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Evaluating the impact of micro-franchising the distribution of anti-malarial drugs in Kenya on malaria mortality and morbidity

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Abstract

In an effort to increase access to effective anti-malaria drugs to the rural poor, the Kenyan government has partnered with a local non-governmental organization to distribute the drugs free of charge using a micro-franchise system in small privately-owned rural shops. This study uses difference-in-differencœ to evaluate the effectiveness of the program in increasing access to the drugs and hence on its impact on malaria morbidity and mortality. If effective, this system can be recommended for adoption in the distribution of other essential medicines to help in achieving some of the health related millennium development goals (MDGs) in Africa and Asia. The main results show that the program has significantly reduced malaria morbidity. The impact is however less when patients have to walk longer distances to access drugs. Further, the findings show that even without the free anti-malaria drugs, the outlets in themselves have helped reduce malaria morbidity probably due to the presence of other anti-malarial drugs in the outlets. In addition, the program is found to have significant spillover effects. Program impact on mortality is generally insignificant. The program is therefore recommendable for replication.

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1. Introduction

The severity of malaria cannot be over-emphasised. The world Health Organization (WHO) estimates that at least 40% of the world population is at risk of malaria. The WHO also documents that malaria kills a child in the world every 30 seconds. It is estimated that around 350-500 million clinical malaria episodes occur annually with over 60 per cent of the cases of clinical malaria and around 90 per cent of the deaths (approximately 1 million) occurring in Africa south of the Sahara (WHO, 2006). WHO (2006) also estimates that malaria accounts for about 20 per cent of all childhood deaths. In Kenya, UNPD (2006) estimates that the population at risk of malaria is 100 per cent with 16 per cent at negligible risk, 30 per cent epidemic risk and 54 per cent endemic risk. The proportion of deaths attributed to malaria is estimated at 27.6 per cent while the proportion of morbidity inpatients attributed to malaria is reported to be 64.7 per cent (MOH, 2001 and WHO, 2008).

Recognizing its severity, the United Nations Millennium Development Goals (MDGs) explicitly puts malaria as one of its millennium health challenges to be addressed. The eighth target of the MDGs is to halt by 2015 and begin to reverse the incidence of malaria and other major diseases.

There are several preventive interventions already in place to contain the spread of malaria. These interventions include the use of treated bednets, spraying of houses with insecticides among other measures. Other than the preventive measures, curative measures also remain a major emphasis in containing the incidence of severe cases of malaria. One of the progress indicators towards achieving the eighth MDG goal on malaria is the proportion of population in malaria-risk areas using effective malaria prevention and treatment measures. This indicator recognises the importance of not just the preventive measures to contain malaria but also treatment (curative) measures. But even with this recognition, access to timely and effective anti-malaria medicines among the rural poor remains largely lacking. WHO (2006) notes that the burden of malaria is compounded by the fact that barely half of the cases (53 per cent) receive appropriate anti-malaria drugs from formal health facilities. MOH (2001) estimated that only 2.2 per cent of the children with malaria received the correct treatment within 24 hours of the onset of fever in the districts

surveyed in Kenya. Because of the challenge of accessing timely and effective anti-malaria treatment measures, most governments and organizations have tried more innovative ways to increase access to anti-malaria medicine as a better way of reaching the often-neglected population especially in rural areas with impassible roads and no government facilities.

The government of Kenya in partnership with a local non-governmental organization (NGO), the Sustainable Healthstore Foundation (SHF), in 2005 initiated an innovative way of increasing access to a more effective anti-malaria drug called Coartem using a micro-franchise system. In this program, the medicines are provided for free by the government through the central procurement body called the Kenya Medical Supplies Agency (KEMSA) and distributed to the rural poor through SHF and small privately-owned rural shops branded as Child and Family Wellness (CFW) shops. The CFW-shop owners are in a franchise agreement with SHF on issues of procurement, medical and business best practices including diagnostics, record keeping and general management of the shops. The CFW-shops provide the medicines to patients for free only charging a screening fee. The shops are located deep in the rural villages where no public health facilities exist and therefore have the ability to serve the most unreachable patients.

The overall goal of this initiative is to increase access to effective anti-malaria drugs (Coartem) in the rural areas of Kenya. Increased access to effective anti-malaria treatment other than being directly linked to the eighth MDG target as a progress indicator by increasing "the proportion of population in malaria-risk areas using effective malaria …. treatment measures", is also a key strategy of achieving several other MDGs goals concurrently. First, young children and pregnant mothers are at the greatest risk of contracting malaria. Therefore, if access to effective anti-malaria drugs to this vulnerable group is enhanced, there will be a reduction in child mortality and improved maternal health as a result of the reduction of malaria episodes. Second, repeated attacks from malaria among school-going children results in cognitive impairment, low concentration and school absenteeism. Reversing this trend by improving access to effective anti-malaria drugs is a sure way towards achieving the MDG goal of universal primary education.

Lastly, reduction of malaria burden will result in a healthier workforce thus fostering national development that will eradicate extreme poverty and hunger, another of the MDG goals.

Other than addressing the MDG goals, if this system of drug distribution is effective in increasing access to medicines, it can be a better channel through which other essential drugs can be distributed to the rural poor where there are no government health facilities with a great potential for replication in other African and Asian countries that experience similar health challenges. The question however is: Has the program been effective in increasing access to the anti-malarial drugs? And can it be recommended for replication in other countries? The main objective of this study is to answer these questions by evaluating the effectiveness of the program with a view to recommending it for adoption in the distribution of other drugs and for replication in other countries. The outcome indicators of increased access to effective anti-malaria drugs are reductions in malaria mortality and malaria morbidity.

