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FREE DISTRIBUTION OR COST-SHARING? EVIDENCE FROM A RANDOMIZED MALARIA PREVENTION EXPERIMENT*

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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 through a field experiment in Kenya, in which we randomized the price at which prenatal clinics could sell long-lasting antimalarial insecticide-treated bed nets (ITNs) to pregnant women. We find no evidence that cost-sharing reduces wastage on those who 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 average prenatal client in the area in terms of measured anemia (an important indicator of malaria). Cost-sharing does, however, considerably dampen demand. We find that uptake drops by sixty percentage points when the price of ITNs increases from zero to \$0.60 (i.e., from 100% to 90% subsidy), a price still \$0.15 below the price at which ITNs are currently sold to pregnant women in Kenya. We combine our estimates in a cost-effectiveness analysis of the impact of ITN prices on child mortality that incorporates both private and social returns to ITN usage. Overall, our results suggest that free distribution of ITNs could save many more lives than cost-sharing programs have achieved so far, and, given the large positive externality associated with widespread usage of ITNs, would likely do so at a lesser cost per life saved.

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I. Introduction

Standard public finance analysis implies that health goods generating positive externalities should be publicly funded, or even subsidized at more than 100% if the private nonmonetary costs (such as side effects) are high. Although this analysis applies to goods whose effectiveness is independent of the behavior of the recipients (e.g., vaccines, deworming pills administered to schoolchildren), it does not necessarily apply to goods that require active usage (adherence) by their owner for the public health benefits to be realized (e.g., bed nets for reduced malaria transmission, pit latrines for reduced water contamination). For such goods, charging nonzero prices ("cost-sharing") could improve the efficacy of public subsidies by reducing wastage from giving products to those who will not use them. There are three possible effects of positive prices on the likelihood that people who acquire the product use it appropriately. 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 (Oster 1995; Population Services International [PSI] 2003; Ashraf, Berry, and Shapiro forthcoming). Second, a psychological effect: paying a positive price for a good could induce people to use it more if they exhibited "sunk cost" effects (Thaler 1980; Arkes and Blumer 1985). Third, higher prices may encourage usage if they are interpreted as a signal of higher quality (Bagwell and Riordan 1991; Riley 2001).

Although cost-sharing may lead to higher usage intensity than free distribution, it may also reduce 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 2007; Kremer and Miguel 2007). Beyond reducing demand, selection effects are not straightforward in the context of credit and cash constraints: 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 nonlinearities or externalities in the health production function.[1]

This paper estimates the first three parameters and explores the trade-offs 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 proven highly effective in reducing maternal anemia and infant mortality, both directly for users and indirectly for nonusers with a large enough share of users in their vicinity. The manufacture 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; World Health Organization [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 (Ksh) ($0.60). ITNs were thus heavily subsidized, with the highest price corresponding to a 90% subsidy, comparable to the subsidies offered by the major cost-sharing interventions operating in the area and in many other malaria-endemic African countries. 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 subsample of women at home a few months later to check whether they still had the nets and whether they were using them.

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

1. There are other potential channels from the price of a health product to its health impact. For example, the price could influence how the product is cared for (e.g., a more expensive bed net could be washed too frequently, losing the efficacy of its insecticide) or could have spillover effects to other health behaviors. We focus on the four channels described because these are most commonly cited in the debate over pricing of public health products and likely to have first-order impacts on the relationship between prices and health outcomes.

2. The correlation between prices and usage is also potentially the product of signaling effects of prices, but this 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.

follow Karlan and Zinman (forthcoming) and Ashraf, Berry, and Shapiro (forthcoming) and implement a randomized two-stage pricing design. In clinics charging a positive price, a subsample of women who decided to buy the net at the posted price were surprised with a lottery for an additional discount; for the women sampled for this second-stage lottery, the actual price ranged from 0 to the posted price. Among these women, 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 uptake of ITNs drops significantly at modest cost-sharing prices. Demand drops by 60% when the price is increased from zero to 40 Ksh ($0.60). This latter price is still 10 Ksh ($0.15) below the prevailing cost-sharing price offered to pregnant women through prenatal clinics in this region. 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.

Given the very low uptake at higher prices, the sample of women for which usage could be measured is much smaller than the initial sample of women included in the experiment, limiting the precision of the estimates of the effect of price on usage. Keeping this caveat in mind, we find no evidence that usage intensity is increasing with the offer price of ITNs. Women who paid the highest price were slightly more likely (though without statistical significance) 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 visits (the relevant long-run group to consider), usage is highest among women receiving the fully subsidized net. Women who received a net free were also no more likely to have resold it than women paying higher prices. Finally, we did not observe a second-hand market develop. Among both buyers of ITNs and recipients of free ITNs, the retention rate was above 90%.

The finding that there is no overall effect of ITN prices on usage suggests that potential psychological effects of prices on usage are minor in this context, unless they are counteracted by opposite selection effects, which is unlikely. The second-stage randomization enables us to formally test for the presence of sunk-cost

effects (without potentially confounding selection effects) and yields no significant effect of the actual price paid (holding the posted price constant) on usage. This result is consistent with a recent test of the sunk-cost fallacy for usage of a water purification product in Zambia (Ashraf, Berry, and Shapiro forthcoming).

In order to explore whether higher prices induce selection of women who need the net more, we measured baseline hemoglobin levels (anemia rates) for women buying/receiving nets at each price. Anemia is an important indicator of malaria, reflecting repeated infection with malaria parasites, 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, at baseline, than the clients at the control clinics. On the other hand, we find that recipients of free nets are healthier at baseline than the average prenatal population observed at control clinics. We suspect this is driven by the incentive effect the free net had on returning for follow-up prenatal care before the benefits of the previous visit (e.g., iron supplementation) had worn off.

Taken together, our results suggest that cost-sharing ITN programs may have difficulty reaching a large fraction of the populations most vulnerable to malaria. Although our estimates of usage rates among buyers suffer from small-sample imprecision, effective coverage (i.e., the fraction of the population using a program net) can be precisely estimated and appears significantly (and considerably) higher under free distribution than under a 90% subsidy. In other words, we can confidently reject the possibility that the drop in demand induced by higher prices is offset by an increase in usage. Because effective coverage declines with price increases, the level of coverage under cost-sharing is 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 at least as cost-effective as partially but still highly subsidized distribution, such as the cost-sharing program for ITNs that was under way in Kenya at the time of this study. We also find that, for the full range of parameter values, the number of child lives saved is highest when ITNs are distributed free.

Our results have to be considered in their context: ITNs have been advertised heavily for the past few years in Kenya, both by the Ministry of Health and by the social-marketing

nongovernmental organization Population 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. Our results thus do not speak to the debate on optimal pricing for health products that are unknown to the public.

But if widespread awareness about ITNs explains why price does not seem to affect usage among owners, it makes the price sensitivity we observe all the more puzzling. Although large effects of prices on uptake have been observed in other contexts, they were found for less well-known products, such as deworming medication (Kremer and Miguel 2007) and contraceptives (Harvey 1994). Given the high private returns to ITN use and the absence of a detected effect of price on usage, the price sensitivity of demand we observe suggests that pregnant women in rural Kenya are credit- or saving-constrained.

The remainder of the paper proceeds as follows. Section II presents the conceptual framework. Section III provides background information on ITNs and describes the experiment and the data. Section IV describes the results on price elasticity of demand, price elasticity of usage, and selection effects on health. Section V presents a cost-effectiveness analysis, and Section VI concludes.

II. A Simple Model of Pigouvian Subsidies

This section develops a simple model to highlight the parameters that must be identified by the experiment to determine the optimal subsidy level. Assume that ITNs have two uses: a health use, when the net is hung, and a nonhealth use, for which the net is not hung.[3] Nonhealth uses could be using the net for fishing, or simply leaving it in its bag for later use, for example, when a previous net wears out. Health use of the ITNs generates positive health externalities but nonhealth uses do not. Purchasing a net for health or nonhealth purposes costs the same to the household. The price of a net to a household is the marginal cost C minus a subsidy T.

