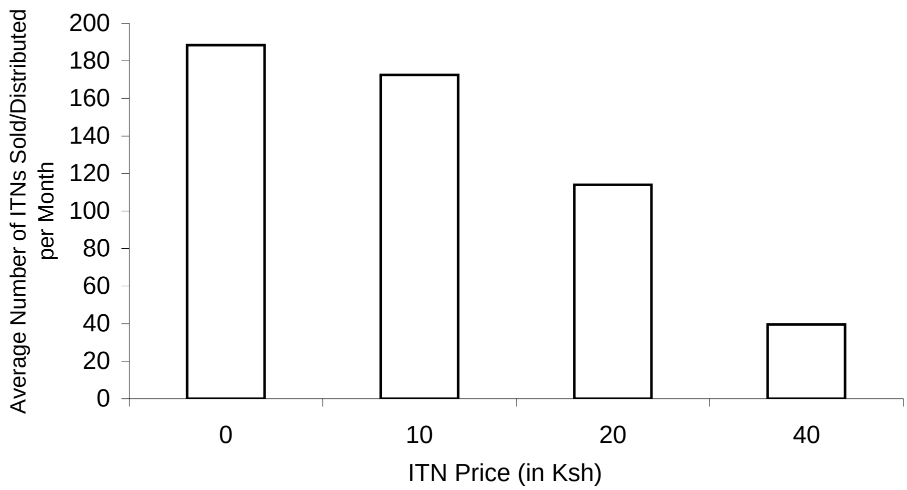
WHO, 2007. WHO Global Malaria Programme: Position Statement on ITNs. http://www.who.int/malaria/docs/itn/ITNspospaperfinal.pdf

Winch, Peter J, et al.1997. "Social and Cultural Factors affecting rates of regular retreatment of mosquito nets with insecticide in Bagamoyo District, Tanzania." *Tropical Med Int Health* 2: 760-770.

Wooldridge, Jeffrey M. (2004): "Cluster-Sample Methods in Applied Econometrics," *American Economic Review*, 93(2), 133-138.