To evaluate the impacts of the shops on malaria morbidity and malaria mortality, we use difference-in-differences estimation with longitudinal data from January 2004 to December 2007. The data was collected from 371 sub-locations in five Districts of Central Kenya and Nairobi Area (the reason for the choice of 371 sub-locations is given in section 3.3). We use alternative definitions of treatment as given in section 4.2 and section 5 to evaluate the impact of treatment on the treated sub-locations.

The main results show that following the introduction of the program, malaria morbidity significantly declined by about 247 cases on average or 6 per cent in the sub-locations with all their borders within 5kms to the nearest outlet (CFW-shop) providing free Coartem. Bed nets are found to have statistically insignificant impacts on malaria morbidity, a possible indication that the usage of bednets could be low in the areas under study. The magnitude of impact is found to be smaller when the patients have to walk longer distances to access the drugs. The results further show that the program impacts are bigger when spillover effects to the neighboring sub-locations are accounted for underlining the fact that patients are not restricted by the sub-location boundaries in accessing the medicines, but only the distance to the shops. The

findings further show that the mere existence of the outlets even without the free anti-malarial drugs has reduced malaria morbidity in the areas where the shops are located. This implies that even without the free anti-malarial drugs, the outlets are still important in reducing malaria morbidity and construction of more outlets should be encouraged. The general conclusion is that the program has significantly increased access to the free anti-malaria drugs and is therefore recommendable for adoption in the distribution of other essential drugs and for replication in other countries. The impacts of the program on malaria mortality were generally statistically insignificant and therefore are not reported. The insignificant impact on mortality can be attributed to the fact that mortality rates in the areas under study were already low even before the introduction of the program as compared to morbidity rates. The significant impact of the program on morbidity even though the program is curative is expected since we define morbidity as the number of severe cases of malaria (see definition of variables in the appendix B)

The remaining part of this paper is organised as follows; Section two gives the details of the program, section three gives the empirical strategy adopted, choice of variables and data used, section four gives the empirical results from the main model while section five gives the results from alternative definitions of treatment and sensitivity analysis. Section six gives the summary, conclusions and recommendations of the study.

2. Program Description

2.1 The structure of the program

Kenyan government in 1995, through the Division of Malaria Control under the Ministry of Health and with the assistance from the Global Fund to fight malaria, HIV/AIDS and tuberculosis embarked on an innovative program of expanding access to a new and more effective anti-malaria medicine called Coartem in the rural areas of Kenya in partnership with SHF. This was in recognition of the fact that lack of access to effective treatment measures in the rural areas where there are no government health facilities and no good roads for mobile clinics has been a major hindrance to reducing the incidence of malaria.

The local NGO, SHF, is in a micro-franchise agreement with small private retail shops in the rural areas. The small retail shops all branded as CFW-shops are run as private enterprises but procure their medicines at subsidised rates from SHF. The shops sell a full range of medicines for several ailments. In the case of anti-malaria drugs, the CFW-shops get Coartem from the government for free through the SHF and give them out to the malaria patients for free. The shops only charge a small fee for screening patients for malaria before giving them the medicine. The screening fee is approximately 0.25 US dollars. It is worth noting here that the same screening fee is charged in government hospitals too. The shop owners are bound by the franchise agreement to adhere to good practice in diagnosing and dispensing medicine. In this regard, SHF insists that the person who diagnoses and dispenses the medicine must be a trained and registered nurse, registered with the Kenya Medical Practitioners and Dentists Board (KMPDB). The owner of the shop can however be the same nurse or someone else who is not necessarily a nurse (any businessman). There are strict franchise rules and treatment standards that govern how the outlets are run and what drugs can be sold there. There is also a thorough training program that ensures every operator knows how to diagnose the target conditions and accurately prescribe the correct medicines. This is cemented by continuing education on clinical skills and management practices. In addition, there is a centralised procurement system through the government agency, the Kenya Medical Supplies Agency (KEMSA), which ensures that no counterfeit medicine is given out. The shop owners are also required by the franchise agreement to follow a strict record keeping regime that compiles patient records and vital health statistics, as well as financial performance statistics for each shop. There is a consistent monitoring program that ensures that every outlet is operating to standard. This is reinforced by regular reports along with routine and surprise inspections and investigations to test and maintain compliance with franchise regulations.

2.2 What makes the program unique?

So what makes this program unique and why is it different from other channels of distributing the medicine like public hospitals? The uniqueness of the program is anchored in its main objective of increasing access to effective anti-malarial drugs free of charge. The location of the CFW-shops in the rural areas nearer to

the people ensures that more patients who could have otherwise not accessed the medicines from the often far away public health facilities are cared for. On the other hand, the fact that the medicines are free ensures that even those who would not have afforded the drugs are able to get them making the CFW-shops more preferred to the other privately-owned chemists in the villages. It also increases access by eliminating corruption (no stealing of drugs) that would normally occur in the public health facilities. It also ensures prompt procurement due to reduced bureaucracy and therefore medicine can be accessed when needed. The shops also provide prompt and effective services as well as reduced negligence. The main reason for effective service in the shops is that the shop owners are private businessmen who would want to attract more patients to their clinics in order to get more money from screening that would otherwise have been paid to the public hospitals. Effective and prompt service and reduced negligence also result from the strict monitoring and supervision that the CFW-shops are subjected to by the franchise agreement. As a result, there are no long queues in the CFW-shops which are common in government clinics. Long queues can easily discourage sick patients from waiting for the medicine. Finally, the shops offer personalised service and advice to patients in their local languages, something that the patients do not get in government hospitals. Most government hospital staff do not have to know the local language and therefore patients who do not understand the national language (Kiswahili or English) can easily misunderstand the instructions given on the doses in government hospitals and this can sometimes be fatal.