We call h the number of nets used for health purposes and n the number of nets used for nonhealth purposes. The household

3. We thank an anonymous referee for suggesting this formalization.

utility is $U = u(h) + v(n) - (C - T)(h + n) + kH$, where $u(h)$ is the utility from having hanging nets, with $u' \geq 0$ and $u'' \leq 0$; $v(n)$ is the utility from nonhanging nets, with $v' \geq 0$ and $v'' \leq 0$; H is the average number of nets used for health purposes per household; and the constant k represents the positive health externality.[4]

When choosing how many nets to invest in, the household ignores the health externality and chooses h and n such that $u'(h) = v'(h) = C - T$. Increasing the size of the subsidy T increases households' investment in nets for health use, and thus the health externality. Because the subsidy is common for all nets, however, increasing T might also affect households' investment in nets for nonhealth use. Call N the average number of nets used for nonhealth purposes per household. The marginal cost of increasing the health externality is $T \times [d(H + N)/dT]$, whereas the marginal benefit is only $k \times (dH/dT)$. The efficient subsidy level is the level that equates the marginal cost of increasing the externality to the marginal benefit of increasing it:

$$T = [k \times (dH/dT)]/[d(H + N)/dT].$$

If N does not respond to the subsidy ($dN/dT = 0$), the optimal subsidy is k, the level of the externality, as in Pigou's standard theory. But if subsidizing H distorts the amount of N consumed upward, the optimal subsidy is lower than the level of the externality. The gap between the level of the externality and the optimal subsidy level will depend on how sensitive the hanging of nets is to price, relative to total ownership of nets. In other words, what we need to learn from the experiment is the following: when we increase the price, by how much do we reduce the number of hanging nets (nets put to health use), and how does it compare to the reduction in the total number of nets acquired?

This simple model could be augmented to incorporate imperfect information (for the household) on the true returns to hanging nets, especially on the relative curvature of $u(.)$ and $v(.)$. The lack of information could be on the effectiveness or the quality of ITNs. In this context, households could use the subsidy level as a signal of effectiveness or quality (i.e., if households interpret the size of the subsidy as the government's willingness to pay to increase coverage and thus as a measure of the net's likely effectiveness).

4. For simplicity we assume that the positive health externality is linear in the share of the population that is covered with a net. In reality the health externality for malaria seems to be S-shaped.

In such a case, subsidizing H would distort the amount of N consumed *downward*, and the optimal subsidy would be greater than the level of the externality. Alternatively, households could lack information on the nonmonetary transaction cost of hanging the net and underestimate this cost when they invest in nets for health use. Once households realize how much effort is required to hang the net (hanging it every evening and dehanging it every morning can be cumbersome for households that sleep in their living rooms), they might decide to reallocate a net from health use to nonhealth use. Households that suffer from the sunk-cost fallacy, however, would be less likely to reallocate a net from health use to nonhealth use if they had to pay a greater price for the net. This could be formalized, for example, by adding an effort cost in the function $u(.)$, and assuming that the disutility of the effort needed to hang the net is weighted by the relative importance of the nonmonetary cost (effort) in the total cost of the net (nonmonetary cost + monetary cost). Increasing the subsidy level (decreasing the price) would then increase the disutility of putting forth effort to hang the net and increase the likelihood that households do not use the net. This sunk cost effect would lead to an *upward* distortion of N, and imply a subsidy level lower than the level of the externality.

For a quick preview of our findings, Figure I plots the demand curve and the "hanging curve" observed in our experiment. The slope of the top curve is an estimate of $-d(H + N)/dT$ and the slope of the bottom curve estimates $-dH/dT$. We find no systematic effect of the price on the ratio of these two slopes. When the price decreases from 10 Ksh to 0, the ratio of hanging nets to acquired nets actually increases, suggesting that the full subsidy (a price of zero) distorts the demand for nonhanging nets downward. However, at higher price levels, the effect of changing the subsidy is different. The ratio increases when the price decreases from 40 to 20 Ksh and from 20 to 10 Ksh. Overall, however, the ratio remains quite close to 1 over the price range we study.

III. Background on ITNs and Experimental Setup

III.A. Background on Insecticide-Treated Nets

ITNs have been shown to reduce overall child mortality by at least 20% in regions of Africa where malaria is the leading cause of death among children under five (Lengeler 2004). ITN

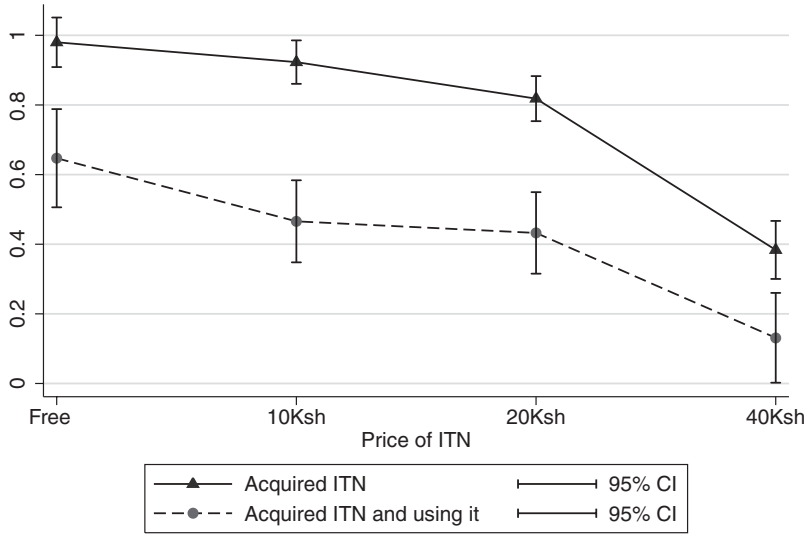

FIGURE I
Ownership vs. Effective Coverage

Sample includes women sampled for baseline survey during clinic visit, and who either did not acquire an ITN or acquired one and were later randomly sampled for the home follow-up. Usage of program ITN is zero for those who did not acquire a program ITN. Error bars represent ±2.14 standard errors (5% confidence interval with fourteen degrees of freedom). At the time this study was conducted, ITNs in Kenya were social-marketed through prenatal clinics at a price of 50 Ksh.

coverage protects pregnant women and their children from the serious detrimental effects of maternal malaria. In addition, ITN use can help avert some of the substantial direct costs of treatment and the indirect costs of malaria infection on impaired learning and lost income. Lucas (forthcoming) estimates that the gains to education from a malaria-free environment alone more than compensate for the cost of an ITN.

Despite the proven efficacy and increasing availability of ITNs on the retail market, the majority of children and pregnant women in sub-Saharan Africa do not use ITNs.[5] 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. However, the price that is charged for the net

5. According to the World Malaria Report (2008), which compiled results from surveys in 18 African countries, 23% of children and 27% of pregnant women sleep under ITNs.

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 a positive price is needed to screen out people who will not use the net, and thus avoid wasting the subsidy on nonusers. 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 (Schellenberg et al. 2001; PSI 2003). 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, considered key to ensuring a sustainable supply of ITNs.

Proponents of full subsidization argue that, although the private benefits of ITN use can be substantial, ITNs also have important positive health externalities deriving from reduced disease transmission.[6,7] 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 infection were as strong among nonbeneficiary households within 300 meters of beneficiary villages as they were among households in the beneficiary villages themselves (Gimnig et al. 2003).[8] Although 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% 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).

6. The external effects of ITN use derive 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.

7. 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).

8. In a similar study in Ghana, Binka, Indome, and Smith (1998) find that child mortality increases by 6.7% with each 100-meter shift away from the nearest household with an ITN.

III.B. Experimental Setup

The experiment was conducted in twenty 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 forty weeks of gestation, and as a consequence of the high resulting levels of maternal anemia, 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% of households in Western Kenya had at least one net and 6.7% had a treated net (an ITN); 12.4% of children under five slept under a net and 4.8% under an ITN; 6% of pregnant women slept under a net the night before and 3% under an ITN. Net ownership is very 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 nine months and five years of age and distributed a free long-lasting ITN to each mother who brought her children to be vaccinated. The 2008 World Malaria Report uses ITN distribution figures to estimate that 65% of Kenyan households now own an ITN. A 2007 survey conducted (for a separate project) in the area of study among households with school-age children found a rate of long-lasting ITN ownership around 30% (Dupas 2009b).