Figure 1
Demand for ITNs

1a. Monthly Net Sales Across ITN Prices



1b. Monthly Prenatal Attendance Across ITN Prices

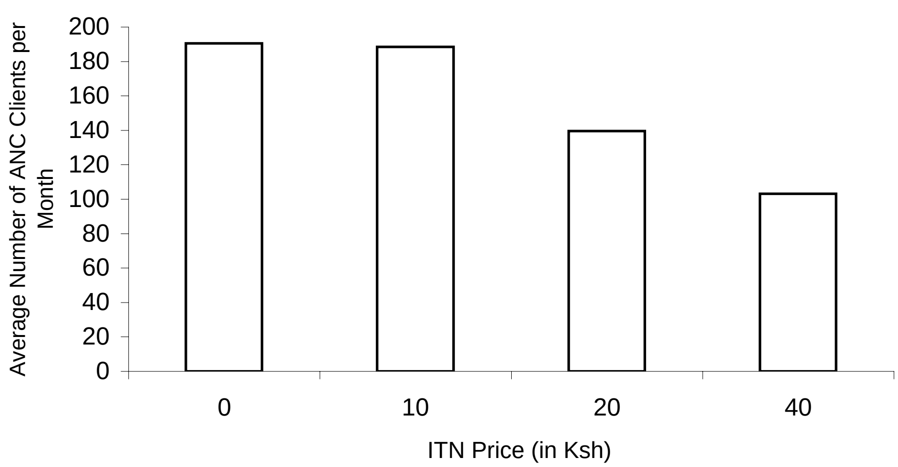
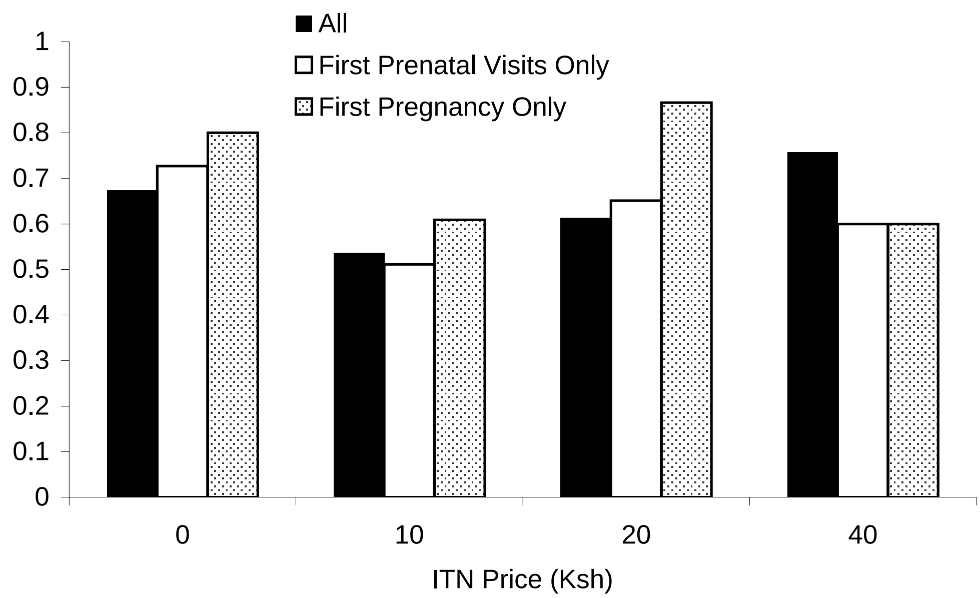
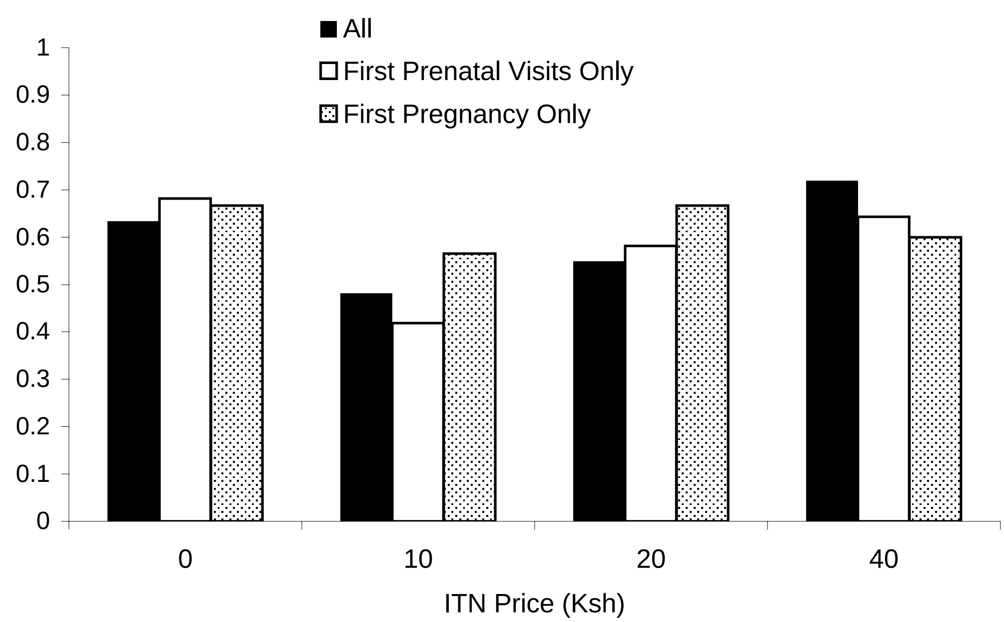


Figure 2
ITN Usage Rates Across ITN Prices

2a. Share of "Takers" who report using the ITN at home follow-up visit, by ITN price

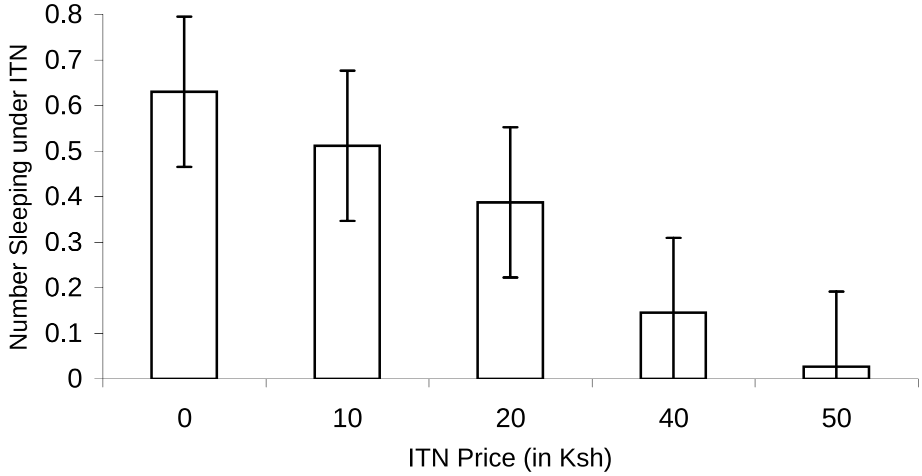


2b. Share of "Takers" who have the ITN visibly hanging at follow-up visit, by ITN Price



