The Impact of Conditional In-Kind Subsidies on Preventive Health Behaviors: Evidence from Western Kenya

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July 11, 2005

Abstract

Malaria and HIV are two major threats to maternal and child health in Africa. Highly effective prevention technologies exist, such as insecticide-treated bednets, prophylactic drugs for malaria, and antiretroviral prophylaxis against mother-to-child transmission of HIV, but they remain unused by most African mothers. I designed and implemented an NGO program that provided free insecticide-treated bednets to pregnant women conditional on their enrolment at a prenatal clinic. The program increased the uptake of prenatal care services by 117%, which in turn generated an 84% increase in the uptake of HIV testing services by women and a 59% increase in the number of follow-up visits at the prenatal clinic. This suggests that pregnant women acquire information on available preventive drugs and services during their first visit to a clinic. Thus, by ensuring that pregnant women come for the first visit, a conditional transfer can be used to cost-effectively increase the take-up of preventive health services. In areas of intense malaria transmission and high HIV prevalence, providing free treated nets to pregnant women through prenatal clinics could save the lives of 18 babies per 1,000 pregnancies at a cost of US $441 per child life saved.
(JEL: I12, J13, D61)

* I would like to thank Esther Duflo, Seema Jayachandran, Michael Kremer, Kudzaishe Takavarasha, as well as participants in the CID graduate lunch seminar at Harvard University for very helpful comments. Special thanks to Elizabeth Beasley and Jessica Cohen without whom TamTam Africa would not exist. I also thank ICS Africa and the Kenya Ministry of Health for their cooperation in all stages of the project, and I would especially like to acknowledge the contributions of Moses Barasa, Laban Benaya, Jessica Morgan, Carol Nekesa, Ian Tomb and Maureen Wechuli. Gratitude is also extended to the nurses of Sioport Health Center, Nambuku Dispensary and Nangina Dispensary for implementing the program. All errors are my own.

1. INTRODUCTION

Preventing new cases of malaria and HIV among pregnant women and children could tremendously improve maternal and child health in Africa. Evidence from a series of randomized controlled trials conducted in various areas of endemic malaria suggest that wide-scale use of insecticide-treated mosquito nets (ITNs) could reduce overall child mortality by up to 20 percent (D'Alessandro et al., 1996; Lengeler, 2001; Ter Kuile et al, 2003). The risk of mother-to-child transmission of HIV (MTCT) can be reduced by 30 to 50 percent through a short-course of antiretroviral prophylaxis (nevirapine) at the cost of US$ 4 per mother-child pair (Guay *et al*., 1999; Marseilles *et al*., 1999; De Cock *et al*., 2000). In the absence of antiretroviral drugs, the risk of MTCT can still be reduced through the adoption of safe obstetric practices[1] at delivery and adapted breastfeeding practices[2] (Stoto and Goldman, 2003).

Yet, the take-up of these preventive measures remains severely limited in most parts of sub-Saharan Africa. Only 15% of African children less than 5 years of age sleep under a net, and 2% under an ITN (Monasch et al., 2004). Likewise, only 16.9 percent of Kenyan women between 25 and 29 years of age have ever been tested for HIV (KDHS 2003). Yet, in order to prevent the transmission of the HIV virus to her child, a woman must first know that she has HIV. In response, most African countries are including presumptive treatment of malaria and

[1] In rich countries, elective caesarian section has been shown to reduce the risk of HIV-MTCT by 50% (Stoto and Goldman, 2003). In developing countries, safe and elective C-sections are rarely an option. However, medically-assisted delivery has been shown to reduce the risk of transmission compared to home delivery or delivery by untrained traditional birth attendants (Stoto and Goldman, 2003).

[2] In rich countries, the CDC recommends no breastfeeding at all, since the breast milk of women infected with HIV has enough virus in it to infect their newborn. In poorer countries, however, this strategy is often not an option since formula milk is expensive and must be mixed with clean water, which might be unavailable in rural areas. Therefore the WHO and UNAIDS recommend that women in developing countries adopt Exclusive Breastfeeding and Early Weaning (EBEW).

voluntary HIV testing as part of routine prenatal care, as recommended by WHO and UNAIDS (UNAIDS, 2003). This will not be enough, however, if the most vulnerable do not seek prenatal services.

In this paper, I argue that fully-subsidizing ITNs for pregnant women enrolling at a prenatal clinic is a highly cost-effective strategy to improve maternal and child health. This approach has two advantages. First, as suggested by Guyatt et al. (2002a), using existing prenatal clinics both facilitates distribution and lowers the associated costs. In addition, as I show in this paper, making the subsidy conditional on enrollment at a prenatal clinic increases the health impact, by generating a strong incentive for pregnant women to seek prenatal care, and to seek it early.

I evaluate a pilot NGO program that delivers long-lasting ITNs to prenatal clinics in Western Kenya. Pregnant women who enroll for prenatal care in program clinics receive a free ITN upon their first prenatal visit. I find that such a conditional subsidy considerably increases the uptake of prenatal services, including those geared at preventing mother-to-child transmission of HIV. The overall health impact of the full-subsidy thus goes much beyond the reduction of the burden of malaria, especially in areas of high HIV prevalence.

The findings of this paper speak to the ongoing policy debate regarding the desirability of subsidies for ITNs. Since 87% of women who do not own nets cite financial reasons for their lack (Guyatt et al., 2002b), many have argued that the benefits of increased ITN coverage cannot be immediately achieved without full subsidies (Evans *et al*., 1997; Guyatt *et al*., 2002b; Sachs, 2005; Hawley *et al*., 2003; Wiseman *et al*., 2003). The case for full subsidies is made stronger by the presence of positive externalities. Recent findings from Western Kenya

show that high levels of ITN coverage within the community reduce the overall infective mosquito population (Howard *et al*., 2000; Gimnig *et al*., 2003).

But others point out that a large-scale, untargeted distribution of highly subsidized nets is not sustainable (Roll Back Malaria, 2002). Social marketing, where the individual user bears a share of the cost, is often proposed as a more sustainable way to increase ITN ownership (Hanson et al., 2003). However, cost sharing has been shown to dampen take-up of public-health goods and services. In Kenya, the take-up of a highly effective school-based child de-worming intervention fell by 80% relative to free treatment after the introduction of a user fee of about 20% of the cost (Kremer and Miguel, 2004). An ITN social marketing program in southern Tanzania that required customers to bear 22% of the cost achieved ITN coverage of less than 25% in two years (Hanson et al. 2003). In contrast, I find that full subsidies generate a very large and immediate increase in ITN coverage.

Previous studies of the cost-effectiveness of ITN distribution programs assume that the reduction in the burden of malaria is the only associated benefit. In this paper, however, I show that the provision of free ITNs through prenatal clinics has positive spillovers. Distributing 100 ITNs through a prenatal clinic leads not only to 80 additional pregnant women sleeping under an ITN every night, but also to 46 additional pregnant women seeking prenatal care; 28 additional follow-up prenatal visits being made; and 27 additional women getting tested for HIV. These results support existing evidence that conditional subsidies can efficiently be used to overcome private inertia to take up public health services. Under PROGRESA, Mexico's poverty reduction program, low-income families were given a subsidy on condition they obtained a range of health services including nutrition monitoring and supplements for children and lactating mothers, growth monitoring for the under-fives, prenatal care and child

immunizations. The program generated a significant increase in utilization of services and improvement in various measures of health (Gertler and Boyce, 2001). With regards to incentives to get tested for HIV, a randomized controlled experiment in Malawi shows that small cash incentives are sufficient to generate large take-up of VCT services (Thornton, 2005).

Some opponents of full-subsidies argue that goods given for free are less valued by beneficiaries than when they are provided at a positive price: people would be much more likely to use a product (an ITN, a condom) that they've paid for, because they are making an investment in their health when they buy it (Family Health International, 2005). Making the full-subsidy conditional on enrollment at a prenatal clinic circumvents this problem somewhat, since pregnant women have to make the investment of traveling to the clinic. In addition, having nurses hand in the ITNs to pregnant women during prenatal care visits possibly emphasizes the health benefits of ITN use. I find a compliance rate of 85 percent with every-night ITN use among beneficiaries of a full-subsidy.

Overall, this paper suggests that delivering free ITNs to pregnant women through prenatal clinics is highly cost-effective. If conducted in areas of endemic malaria and high HIV prevalence, such an approach can save 18 lives per 1,000 pregnancies, at a cost of US$441 per life saved.

The remainder of the paper proceeds as follows. Section 2 provides background information on the intervention. Section 3 presents the estimation strategy and the findings. Section 4 presents the cost-benefit analysis. The final section concludes.