Our experiment targeted ITN distribution to pregnant women visiting health clinics for prenatal care.[9] We worked with 20 rural public health centers chosen from a total of 70 health centers in the region, 17 of which 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: four clinics formed the control group; five clinics were provided with ITNs

9. The ITNs distributed in our experiment were PermaNets, sold by Vestergaard Frandsen. They are circular polyester bed nets treated with the insecticide Deltamethrin and maintain efficacy without retreatment for about three to five years (or about twenty washes).

and instructed to give them free of charge to all expectant mothers coming for prenatal care; five clinics were provided with ITNs to be sold at 10 Ksh (corresponding to a 97.5% subsidy); three clinics were provided with ITNs to be sold at 20 Ksh (95.0% subsidy); and the last three clinics were provided with ITNs to be sold at 40 Ksh (90% subsidy). The highest price is 10 Ksh below the prevailing subsidized price of ITNs in this region, offered through PSI to pregnant women at prenatal clinics.[10] Table I presents summary statistics on the main characteristics of health centers in each group. Although the relatively small number of clinics leads to imperfect balancing of characteristics, the clinics appear reasonably similar across ITN price assignment and we show below that controlling for clinic characteristics does not change our estimates except to add precision.

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 5,000 Ksh (approximately $75) if no evidence of "leakage" or mismanagement of the ITNs or funds was observed. Clinics were informed that random spot checks of their record books would be conducted, as well as visits to a random subsample of beneficiaries to confirm the price at which the ITNs had been sold and to confirm that they had indeed purchased ITNs (if the clinic's records indicated so). Despite this, we observed leakages and mismanagement of the ITNs in four of the eleven clinics that were asked to sell ITNs for a positive price. We did not observe any evidence of mismanagement in the five clinics instructed to give out the ITNs for free. Of the four clinics that mismanaged the ITNs, none of them altered the price at which ITNs were made available to prenatal clients, but they sold some of the program ITNs to ineligible recipients (i.e., nonprenatal clients).

The ITN distribution program was phased into program clinics between March and May 2007 and was kept in place for at least three 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

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

TABLE I
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)	*p*-value, joint test 1	*p*-value, joint test 2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average monthly attendance in 2006 (first visits ONLY)	67 [46.3]	63	75	54	62	.769	.965
Average monthly attendance in 2006 (first + subsequent visits)	114 [69.4]	117	164	106	122	.565	.847
Prenatal enrollment fee (in Ksh)	10.0 [8.2]	12.0	4.0	13.3	10.0	.292	.619
Fraction of clinics with HIV testing services	0.50 [0.58]	0.40	0.80	0.67	0.33	.507	.713
Total other prenatal clinics within 10 kilometers (km)	3.8 [2.9]	3.4	3.6	4.3	5.0	.769	.758
Distance (in km) to closest prenatal clinic in the sample	11.3 [2.6]	13.3	13.0	12.1	11.4	.743	.593
Number of clinics	4	5	5	3	3		

Notes: Standard deviations presented in brackets. At the time of the program, $US 1 was equivalent to around 67 Kenyan shillings (Ksh). Prenatal clinics were sampled from a pool of seventy prenatal clinics over four districts in Kenya's Western Province: Busia, Bungoma, Butere, and Mumias. Joint test 1: Test of equality of means across four treatment groups. Joint test 2: Joint test that means in treatment groups are equal to mean in control group.

procedures these clinics used at prenatal care visits, which in principle included a discussion of the importance of bed net usage.

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 surprised by the opportunity to participate in a lottery for an additional promotion by picking an envelope from a basket. All women given the opportunity to participate in the lottery agreed to pick an envelope. The final price paid by these women was 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 40 Ksh. 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 second-stage discount.[11]

III.C. Data

Three types of 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 levels were 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 were selected to be visited at their homes three to ten weeks after their net purchases. All home visits were conducted within three weeks in July 2007 to ensure that all respondents faced the same environment (especially in terms of malaria seasonality) at the time of the follow-up. Of this subsample, 92% (226 women) were found and consented to be interviewed. During the home visits, respondents were asked to show the net, whether they had started using it, and who was sleeping under it. Surveyors

11. By comparing days with and those without the lottery, we can test whether women heard about the lottery on days we did the lottery. We do not find evidence that uptake was higher on the days we performed the lottery; we also do not observe a significant increase in the uptake of nets after the first lottery day (data not shown).

checked to see whether the net had been taken out of the packaging, whether it was hanging, and the condition of the net.[12] Note that, at the time of the baseline survey and ITN purchase, women were not told that follow-up visits could be made at their homes. What's more, neither the clinic staff nor the enumerators conducting the baseline surveys knew that usage would be checked. This limits the risk that usage behavior might be abnormally high during the study period. Also note that we do not observe an increase in reported or observed usage over the three weeks during which the home surveys were conducted. This suggests that the spread of information about the usage checks was limited and unlikely to have altered usage behavior.

III.D. Clinic-Level Randomization

The price at which ITNs were sold was randomized at the clinic level, but our outcomes of interest are at the individual level: uptake, usage rates, and health. 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 using the cluster-correlated Huber–White covariance matrix method. In addition, because the number of clusters is small (sixteen treatment clinics), the critical values for the tests of significance are drawn from a t-distribution with fourteen ($= 16 - 2$) degrees of freedom (Cameron, Miller, and Gelbach 2007). The critical values for the 1%, 5%, and 10% significance levels are thus 2.98, 2.14, and 1.76, respectively.

Another approach to credibly assessing causal effects with a limited number of randomization units is to use (nonparametric) randomization inference, first proposed by Fisher (1935), later developed by Rosenbaum (2002), and recently used by Bloom et al. (2006). Hypothesis testing under this method is done as follows. For each clinic, we observe the share of prenatal clients who purchased a net (or were using a net). Let y_i denote the observed purchase rate for clinic i. For each clinic $i = 1, 2, \ldots, 16$, $Y_i(P_i)$ represents the purchase rate at clinic i when the ITN price at clinic i is P_i, $P_i \in [0, 10, 20, 40]$. The outcome variable is a function of

12. The nets that were distributed through the program were easily recognizable through their tags. Enumerators were instructed to check the tags to confirm the origin of the nets.

the treatment variable and potential outcomes:

$$y_i = \sum_{k=0,10,20,40} (1|P_i = k)Y_i(k).$$

The effect of charging price k in clinic i (relative to free distribution) is

$$E_{ki} = Y_i(k) - Y_i(0).$$

To make causal inferences for a price level k via Fisher's exact test, we use the null hypothesis that the effect of charging k is zero for all clinics:

$$H0 : E_{ki} = 0 \text{ for all } i = 1, \ldots, 16.$$

Under this null hypothesis, all potential outcomes are known exactly. For example, although we do not observe the outcome under price 0 for clinic i subject to price $k > 0$, the null hypothesis implies that the unobserved outcome is equal to the observed outcome, $Y_i(0) = y_i$.

For a given price level k, we can test the null hypothesis against the alternative hypothesis that $E_{ki} \neq 0$ for some clinics by using the difference in average outcomes by treatment status as a test statistic:

$$T_k = \frac{\sum (1|P_i = k)y_i}{\sum (1|P_i = k)} - \frac{\sum (1|P_i = 0)y_i}{\sum (1|P_i = 0)}.$$

Under the null hypothesis, only the price variable P is random, and thus the distribution of the test statistic (generated by taking all possible treatment assignments of clinics to prices) is completely determined by that of P. By checking whether T_k^{obs}, the statistic for the "true" assignment of prices (the actual assignment in our experiment), falls in the tails of the distribution, we can test the null hypothesis. We can reject the null hypothesis with a confidence level of $1 - \alpha$ if the test statistic for the true assignment is in the $(\alpha/2)\%$ tails of the distribution. This test is nonparametric because it does not make distributional assumptions. We call the p-values computed this way "randomization inference p-values."