Notes: Observations: All: 226, First visit: 175 , First Pregnancy: 122

Figure 3. Share of Prenatal Clients Sleeping under an ITN, by ITN Price



Notes: Figure shows coefficients estimated with a Linear Probability Model. Error bars represent +/- 2.14 standard error (5% confidence interval with 14 degrees of freedom). In Kenya, ITNs are currently social-marketed through prenatal clinics at the price of 50Ksh .

Figure 4

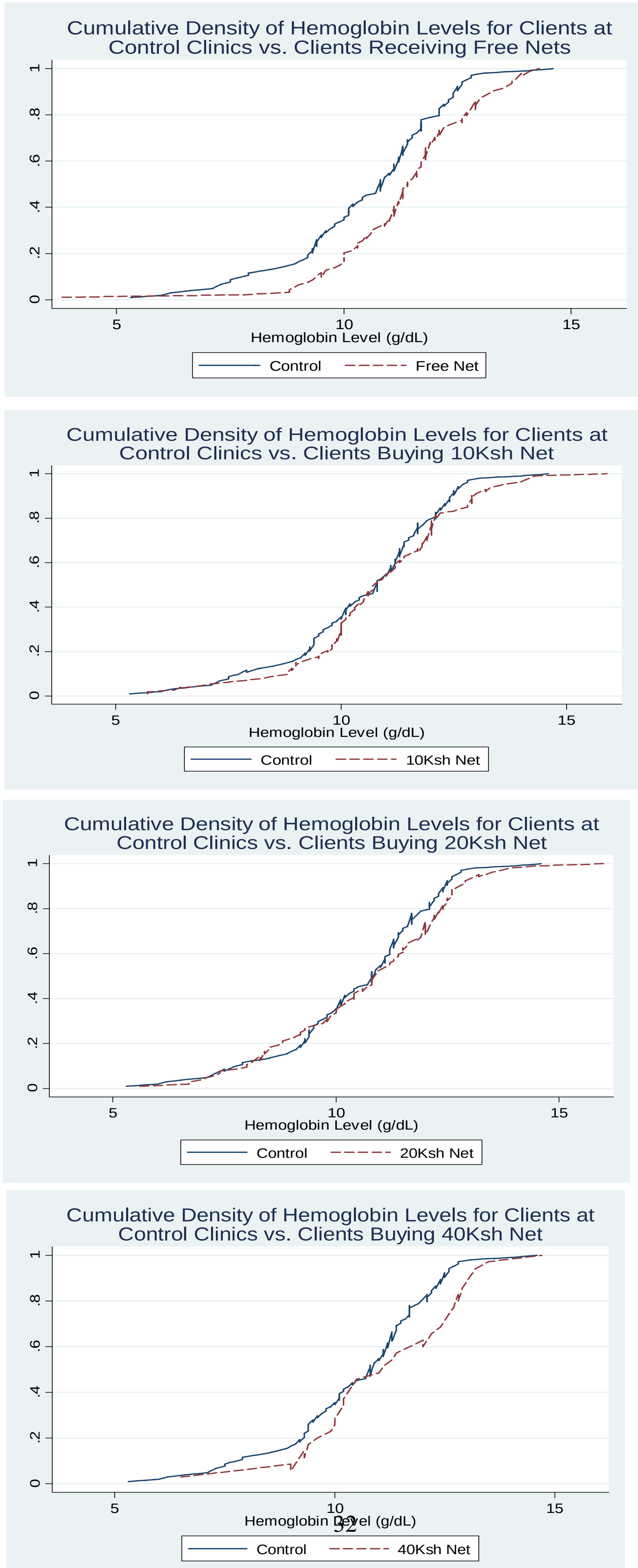
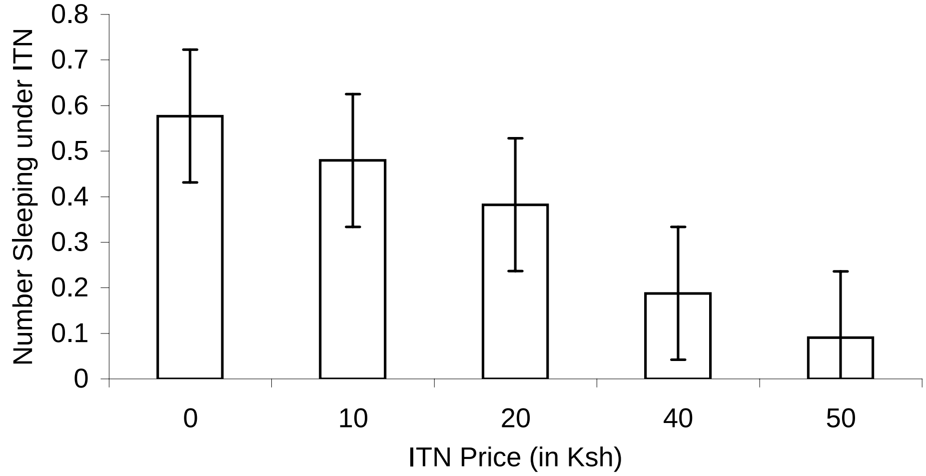