2. BACKGROUND

2.1 MALARIA AND HIV/AIDS IN PREGNANCY

Infectious and parasitic diseases, such as malaria and AIDS, contribute half the disease burden of Africa (WHO, 2003). Africa bears 90 percent of the world's burden of *falciparum* malaria. Pregnant women and children under the age of five are particularly vulnerable. Malaria infection during pregnancy can have adverse effects on both mother and fetus, including maternal anemia, fetal loss, premature delivery, intrauterine growth retardation, and delivery of low birth-weight infants. Malaria is also a leading cause of death for African children aged five and below. Altogether, malaria accounts for at least 20 percent of all deaths in children below five years of age in Sub-Saharan Africa (WHO, 2001).

People living in Africa, south of the Sahara, now account for 90 percent of the global HIV/AIDS cases. Studies at prenatal clinics suggest that in several parts of southern and east Africa the prevalence of HIV now exceeds 25 percent among pregnant women (UNAIDS/WHO, 2003). In the absence of any intervention, 25 to 40 percent of HIV positive women will transmit the virus to their unborn or newborn children (De Cock et al., 2000). The majority of HIV infected babies will die before the age of five.

Recent research suggests that dual infection by malaria and HIV in pregnancy can have dramatic consequences. HIV infection increases the risk of placental malaria (Verhoeff et al., 1999), while acute malaria infection increases the viral load in HIV infected patients (Corbett et al, 2002), thus potentially increasing their infectiousness. A public health program to prevent mother-to-child transmission of HIV by treatment with nevirapine in Cameroon showed a high correlation between rainfall in a given month and the risk of MTCT of HIV in children born

three months later (Ayouba et al, 2003). The role of malaria in this pattern is highly suspected, since the interval of three months observed is consistent with the *Plasmodium* life cycle.

2.2 Background in Western Kenya

Malaria transmission: Malaria is endemic in the Busia District of Western Kenya, where this study takes place. Transmission occurs throughout the year with two seasonal peaks reflecting the rainfall pattern. In two nearby districts, a study by the CDC and the Kenyan Medical Research Institute has shown that women may receive as many as 230 infective bites during their 40 weeks gestation (Ter Kuile *et al*, 2003). Therefore malaria and anemia are common during pregnancy and up to a third of all infants are born premature, small-for-gestational age, or with low birth weight (Ter Kuile *et al*, 2003).

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HIV prevalence: Mother-to-child transmission of HIV contributes heavily to the mortality of children under-five years. Around 100,000 Kenyan children are currently living with HIV[3]. Ten percent of the reported AIDS cases occur in children under the age of five years. In Busia District, Western Kenya, where this study took place, the proportion of pregnant women infected with HIV was estimated between 22 and 33 percent at the beginning of the 21st century (NASCOP, 2001).

Prenatal care: Pregnant women have to pay a fee of 15 Kenyan shillings (around US$ 0.19) to enroll at the prenatal clinic. To receive the optimum package of services, expectant mothers have to visit the prenatal clinic early and at least twice during their pregnancy. The prenatal

[3] PMTCT: Technical and Programmatic Issues. National Stakeholders Meeting on PMTCT, August 2002.

care package offered by the Government of Kenya includes: micronutrient supplementation, screening for sexually transmitted infections, screening for anemia, counseling on HIV MTCT, infant feeding counseling, and two injections of tetanus toxoid[4]. In addition, in malaria endemic areas, pregnant women are entitled to two free preventive anti-malarial treatment doses in the second and third trimester of pregnancy. Such presumptive intermittent treatment (IPT) of malaria in pregnancy has been shown to be highly effective at reducing the risk of placental infection and the number of low birth weight babies (Schultz et al., 1994).

2.3 PROGRAM DESCRIPTION

The pilot program studied here was designed and funded by TAMTAM ("Together Against Malaria! Tuafue Afya Na Maisha[5]!"), an NGO based in the USA. The program was implemented in Western Kenya, where TAMTAM works in conjunction with another NGO (ICS Africa) and the Kenya Ministry of Health. With financial support from TAMTAM, ICS started providing ITNs in July 2003 to prenatal clinics in the Funyula Division of Busia District, close to the Eastern shore of Lake Victoria. Funyula Division is a rural area with a population of about 85,300 people, 20 percent of whom are children under five years.

The ITN distribution program was implemented in three clinics located in the Northwestern part of Funyula Division. The Ministry of Health runs all three clinics participating in the program, as well as most of the clinics in the region. Women who are HIV-positive are referred to a hospital where they can receive free short courses of nevirapine. Since program inception, the clinics give each pregnant woman a free ITN upon her first prenatal

[4] Tetanus toxoid injections are given during pregnancy for the prevention of neonatal tetanus, a major cause of death among infants in many developing countries.
[5] Swahili for "Let's protect health and life"

visit[6]. Women who had already enrolled at the prenatal clinics by the time the program started received a free net at their next visit.

3. FINDINGS

3.1. DATA AND ESTIMATION STRATEGY

To estimate the impact of the ITN distribution program on the take-up of prenatal services, I use a difference – in – differences estimator with facility-level panel data. The data were made available by the health centers involved in the study, with permission from the Kenyan Ministry of Health. Prenatal registers were collected for the years 2002, 2003 and 2004[7]. The program started in July 2003 ($t=t_0$). Monthly data on enrollment (first visits) and participation (follow-up visits) at prenatal clinics are available for a total period of 31 months, starting 17 months preceding program inception (February 2002 to June 2003) and continuing for 14 months after the introduction of the program (July 2003 to August 2004). Data on enrollment for HIV testing are available for 28 months, from February 2002 to May 2004.

For comparability across clinics, all monthly data are normalized against an average of 100 in the pre-program period:

$$NX_{ct} = \frac{100 \times X_{ct}}{\frac{1}{\sum t} \sum_{t<t_0} X_{ct}}$$

[6] The program distributes long-lasting ITNs called PermaNets®, manufactured by Vestergaard-Frandsen, a Danish company specializing in disease control textiles. PermaNet® is a ready-to-use, WHO approved, pre-treated mosquito net. It requires no further treatment during its expected life span (4 to 5 years). The netting material is treated with Deltamethrin and a binding chemical to ensure the wash resistance of the insecticide. PermaNet® was developed in response to low re-treatment rates of conventional insecticide-treated mosquito nets observed across Africa.

[7] I used official records that clinics share with the Ministry of Health on a quarterly basis; it is unlikely that the program altered the way the health personnel handled the records.

X_{ct} is the prenatal enrollment (X=E), prenatal participation (X=P), or enrollment for HIV testing (X=H) at clinic *c* in month *m* and year *y*.

There are 9 prenatal clinics included in the analysis, divided into three categories: three program clinics that received free ITNs (the *treatment* group); three non-program clinics located in the same area as the program clinics, but that did not receive any nets; and three clinics outside the program area. Although the clinics in the second category did not receive ITNs, they are likely to have been indirectly affected by the program. For example, pregnant women who value ITNs a lot are likely to have chosen to go to a program clinic, rather than a non-program clinic, in order to get a free ITN, even if they live closer to a non-program clinic. The importance of such substitution effect depends on the distribution of women's preference for ITNs, relatively to the cost of reaching a program clinic.

To control for confounding factors that could have had an impact on the take-up of prenatal care over the period, I use the third category of clinics (prenatal clinics outside the program area) as the comparison group. The difference-in-differences estimator compares the change (before and after the introduction of the program) in monthly enrollment and participation at clinics in the program area with the corresponding change in clinics outside the program area.

Besides the introduction of the program, the program area (Funyula division) and its neighboring areas within Busia district (Nambale, Matayos, and Budalangi divisions), are unlikely to have received asymmetric shocks, since they have very similar characteristics in terms of income levels, morbidity and HIV infection, and are all under the authority of the same administration. Figure 1 presents data on monthly enrollment at prenatal clinics

(aggregated by categories) before and after program inception. For each clinic, the monthly data are normalized against an average of 100 enrollees per month in the pre-program period. The vertical line between June and July 2003 represents the time at which the ITN distribution program was introduced in program clinics. Figure 1 suggests a large similarity in trends and fluctuations across all categories of clinics before the introduction of the program. This suggests that the counterfactual assumption of the difference-in-differences model is reasonable: it is likely that visits to clinics in the program area would have grown at the same rate as in the control area, were it not for the program. Enrollment at clinics outside the program area (comparison clinics) suggests a slight upward trend in take-up of prenatal services over the period, with regular seasonal variations, and no shock around program inception. In contrast, the evolution of enrollment at program clinics shows an upward jump in enrollment between June and July 2003. There is no jump downwards in non-program clinics within the program area, but a gradual decline over 5 months, suggesting that the substitution effect was smoothed over time. However, the overall decline in enrollment at non-program clinics in the program area is much smaller than the jump in enrollment at program clinics, thus suggesting that the substitution effect accounts for only part of the increase in enrollment at program clinics.