3 Empirical strategy

To evaluate the impact of the free malaria drugs, a very natural question comes to mind; what would have been the outcome (morbidity rate and mortality rate) had the government not opted to use the shops to distribute free anti-malaria drugs? To answer this question, we use a difference-in-differences approach to assess the impacts of the program on both morbidity and mortality. The key assumption underlying the difference-in-differences approach is that any selective differences between the treated and the untreated sub-locations are constant over time. In the following sub-section, we briefly lay down the empirical

framework that we follow to calculate the counterfactual outcome in order to determine the effect of treatment on the treated sub-locations.

3.1 Empirical model - Difference-in-difference

The difference in difference (D-in-D) (or "double difference") estimator is defined as the difference in average outcome in the treatment group before and after treatment minus the difference in average outcome in the control group before and after treatment: Following the notation from the evaluation literature let;

$$S = \begin{cases} 1 & treated \;\; sub-location \\ 0 & control \;\; sub-location \end{cases}$$

Let us also define the potential outcome (morbidity or mortality) in the treated sub-location as Y_1 and the potential outcome (morbidity or mortality) in the control sub-location as Y_0. For the treated sub-location, we have the observed mean outcome under the condition of intervention $\mathrm{E}\left(\mathrm{Y}_1 \middle| S=1\right)$ and unobserved mean outcome under the condition of control $E\left(Y_0 \middle| S=1\right)$. Similarly, for the control sub-location we have both the unobserved mean under the condition of intervention $E\left(Y_1 \middle| S=0\right)$ and the observed mean under the condition of control $E\left(Y_0 \middle| S=0\right)$. The intermediate task is therefore to construct the counterfactual given as $\mathrm{E}\left(\mathrm{Y}_0 \middle| S=1\right)$ and which is used to calculate the average treatment effect on the treated (*ATET*) given as:

$$ATET = E(Y_1 - Y_0 | S = 1) \qquad (3.1)$$

where $ATET$ is the average treatment effect on the treated.

Empirically, we estimate the impact of the program on the outcome indicators, mortality and morbidity, from a simple D-in-D estimation using a fixed effects model. An alternative approach would have been to estimate the D-in-D after matching the comparison and treatment groups. One common way to match the groups is using propensity scores (the conditional probabilities of treatment given a vector of conditioning

variables) instead of matching on the covariates. Propensity score matching however requires that the number of observations (in this case the number of sub-locations) be large. This unfortunately is not the case in our study because we are limited by the number of shops and sub-locations that we can use given that the existing shops are very few. In addition, we are unable to carry out reliable matching due to the lack of detailed data on characteristics of the sub-locations that might influence participation. To be effective. matching relies on capturing all observable characteristics that influence program participation. We instead use D-in-D without matching to estimate the effect of the program directly using all non-participant sub-locations as controls and including available covariates in the regression models. The Central Kenya region where this study was conducted is characterised by perennial malaria transmission, and malaria is among the leading causes of outpatient visits. Although the region is classified as low malaria risk area, parasitological surveys done by SHF indicated that there was active malaria transmission and this is what prompted SHF to select the region for its pilot operations. The region was also selected because of its proximity to Nairobi for ease of coordination.

3.2 Choice of covariates

We choose control variables based on a review of the health literature to determine what other factors other than the introduction of the program would determine the trends in malaria morbidity and malaria mortality in the sub-locations under study. These variables are:

- Use of treated nets. Here we use the total number of bed nets distributed to the sub-location per month. This data was obtained from the respective district government hospitals.
- Health-seeking behavior of the people. Here we use the number of children who are immunized per month. This variable indicates how the general attitude towards seeking health services in one sub-location is different from that in another sub-location. It is likely that in a sub-location where there is a high percentage of people seeking immunization services for their children, the same trend would be replicated when they are sick from other diseases including malaria.

We only use the two variables as covariates since we are not able to get data on other time varying variables

like household income and education levels at the sub-location level.

3.3 Choice of treated and control sub-locations, data and sample selection

This evaluation employs a 35-month clinical secondary data set from January 2004 to December 2007. The data is obtained from the Division of malaria control, Ministry of Health, Kenya and the Kenya National Bureau of Statistics (KNBS) where sub-location population data was obtained. SHF started to formally distribute the free anti-malaria drugs through the CWF-outlets in December 2006. The roll-out took place at different times in the outlets. Therefore the start of treatment varies from one sub-location to the next depending on when exactly the outlet in that sub-location started stocking the free medicines.

Since the program is new and there are not yet many outlets running, we carry out the evaluation in all sub-locations in the five districts under study. The districts under study are Kirinyaga, Embu, Mbeere, Thika and Nairobi. It is in these five districts that the program was first rolled-out, hence their selection. There are a total of 371 sub-locations in the five districts. Kenya is divided into 8 administrative provinces. Each province is then divided into districts. Each District into divisions and divisions divided into locations. Each location is divided into sub-locations which are the lowest administrative area. All sub-locations are different in size.