Cumulative Density of Hemoglobin Levels for Clients at Control Clinics vs. Clients Receiving Free Nets
0
.2
.4
.6
.8
1
5
10
15
Hemoglobin Level (g/dL)
Control
Free Net
Cumulative Density of Hemoglobin Levels for Clients at Control Clinics vs. Clients Buying 10Ksh Net
0
.2
.4
.6
.8
1
5
10
15
Hemoglobin Level (g/dL)
Control
10Ksh Net
Cumulative Density of Hemoglobin Levels for Clients at Control Clinics vs. Clients Buying 20Ksh Net
0
.2
.4
.6
.8
1
5
10
15
Hemoglobin Level (g/dL)
Control
20Ksh Net
Cumulative Density of Hemoglobin Levels for Clients at Control Clinics vs. Clients Buying 40Ksh Net
0
.2
.4
.6
.8
1
5
10
15
Hemoglobin Level (g/dL)
Control
40Ksh Net

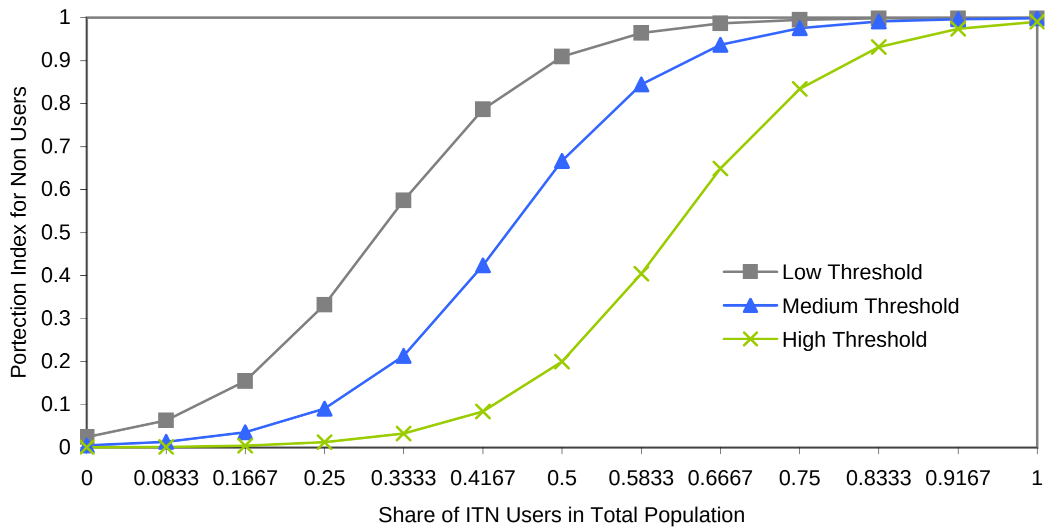
Figure 5. Share of Anemic Prenatal Clients Sleeping under an ITN, by ITN Price



Notes: Figure shows coefficients estimated with a Linear Probability Model. Error bars represent +/- 2.14 standard error (5% confidence interval with 14 degrees of freedom).