I study the impact of the program on four behavioral outcomes: (a) enrollment for prenatal services; (b) ITN use; (c) participation at prenatal clinics; and (d) take-up of HIV testing. For (a) and (c), I compute the difference-in-difference with the following specification:

$$(1) \qquad NX_{ct} = C + \chi_c + \alpha \times t + \beta \times Post + \delta_T \times Z_T \times Post + \delta_{C1} \times Z_{C1} \times Post + \varepsilon_{ct}$$

NX_{ct} the normalized monthly enrollment/participation at the prenatal clinic *c* in period *t*. χ_c is a fixed effect for each clinic. α measures the monthly trend. *Post* is an indicator of whether it is the period covered by the program, starting in July 2003. $Z_C = (Z_T, Z_{C1})$ is a vector of indicator variables for each group of clinics in the program area: program clinics (c=*T*) and non-program clinics in program area (c=*C1*). The disturbance term ε_{cmy} consists of random clinic/month shocks. The data cover 24 months, 12 pre-program and 12 post-program. Since the data are normalized against a pre-program mean of 100 for each clinic, the constant term C is common for all categories of clinics.

The trend in take-up of prenatal services will be measured by α. The before-after difference in take-up in control clinics will be captured by β. δ_T will measure the impact of the program on enrollment at program clinics. The substitution effect (women switching from non-program to program clinics in the program area) will be captured by δ_{C1}. The net take-up effect of the program in the program area will thus be estimated by $\delta_T + \delta_{C1}$.

To measure the impact of the program on the take-up of HIV testing, I use take-up among men as an additional control and compute the triple difference with the following specification:

$$(2) \qquad NH_{sct} = C + \sigma_c + \theta \times t + \rho \times Post + \gamma \times Treat \times Post + \varphi \times Women \times Post + \eta \times Women \times Treat \times Post + \varepsilon_{sct}$$

NH_{sct} is the normalized monthly uptake of HIV testing by individuals of gender *s* at clinic *c* in month *t*. *Post*, *Women* and *Treat* are dummy variables. The disturbance term ε_{sct} consists of random gender/clinic/month shocks. Since the data are normalized for each clinic-gender against a mean of 100 in the pre-program period, the constant term C is common to all categories.

The triple difference, or difference-in-differences-in-differences estimator (DDD) of the impact of the program on the take-up of HIV testing by women will be measured by η.

3.2. IMPACT ON ENROLLMENT FOR PRENATAL CARE SERVICES

Panel a of column 1 in Table 1 presents the estimation of equation (1) for enrollment at prenatal clinics. The results show no upward trend in prenatal enrolment over the period studied (α=0) and no before-after difference in enrollment in the control clinics (β=0). On the other hand, the program generated a 155% increase in enrollment at program clinics (δ_T), and a 39% decrease in enrollment at non-program clinics in the program area (δ_{CI}). This suggests that the substitution effect explains a quarter (39/155) of the observed increase in enrollment in program clinics after the start of the program.

Overall, the program generated a substitution effect of 39% and a net take-up effect of 117% at the clinics benefiting from the ITN distribution (Panel b). In real terms, since the average enrollment at program clinics before the program was 118 clients per month, there are 138 women (118 x 117%) who seek prenatal services each month at program clinics, who would not have sought prenatal services in the absence of the program. On the other hand, since program inception, enrollment at program clinics has reached an average of 302 new clients per month, thus costing 302 ITNs per month to the program. This means that each ITN

delivered leads to 0.46 extra women (138/302) to seek prenatal care. These additional women would not have sought prenatal care in the absence of the program. This means, in turn, that prenatal care coverage was at most 60 percent before the introduction of the program.

3.3. IMPACT ON ITN COVERAGE

The large impact of the ITN distribution program on enrolment at prenatal clinics in the program area suggests that pregnant women assign to ITNs a value that overwhelms the opportunity and transportation costs of going for prenatal care. Women might value an ITN as a health commodity and for its market value. For women with tight budget constraints, the market value of the ITN is likely to overwhelm the discounted health benefits of using the net for oneself. To estimate what fraction of women sold their net after collecting it for free at the prenatal clinic, ICS conducted follow-ups during unannounced home visits in December 2004 and January 2005. Enumerators went in the catchments' areas of the three prenatal clinics enrolled in the program and asked community members to direct them to the homes of women who were expecting or had a child below one year of age. Out of the 5,500 women who had visited one of the three prenatal clinics enrolled in the program between July 2003 and October 2004, 213 were interviewed three to twelve months after their visit to the prenatal clinic. Of these 213, ninety percent (191 women) agreed to let the ICS enumerators inside the house to show the ITN received at the prenatal clinic and 85% declared sleeping under an ITN every night (Table 3). Since pre-program ITN use was below 5% in the program area (KDHS 2003, Guyatt et al, 2004b), we can infer that an additional 0.80 pregnant women sleep under an ITN for each ITN distributed (Table 4).

These results contrast with common claims that goods given for free are less valued by beneficiaries than when they are provided at a positive price. Two mechanisms can be at play here. First, since the full-subsidy was conditional on prenatal attendance, self-selection might have taken place, whereby only women who value ITN as a health commodity decided to invest in a trip to the prenatal clinic. Given the very large impact of the program on enrollment at prenatal clinics, however, it seems like a large fraction of women do value ITNs as a health commodity. Second, providing ITNs through prenatal clinics is likely to signal their importance as a health tool for pregnant women. Thus, women who sought prenatal care at a program clinic independently of the incentive provided by the ITN program might have revised upwards their beliefs about the benefits of ITN use as they received the ITN and advices on its use by trained health professionals.

3.4. IMPACT ON PARTICIPATION AT PRENATAL CLINICS

We saw in section 3.2 that, in the program area, 46 percent of pregnant women would not have sought prenatal care in the absence of the program. If these "extra" women enrolled solely in order to get the free net, one should not expect them to come back to the prenatal clinic for a follow-up visit. If, however, women learn about the benefits of prenatal care during the first visit, some of them might decide to come for a second visit. Figure 2 shows that the program generated a sharp increase in the number of follow-up visits in program clinics.

Column 2 in Table 1 presents the estimation of equation (1) for participation at prenatal clinics[8]. In addition to an overall before-after increase of 15 percent in all clinics, the number

[8] Right after the start of the program, a lot of pregnant women who had enrolled for prenatal care came back for a revisit in order to get the free net. To exclude these women from sample and estimate the participation of rates of women who enrolled after the start of the program, I excluded the months of July and August 2003 in the analysis.

of revisits increased by 88 percent in the program clinics, while it decreased by 29 percent in the non-program clinic in the area. Overall, the program generated an increase of 59 percent in the number of revisits (Panel b, column 2), which corresponds 0.28 additional revisits per ITN distributed.

The total number of follow-up visits can be higher than the number of enrollees, since a woman can come for multiple follow-up visits. Data collected before the start of the program in two clinics suggest that around 55 percent of women did at least one follow-up visit. Among them, the average number of follow-up visits was 2.

The program generated a smaller increase in follow-up visits (59 percent) than in first visits (117 percent). Not surprisingly, pregnant women who enrolled for prenatal care because of the program did not attend the prenatal clinic as often as pregnant women who would have enrolled anyway. Nonetheless, the number of follow-up visits did increase substantially. This suggests that the participation rate among "extra" women was strictly positive, and half as high as the participation of "regular" women (59/117=0.5). This means that, if 55 percent of pregnant women who normally enroll for prenatal care did at least one follow-up visit, at least a quarter of the women who enrolled *for* the ITN did at least one follow-up visit. This result suggests that women learn about the benefits of a second visit during their first visit. This is not surprising, since some of the services offered request two visits, such as intermittent presumptive malaria treatment and tetanus toxoid injections. In order to increase the compliance rate, nurses strongly advise all new prenatal clients to come for a second visit exactly one month or two months (depending on the gestation stage) after the first visit.

3.5. IMPACT ON THE UPTAKE OF HIV TESTING

As discussed in Section 3.2, the introduction of the free ITN distribution program increased the uptake of prenatal care services by 117 percent. Since women are encouraged to use all the services available, including voluntary HIV counseling and testing, one can reasonably expect an increase in enrolment at prenatal clinics to lead to an increase in the number of women who get tested for HIV, the first step in towards the prevention of mother-to-child transmission of HIV (PMTCT). Nduati (2002) reports that in Kenya, about 70% of women who visited a pilot PMTCT site in 2001 decided to get tested for HIV. Cartoux et al. (1998) show that 65 percent of antenatal attendees in developing countries agreed to get tested for HIV.