3.4 Different definitions of the treatment condition

We use different definitions of the treatment condition to evaluate how the results change with the change in the treatment definitions. In the main model, we consider a treated sub-location to be one where all the residents live within 5kms from the nearest outlet stocking free Coartem. If all points (areas) in a sub-location fall within 5kms from the nearest outlet stocking free Coartem, whether that nearest outlet is in the same sub-location or in a neighboring sub-location, then this sub-location is considered as a treated sub-location. This means that all residents of a treated sub-location can access an outlet within 5kms from where they live. This guards against defining as untreated any sub-location without a shop but in which all its residents actually access free Coartem from a shop in the neighboring sub-location. However, if any point

(area) within the sub-location is more than 5kms away from the nearest outlet stocking free Coartem, then the sub-location is considered as a control. This logic is reinforced by the results from our field survey which shows that fewer caregivers are willing to walk to the CFW-outlets if they have to walk for more than 30 minutes to the health facilities. 94 per cent of the respondents indicated that they are willing to walk for up to 30 minutes to access the free anti-malaria drugs. A walk of 30 minutes is roughly a 3.5km distance walk. 4 per cent indicated that they are willing to walk for up to 1hr to access the drugs (around 6kms), and only 1 per cent are willing to walk for up to 2 hrs (a distance of around 11kms) to access the free anti-malaria drugs.

To identify the treated sub-locations out of the 371 sub-locations with this choice criteria, all the CFW-outlets are mapped using the global positioning system (GPS). From this mapping, we measure the distance from all the points of the sub-location to their respective nearest outlet stocking free Coartem. If all distances within the sub-location are less than 5kms to the respective nearest outlet stocking free Coartem, then the sub-location is treated. If any distance within the sub-location is more than 5kms to the nearest outlet stocking free Coartem, then the sub-location is considered a control. Alternative definitions of treatment conditions are used for sensitivity analysis and are given in the section 5.

4. Empirical results

4.1 Descriptive statistics

From both the treated and the control sub-locations, we collected data on total malaria morbidity cases per month measured as the number of severe malaria cases per sub-location per month (inpatient admissions). We also collected data on total malaria mortality cases per month represented by the number of malaria deaths per sub-location per month. The other data that we collected include the number of bed nets given out to the sub-location per month and the number of immunizations per month. These data are obtained from the past clinical records at the Division of malaria control, Ministry of Health, Kenya and from the respective District Hospitals. The descriptive statistics are given in Table 1 in Appendix A. From the descriptive statistics, the average number of mortality cases in the sub-locations is 0.37 while the average

number of morbidity cases is 393. The average distance of the sub-locations away from the nearest outlet is 13kms. The average number of children immunized is found to be 29 while the average number of bednets given by the government is 43.

4.2 Program impact of treatment when distance is restricted to 5Km

In this section we analyze the impact of treatment under the condition of treatment T_1 where we assume that the patients will only walk up to 5kms (and not more) to the nearest shop distributing free anti-malaria medicine. To obtain T_1, we define a treatment dummy *treat1* which equals one if all parts of the sub-location lie within 5kms to the nearest outlet distributing free Coartem and zero otherwise. We also generate a time dummy *timeal1* denoting the time the sub-locations for which *treat1*=1 started receiving free Coartem. We then interact the treatment dummy and the time dummy to obtain the interaction term T_1, that is; $T_1 = treat1 * timeal1$. T_1 therefore denotes the condition of treatment of sub-locations where *treat1*=1. The comparison group is C_{11} where $C_{11} = N - \tilde{T}_1$. $N = 371$ is the total number of sub-locations in the study and $\tilde{T}_1$ is the sample of treated sub-locations for which $T_1 = 1$. The model to be estimated in this sub-section is given as;

$$morb_{it} = b_{10} + b_{11}(bednets)_{it} + b_{12}(immun)_{it} + b_{13}(T_1) + b_{14}d_m + b_{15}YD_{\hat{m}y} + a_i + e_{it} \qquad (4.1)$$

$$morbrate_{it} = a_{10} + a_{11}(bednets)_{it} + a_{12}(immun)_{it} + a_{13}(T_1) + a_{14}d_m + a_{15}YD_{\hat{m}y} + a_i + e_{it} \qquad (4.2)$$

where $morb_{it}$ are the malaria morbidity cases for sub-location i in time t, $morbrate_i$ is the rate of morbidity for sub-location i in time t. $(bednets)_{it}$ and $(immun)_{it}$ are the number of bednets and the number of children immunized (denoting the health-seeking behavior) respectively of sub-location i in time t. a_i are sub-location-specific effects, d_m are the seasonal calendar month effects with $m = 1,2,...,12$ representing the calendar months from January to December. $d_1 = 1$ if $m = 1$ (January) and zero otherwise while $d_2 = 1$, if $m = 2$ and zero otherwise and so on. $YD_{\hat{m}y}$ are the calendar year effects

with $\hat{m}$ representing the adjacent month pairs (Jan-Feb, march-April, May-June and so on) and $y = 2004, 2005, 2006, 2007$. Therefore $YD_{Jan-Feb,2004} = 1$ if $\hat{m} = Jan - Feb$ pair and $y = 2004$ (for the months of January and February 2004) and zero otherwise. In the estimation results given in the Appendix A, the variables $DY_{\hat{m}y}$ are represented by *JanFeb04, MarApr04, MayJun04*, and so on. T_1 is the condition of treatment as defined at the beginning of this section. $i = 1,2,..., N$ are both treated and control sub-locations in the whole sample. The same form of the model is used to analyse the impacts of the program on malaria mortality. Since the sub-location boundaries are determined administratively, the distance to the furthest point of the sub-location from the nearest outlet distributing free Coartem is totally independent of the outcome variables, malaria mortality and morbidity. This independence between outcomes and treatment variables is a critical assumption of the D-in-D.