Figure 6. Scenarios Used in Cost-Effectiveness Analysis

6a. Three hypothetical Scenarios on the "Externality Threshold":
How the Protection Index for Non-Users Varies with
the Proportion of ITN Users in the Population



6b. For a Given Hypothesis on the Externality Threshold:
How the Protection Index for Net Users Varies with
Assumptions on the Effectiveness of ITNs as "Physical Barriers" for Users

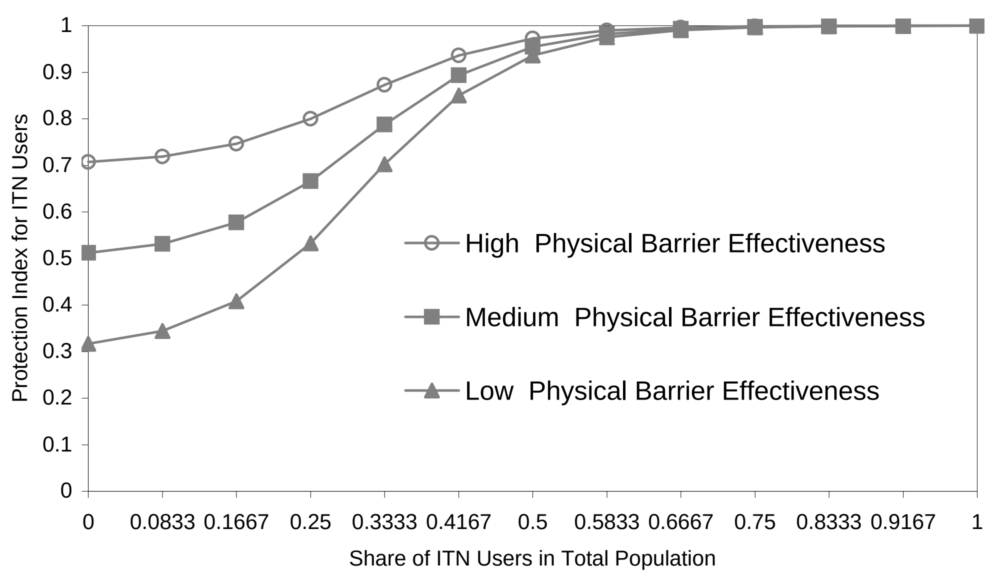


Table 1. Characteristics of Prenatal Clinics in the Sample, by Treatment Group

	Control Group	Treatment Groups *ITN Price:*			
		0 Ksh (FREE)	10 Ksh ($0.15)	20 Ksh ($0.30)	40 Ksh ($0.60)
	(1)	(2)	(3)	(4)	(5)
Average monthly attendance in 2006 (First visits ONLY)	75	63	61	54	62
	(53)	(41)	(41)	(20)	(31)
Average monthly attendance in 2006 (First + Subsequent Visits)	124	117	123	106	122
	(80)	(66)	(92)	(48)	(68)
Prenatal Enrollment Fee (in Ksh)	10	12	14	20	13
	(12)	(8)	(9)	(20)	(11)
Fraction of clinics with HIV testing services	.75	.40	.75	.66	.33
	(.50)	(.55)	(.45)	(.58)	(.58)
Total other prenatal clinics within 10 kilometers (km)	2.75	3	3.6	4.3	4.3
	(2.5)	(1.22)	(.54)	(2.5)	(1.15)
Distance (in km) to closest prenatal clinic in the sample	12.69	13.45	13.32	12.05	12.92
	(2.28)	(1.2)	(1.3)	(1.0)	(2.5)
Number of Clinics	4	5	5	3	3

Notes: At the time of the program, $US 1 was equivalent to around 67 Kenyan Shillings (Ksh). Prenatal clinics were sampled from a pool of 69 prenatal clinics over four districts in Kenya's Western Province: Busia, Bungoma, Butere, and Mumias, covering an area of more than 10,000 square kilometers.

Table 2. Weekly ITN Sales Across Prices

	Dependent Variable is: Weekly ITN Sales					
	(1)	(2)	(3)	(4)	(5)	(6)
ITN Price in Kenyan Shillings (Ksh)	-.797		-.680	-.756		
	(.396)		(.189)	(.096)		
ITN Price = 10 Ksh ($0.15)		-.330			-1.645	6.346
		(16.617)			(5.640)	(1.816)
ITN Price = 20 Ksh ($0.30)		-9.502			-4.870	-8.737
		(15.855)			(13.089)	(1.521)
ITN Price = 40 Ksh ($.60)		-32.420			-29.051	-33.081
		(15.199)			(7.397)	(.419)
Control for Clinic Attendance in 2006			X	X	X	X
Other Clinic Controls				X		X
Mean of Dep. Var in Clinics with Free ITNs	41	41	41	41	41	41
Intracluster Correlation	0.57					