Due to the confidentiality of records pertaining to the HIV status of individuals, I do not have data to measure the impact of the program on the rate of mother-to-child transmission of HIV. However, I can measure whether the program induced an increase in the uptake of HIV testing by women in the program area. At the time of the program inception, voluntary HIV counseling and testing (VCT) services were offered in only one clinic participating in the ITN distribution program, and in one comparison clinic outside the ITN program area. Both clinics offer on-site, rapid HIV testing with same-day results and post-counseling. This means that one prenatal visit is enough for a pregnant woman to know her HIV status, if she decides to take-up this service.

Since the program affected women only, men can be considered as a natural comparison group. Panel a in Table 4 presents the estimation of equation (2). Although the introduction of the program coincided with a large effort by the Kenyan Ministry of Health to promote HIV testing for pregnant women, which may explain the large difference-in-difference (φ), the triple difference estimator suggests that the program induced a net increase

of 84 percent in the uptake of HIV testing by women in the program clinic (Table 4, Panel b). This corresponds to an additional 0.27 women getting tested for each ITN distributed.

This result should be taken with caution, since it relies on a sample of only two clinics over a non-stationery period. However, it suggests that private inertia to take-up HIV testing services is either largely due to opportunity costs (the cost of walking to the clinic, for example), rather than to psychological costs, such as the fear of stigma or the fear of death; or that the fear of stigma or death can be overcome by the hope to save one's baby, once one has received information and counseling on PMTCT by a trained nurse. This result corroborates findings from a randomized controlled experiment conducted in Malawi suggesting that small cash incentives are sufficient to generate a large take-up of HIV testing services (Thornton, 2005).

4. COST-EFFECTIVENESS ANALYSIS

This section computes the cost-effectiveness of fully-subsidizing ITNs for pregnant women through prenatal clinics, taking into account the spillover on the take-up of HIV testing. The results are examined in terms of cost per life saved and cost per Disability Adjusted Life Years (DALYs) saved.

Costs.

The total economic cost of providing bed nets to pregnant women consists of the cost of the ITNs and the cost of delivery. Using existing health care infrastructure to deliver the nets

makes delivery very cheap, if one assumes that staffing levels are sufficient to cope with the extra demand for services generated by the program. The experience from the pilot studied in this paper suggests that this is a reasonable assumption.

I assume that delivering nets to health facilities costs about US$ 0.40 per net[9]. Long-lasting insecticide-treated nets cost US$ 5.25 a piece[10]. Following the results of Guyatt et al. (2002a), I consider a leakage rate of 6% at the facility level[11]. The total cost per net distributed is therefore (0.40 + 5.25) x 1.06 = US$ 6.

I assume that the infrastructure does not need to be upgraded and that VCT and PMTCT services are already available. I consider two induced costs: US$ 8 per person getting tested for HIV (Forsythe et al., 2002) and US$ 4 per HIV-positive woman receiving antiretroviral prophylaxis (Marseilles et al., 1999).

Benefits.

Table 5 presents all the assumptions made in the calculation of deaths and DALYs averted, as well as their references.

I assume a baseline rate of ITN use by pregnant women and children under 3 of 5% (Guyatt et al, 2004b). It is assumed that ITNs provides protection for 4 years when used, and that the compliance with ITN use by ITN owners is 85 percent, as suggested by the findings of the pilot program. The average prevalence of maternal malaria in the area is assumed to be 35

[9] I assume that one driver can deliver 300 nets once a month in 22 clinics, covering a total of 2,650 km per month. I consider a monthly salary of US$ 700 for the driver; a cost of US$ 0.60 per kilometer, and a 15% administration cost.

[10] 2005 price of a large, rectangular PermaNet manufactured by Vestergaard-Frandsen and distributed through their Nairobi office.

[11] This means that 6% of the nets delivered at a prenatal clinic will reach people not targeted by the subsidy. At the pilot clinics studied in this paper, the observed leakage was below 0.5%. However, this might have resulted from the heavy monitoring inherent to the research.

percent (Shulman at al, 2001; Ter Kuile et al, 2003). An expectant mother sleeping under an ITN can expect to reduce the risk of placental malaria by 40 percent (Ter Kuile et al, 2003). Incidence of low birth weight (LBW) is assumed to be 8 percent in the absence of maternal malaria, and 31 percent with placental malaria ((Shulman at al, 2001; Ter Kuile et al, 2003; Guyatt and Snow, 2004a). I ignore the impact of malaria infection on maternal morbidity or mortality (thus underestimating the benefits of ITN use). The potential effect of maternal HIV infection on the risk of maternal malaria is also ignored. Although a worsening effect has been well documented (Ter Kuile et al., 2004), its importance is yet imprecise.

It is assumed that all-cause mortality is 67 per 1000 normal weight, HIV-negative children under the age of five (Shulman at al, 2001; Ter Kuile et al, 2003; Guyatt and Snow, 2004), and that this rate is reduced by 20 percent when children sleep under an ITN (Lengeler, 2001). The impact of malaria infection in childhood on morbidity and possible long-term disabilities is ignored.

It is assumed that, in the absence of any prevention program, there is a 35.9 percent chance that an HIV-positive woman will transmit the virus to her child (Coutsoudis et al, 2001). The administration of a single dose of nevirapine is assumed to have an efficacy of 45 percent (Dabis and Epkini, 2002). Two other prevention measures can be taken in the absence of nevirapine: exclusive breastfeeding and hospital-assisted delivery. These are assumed to have a combined efficacy of 15 percent. The combined efficacy of nevirapine and the other two prevention measures is assumed to be 50 percent (Dabis and Epkini, 2002). This corresponds to a decline of 18 percentage points in the risk of mother-to-child transmission of HIV. It is assumed that, when nevirapine is available, 65 percent of the pregnant women who receive information on HIV-MTCT and counseling on HIV testing agree to take the test

(Cartoux et al. 1998; Nudati, 2002). On the other hand, in the absence of nevirapine, compliance with HIV testing is assumed to be only 35% (this is a conservative assumption based on the pilot experiment).

It is assumed that in the absence of an ITN distribution program at prenatal clinics, 60 percent of pregnant women enroll for prenatal care. This is higher than what I observed in Western Kenya (see section 3.2), but closer to estimates for malaria-endemic areas reported by the Africa Malaria Report (2003). I assume that the introduction of a free bed net program increases attendance at prenatal clinics to 95 percent, as suggested by the pilot findings.

Estimates of death averted were converted into DALYs averted by using a life expectancy at birth (and at age 3) of 50 years (World Development Indicators). Years of life gained were discounted at 3 percent.

Results.

The results of the cost-effectiveness calculations are shown in Table 6. Panel a shows the values of the parameters used for the sensitivity analysis. Panel b considers that HIV prevalence is 15 percent among pregnant women, while Panels c and d consider alternative scenarios where HIV prevalence is 25 and 5 percent respectively.

Under most scenarios, the cost per DALY is well below the threshold of US$ 150 set by the World Bank for high cost-effectiveness (World Bank, 1993). In the absence of any intervention geared at reducing the risk of mother-to-child transmission of HIV, the program can avert 12 child deaths per 1,000 pregnancies (Table 6, column 1). Once I include the impact of the program on the uptake of PMTCT services, the number of deaths averted increases by 47%, up to 18 per 1,000 pregnancies (Table 6, column 6). Hence, in areas of stable malaria

with a 15% prevalence of HIV among pregnant women, distributing free ITNs to pregnant women who enroll at prenatal clinics offering VCT and PMTCT services costs US$ 441 per life saved (Table 6, column 4, panel b). This corresponds to a cost of US$ 18.8 per DALY saved.

Under scenarios where there is low compliance with ITN use, low up-take of HIV testing, or high baseline prenatal coverage, the cost effectiveness declines but the cost per DALY remains under US$ 25, and the cost per child death averted remains below US$ 600[12]. In comparison, the estimated cost per child death averted was US$ 1,214 per year in the community-based randomized trial of unconditional ITN distribution by CDC in Western Kenya (Wiseman et al, 2003). This suggests that targeting pregnant women at prenatal clinics is more cost-effective than distributing nets systematically to all households. The approach evaluated in this paper also compares favorably with the social-marketing of ITNs in Tanzania (KINET) in the late 1990s, where the cost per death averted associated with treated nets was US$ 1559 and the corresponding cost per DALY averted was US$ 57 (Hanson et al., 2003). The main advantage of the free distribution through prenatal clinics over social marketing is the impact on coverage. While, as we have shown here, a full subsidy at prenatal clinics generates an immediate increase in coverage, the impact of social marketing programs is much more limited, and also slower. The KINET program in Tanzania achieved ITN coverage of less than 25% after two years of implementation, and 54% after four years. Hanson et al. (2003) computed that the KINET social-marketing program could achieve a cost per DALY saved of US$ 22 and a cost per life saved of US$ 587 after four years.