IV. Results

IV.A. Clinic-Level Analysis: Randomization Inference Results

Table II presents the results of randomization inference tests of the hypotheses that the three positive prices in our experiment

TABLE II
CLINIC-LEVEL ANALYSIS: FISHERIAN PERMUTATION TESTS

	Average weekly ITN sales over first 6 weeks						Share of prenatal clients who acquired program ITN					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Takeup												
Mean in free group	41.03						0.99					
Difference with free group:												
ITN price = 10 Ksh	−3.43	−13.77					−0.07	−0.07				
S.E.	(18.60)	(13.98)					(0.03)**	(0.03)*				
Randomization inference p-value	.824	.460					.125	.091				
ITN price = 20 Ksh			−13.87	−10.75					−0.17	−0.18		
S.E.			(20.36)	(18.16)					(0.02)***	(0.02)***		
Randomization inference p-value			.64	.61					.000	.036		
ITN price = 40 Ksh					−32.12	−34.03					−0.58	−0.58
S.E.					(25.05)	(22.00)					(0.06)***	(0.05)***
Randomization inference p-value					.23	.19					.000	.018
Clinic-level controls		X		X		X		X		X		X
Number of clinics	10	10	8	8	7	7	10	10	8	8	8	8
R^2	.00	.54	.07	.39	.25	.54	.45	.45	.93	.96	.95	.97
# of possible assignments for random inference	252	252	56	56	21	21	252	252	56	56	56	56

TABLE II
(CONTINUED)

	Share using program ITN at follow-up (unconditional on takeup)					
	(13)	(14)	(15)	(16)	(17)	(18)
Panel B: Effective coverage						
Mean in free group	0.70					
Difference with free group:						
ITN price = 10 Ksh	−0.18	−0.17				
S.E.	(0.13)	(0.14)				
Randomization inference p-value	.173	.206				
ITN price = 20 Ksh			−0.27	−0.27		
S.E.			(0.13)*	(0.14)		
Randomization inference p-value			.071	.143		
ITN price = 40 Ksh					−0.55	−0.54
S.E.					(0.14)***	(0.15)**
Randomization inference p-value					.018	.054
Clinic-level controls		X		X		X
Number of clinics	10	10	8	8	8	8
R^2	.2	.22	.42	.42	.71	.73
# of possible assignments for random inference	252	252	56	56	56	56
Ratio [$(\Delta H/\Delta T)$ from Panel B / $(\Delta(H+N)/\Delta T)$ from Panel A]	2.571	2.429	1.588	1.500	0.948	0.931
Standard error of ratio $(\Delta H/\Delta T)/(\Delta H+N/\Delta T)$	2.107	1.418	0.598	0.822	0.185	0.153

Notes: Panel A, columns (1)–(6): Sales data from clinics' records. Data missing for one clinic due to misreporting of sales. Panel A, columns (7)–(12), and Panel B: Individual data collected by research team, averaged at the clinic level (the level of randomization). "Using program ITN" is equal to 1 only for those who (1) acquired the ITN and (2) had the ITN hanging in the home during an unannounced visit. Standard errors in parentheses, estimated through linear regressions. P-values for treatment effects computed by randomization inference.

***, **, * Significance at 1%, 5%, and 10% levels, respectively.

had no effect on demand and coverage. The data used in Table II were collapsed at the clinic level. (The raw data on clinic level outcomes are provided in the Online Appendix). We have two indicators of demand presented in Panel A: average weekly sales of ITNs (recorded by the clinics) in columns (1)–(6) and the share of surveyed pregnant women who acquired an ITN in columns (7)–(12). Panel B shows the rate of effective coverage: the share of surveyed pregnant women in the clinic who not only acquired the ITN but also reported using it at follow-up. For each outcome (sales, uptake, effective coverage), we present the estimated effect of prices both without and with clinic-level controls. We present the standard errors estimated through parametric linear regressions, as well as the randomization inference p-values.

Results in columns (1)–(6) suggest that, although the ITN sales were lower on average in clinics charging a higher price for the ITN, none of the differences between clinics can be attributed to the price. Even the $32/41 = 78\%$ lower sales in the clinics charging 40 Ksh are not significant. Note, however, that the sales data are missing for one of the three 40 Ksh clinics, and as a consequence the power of the randomization inference test in columns (5) and (6) is extremely low: there are only 21 possible assignments of seven clinics to two groups of sizes five and two, and each of them has a $1/21 = 4.76\%$ chance of being selected. This means that even the largest effect cannot fall within the 2.5% tails of the distribution, and randomization inference would thus fail to reject the null hypothesis of no price effect with 95% confidence no matter how large the difference in uptake between 0 Ksh and 40 Ksh clinics is (Bloom et al. 2006).

The power is higher for the tests performed on the survey data (columns (7)–(12) of Panel A, and Panel B), but still lower relative to tests that impose some structure on the error term. Nevertheless, the p-values in columns (9)–(12) suggest that we can reject the hypothesis that charging either 20 or 40 Ksh for nets has no effect on uptake with 95% confidence. In particular, uptake of the net is 58 percentage points lower in the 40 Ksh group than in the free distribution group, and the confidence level for this effect is 98%. The results on effective coverage (usage of the net unconditional on uptake) are weaker for the 20 Ksh treatment but still significant for the 40 Ksh treatment: effective coverage is 54 percentage points lower in the 40 Ksh group than in the free distribution group, and the confidence level for this effect is 94%.

As shown in Section II, the key parameter of interest in determining the optimal subsidy level is the ratio $(\Delta H/\Delta T)/(\Delta(H + N)/\Delta T)$. We compute this ratio for $\Delta T = 10$ Ksh, $\Delta T = 20$ Ksh, and $\Delta T = 40$ Ksh at the bottom of Panel B in Table II. The ratio is greater than 1 for price changes from 0 to 10 Ksh or 0 to 20 Ksh, but the standard errors are massive and there is little informational content in those numbers. For $\Delta T = 40$ Ksh, the ratio is more precisely estimated, at 0.95, still quite close to 1. The standard error of this ratio is 0.18 in the absence of covariates, and implies a 95% confidence interval of [0.58–1.31]. When we control for clinic-level covariates in the estimations of the two effects, the confidence interval on the ratio is somewhat reduced to [0.63–1.23].

The finding in Table II that effective coverage is statistically significantly lower by 54 percentage points in the 40 Ksh group (the group that proxies the cost-sharing program in place in Kenya at the time of the study) compared to the free distribution group is the main result of the paper. In the remainder of the analysis, we investigate the effects in more detail by conducting parametric analysis on the disaggregated data with cluster standard errors adjusted for the small number of clusters.

IV.B. Micro-Level Analysis: Price Elasticity of Demand for ITNs

Table III presents coefficient estimates from OLS regressions of weekly ITN sales on price. 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 eight nets for each 10 Ksh increase in price. Because clinics distributing ITNs for free to their clients distribute an average of 41 ITNs per week, these estimates imply that a 10 Ksh increase in ITN price leads to a 20% decline in weekly ITN sales. The specification in column (4) regresses weekly ITN sales on indicator variables for each ITN price (0 Ksh is excluded). Raising the price from 0 to 40 Ksh reduces demand by 80% (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). These results are not sensitive to adding controls for time effects (columns (2) and (5)).

Columns (3) and (6) present results of robustness checks conducted by including various characteristics of the clinics as controls. Because net sales are conditional on enrollment at prenatal clinics, one concern is that our demand estimates are confounded

TABLE III
WEEKLY ITN SALES ACROSS PRICES: CLINIC-LEVEL DATA

	Weekly ITN sales					
	(1)	(2)	(3)	(4)	(5)	(6)
ITN price in Kenyan shillings (Ksh)	−0.797	−0.797	−0.803			
	(0.401)*	(0.403)*	(0.107)***			
ITN price = 10 Ksh ($0.15)				−0.33	−0.33	1.52
				(16.81)	(16.92)	(4.37)
ITN price = 20 Ksh ($0.30)				−9.50	−9.50	−14.08
				(16.04)	(16.14)	(5.00)**
ITN price = 40 Ksh ($0.60)				−32.42	−32.42	−33.71
				(15.38)*	(15.47)*	(2.88)***
Number of weeks since program started		−5.08	−5.08		−5.08	−5.08
		(1.41)***	(1.46)***		(1.42)***	(1.48)***
Average attendance in 2006 (first visits)			1.48			1.56
			(0.21)***			(0.22)***
Average attendance in 2006 (total)			−0.46			−0.50
			(0.15)***			(0.15)***
Prenatal enrollment fee (in Ksh)			−0.77			−0.54
			(0.27)**			(0.32)
ANC clinic offers HIV testing services			14.08			7.07
			(7.44)*			(7.65)

TABLE III
(CONTINUED)

	Weekly ITN sales					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to the closest ANC clinic			−1.08			−1.84
			(0.77)			(0.68)**
Distance to the closest ANC clinic in the sample			−8.85			−9.63
			(2.89)***			(2.70)***
Observations (clinic-weeks)	90	90	90	90	90	90
R^2	.13	.21	.64	.14	.23	.65
Mean of dep. var. in clinics with free ITNs	41.03					

Notes: Each column is an OLS regression of weekly ITN sales on ITN price or on a set of indicator variables for each price (0 Ksh is excluded). All regressions include district fixed effects. The sample includes fifteen clinics in three districts over six weeks after program introduction. (One 40 Ksh clinic is not included because of problems with net sales reporting.) Standard errors in parentheses are clustered at the clinic level. Given the small number of clusters (fifteen), the critical values for T-tests were drawn from a t-distribution with 13 (15 − 2) degrees of freedom.