Notes: Each column is an OLS regression of weekly ITN sales on ITN price or on a set of indicator variables for each price (0Ksh is excluded). All regressions include district fixed effects. Standard errors in parentheses are clustered at the clinic level. Given the small number of clusters (16), the critical values for T-tests should be drawn from a t-distribution with 14 (16-2) degrees of freedom. The sample includes 15 clinics in 3 districts over 6 weeks after program introduction. (One 40Ksh clinic is not included because of problems with net sales reporting.) Controls for clinic attendance in 2006 include average total monthly visits and average first monthly visits between February and September (the months for which we have complete attendance data for all clinics). Other clinic controls include the fee (if any) charged for a prenatal care visit, whether or not the clinic offers voluntary counseling and testing for HIV or prevention-of-mother-to-child-transmission of HIV services, the distance between the clinic, and the closest other clinic or hospital and the distance between the clinic and the closest other clinic or hospital in the program.

Table 3. Demand for ITNs Across Prices

	Dependent Variable is: Indicator for Bought/Received an ITN					
	(1)	(2)	(3)	(4)	(5)	(6)
ITN Price in Kenyan Shillings (Ksh)	-.015	-.017	-.015		-.018	-.011
	(.002)	(.002)	(.000)		(.003)	(.002)
Constant (ITN Price = 0)				.989		
				(.010)		
ITN Price = 10 Ksh ($0.15)				-.073		
				(.018)		
ITN Price = 20 Ksh ($0.30)				-.172		
				(.010)		
ITN Price = 40 Ksh ($0.60)				-.605		
				(.035)		
Time Controls		X				
Clinic Controls			X			
First Visit Only					X	
First Pregnancy Only						X
Observations	424	389	385	424	201	134
Sample Mean of Dep. Var	0.98	0.98	0.98	0.98	1.00	0.97
Intra-Cluster Correlation	0.23					

Notes: Data is from clinic-based surveys conducted throughout the first 6 weeks of the program. All regressions include district fixed effects. Standard errors in parentheses are clustered at the clinic level; given the small number of clusters (16), the critical values for T-tests should be drawn from a t-distribution with 14 (16-2) degrees of freedom. All specifications are OLS regressions of an indicator variable equal to one if the respondent bought or received an ITN for free on the price of the ITN, except Column 4 in which regressors are indicator variables for each price (price=0 is excluded).

Time controls include fixed effects for the day of the week the survey was administered and a variable indicating how much time had elapsed between the day the survey was administered and the program introduction. Clinic controls inlclude total monthly first ANC visits between April-June of 2006, the fee charged for a prenatal care visit, whether or not the clinic offers voluntary counseling and testing for HIV or prevention-of-mother-to-child-transmission of HIV services, the distance between the clinic and the closest other clinic or hospital and the distance between the clinic and the closest other clinic or hospital in the program.

Table 4. ITN Usage Rates Across Prices

	Dependent Variable is:								
	Respondent is currently using the ITN acquired through the program							ITN is Visibly Hanging	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant (ITN Price = 0)	.564	.366	.656	.604	.703	.744	.808	.524	.637
	(.069)	(.225)	(.093)	(.083)	(.116)	(.058)	(.046)	(.074)	(.109)
ITN Price	.004	.003		.000		-.002		.003	
	(.004)	(.004)		(.004)		(.004)		(.003)	
ITN Price = 10ksh			-.126		-.205		-.220		-.155
			(.119)		(.139)		(.081)		(.128)
ITN Price = 20ksh			-.020		-.030		.080		-.093
			(.105)		(.126)		(.094)		(.122)
ITN Price = 40ksh			.106		-.091		-.205		.081
			(.134)		(.151)		(.188)		(.127)
Time Controls		X							
First Visits Only				X	X				
First Pregnancy Only						X	X		
Obs	224	211	224	125	125	58	58	220	220
Sample Mean of Dep. Var	0.62	0.62	0.62	0.61	0.61	0.72	0.72	0.57	0.57
Intra-Cluster Correlation	0.04								
Joint F-Test			1.90		1.21		1.45		2.10
Prob > F			0.13		0.31		0.24		0.10

Notes: Data is from home visits to a random sample of patients who bought nets at each price. Home visits were conducted for a subsample of patients roughly 3 - 6 weeks after their prenatal visit.