[12] For a more detailed discussion of the cost-effectiveness results, see Annex 1.

5. CONCLUSION

Prevention of malaria and HIV infection is one of the surest ways to improve maternal and child health in Africa. However, highly effective and consensual prevention technologies such as ITNs and antiretroviral prophylaxis remain inaccessible to most African mothers. Some intended beneficiaries have not taken up available prevention services, perhaps because they lack the information, the resources or the power to decide. Cash subsidies, such as those given under PROGRESA in Mexico, provide a clear incentive for people to seek public health services. The findings of this paper suggest that non-cash subsidies can cause private citizens to undergo similar health-seeking behavioral changes. An NGO program that delivered free insecticide-treated bednets through prenatal clinics generated an increase of 117% in the uptake of prenatal services. This, in turn, increased the number of expectant mothers who received counseling on HIV testing, and generated an 84% increase in the uptake of HIV testing services by women.

Conventional economic theory suggests that restricted transfers yield the same or lower increments in individual welfare as unconstrained cash transfers (Thurow, 1974). However, encouraging the use of a particular service or commodity by imposing how the transfer should be spent (for example, by giving a voucher for an ITN rather than cash) can be justified in various cases. The first case is the presence of externalities, i.e. when the consumption of a good benefits not only the individual that directly consumes the good, but also others around her. In public health, any service aimed at the prevention or treatment of an infectious disease has such property. This is why vaccination is usually massively subsidized. A similar argument could apply for the distribution of ITNs, since the social benefits of using an ITN seem to

exceed the private benefits (Howard *et al*., 2000; Gimnig *et al*., 2003). A second justification for restricting consumer's choices through in-kind subsidies can be found in the presence of heterogeneous preferences among household members. Giving cash to a pregnant woman may not help her and her child if another household member captures the cash for his own consumption. A third reason for directing spending can be that people do not always know what is good for them. For example, in the presence of hyperbolic time-discounting, people will under-consume goods that bring benefit in the future and over-consume goods that bring immediate reward. Last, when a redistribution system is corrupted, making in-kind transfers may be the only way to ensure that programs reach their target population. People in charge of delivering an in-kind transfer might be unable to benefit from a good that is only usable by certain categories of individuals. An ITN for pregnant women, albeit more liquid than a school voucher, is still more illiquid an asset than cash.

The findings in this paper suggest that fully subsidizing insecticide-treated bednets for pregnant women living in malaria-endemic areas of high HIV prevalence could generate important benefits for maternal and child health if the subsidy is conditional on prenatal enrollment. It is much more cost-effective than an unconditional community-based distribution, at a cost per child death averted of US$ 441 versus US$ 1,214. This suggests that, when resources are limited, ITN distribution programs should use prenatal clinics as a gateway. More generally, these results suggest that conditional in-kind subsidies for consumers could efficiently be used to overcome private inertia to take up public health services. Future research is needed, however, to measure the crowding out effects that in-kind subsidies may have on the commercial sector.

REFERENCES

Ayouba, A., Nerrienet E, Menu E, Lobe MM, Thonnon J, Leke RJI, Barre-Sinoussi F, Martin P and Cunin P. (2003). Moter-to-Child Transmission of HIV-1 in relation to the season in Yaounde, Cameroon. American Journal of Tropical Medicine and Hygiene 69 (4): 447-449.

Cartoux, M. et al. (1998). Acceptability of voluntary HIV testing by pregnant women in developing countries: an international survey. *AIDS* 12(18): 2489-2493.

Coutsoudis A et al. (2001). Method of feeding and transmission of HIV-1 from mothers to children by 15 months of age: prospective cohort study from Durban, South Africa. *AIDS.* 2001 Feb 16;15(3):379-87.

Dabis, F. and Ekpini, ER. HIV-1/AIDS and maternal and child health in Africa. *The Lancet*. Vol 359. Jun 15, 2002.

De Cock KM, Fowler MG, Mercier E, De Vincenzi I, Saba J, Hoff E, Alnwick DJ, Rogers M, Shaffer N. (2000). Prevention of Mother-to-child HIV transmission in resource poor countries. Translating research into policy and practice. *JAMA 283:* 1175--1182.

Evans DB, Azene G, Kirigia J. (1997). Should governments subsidize the use of insecticide-impregnated mosquito nets in Africa? Implications of a cost-effectiveness analysis. *Health Policy Plan.* Jun;12(2):107-14.

Family Health International (2005). *The Tanzania AIDS Project: Building Capacity, Saving Lives. The AIDSCAP Response, 1993-1997*. Chapter 3: Selling Protection: Condom Social Marketing.
http://www.FHI.org/en/HIVAIDS/pub/Archive/aidscapreports/tanzaids/chap3.htm

Forsythe S, et al. (2002). Assessing the cost and willingness to pay for voluntary HIV counselling and testing in Kenya. *Health Policy Plan*. Jun;17(2):187-95.

Gertler, P and S. Boyce. (2001) An Experiment in Incentive-Based Welfare: The Impact of PROGESA on Health in Mexico. Mimeo, UC Berkeley.

Gimnig JE, Kolczak MS, Hightower AW, Vulule JM, Schoute E, Kamau L, Phillips-Howard PA, ter Kuile FO, Nahlen BL, Hawley WA. (2003). Effect of Permethrin-Treated Bed Nets on the Spatial Distribution of Malaria Vectors in Western Kenya. *Am J Trop Med Hyg*, 68 (suppl 4): 115-120.

Goodman CA, Coleman PG, Mills AJ (1999). Cost-effectiveness of malaria control in sub-Saharan Africa. *Lancet*, July 31;354(9176):378-85

Guay LA, Musoke P, Fleming T, et al. (1999). Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: HIVNET012 randomized trial. *Lancet*, 354: 795-802.

Guyatt HL, Gotink MH, Ochola SA, Snow RW. (2002a). Free bednets to pregnant women through antenatal clinics in Kenya: a cheap, simple and equitable approach to delivery. *Tropical Medicine and International Health*, Volume 7, pp 409–420.

Guyatt HL, Ochola SA, Snow RW. (2002b). To poor to pay: charging for insecticide-treated bednets in highland Kenya. *Tropical Medicine and International Health*, Volume 10, pp 846-850.

Guyatt HL, Snow RW. (2004a). Impact of Malaria during Pregnancy on Low Birth Weight in Sub-Saharan Africa. *Clinical microbiology reviews*, Oct. 2004, p. 760-769.

Guyatt, H. L., Noor, A. M., Ochola, S. A. & Snow, R. W. (2004b). Use of intermittent presumptive treatment and insecticide treated bed nets by pregnant women in four Kenyan districts. *Tropical Medicine & International Health* 9 (2), 255-261.

Hanson, K. et al. (2003). Cost-effectiveness of social marketing of insecticide-treated nets for malaria control in the United Republic of Tanzania. Bulletin of the World Health Organization 2003 81(4).

Hawley et al. (2003). Implications of the western Kenya permethrin-treated bednet study for policy, program implementation, and future research. *Am J Trop Med Hyg*, 68 (suppl 4): 168-173.

Howard SC, Omumbo J, Nevill C, Some ES, Donnelly CA, Snow RW. (2000). Evidence for a mass community effect of insecticide-treated bednets on the incidence of malaria on the Kenyan coast. *Trans R Soc Trop Med Hyg* 94: 357-60.

KDHS, 2003. Kenya Demographic and Health Survey. 2003 Final Report.

Kremer, M., and E.Miguel (2004). The Illusion of Sustainability. Mimeo, Harvard University.

Lindblade KA, Eisele TP, Gimnig JE, et al. Sustainability of reductions in malaria transmission and infant mortality in western Kenya with use of insecticide-treated bednets: 4 to 6 years of follow-up. JAMA. 2004;291:2571-2580.

Malcolm, A. et al. (1998). HIV-related stigmatization and discrimination: its forms and contexts. *Critical Public Health* 8(4):347-370.

Marseilles, E., Kahn, K.G., Mmiro, F. et al. (1999). Cost-effectiveness of single-dose nevirapine regimen for mothers and babies to decrease vertical HIV-1 transmission in Sub-Saharan Africa. *Lancet*, 354: 803-809.