The average morbidity of the treated sub-locations under definition T_1 is 361.2 cases. Using the levels of morbidity as the dependent variable, the results are given in Table 2 in Appendix A. The results show that the introduction of the program has had a negative and significant[4] impact on malaria morbidity. An additional outlet giving free Coartem is found to reduce malaria morbidity by 247 cases in the treated sub-locations. Using the rates of morbidity as the dependent variable, the results given in Table 2 in Appendix A, show that following the introduction of the program, malaria morbidity rate significantly declined by 6 per cent in the sub-locations with all their borders within 5kms to the nearest outlet providing free Coartem.

People's health seeking behavior is found to have a statistically significant and positive impact on malaria morbidity. The results show that an additional health seeker, increases malaria morbidity by 0.42 cases. The average health-seeking rate is 29.59 (see the descriptive statistics table in Table 1 in Appendix A). This shows that the positive impact obtained is not substantially significant. Bed nets are found to have

[4] Significance as used in the text refers to statistical significance.

statistically insignificant impacts on malaria morbidity. This could probably be an indication that the people have been given the nets but they do not use them much. This result is not surprising. A survey conducted by the Kenya's Ministry of Health (MOH) in 2000 in Gucha, Siaya and Bondo Districts estimated the proportion of children sleeping under malaria-treated nets as 11.8 per cent in those districts, whereas a similar survey done in 2001in Kwale, Makueni, Kisii/Gucha and Bondo Districts estimated the proportion as 4.6 per cent in the districts.

Except for the dummy for the month of May, June and November, all the other monthly (seasonal) dummies are found to be statistically significant at the 5 per cent level. The highest seasonal increase in malaria morbidity is recorded in the months of July and August. These apparently are the cold and wet months in the annual cycle which has the most conducive weather for mosquito breeding. On the other hand, the highest seasonal reduction in malaria morbidity is recorded in the months between September and December. Again, this is the period in the year when Kenya experiences hot and dry weather which is not conducive at all for mosquito breeding. These findings are important for the timing of intervention measures in the prevention of malaria like the provision of bed-nets. It would be more beneficial to give more bed nets between July and August as this is the time that mosquitoes breed most. The year effects show that malaria morbidity was lowest in 2004, followed by 2007 and highest in 2005 followed by 2006. This could be an indication that in 2004, there was a longer dry season over the months and this helped reduced malaria morbidity compared to the other years. The results however show no significant reduction in mortality cases and rates at the 5 per cent level in the treated sub-locations.

5 Alternate specifications and sensitivity analysis

5.1 Impact of treatment when distance is restricted to 10Km

For comparison purposes with the main model, we consider several alternative definitions of the treatment condition. In this section we analyze the impact of treatment under the condition of treatment T_2 where we assume that patients can walk for up to 10kms (and not more) to access the anti-malaria medicines. The

model is estimated using a specification similar to the previous section but now defining $T_2 = treat2 * timeal2$ where $treat2$ equals one if all of the sub-location's borders lie within 10kms to the nearest outlet distributing free Coartem and $timeal2$ is a time dummy variable for the sub-locations for which $treat2 = 1$. The comparison group is C_{12} where $C_{11} \neq C_{12} = N - \tilde{T}_2$. $N = 371$ is the number of sub-locations in the study and $\tilde{T}_2$ is the sample of treated sub-locations for which $T_2 = 1$. (also see the definition of variables in Appendix B).

The results considering this treatment condition with the levels and rates of morbidity as the outcome variables are given in Table 3 (columns 2 and 3 T2C1-levels and T2C1-rates respectively) in Appendix A. The results show that the impact on morbidity of the introduction of the distribution of the free anti-malaria drugs through the CFW-shops is significantly different from zero. An additional outlet providing free anti-malaria drugs is found to reduce malaria morbidity by 58 cases. This impact is smaller than when the distance the patients could walk was restricted to 5kms. Using the rates of malaria morbidity as the dependent variable, the results show that the program has reduced malaria morbidity by 3 per cent in the areas up to 10kms around the outlets providing free Coartem. This is down from the 6 per cent reduction obtained for the areas within 5kms of the nearest outlet providing free Coartem. The results imply that not many patients visit the outlets when they are far away from where the patients live to get medicine even if the medicine is free. It is therefore expected that the impact of the far away outlets if the outlets were to sell the medicines would be even smaller. The treatment condition T_2 considers some patients who live far away from the outlets as treated when in fact they are not since they are not willing to travel to the outlets with the free drugs to access the medicine.

The results also show that the impact of the program on malaria mortality is statistically insignificant. Given the insignificance of these results, the tables of the results are not provided here.

5.2 Program impact only in the sub-locations with outlets giving free Coartem

The next alternative treatment definition is where only the sub-locations with an outlet providing free Coartem are considered as treated. All the other sub-locations without an outlet providing free Coartem are considered as comparisons. In addition, the sub-locations with outlets that were selling the anti-malaria drug in a given month are also considered not treated in the months they were selling the anti-malaria drugs just like in the case of T_1 and T_2. In this case, it is assumed that the patients from a sub-location without a treated outlet will not use the outlets in another sub-location even if that outlet is near the border and therefore nearer to them. The condition of treatment here is denoted by T_3 which is the interaction term between the sub-location's condition of treatment *allwithal*, and the time of treatment, *timeal*, denoting the time the sub-location started distributing free Coartem that is; $T_3 = allwithal*timeal$. The comparison group is C_{13} where $C_{12} \neq C_{13} = N - \tilde{\tilde{T}}_3 \neq C_{11}$ with $N = 371$ being the number of sub-locations in the study and $\tilde{\tilde{T}}_3$ is the sample of treated sub-locations for which $T_3 = 1$.