***, **, * Significance at 1%, 5%, and 10% levels, respectively.

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 columns (3) and (6) control for monthly prenatal attendance at each clinic in 2006, as well as 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.

One might be concerned that our net sales data are biased due to (a moderate amount of) mismanagement, theft, and misreporting by clinics. Further, because the number of observations in Table III is 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 IV presents additional estimates of demand based on individual-level data from surveys conducted among all prenatal clients who visited the clinics on the randomly chosen days when baseline surveys were conducted. These specifications correspond to linear probability models where the dependent variable is a dummy equal to one if the prenatal client 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 -0.015 on ITN price in column (1) implies that a 10 Ksh ($0.15) increase in the price of ITNs reduces demand by fifteen percentage points (or roughly 20% at the mean purchase probability of .81). This is very consistent with the results based on net sales and corresponds to a price elasticity (at the mean price and purchase probability) of $-.37$. These results imply that demand for ITNs is 75% lower at the cost-sharing price prevailing in Kenya at the time of the study (50 Ksh or $0.75) than it is under a free distribution scheme.

TABLE IV
DEMAND FOR ITNS ACROSS PRICES: INDIVIDUAL-LEVEL DATA

	Bought/received an ITN during prenatal visit							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ITN price in Kenyan shillings (Ksh)	−0.015	−0.017			−0.018	−0.012	−0.016	
	(0.002)***	(0.001)***			(0.001)***	(0.002)***	(0.002)***	
ITN price = 10 Ksh ($0.15)			−0.073	−0.058				0.046
			(0.018)***	(0.037)				(0.034)
ITN price = 20 Ksh ($0.30)			−0.172	−0.331				−0.350
			(0.035)***	(0.102)***				(0.142)**
ITN price = 40 Ksh ($0.60)			−0.605	−0.656				−0.635
			(0.058)***	(0.037)***				(0.061)***
Time controls		X		X	X	X	X	X
Clinic controls		X		X	X	X	X	X
Restricted sample: first prenatal visit					X			
Restricted sample: first pregnancy						X		
Restricted sample: did not receive free ITN previous year							X	X
Observations	424	424	424	424	201	134	266	266
R^2	.26	.28	.32	.32	.42	.24	.32	.33
Mean of dep. var.	0.81	0.81	0.81	0.81	0.77	0.84	0.84	0.84
Intracluster correlation	.23							

Notes: Data are from clinic-based surveys conducted in April–June 2007, throughout the first six 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 (sixteen), the critical values for T-tests were 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 columns (4) and (8), 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 include total monthly first prenatal care visits between April and 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.

***, **, * Significance at 1%, 5%, and 10% levels, respectively.

In column (2) of Table IV, we add controls for when the survey was administered, including day-of-the-week fixed effects and the time elapsed since program introduction, as well as controls for the clinic characteristics used in Table III, column (3). The coefficient estimate for price remains very close to that obtained in the basic specification.

Columns (3) and (4) present estimates of demand at each price point. In the absence of clinic or time controls, the decrease in demand for an increase in price from 0 to 10 Ksh is estimated at seven percentage points (larger than suggested by the clinic-level ITN sales in Table III). An increase in price from 20 to 40 Ksh leads to a 43–percentage point drop in demand.

Column (5) presents demand estimates for the restricted sample of women who are making their first prenatal care visits for their current pregnancies. It is 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, because 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 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, because the Measles Initiative ran a campaign in July 2006 (nine months before the start of our experiment) throughout Kenya to vaccinate children between nine months and five 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 pregnancies only. When we restrict the sample in this way, the coefficient on ITN price drops to -0.012. This implies that women in their first pregnancies 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 50 Ksh.

Our baseline survey asked respondents if they had received a free ITN in the previous year, and 37.3% said they did. In columns

(7) and (8), we focus on the 63% who reported *not* having received a free ITN and estimate how their demand for an ITN in our program was affected by price. We find a coefficient on price very similar to that obtained with the full sample (−0.016), and the specifications with dummies for each price group generate estimates that are also indistinguishable from those obtained with the full sample.

Nearly three-quarters of prenatal clients walked to the clinics for prenatal care. Because clinics included in our sample were at least 13 kilometers from one another, it is unlikely that prenatal clients would switch from one of our program clinics to another. However, it is likely that our program generated some crowd-out of prenatal clients at nonprogram clinics in the vicinity, particularly in the case of free nets. Because these "switchers" are driven by price differences in ITNs that would not exist in a nationwide distribution program, we should look at the demand response of those prenatal clients who, at the time of the interview, were attending the same clinic that they had in the past. In Online Appendix Table A.1, we replicate Table IV for this subsample of prenatal clients who did not switch clinics. The results are nearly unchanged, suggesting that the same degree of price sensitivity would prevail in a program with a uniform price across all clinics.

In sum, our findings suggest that demand for ITNs is not 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 10 Ksh ($0.15) increase in ITN price decreases demand by 20%. 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.

IV.C. Price-Elasticity of the Usage of ITNs

Usage Conditional on Ownership. Let us start this section with an important caveat: Our sample size to study usage conditional on uptake is considerably hampered by the fact that uptake was low in the higher-priced groups: only a small fraction of the respondents interviewed at baseline in the 40 Ksh group purchased an ITN and could be followed up at home for a usage check.

Keeping this caveat in mind, Figure II shows the average usage rate of program-issued ITNs across price groups. The top panel shows self-reported usage rates, and the bottom panel shows the likelihood that the ITN was found hanging, both measured during

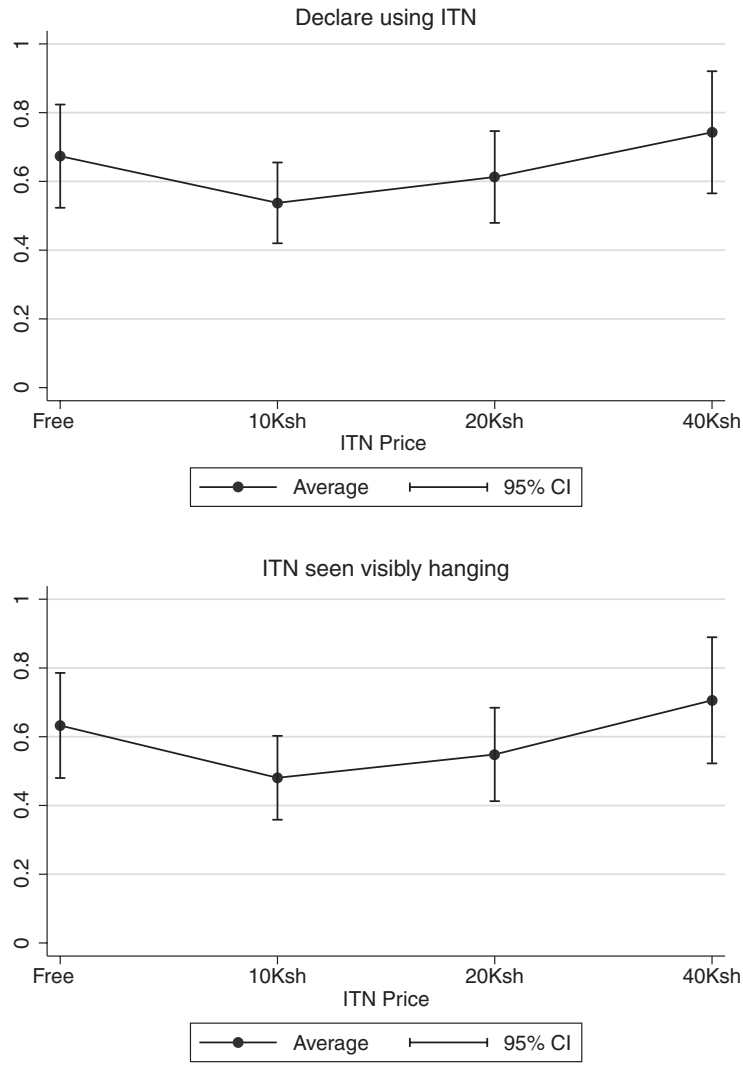

FIGURE II
Program ITN Usage Rates (Conditional on Uptake) by ITN Price
Error bars represent ±2.14 standard errors (95% confidence interval with fourteen degrees of freedom). Number of observations: 226.