Monasch R, Reinisch A, Steketee R, 2004. Child coverage with mosquito nets and malaria treatment from population-based surveys in African countries: a baseline for monitoring progress in Roll Back Malaria. Am J Trop Med Hyg 71 (Suppl 2): 232–238

NASCOP (2001). AIDS in Kenya: Background, Projections, Impact, Interventions, Sixth Edition.

Nduati, R. (2002). PMTCT – Lessons from the Feasibility Studies. Manuscript, University of Nairobi/NARESA.

Roll Back Malaria (2002). Scaling-up insecticide-treated netting programmes in Africa: A Strategic Framework for Coordinated National Action. WHO, Geneva. Available online at: http://www.who.int/malaria/cmc_upload/0/000/015/845/itn_programmes.pdf

Sachs, J. (2005). *The end of Poverty*: *Economic Possibilities for Our Time*. Penguin Press.

Schultz U et al. (1994). The efficacy of antimalarial regimens containing sulphadoxine-pyrimethamine and/or chloroquine in preventing peripheral and placental *Plasmodium falciparum* infection among pregnant women in Malawi. *American Journal of Tropical Medicine and Hygiene*, 51 (5): 515-22.

Schultz, T. P. (2000) The impact of PROGRESA on school enrollments: final report, Washington, International Food Policy Research Institute

Shulman CE et al. (2001). Malaria in pregnancy : adverse effects on haemoglobin levels and birthweight in primigravidae and multigravidae. *Tropical Medicine and International Health*, Vol. 6 (10): 770-778.

Steketee RW et al. (2001). The burden of malaria in pregnancy in malaria-endemic areas. *American Journal of Tropical Medicine and Hygiene*, 64 (1,2 S):28-35

Stoto M. and A.S. Goldman, 2003. Preventing Perinatal Transmission of HIV. RAND, DRU-3071-IOM.

Ter Kuile, F.O. et al. (2003). Reduction of malaria during pregnancy by permethrin-treated bed nets in an area of intense perennial malaria transmission in western Kenya. *American Journal of Tropical Medicine and Hygiene*, 68 (suppl 4): 50-60.

Ter Kuile F.O.et al. (2004). The Burden of co-infection with Human Immunodeficiency Virus Type 1 and Malaria in Pregnant Women in Sub-Saharan Africa. *American Journal of Tropical Medicine and Hygiene*, 71 (suppl 2): 41-54.

Thornton, R. (2005). The demand for health information: Randomization and HIV testing in Malawi. Mimeo, Harvard University.

Thurow, L. C. (1974) "Cash versus in-kind transfers." *The American Economic*

Review, 64,(2): 190-195.

UNAIDS (2003). Progress Report on the Global Response to the HIV/AIDS Epidemic, 2003. (Follow-up to the 2001 United Nations General Assembly Special Session on HIV/AIDS). Geneva, Switzerland.

UNAIDS/WHO (2003). *AIDS epidemic update 2003.* Geneva, UNAIDS.

Verhoeff et al. (1999). Increased prevalence of malaria in HIV-infected pregnant women and its implications for malaria control, *Tropical Medicine & International Health*, Vol. 4 Issue 1.

World Bank (1993). *World Development Report: Investing in Health.* Oxford University Press: New York.

World Bank (1999). World Development Indicators (*www.worldbank.org*)

WHO (2000). *Expert Committee on Malaria. Twentieth report*. Geneva. WHO Technical Report Series, No. 892.

WHO (2001). *World Health Report 2001. Mental Health: new understanding, new hope.* Geneva.

WHO/UNICEF. (2003). Africa Malaria Report 2003.

Wiseman, V., Hawley WA, Ter Kuile FO, Phillips-Howard PA, Vulule JM, Nahlen BL and Mills AJ. (2003). The cost-effectiveness of permethrin-treated bed nets in an area of intense malaria transmission in western Kenya. *Am J Trop Med Hyg,* 68 (suppl 4): 161-167.

Figure 1

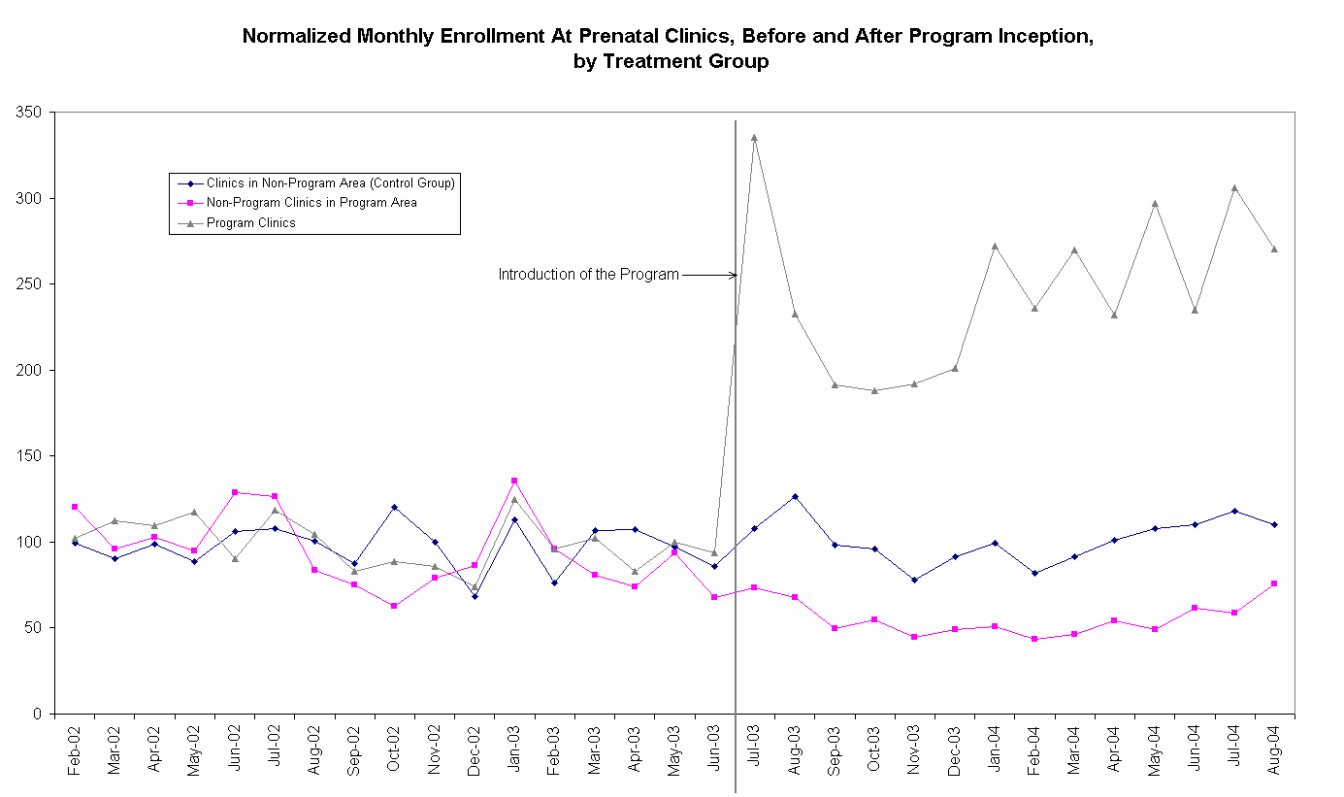
Normalized Monthly Enrollment At Prenatal Clinics, Before and After Program Inception, by Treatment Group
Clinics in Non-Program Area (Control Group)
Non-Program Clinics in Program Area
Program Clinics
Introduction of the Program
350
300
250
200
150
100
50
0
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04