The estimation results with the levels and rates of morbidity as the dependent variables are given in Table 3 (columns 4 and 5, T3C1-levels and T3C1-rates respectively) in Appendix A. The results using both levels and rates show that the impact of providing free anti-malaria drugs through the outlets on malaria morbidity is statistically insignificant. This result could be indicative of the fact that it is not important to the patients whether or not the outlets are located in their sub-locations, but how far the outlets are from where they live. It is sometimes the case that an outlet is located in a sub-location but the outlet is very far away from the majority of the residents of the same sub-location to the extent that only a small fraction of the total sub-location population uses it.

The results using T_3 as the condition of treatment also show that, the impact of the program on malaria mortality is statistically insignificant. In the next sub-sections, we focus more on the interpretation of the

results of the impacts of the program on morbidity since the impact of the program on mortality is consistently found to be insignificant.

5.3 Impacts of selling Coartem

In this section, we consider the impact of the outlets that were selling the anti-malaria drugs on malaria morbidity. First we generate a treatment dummy for the sub-locations that had outlets selling Coartem and call it *sell. sell* equals one for sub-locations with outlets that were selling Coartem and zero otherwise. This treatment dummy variable is then interacted with a time dummy variable denoting the time the outlets started selling Coartem called *timesell* to obtain the interaction term *selltreat*. The condition of treatment $T_5 = 1 \; if \; T_4 = 1$ or if $selltreat = 1$ where- T_4=1 if T_3=1 or if T_1=1 (see definition of variables in the appendix B). The comparison group here is C_{15} where $C_{15} = N - \tilde{T}_5$ and $\tilde{T}_5$ is the sample of treated sub-locations for which $T_5 = 1$.

The results with this treatment definition are given in Table 3 (columns 8 and 9, T5C1-levels and T5C1-rates respectively) in Appendix A. The results, show that the impact of the outlets that were selling Coartem is still negative and statistically different from zero. The program's introduction to an additional sub-location reduces morbidity by 147 cases and by 3.9 per cent when the rate of morbidity is used. This signifies an improvement in the impact of the program from a reduction of morbidity by 131 cases and 3.7 per cent (levels and rates respectively) when the condition of treatment excludes the outlets that were selling Coartem as defined by T_4 (Table 3 columns 6 and 7, T4C1-levels and T4C1-rates respectively in Appendix A). This implies that even if the outlets sell the anti-malaria drugs, their presence and the presence of other anti-malaria drugs in the outlets helped to reduce malaria morbidity. This could be explained by the fact that the anti-malaria drugs were now nearer to the patients and therefore access to them was increased. The results further show that, the impact of the program on malaria mortality when the treatment condition is defined as T_5 is statistically insignificant.

5.4 Effect of spillovers to the other sub-locations

In this section we analyze the impact of treatment under definitions $T_q = T_1, T_2, T_3, T_4, T_5$ as given in the previous sub-sections but with a new comparison group C_{2q} instead of C_{1q} where $q = 1,2,3,4,5$. The comparison group C_{2q} includes sub-locations in group C_{1q} which do not share a common border with the sub-location in the treated sample $\tilde{T}_q$. Remembering that the sample of sub-locations in $\tilde{T}_1 = N - C_{11}$ and assuming for instance that the sample of sub-locations in C_{11} that share a common border with the sub-locations in the sample $\tilde{T}_1$ (sub-locations for which $T_1 = 1$) is denoted by B_1, then $C_{21} = C_{11} - B_1$. The sample of treated sub-locations in $\tilde{T}_1$ and the definition of T_1 remain the same as before but the sample of the comparison group is reduced by B_1 from C_{11} to C_{21}. In this first example, the total sample is $(N - B_1)$. Having re-sampled, we then analyse the impact of the program on malaria morbidity for each of the treatment conditions $T_q = T_1, T_2, T_3, T_4, T_5$ leaving out of the estimation the sample $B_q = (C_{1q} - C_{2q})$ which is the sample of sub-locations which share a common border with the sub-locations in $\tilde{T}_q$. This is done in order to filter out the spillover effects of the program to the neighboring sub-locations.

The results from the estimations are summarised in Table 4 in appendix A. The results shows that, when the distance of treatment is restricted to 5kms, the program has a negative and statistically significant impact on malaria morbidity. An additional outlet reduces malaria morbidity by 243 cases (see Table 4 column 2 – T1C2-levels), down from 247 cases obtained when the sub-locations with the common borders are included in the sample (see Table 2 –in levels). The results using the rate of morbidity as the dependent variable shows that, the distribution of the free anti-malaria drugs through the CFW-shops has significantly reduced malaria morbidity by about 5.5 per cent (Table 4 column 3 – T1C2-rates), down from 6 per cent obtained with the whole sample(see Table 2 –in rates).. When the distance is restricted to 10kms, the impact of the program is still negative and statistically different from zero, but the magnitude is smaller (reduces by