an unannounced home visit by an enumerator. On average, 62% of women visited at home claimed to be using the ITN they acquired through the program, a short-term usage rate that is very consistent with previous usage studies (D'Alessandro 1994; Alaii et al. 2003). The observed hanging rate was only slightly lower, at 57%. However, we find little variation in usage across price groups, and no systematic pattern. This is confirmed by the regression estimates of selection effects on usage, presented in Table V. Our coefficient estimate on ITN price in column (1) is positive, but insignificant, suggesting that a price increase of 10 Ksh increases usage by four percentage points, representing an increase of 6% at the mean. The confidence interval is large, however, and the true coefficient could be on either side of zero (the 95% confidence interval is -0.004; 0.012). These estimates correspond to a price elasticity of usage (at the mean price and usage rate) of 0.097. Adding controls in column (2) does not improve precision but reduces the size of the estimated effect. The results also hold when the sample is restricted to the subsample of women coming for their first prenatal visit, women in their first pregnancy, or to those who reported not having received a free ITN the previous year (data not shown).

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 or 20 Ksh are less likely to be using their ITNs than women receiving them for free, but women who pay 40 Ksh appear close to 10% more likely to be using their ITNs. In none of the cases, however, can we reject the null hypothesis that price has no effect on intensity of usage.

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.[13] Of those women who claimed to be using the ITN, 95% had the net hanging. Results for whether or not the net is hanging (columns (5) and (6)) are very similar to those using self-reported usage.

One might be concerned that usage rates among prenatal clients receiving a free net are higher than they would be under a one-price policy, because pregnant women who value an ITN

13. Having the insecticide-treated net hanging from the ceiling creates health benefits even if people do not sleep under the net, because it repels, disables, and/or kills mosquitoes coming into contact with the insecticide on the netting material (WHO 2007).

TABLE V
ITN USAGE RATES ACROSS PRICES, CONDITIONAL ON OWNERSHIP

	Respondent is currently using the ITN acquired through the program				ITN is visibly hanging	
	(1)	(2)	(3)	(4)	(5)	(6)
ITN price	0.004	0.003			0.003	
	(0.004)	(0.003)			(0.003)	
ITN price = 10 Ksh			−0.125	−0.094		−0.154
			(0.120)	(0.103)		(0.129)
ITN price = 20 Ksh			−0.017	−0.017		−0.088
			(0.107)	(0.119)		(0.124)
ITN price = 40 Ksh			0.098	0.125		0.071
			(0.135)	(0.123)		(0.131)
Time controls		X		X		
Clinic controls		X		X		
Observations	226	226	226	226	222	222
Sample mean of dep. var.	0.62	0.62	0.62	0.62	0.57	0.57
R^2	.01	.06	.03	.07	.01	.03
Intracluster correlation	.04					
Joint F-test			1.14	1.16		1.87
Prob > F			.37	.36		.18

Notes: Data are from home visits to a random sample of patients who bought nets at each price or received a net for free. Home visits were conducted for a subsample of patients roughly three to six 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 (sixteen), the critical values for T-tests were drawn from a t-distribution with 14 (16 − 2) degrees of freedom. The specifications in columns (2) and (4) control 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, as well as the clinic controls in Table III.

highly may have switched clinics in order to get a free net. We show in Online Appendix Table A.2 that, as with our demand estimates, usage rates among the subsample of women who did not switch clinics (i.e., attended the same prenatal clinic after our program was introduced as before it) are not different from the sample as a whole.

Overall, one might be surprised that the level of net usage is not higher than 60%. This result might come from the fact that usage was measured a relatively short time after the net was purchased. In the usage regressions, the coefficients on time controls (not shown) suggest that usage increases as time passes after the ITN purchase. Among women not using the net, the most common reasons given for not using it were waiting for the birth of the child and waiting for another net (typically untreated with insecticide) to wear out. Dupas (2009a) finds that, among the general population, usage among both buyers and recipients of free ITNs is around 90% a year after the ITNs were acquired.

Unconditional Usage: "Effective Coverage." Although our estimates of usage rates among buyers suffer from small sample size imprecision, effective coverage (i.e., the fraction of the population using a program net) can be precisely estimated. Figure I presents effective coverage with program ITNs across ITN prices. The corresponding regression is presented in Table VI, column (1). The coefficient on price is -0.012, significant at the 1% level. This corresponds to a price elasticity of effective coverage of -0.44. The share of prenatal clients that are protected by an ITN under the free distribution scheme is 65%, versus 15% when ITNs are sold for 40 Ksh; this difference is significant at the 1% level (column (3)). The results are robust to the addition of clinic controls (columns (2) and (4)), and hold for all subgroups (data not shown).

Overall, our results suggest that, at least in the Kenyan context, positive prices do not help generate higher usage intensity than free distribution. 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

TABLE VI

EFFECTIVE COVERAGE: ITN USAGE RATES ACROSS PRICES, UNCONDITIONAL ON OWNERSHIP

	Respondent is currently using an ITN acquired through the program			
	(1)	(2)	(3)	(4)
ITN price	−0.012	−0.010		
	(0.003)***	(0.002)***		
ITN price = 10 Ksh			−0.188	0.020
			(0.123)	(0.145)
ITN price = 20 Ksh			−0.203	−0.143
			(0.097)*	(0.104)
ITN price = 40 Ksh			−0.504	−0.389
			(0.112)***	(0.095)***
Time controls		X		X
Clinic controls		X		X
Observations	259	259	259	259
Sample mean of dep. var.	0.42	0.42	0.42	0.42
Mean in (ITN price = 0) group	0.65	0.65	0.65	0.65
Intracluster correlation	.02			
Joint F-test			12.71	8.12
Prob > F			.00	.00

Notes: Data are from random sample of patients who visited program clinics. Usage for those who acquired the ITNs was measured through home visits conducted roughly three to six 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 (sixteen), the critical values for T-tests were drawn from a t-distribution with 14 (16 − 2) degrees of freedom.

***, **, * Significance at 1%, 5%, and 10% levels, respectively.

of protection against malaria. In addition, PSI has been conducting a very intense advertising campaign for ITN use throughout Kenya over the past five 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. Thus, a large number of prenatal clients may value ITNs but be unable to pay higher prices for them.

IV.D. 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 VII presents estimates of the effect of price (columns (1) and (2)) and of the act of paying (columns (3)–(6)) 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. Because the uptake of ITNs decreased sharply with the price, the sample we have at hand to test for the presence of sunk cost effects is small, and therefore the precision of the estimates we present below is limited.

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. The 95% confidence interval is $(-0.0158; 0.0098)$, suggesting that a 10 Ksh increase in price could lead to anything from a decrease of sixteen to an increase of ten percentage points in usage. Larger effects on either side can be confidently rejected, however. Adding controls, including a dummy for having received a free ITN from the government in the previous year, does not reduce the standard error but decreases the coefficient of price further, enabling us to rule out sunk cost effects of more than seven percentage points per 10 Ksh increase in price (column (2)).