Figure 2

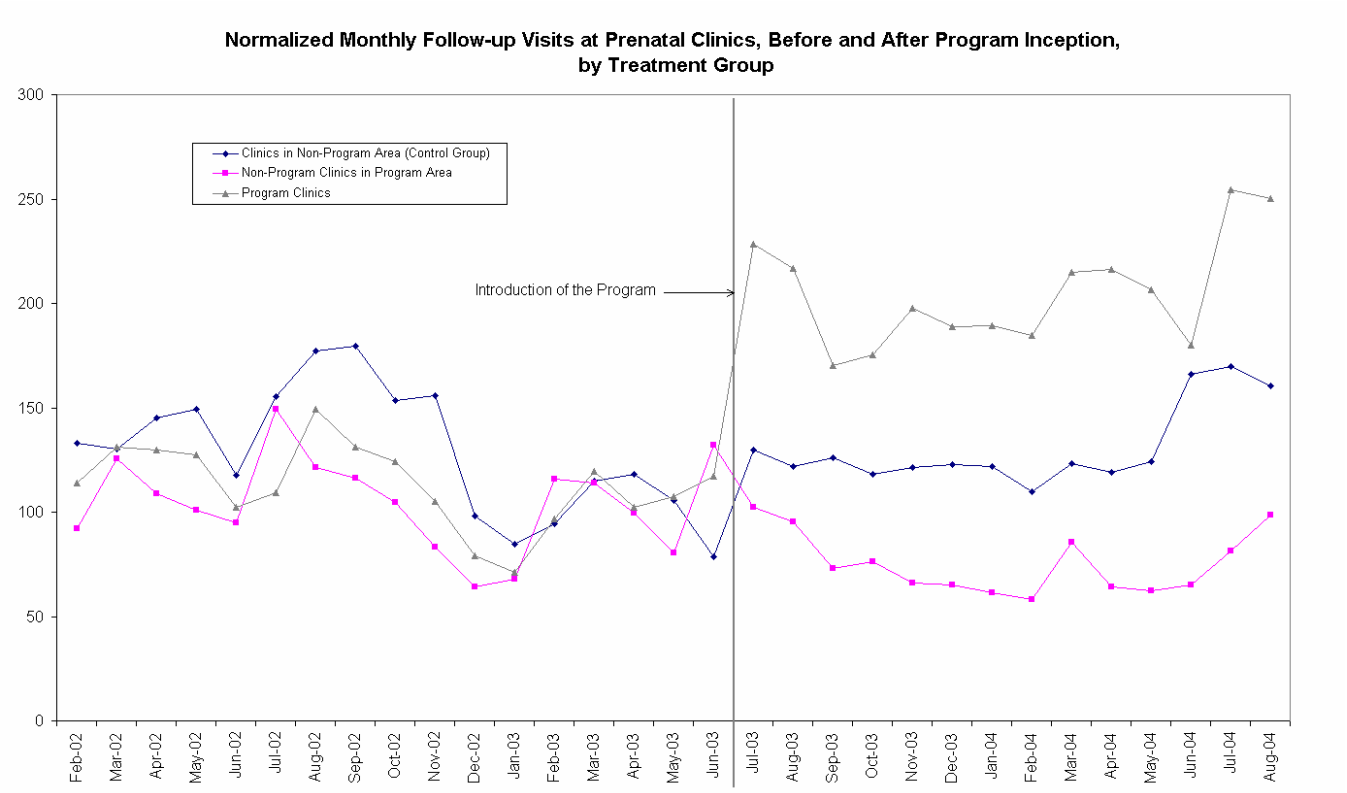
Normalized Monthly Follow-up Visits at Prenatal Clinics, Before and After Program Inception, by Treatment Group
Clinics in Non-Program Area (Control Group)
Non-Program Clinics in Program Area
Program Clinics
Introduction of the Program
300
250
200
150
100
50
0
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04

Figure 3


Normlized Monthly Take-up of HIV Testing by Gender:
Control Clinic
Men
Women
500
450
400
350
300
250
200
150
100
50
0
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
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Apr-04

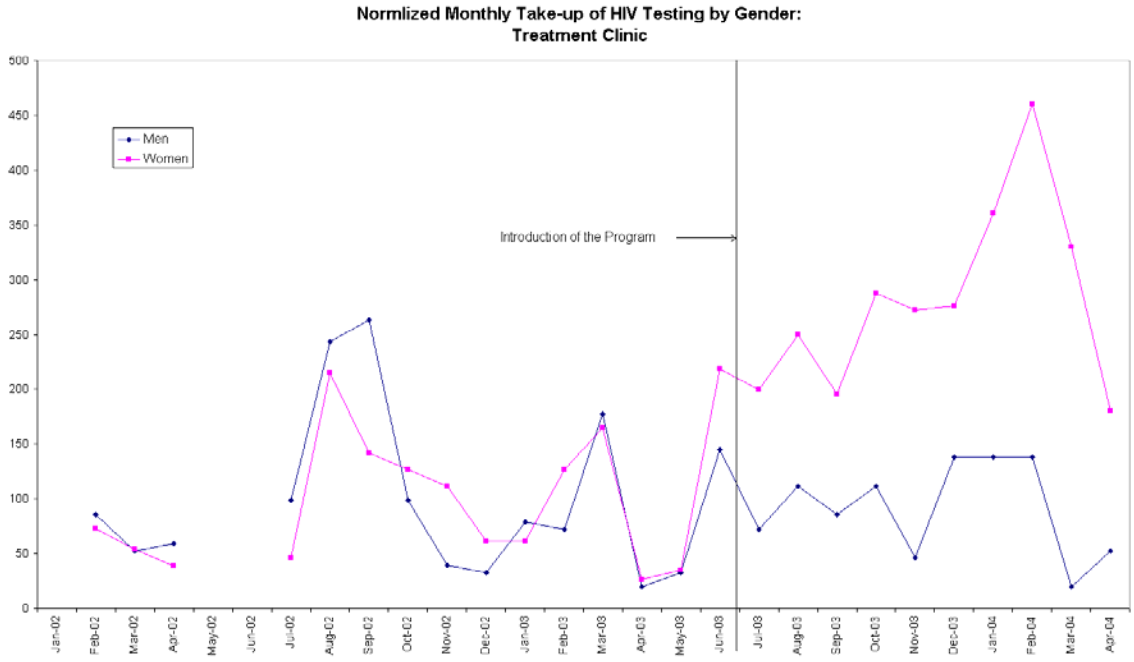
Normlized Monthly Take-up of HIV Testing by Gender:
Treatment Clinic
Men
Women
Introduction of the Program
500
450
400
350
300
250
200
150
100
50
0
Feb-02
Mar-02
Apr-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Feb-03
Mar-03
Apr-03
May-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Feb-04
Mar-04
Apr-04

Table 1
Impact on take-up of prenatal services and follow-up visits

Panel a. Regression		*Dependent Variable*	
		(1) Normalized monthly enrollment for prenatal services	(2) Normalized monthly follow-up visits
Monthly Trend	α	0.08	-0.582
		(0.72)	(0.70)
Post=1	β	-0.21	16.316
		(12.75)	(11.66)
Program Clinic (T) x (Post = 1)	δ_T	155.79	88.176
		(12.651)***	(11.736)***
Non-Program Clinic in Program Area (C1) x (Post = 1)	δ_{C1}	-38.70	-29
		(12.762)***	(12.182)**
Constant	C	84.42	82
		(12.554)***	(12.916)***
# clinic-months		215	191
R-squared		0.76	0.68

Standard errors in parentheses. Clinic fixed effects are not presented here but included in the regressions.

* significant at 10%; ** significant at 5%; *** significant at 1%

Panel b. Measure of Net Take-up Effect in Program Area			
Substitution Effect	$-\delta_{C1}$	39%	29%
Net Take-up Effect	$\delta_T + \delta_{C1}$	117%	59%
Pre-Program Take-Up in Program Clinics (Monthly average)	*Mpre*	118	141
Additional Clients from Substitution Effect	$AS = Mpre \times S$	46	41
Additional Clients from Take-Up Effect	$AT = Mpre \times T$	138	83
Number of ITN provided each month = Number of Enrollees	$N = Mpre + AT + AS$	302	
Additional client per ITN provided	AT / N	0.46	0.28

Table 2.
Compliance with ITN use among prenatal clients of program clinics

Number of women visited at home	**213**	**100%**	
Received a free ITN at the prenatal clinic	**213**	**100%**	
Able to show the ITN at home	**191**	**90%**	***100%***
Sleeps under the ITN every night	176	83%	*92%*
Sleeps under the ITN some times	8	4%	*4%*
Does not use the ITN	7	3%	*4%*
Does not have the ITN at home	**22**	**10%**	***100%***
Has another treated net	5	2%	*23%*
Sleeps under the net every night	4	2%	*18%*
Overall compliance with ITN use	**180**	**85%**	

Table 3.
Program Impact on ITN Coverage

	BEFORE July 2002-June 2003	**AFTER July 2003-June 2004**	**Diff**	**Number of Nets provided**
Program Clinics	5	85	80	100
Number of additional woman-child pair covered by ITN given			0.80	

Table 4
Impact on take-up of HIV testing

Panel a. Regression		*Dependent Variable*
		(1) Normalized monthly uptake of HIV testing services
Monthly Trend	θ	-2.063
		(1.95)
Post =1	ρ	4.287
		(33.19)
(Treat=1) x (Post=1)	γ	3
		(33.15)
(Women=1) x (Post=1)	φ	88
		(27.622)***
(Women=1) x (Treat=1) x (Post=1)	η	84
		(38.165)**
Constant	C	126
		(27.436)***
# gender-clinic-months		84
R-squared		0.48

Standard errors in parentheses. Clinic fixed effects are not presented here but included in the regressions.