49 cases as given in Table 4 column 4 – T2C2-levels) than when the sub-locations with common borders to the sample $\tilde{T}_2$ are included as part of the comparison group (reduction by 58 cases as given in Table 3 column 2 – T2C1-levels). The results with the rate of morbidity as the dependent variable and the treatment condition T_2 show that, the program has significantly reduced morbidity by 2 per cent (see Table 4 column 5 – T2C2-rates), down from 3 per cent obtained with the inclusion of the sub-locations with common borders with $\tilde{T}_2$. Considering the impacts of the program on only the sub-locations with outlets providing the free Coartem as defined by T_3, the results indicate that excluding the sub-locations with common borders with the sub-locations in $\tilde{T}_3$, reduces morbidity by 25 cases (Table 4 column 6 – T3C2-levels) up from 24 cases, but the impact is not statistically significant just like in the case of the results with the treated sample $\tilde{T}_3$ with the comparison group C_{13}. The results obtained using morbidity rate as the dependent variable also returns a statistically insignificant impact coefficient, confirming the earlier results that the program has had no significant impact on morbidity if only the sub-locations with outlets distributing free Coartem are considered as treated. When the treatment condition is T_4, the results show a statistically significant reduction in morbidity brought about by the introduction of the program. The results show that morbidity reduces by 122 cases (Table 4 column 8 – T4C2-levels). This again is lower than the impact of the program when the spillover effects to the neighboring sub-locations are considered. Analyzing the impacts of the program on the treatment group defined by $\tilde{T}_5$ for which $T_5 = 1$ (including as treated the sub-locations that were selling the anti-malaria medicine in any one month), the results show that the distribution of the free anti-malaria drugs through the outlets has had a statistically significant impact on malaria morbidity in the treated sub-locations. The program has reduced malaria morbidity by 146 cases (Table 4 column 10 – T5C2-levels), down from 147 obtained with the whole sample.

5.5 Impact of the outlets on morbidity whether stocking Coartem or not

In this model, the condition of treatment is a sub-location with an outlet. This does not consider whether the outlet stocks Coartem or not (free or sold). From our field survey, we found out that some outlets do not stock Coartem but stock some other alternative anti-malarial drugs. Given that the outlets are nearer to the patients than public hospitals, it is expected that the mere existence of an outlet in a sub-location is likely to reduce malaria morbidity and mortality in that sub-location since patients will prefer to use it than travel to other health facilities far away. We use this model to determine the impact of the outlets (and not the free Coartem) on malaria morbidity in the sub-locations. To construct the variable representing the condition of treatment, first we generate a treatment dummy variable and call it *outlet* with ones if the sub-location has an outlet (either a shop or a clinic) and zeros for sub-locations without any outlet. The variable *outlet* is then interacted with a time dummy variable denoting the time when each of the outlets were built and we call it *timeoutlet*. The resulting variable from this interaction denotes the condition of treatment and is called *treatoutlet.*

The results from this estimation with the levels and rate of morbidity as the outcome variables are given in Table 6 (columns 2 and 3). The results show that, the impact of the outlets on the levels of malaria morbidity is negative and statistically different from zero. An additional outlet built reduces malaria mortality by 121 cases. Considering the rate of morbidity as the dependent variable, the results show that the building of outlets in those sub-locations has reduced malaria morbidity by 1.8 per cent. This implies that the existence of the outlets in the sub-locations in itself have reduced malaria morbidity even without the free anti-malaria drugs. The reason for this impact is probably the existence of other (sold) anti-malaria drugs now nearer to the people in the outlets. This therefore means that even if the government were to stop providing the free anti-malarial drugs, the outlets are still important in reducing malaria morbidity and construction of more outlets will be beneficial. It is important however to note here that the impact of the outlets alone as obtained in this section is less than the impact of the outlets that stocked the free drugs (see

Table 2 in the Appendix A). This underscores the importance of providing the free anti-malarial drugs and hence the program.

5.6 False Experiment

In this sub-section, we code a false treatment variable FT1 that equals one (for sub-locations that are treated in at least one month under definition T_4) in the three months prior to the first month in which $T_4 = 1$ and zero in all other months and sub-locations. The idea behind this experiment is to test our main results. We know for sure that there was no treatment in the three months prior to the first month in which $T_4 = 1$. If the results from the false treatment give us an impact greater than the impact obtained with the main results, then we know that the impact of treatment was not substantially significant. But if the impact improves after treatment, then we conclude that the program had a substantially significant impact. The models that we estimate in this sub-section are given as:

$$morb_{it} = b_{70} + b_{71}(bednets)_{it} + b_{72}(immun)_{it} + b_{73}(TF1) + b_{74}T_4 + b_{75}d_m + b_{76}YD_{\hat{m}y} + a_i + e_{it} \quad (4.3)$$

$$morbrate_{it} = a_{70} + a_{71}(bednets)_{it} + a_{72}(immun)_{it} + a_{73}(FT1) + a_{74}T_4 + b_{75}d_m + a_{76}YD_{\hat{m}y} + a_i + e_{it} \quad (4.4)$$

The variables remain as defined in section 4.2. Results from the estimations given in Table 3 columns 10 and 11, show that the impact in the three months before the introduction of the free anti-malaria drugs was a reduction in morbidity by 112 cases. This could be attributed to the fact that, even before the introduction of the free anti-malaria drugs Coartem, the outlets stocked a number of anti-malaria drugs including quinine; artemether and coarsucam among others. With the introduction of the free anti-malarial drugs in the outlets, the impact of the outlets increased (a reduction of morbidity by 141 cases) as can be seen from the coefficient of T_4 in Table 3 (columns 10 FT1-levels) in Appendix A. Using morbidity rates, the results indicate that before the start of the distribution of the free anti-malaria drugs through the outlets, the impact of the outlets was a reduction in malaria morbidity by 2.3 per cent (Tables 3 columns 11 - FT1-rates). After the introduction of the program, the treatment as defined by T_4 increased the impact by reducing malaria morbidity by 4.1 per cent. This shows that, the free anti-malaria drugs led to a substantially significant

reduction in malaria morbidity compared to the reduction that was there before (occasioned by the existence of the outlets and other anti-malaria drugs in those sub-locations).