TABLE VII

SUNK COST EFFECTS? ITN USAGE RATES ACROSS PRICES (CONDITIONAL ON OWNERSHIP), HOLDING WILLINGNESS TO PAY CONSTANT

	Respondent is currently using the ITN acquired through the program					ITN is visibly hanging
	(1)	(2)	(3)	(4)	(5)	(6)
Transaction price	−0.003	−0.006				
	(0.006)	(0.006)				
Transaction price > 0			−0.017	−0.072	−0.065	−0.084
			(0.100)	(0.101)	(0.100)	(0.099)
Got a free ITN the previous year		−0.192			−0.191	−0.165
		(0.100)*			(0.101)*	(0.102)
Still pregnant at time of follow-up		−0.234		−0.195	−0.231	−0.213
		(0.121)*		(0.122)	(0.122)*	(0.125)*
First prenatal visit		0.202		0.199	0.202	0.121
		(0.102)**		(0.103)*	(0.104)*	(0.107)
First pregnancy		0.148		0.184	0.153	0.063
		(0.104)		(0.100)*	(0.104)	(0.106)
Time to clinic		0.000		0.000	0.000	0.000
		(0.001)		(0.001)	(0.001)	(0.001)
Time elapsed since ITN purchase		0.015		0.014	0.015	0.011
		(0.006)***		(0.006)**	(0.006)***	(0.005)**
Observations	132	123	132	124	123	121
Sample mean of dep. var.	0.58	0.58	0.58	0.58	0.58	0.53
F stat		3.23		2.99	3.60	1.97
Prob > F		.00		.01	.00	.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. Some of the individual control variables are missing for some respondents.

***, **, * Significance at 1%, 5%, and 10% levels, respectively.

In column (3), the coefficient for the act of paying a positive price is also negative, suggesting that if the act of paying had any effect, it would decrease usage rather than increase it, but here again the coefficient cannot be confidently distinguished from zero. The 95% confidence interval for this estimate is quite large and suggests that a 10 Ksh increase in price could lead to anything from a decrease of 22 to an increase of 20 percentage points in usage.

Overall, these results suggest that, in the case of ITNs marketed through health clinics, there is no large positive psychological effect of price on usage. We do not have data on baseline time preferences to check 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.

If usage might not increase with price, what about the private benefits to the users? Is it the case that the users reached through the 40 Ksh distribution system are those who 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. 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.

IV.E. 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 people are not able (do not have the cash) to pay what they would be willing to pay in the absence of

credit constraints. The optimal subsidy level will have to be low enough to discourage women who do not need the product from buying it, although 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 levels. Women who are anemic (i.e., with low hemoglobin levels) 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.

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 III plots the cumulative density functions (CDFs) of hemoglobin levels for women buying/receiving a net at each price relative to women in the control group. The surprising result in Figure III is that the CDFs for women receiving free nets stochastically dominates the distribution in the control group, implying that women who get free nets are *healthier* than the average prenatal woman (Panel A). In contrast, the CDFs of hemoglobin levels of women who pay a positive price (whether 10, 20, or 40 Ksh) are indistinguishable from the CDFs of women in the control clinics (Panels B, C, and D). In other words, women who pay a higher price do not appear to be sicker than the average prenatal clients in the area.[14]

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? Dupas (2005) shows that there is a strong incentive effect of free ITNs on enrollment for prenatal care. To test whether such an effect was at play in our experiment, Table VIII 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)–(5)). The results provide some evidence that the incentive effect of free ITNs was strong: women who came for free nets were 12%

14. 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. Following Præstgaard (1995), we use the bootstrap method to adjust the p-values for clustering at the clinic level. The results of the tests are presented in the notes of Figure III. We can reject the null hypothesis of equality of distributions between women who receive free nets and those attending control clinics at the 10% significance level. We cannot reject the equality of distributions for women in the control population and those paying 10, 20, or 40 Ksh for an ITN.

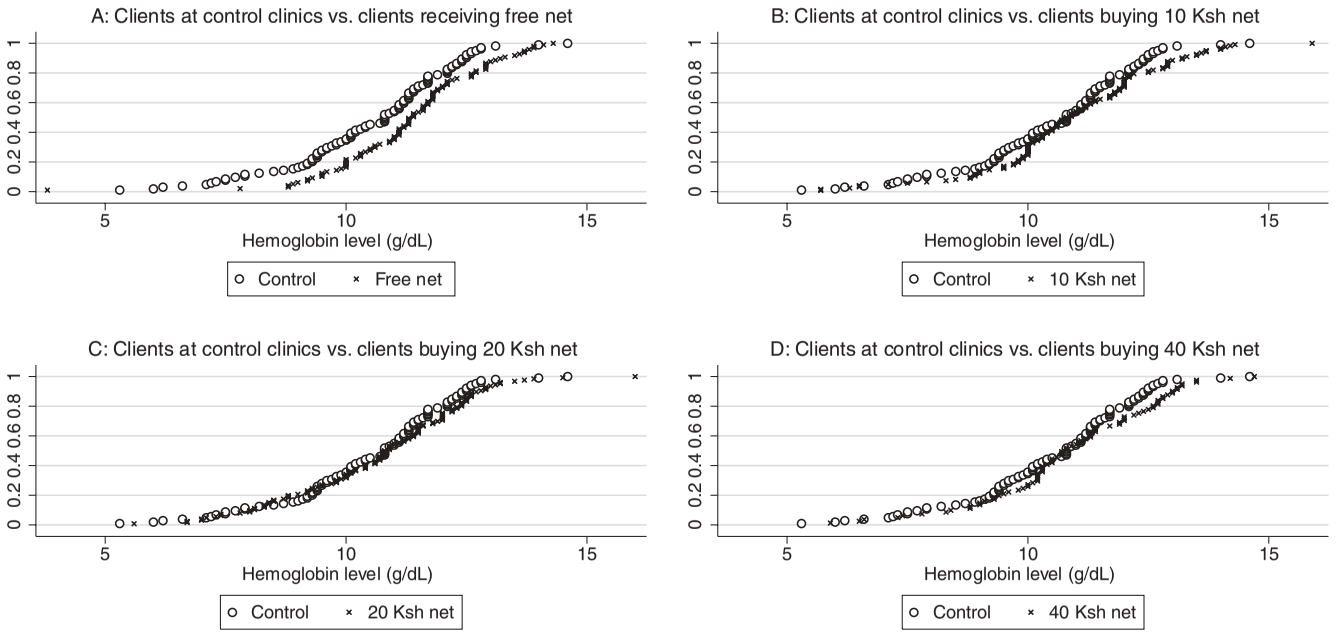

FIGURE III
Cumulative Density of Hemoglobin Levels among ITN Recipients/Buyers

The *p*-values for Kolmogorov–Smirnov tests of equality of distribution (adjusted for clustering at the clinic level by bootstrap) are .091 (Panel A), .385 (Panel B), .793 (Panel C), and .781 (Panel D). Number of observations: 198 (Panel A), 217 (Panel B), 208 (Panel C), and 139 (Panel D).

TABLE VIII
CHARACTERISTICS OF PRENATAL CLIENTS BUYING/RECEIVING ITN RELATIVE TO CLIENTS OF CONTROL CLINICS

	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 A. Characteristics of visit to prenatal clinic				
First prenatal visit	0.48	−0.12	−0.02	0.03	0.02
for current pregnancy	*0.50*	(0.06)**	(0.04)	(0.06)	(0.04)
Walked to the clinic	0.73	−0.12	0.04	0.07	−0.16
	0.45	(0.13)	(0.07)	(0.06)	(0.08)*
If took transport to clinic:	4.58	3.52	0.79	−1.17	4.27
price paid (Ksh)	*10.83*	(3.29)	(1.78)	(1.37)	(1.94)**
Can read Swahili	0.81	0.10	0.05	0.00	0.09
	0.40	(0.03)***	(0.05)	(0.04)	(0.02)***
Wearing shoes	0.61	0.06	0.07	−0.11	0.11
	0.49	(0.12)	(0.12)	(0.12)	(0.12)
Respondent owns	0.19	0.00	0.01	0.12	0.07
animal assets	*0.39*	(0.06)	(0.05)	(0.05)**	(0.09)
	Panel B. Health status				
Hemoglobin level (Hb),	10.44	0.94	0.49	0.22	0.48
in g/dL	*1.77*	(0.34)**	(0.49)	(0.47)	(0.78)
Moderate anemia	0.69	−0.18	−0.09	−0.08	−0.05
(Hb < 11.5 g/dL)	*0.46*	(0.07)**	(0.12)	(0.10)	(0.19)
Severe anemia	0.16	−0.10	−0.01	0.07	−0.06
(Hb ≤ 9 g/dL)	*0.37*	(0.06)	(0.07)	(0.09)	(0.11)
Observations	110	98	120	99	28