Each column is an OLS regression of the dependent variable indicated by column on either the price of the ITN or an indicator variable for each price. All regressions include district fixed effects. Standard errors in parentheses are clustered at the clinic level ; Given the small number of clusters (16), the critical values for T-tests should be drawn from a t-distribution with 14 (16-2) degrees of freedom. The specification in Column (2) controls for the number of days that have elapsed since the net was purchased, the number of days that have elapsed since the program was introduced at the clinic in which the net was purchased and whether the woman has given birth already, is still pregnant, or miscarried.

Table 5. ITN Usage Rates Across Prices, Holding Willingness to Pay Constant

	Dependent Variable is:							
	Respondent is currently using the ITN acquired through the program						ITN is Visibly Hanging	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Transaction Price	-.003	-.006	-.006					
	(.006)	(.006)	(.006)					
Transaction Price > 0				-.008	-.072	-.065	.010	-.047
				(.100)	(.101)	(.100)	(.101)	(.103)
Individual Controls								
Got a Free ITN the Previous Year			-.192			-.191		-.147
			(.100)			(.101)		(.103)
Has not yet delivered		-.198	-.234		-.195	-.231		-.216
		(.121)	(.121)		(.122)	(.122)		(.124)
Bought ITN at First Prenatal Visit		.199	.202		.199	.202		.131
		(.102)	(.102)		(.103)	(.104)		(.107)
First Pregnancy		.180	.148		.184	.153		.120
		(.100)	(.104)		(.100)	(.104)		(.107)
Time to clinic		.001	.000		.000	.000		.000
		(.001)	(.001)		(.001)	(.001)		(.001)
Time Elapsed since ITN Purchase		.014	.015		.014	.015		.017
		(.006)	(.006)		(.006)	(.006)		(.006)
Constant	.591	.152	.248	.579	.147	.242	.537	.165
	(.052)	(.200)	(.200)	(.054)	(.201)	(.201)	(.055)	(.207)
Observations	130	124	123	130	124	123	128	121
Sample Mean of Dep. Var	0.58	0.58	0.58	0.58	0.58	0.58	0.52	0.52
F Stat		2.64	3.23		2.99	3.6		1.97
Prob >F		0.02	0.00		0.01	0.00		0.07

Notes: Standard errors in parentheses. Estimates are from linear probability models with clinic fixed effects, estimated on the sample of women who 1) visited a clinic where ITNs were sold at a positive price; 2) decided to buy an ITN at the posted price; and 3) were sampled to participate in the ex post lottery determining the transaction price they eventually had to pay to take the net home. The transaction prices ranged from 0 (free) to the posted price.

Table 6. Characteristics of Prenatal Clients Buying/Receiving Nets Relative to Control Clients

Panel A: Kolmogorov-Smirnov Test for Equality of Distribution of Hb levels between Prenatal Clients of Control Clinics and Prenatal Clients receiving/buiying an ITN in:

	Clinics Selling at 0 Ksh (FREE)	Clinics Selling at 10 Ksh ($0.15)	Clinics Selling at 20 Ksh ($0.30)	Clinics Selling at 40 Ksh ($0.60)
	(1)	(2)	(3)	(4)
D	.21	.12	.13	.21
P-Value	.02	.47	.30	.17
Obs	198	217	208	139

Panel B: Regressions

	Mean in Control Clinics	*Differences with Control Clinics* 0 Ksh (FREE)	10 Ksh ($0.15)	20 Ksh ($0.30)	40 Ksh ($0.60)
	(1)	(2)	(3)	(4)	(5)
		Panel B1. Health Status			
Hemoglobin Level (Hb), in g/DL	0.55	-0.20	-0.03	-0.01	-0.01
	0.50	(0.07) ***	(0.11)	(0.11)	(0.15)
Moderate Anemia (Hb < 11.5 g/dL)	0.16	-0.10	-0.01	0.07	-0.06
	0.37	(0.06)	(0.07)	(0.09)	(0.11)
Severe Anemia (Hb < 9 g/dL)	0.42	-0.05	-0.11	-0.06	-0.05
	0.50	(0.05)	(0.04) **	(0.09)	(0.11)
		Panel B2. Characteristics of Visit to Prenatal Clinic			
First Prenatal Visit for Current Pregnancy	0.48	-0.12	-0.02	0.03	0.02
	0.50	(0.06) **	(0.04)	(0.06)	(0.04)
First Pregnancy	0.21	0.09	0.15	0.08	0.14
	0.41	(0.04) **	(0.04) ***	(0.04) **	(0.15)
Paid for Transportation to Clinic	0.17	0.14	0.04	-0.07	0.16
	0.37	(0.14)	(0.06)	(0.06)	(0.06) **
Price paid to reach the clinic (Ksh)	4.58	3.52	0.79	-1.17	4.27
	10.83	(3.29)	(1.78)	(1.37)	(1.94) **
Obs	108	38	120	99	28