* significant at 10%; ** significant at 5%; *** significant at 1%

Panel b. Measure of Total Impact in Program Area		
Take-up Effect	η	84%
Pre-Program Mean Take-up of HIV testing in Program Clinic	*Mpre*	29
Additional Clients after Program Inception	*A= Mpre x T*	24
Number of ITN provided in Program Clinic (monthly post-program average)		92
Additional client per ITN provided	*T / N*	0.27

Table 5.
Assumptions and references used in cost-effectiveness calculations

Assumptions	Value	References
Prevalence of maternal malaria without ITN	0.35	Shulman et al, 2001; Ter Kuile et al., 2003.
Efficacy of ITNs at preventing maternal malaria	40%	Ter Kuile et al., 2003.
Prevalence of LBW without maternal malaria	0.08	Shulman et al, 2001; Ter Kuile et al., 2003; Guyatt and Snow, 2004a.
Prevalence of LBW with maternal malaria	0.31	Shulman et al, 2001; Ter Kuile et al., 2003; Guyatt and Snow, 2004a.
Infant Mortality for LBW children without ITN	0.162	Guyatt and Snow, 2004a.
All-cause under-five mortality without ITN, normal weight HIV-negative babies	0.067	Author's computations based on all the above
Efficacy of ITNs at reducing under-five all cause mortality	20%	Lengeler, 2001.
Risk of MTCT of HIV without malaria	0.359	Coutsoudis et al., 2001.
Uptake of HIV testing by pregnant women when counseled on MTCT at prenatal visit, in the presence of Nevirapine	65%	Cartoux et al., 1998 ; Nduati, 2002.
Efficacy of PMTCT measures without nevirapine	15%	
Efficacy of PMTCT measures with nevirapine	50%	Dabis and Ekpini, 2002.
Life expectancy at birth	50 years	World Bank Development Indicators
Discount Rate	3%	Jamison, 1993.
Rate of ITN use by pregnant women and children under-three in the absence of a program	5%	Guyatt et al., 2004b.

Table 6.
Cost-Effectiveness Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		(1) + Impact of malaria infection on MTCT	(1) + HIV testing only	(1) + HIV testing and Nevirapine	(4) + Low comp-liance with ITN use	(4) + Low comp-liance with HIV testing	(4) + High baseline prenatal care coverage	(4) + Costs of VCT and Nevirapine borne by other program
Panel a: Varying Parameters								
Additional risk of MTCT with malaria infection	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Efficacy of PMTCT interventions	-	0.00	0.15	0.50	0.50	0.50	0.50	0.50
Compliance with ITN use	0.85	0.85	0.85	0.85	0.60	0.85	0.85	0.85
Compliance with HIV testing	-	-	0.35	0.65	0.65	0.35	0.65	0.65
Prenatal care coverage at baseline	0.60	0.60	0.60	0.60	0.60	0.60	0.90	0.60
Panel b: High HIV prevalence (15%)								
Low birth weights averted per 1,000 pregnancies	23.1	23.0	23.1	23.5	16.1	23.3	23.5	23.5
Infant HIV infections averted per 1,000 pregnancies	0.0	3.2	1.0	6.1	6.1	3.3	0.9	6.1
Under-five malaria deaths averted	11.5	11.4	11.5	11.7	8.3	11.6	11.7	11.7
Total Deaths averted per 1,000 pregnancies	12.2	15.0	13.2	18.0	14.2	15.4	13.2	18.0
DALYs averted per 1,000 pregnancies	299	360	319	424	331	366	321	424
Cost / Death averted (US$)	$492	$399	$531	$441	$560	$459	$475	$332
Cost / DALY averted (US$)	$20.1	$16.7	$21.9	$18.8	$24.0	$19.3	$19.6	$14.1
Panel c: Very High HIV prevalence (25%)								
Low birth weights averted per 1,000 pregnancies	22.2	22.0	22.3	22.9	15.7	22.6	22.9	22.9
Infant HIV infections averted per 1,000 pregnancies	0.0	5.2	1.6	10.2	10.2	5.5	1.5	10.2
Under-five malaria deaths averted	11.1	11.0	11.1	11.4	8.1	11.2	11.4	11.4
Total Deaths averted per 1,000 pregnancies	11.7	16.5	13.3	21.5	17.7	17.0	13.4	21.5
DALYs averted per 1,000 pregnancies	289	390	323	498	407	401	325	498
Cost / Death averted (US$)	$511	$364	$524	$375	$454	$418	$468	$279
Cost / DALY averted (US$)	$20.8	$15.4	$21.6	$16.2	$19.8	$17.7	$19.3	$12.0
Panel d: Low HIV prevalence (5%)								
Low birth weights averted per 1,000 pregnancies	24.0	23.9	24.0	24.1	16.5	24.0	24.1	24.1
Infant HIV infections averted per 1,000 pregnancies	0.0	1.1	0.3	2.0	2.0	1.1	0.3	2.0
Under-five malaria deaths averted	11.9	11.9	11.9	12.0	8.5	12.0	12.0	12.0
Total Deaths averted per 1,000 pregnancies	12.7	13.6	13.0	14.6	10.7	13.7	13.0	14.6
DALYs averted per 1,000 pregnancies	309	329	315	351	255	331	316	351
Cost / Death averted (US$)	$474	$441	$538	$538	$736	$511	$482	$410
Cost / DALY averted (US$)	$19.4	$18.2	$22.1	$22.4	$30.8	$21.1	$19.8	$17.1

Annex 1.

Cost-effectiveness

Description of Results (Table 6)

Columns 1 and 2 consider a very poor setting with no access to PMTCT measures and no possibility of getting tested for HIV. In such a context, providing free ITNs through prenatal clinics is likely to avert 23.1 low-weight births and 11.5 malaria-related under five deaths for 1,000 pregnancies (column 1). In total, 12.2 deaths will be averted, at a cost of US$ 492 per life saved and US$ 20.1 per DALY saved. This compares favorably with the cost-effectiveness threshold of US$ 150 per DALY (World Bank, 1993).

Column 2 allows malaria to be a risk factor for mother-to-child transmission of HIV, while keeping prevention measures unavailable. Under the assumption that maternal malaria increases the risk of MTCT of HIV by 15 percent (i.e. 5.4 percentage-points), providing free insecticide-treated bed nets through prenatal clinic could save 15 lives per 1,000 pregnancies, at a cost per life saved of US$ 399 and a cost per DALY saved of US$ 16.7. However, there is no consensus on the effect of co-infection on the risk of HIV-MTCT, and therefore this effect will be ignored in the next columns.

In columns 3 to 8, I include the spillover of the ITN distribution program on the take-up of PMTCT services. I thus consider that HIV testing is considered available at prenatal clinics, as well as some varying degree of PMTCT intervention. Column 3 represents the case where antiretroviral regimens are not available. The only PMTCT interventions available are safe obstetric practices and alternative breastfeeding practices (mainly, exclusive breastfeeding and early weaning). In such a scenario, for 1,000 ITN distributed, an additional 122 women will get tested for HIV, and the program will save 14 lives at a cost per DALY saved of US$ 21.9.

In column 4, full PMTCT services are available: HIV testing, nevirapine for HIV positive women, hospital delivery, and counseling on exclusive breastfeeding and early weaning. In such a setting, providing free treated bed nets through prenatal clinics appears extremely cost-effective: 18 lives saved per 1,000 pregnancies, at a cost of US$ 441 per life saved and a cost per DALY saved of US$ 18.8.

Sensitivity analysis

The cost-effectiveness of providing free ITNs to pregnant women through prenatal clinics seems very robust. Even with a relatively low compliance rate with ITN use (65 percent usage of the net among beneficiaries, column 5), the cost per DALY saved is below the threshold, at US$ 24. If we assume that only a third (35 percent) of prenatal clients will get a HIV test even in the presence of nevirapine, the cost per DALY saved remains very competitive, at US$ 19.3 (column 6). Column 7 presents a case where already 90 percent of pregnant women attend prenatal care in the absence of the program. The number of mother-to-child HIV infections averted thanks to the program would be less than one, but the cost per DALY saved would remain competitive, at US$ 19.6.

In case of very high HIV prevalence (25%), the cost-effectiveness of the program is enhanced in the presence of HIV-MTCT prevention tools (Table 6, Panel c). In the best case scenario, presented in column 4, an ITN distribution program through prenatal clinics could

avert more than 10 baby infections per 1,000 pregnancies, in addition to the malaria-related deaths averted. The cost per DALY saved would then be US$ 16.2.
An ITN distribution program in areas with lower HIV prevalence (5%) would also be cost-effective, with up to 14.6 lives saved and a cost per DALY saved of US$ 22.4 (Table 6, Panel d).