Notes: For each variable, column (1) shows the mean observed among prenatal clients enrolling in control clinics; the standard deviations are presented in italics. Columns (2), (3), (4), and (5) show the differences between "buyers" in the clinics providing ITNs at 0, 10, 20, and 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 (sixteen), the critical values for T-tests were drawn from a t-distribution with 14 (16 − 2) degrees of freedom.
***, **, * Significance at 1%, 5%, and 10% levels, respectively.

more likely to be coming for a repeat visit and 12% less likely to have come by foot (i.e., more likely to have come by public transportation), and they paid about 3.5 Ksh more to travel to the clinic than women in the control group (Panel A). These results suggest that the free ITN distribution induced women who had come to the clinic before the introduction of the program to come back for a revisit earlier than scheduled, and therefore before the health benefits of their first prenatal visit had worn out.[15] As a result,

15. 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.

as seen in Figure III, women receiving free nets are substantially less likely to be anemic (eighteen percentage points off of a base of 69% in Panel B of Table VIII).[16]

In absolute terms, however, the *number* of anemic women covered by an ITN is substantially greater under free distribution than under cost-sharing. As shown in Table VIII, the great majority of pregnant women in Kenya are moderately anemic (71%). All of them receive ITNs under free distribution, but only 40% of them invest in ITNs when the price is 40 Ksh (Table IV). Given that usage of the ITN (conditional on ownership) is similar across price groups, effective coverage of the anemic population is thus 60% lower under cost-sharing.[17]

Finally, it is interesting to note in Table VIII that women who bought nets for 40 Ksh were more likely to pay for transportation and paid more to come to the clinic than the control group. Women who paid 40 Ksh were also more likely to be literate, more likely to be wearing shoes, and more likely to report owning animal assets. Not all of these differences are statistically different from zero, given the small-sample problem, but overall these results are suggestive that selection under cost-sharing happened at least partially along wealth lines.[18]

V. Cost-Effectiveness Analysis

This section presents estimates of the cost-effectiveness of each pricing strategy in terms of children's lives saved. 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.

An important dimension to keep in mind in the cost-effectiveness analysis is the nonlinearity in the health benefits associated with ITN use: high-density ITN coverage reduces overall transmission rates and thus positively affects the health of both

16. Because some of the women who received free nets appear to have traveled farther and spent more money on travel to the clinic, one might expect that this group was composed of many switchers from nonprogram clinics. However, we find that the effects of price on selection in terms of health are unchanged for the subsample of women staying with the same clinic (Online Appendix Table A3).

17. The usage results in Table V hold when the sample is restricted to moderately anemic women (data not shown).

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

nonusers and users. The results of a 2003 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, p. 121). In this context, we propose the following methodology to measure the health impact of each ITN pricing scheme: we create a "protection index for nonusers" (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 nonusers and to (roughly) approximate the total number of child lives saved, as well as the cost per life saved. Because the relative importance of the "physical barrier" effect and of the externality are uncertain, we consider three possible values for the parameter of the logistic function predicting the protection index for nonusers (the "threshold externality parameter") and three possible values for the effectiveness of ITNs as physical barriers. This gives us a total of $3 \times 3 = 9$ different scenarios and 9 different cost-per-life-saved estimates for each of the four pricing strategies.

The cost-effectiveness estimates are presented in Table IX. These estimates are provided to enable comparisons across distribution schemes, but their absolute values should be taken with caution, as they rely on a number of coarse assumptions (the details of the calculations are provided in the Online Appendix). In particular, two key assumptions made are the following: (1) 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 40 Ksh more to the social planner than an ITN sold for 40 Ksh. We thus ignore money management costs associated with cost-sharing schemes. (2) We assume that 65% of households will experience a pregnancy within five years and be eligible for the ITN distribution program.[19]

The estimates in Table IX suggest that, under all nine scenarios we study, child mortality is reduced more under free distribution than any cost-sharing strategy (Panel A). This result is not

19. Making less conservative assumptions would increase the relative cost-effectiveness of free distribution programs.

TABLE IX
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 (1)	Medium (2)	Low (3)	High (4)	Medium (5)	Low (6)	High (7)	Medium (8)	Low (9)
		Panel A. Child lives saved per 1,000 prenatal clients								
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
		Panel B. Cost per child life saved (US$)								
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

Notes: Each cell corresponds to a separate state of the world. To this date, existing medical evidence on the relative importance of the physical barrier provided by an ITN and on the externality threshold is insufficient to know which cells are closest to the actual state of the world. See Online Appendix for details on how these estimates were computed and the hypotheses they rely on.

surprising considering the large negative effect of cost-sharing on the share of ITN users in the population. Under the low threshold assumption for the externality effect, in terms of cost per life saved, we find that charging 40 Ksh is more cost-effective than free distribution if the physical barrier effect of ITNs is high (Panel B, 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 B, 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, because not all households experience a pregnancy. That said, given the very large standard errors on the usage estimates, the differences observed across schemes in cost per life saved typically 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.

VI. Discussion and 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. The cost-sharing model of selling nets for $0.50 to mothers through prenatal clinics is believed to reduce waste because "it gets the nets to those who both value them and need them" (Easterly 2006, p. 13). Our randomized pricing experiment in western Kenya finds no evidence to support this assumption. 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. Although it doesn't increase usage intensity, cost-sharing does considerably

dampen demand: we find that the cost-sharing scheme ongoing in Kenya at the time of this study 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 the average prenatal woman in the area. We also find that localized, short-lived free distribution programs disproportionately benefit healthier women who can more easily travel to the distribution sites.

Although 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 diminished the risk that a zero or low price be perceived as a signal of bad quality.

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 (2007) found 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) found that households that 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. In a study conducted with the general Kenyan population, Dupas (2009b) randomly varied ITN prices over a much larger range (between \$0 and \$4), and also found no evidence that charging higher prices leads to higher usage intensity. Dupas (2009b) also found that the demand curve for ITNs remains unaffected by common marketing techniques derived from psychology (such as the framing of marketing messages, the gender of the person targeted by the marketing, or verbal commitment elicitation), further suggesting that the high price-elasticity of the demand for ITNs is driven mostly by budget constraints.

Our finding that usage of ITNs is insensitive to the price paid to acquire them contrasts with the finding of Ashraf, Berry, and Shapiro (forthcoming), in which Zambian households that paid a

higher price for a water-treatment product were more likely to report treating their drinking water two weeks later. Their experimental design departs from ours in multiple ways that could explain the difference in findings. First, because the range of prices at which the product was offered in their experiment did not include zero, Ashraf, Berry, and Shapiro do not measure usage under a free distribution scheme. Second, in contrast to a bed net that can be used for three years before it wears out, the bottle of water disinfectant used in Ashraf, Berry, and Shapiro lasts for only about one month if used consistently to treat the drinking water of an average family; in this context, it is possible that households that purchased the water disinfectant but were not using it two weeks later had stored the bottle for later use (e.g., for the next sickness episode in their household or the next cholera outbreak), and therefore the evidence on usage in Ashraf, Berry, and Shapiro has a different interpretation from ours. In addition, the baseline level of information about the product (its effectiveness, how to use it) might have differed across experiments.

Although ITN distribution programs that use cost-sharing are less effective and not 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 (Mushi et al. 2003; Webster, Lines, and Smith 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. Another important dimension of the debate on free distribution versus cost-sharing is the effect of full subsidies on the distribution system. In particular, the behavior of agents on the distribution side, notably health workers in our context, could depend on the level of subsidy. Although user fees can be used to incentivize providers (World Bank 2004), free distribution schemes have been shown to be plagued by corruption (in the form of diversion) among providers (Olken 2006). Our experiment focused on the demand side and was not powered to address this distribution question. As with most randomized experiments, we are unable to characterize or quantify the impact of the various possible distribution schemes when they have been scaled up and general equilibrium effects have set in. Our experimental results should thus be seen as one piece in the puzzle of how to increase uptake of effective, externality-generating health products in resource-poor settings.

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