Notes on Panel B: For each variable, Column 1 shows the mean observed among prenatal clients enrolling in control clinics; the standard deviations are presented in italics. Column 2 (3, 4, 5) shows the differences between "buyers" in the clinics providing ITNs at 0 (10, 20, 40) Ksh and prenatal clients enrolling in control clinics. Standard errors in parentheses are clustered at the clinic level; given the small number of clusters (16), the critical values for T-tests were drawn from a t-distribution with 14 (16-2) degrees of freedom.

Table 7. Share of Households Using an ITN in Total Population

ITN Price (Ksh)	Subsidy per ITN Sold (Ksh)	Share of Prenatal Clients Who get an ITN *(Table 3, Col. 2)*	Actual Cost (Ksh)	% of ITN owners that are using it *(Table 4, Col. 4)*	Share of Users among Housholds With Prenatal Client	Subsidy Cost per User Household (Ksh)	Share of Net Users in Total Population After 5 Years of Distribution		
							If 65% of HH experience a pregnancy within 5 years	If 75% of HH experience a pregnancy within 5 years	If 85% of HH experience a pregnancy within 5 years
0	455	0.98	446	0.66	0.64	694	0.42	0.48	0.55
10	445	0.93	414	0.53	0.49	840	0.32	0.37	0.42
20	435	0.83	361	0.64	0.53	684	0.34	0.40	0.45
40	415	0.40	166	0.76	0.30	545	0.20	0.23	0.26

This table estimates the share of ITN users in the entire population that would result under each price scenario assuming that distribution programs would last for 5 years. We propose three possibilities for the share of households with a pregnant woman in a 5 year period and compute the resulting share of ITN users in the entire population.

Table 8. Cost-Effectiveness Comparisons

		Hypothesis on Externality Threshold:								
		Low			Medium			High		
		Hypothesis on Physical Barrier effectiveness:			*Hypothesis on Physical Barrier effectiveness:*			*Hypothesis on Physical Barrier effectiveness:*		
Subsidy Level	ITN Price (Ksh)	High	Medium	Low	High	Medium	Low	High	Medium	Low
		1	2	3	4	5	6	7	8	9
A. Protection Index for Non-Users										
100.0%	0	0.80	0.80	0.80	0.45	0.45	0.45	0.09	0.09	0.09
97.5%	10	0.53	0.53	0.53	0.19	0.19	0.19	0.03	0.03	0.03
95.0%	20	0.60	0.60	0.60	0.23	0.23	0.23	0.04	0.04	0.04
90.0%	40	0.21	0.21	0.21	0.05	0.05	0.05	0.01	0.01	0.01
B. Protection Index for Users										
100.0%	0	0.94	0.90	0.86	0.83	0.72	0.61	0.73	0.55	0.36
97.5%	10	0.86	0.77	0.67	0.76	0.59	0.43	0.71	0.51	0.32
95.0%	20	0.88	0.80	0.72	0.77	0.62	0.46	0.71	0.52	0.33
90.0%	40	0.76	0.60	0.44	0.71	0.52	0.33	0.70	0.50	0.30
C. Children Lives Saved Per 1000 Prenatal Client										
100.0%	0	38	37	36	30	27	24	22	17	11
97.5%	10	29	28	26	20	16	13	15	11	7
95.0%	20	32	30	28	22	19	15	17	12	8
90.0%	40	16	14	12	11	8	6	9	7	4
D. Cost per Child Life Saved (USD)										
100.0%	0	$200	$206	$212	$255	$284	$321	$352	$460	$662
97.5%	10	$234	$251	$270	$348	$421	$531	$448	$609	$949
95.0%	20	$189	$200	$213	$274	$325	$399	$361	$487	$748
90.0%	40	$175	$201	$235	$261	$339	$483	$302	$418	$678

In this table, we assume that the share of households experiencing a pregnancy within five years is 65%. Making a less conservative assumption would increase the cost-effectiveness of free distribution compared to cost-sharing.

The protection index for non-users is computed as a logistic function of the share of users in the total population as represented in Figure 8. The protection index for users is a coverage-dependant weighted sum of the protection index for non-users and the index on the physical barrier effectiveness of ITNs, as represented on Figure 8.