5.7 Sensitivity Analysis

In this sub-section, we report the results of the sensitivity analysis of the impacts of the program on malaria morbidity. We leave out of this estimation, 20 per cent of outlying sub-locations, both treated and comparison, with the highest average morbidity rates over all the periods in the data. To do this, we generate the eightieth percentile of the treated sub-locations by average morbidity and the same for the comparison sub-locations. We then leave out of this estimation, the sub-locations in both groups with average morbidity above the 80^{th} percentile. Assuming that the set of the 20 per cent of the sub-locations, both treated and comparisons, with highest average morbidity is represented by H_q^t for the treated and H_q^c for the control group, for each treatment definition $T_q = T_1, T_2, T_3, T_4, T_5$, where $q = 1,2,3,4,5$, then the total sample after excluding the 20 per cent becomes $\left(N - \left(H_q^t + H_q^c\right)\right)$.

The results from this estimation given in Table 5 in Appendix A show that, when the condition of treatment is restricted to 5kms (T_1), the impact of the free anti-malaria drugs is a significant reduction in malaria morbidity by 158 cases (see Table 5 columns 2 - T1C1-levels) in Appendix A. This impact is lower than the reduction by 247 cases obtained if the whole sample is included as $N = \left(\tilde{T}_1 + C_{11}\right)$ (as given in Table 2). The results assuming that the patients who live up to 10kms away from the nearest outlet will access the free drugs from that outlet (T_2) show that, if the 20 per cent of the sub-locations with the highest average morbidity are left out, the impact of providing the free anti-malaria drugs through the outlets reduces morbidity by 71 (see Table 5 columns 4 T2C1-levels) in Appendix A. This again is lower than in the case where we assume that only the patients who live up to 5kms away will access the free drugs from the shop. The reduction by 71 cases is however larger than the impact obtained if the whole sample $N = \left(\tilde{T}_2 + C_{12}\right)$ is considered (for the 10kms in Table 3 columns 1 T2C1-levels) in Appendix A. This may be an indication

that among the sub-locations with their entire boundaries within 10kms of the nearest outlet, the sub-locations with the highest average morbidity among them also experienced lesser intensity of the program impact. This is why removing them from the estimation increases the program impact. This is logical because, it could be the case that the sub-locations that were far a way from the outlets did not feel the impact of the outlets because of distance and therefore had higher than average morbidity rates. In this case removing the sub-locations with higher than average morbidity rates turns out to be equivalent to removing the sub-locations that were further away from the nearest outlets. This is likely the opposite with the sub-locations that are within 5kms of reach to the nearest outlet as defined by T_1 where the impact declined after filtering out the 20 per cent. The impact of the program is likely to have been more intense on the excluded sub-locations than the ones with below the 80^{th} percentile average morbidity. The impact of the program on only the sub-locations with the outlets providing free anti-malaria drugs within their borders as defined by T_3 is found to be negative and statistically different from zero. The program reduces morbidity by 45 cases (Table 5 columns 6 T3C1-levels) in Appendix A. This is an increase in the impact of the program from a reduction by 24 cases obtained for the whole sample (Table 3 columns 4 T3C1-levels). Surprisingly, the impact is now statistically different from zero unlike in the previous cases when the 20 per cent were included. This is a strong indication that including the 20 per cent of the sub-locations with the highest average morbidity in this category understates the impact of the program to the extent that the impact becomes insignificant. This implies that the impact of the program on the 20 per cent of the sub-locations with the highest average morbidity in this category was low and insignificant. The impact of the program on morbidity considering as treated those outlets that were selling the anti-malarial drugs as defined by T_5 is found to be negative and statistically different from zero. The results show that, an additional one outlet stocking Coartem, whether providing free Coartem or selling it, leads to a reduction in morbidity by 106 cases (Table 5 columns 10 - T5C1-levels)

In all cases, the impacts of the program obtained after excluding 20 per cent of both the treated and control sub-locations with the highest average morbidity for all definitions of treatment conditions

$T_q = T_1, T_2, T_3, T_4, T_5$, are all negative and statistically different from zero. This implies that the impact is not exaggerated by the omission of the outliers. In fact, in some cases, the outlier underrated the impact of the program since it seems that the program impact was not very intense in the sub-locations with the highest average morbidity compared to the ones with lower average morbidity for the 10km case probably due to distance.

6. Summary, Conclusions and recommendations

This study evaluates the effectiveness of an innovative anti-malarial distribution program initiated between the government of Kenya and a local NGO, the Sustainable Healthstore Foundation (SHF). The program's objective is to increase access to free anti-malaria medicine to the rural poor. Under this partnership, the government provides anti-malarial drugs Coartem free of charge to SHF, who then distribute the drugs free of charge using its micro-franchise network. Under the franchise, small (privately owned) shops called the Child and Family Wellness (CFW) shops, located in the rural areas where there are no public health facilities, stock and distribute drugs for different ailments including the free anti-malaria drugs. The CFW-shops only charge screening fee.

Given the potential of this program in increasing access of essential drugs to the rural poor with limited access to public health facilities, the objective of this study is to evaluate its effectiveness with the aim of recommending it for replication in the distribution of other essential drugs and for adoption in other countries. The outcome indicators of program effectiveness are reduced malaria mortality and morbidity. The evaluation is done in 371 sub-locations from five districts in Kenya using difference-in-difference estimations procedure. Different treatment conditions are defined and used in the analysis.

The main result is that following the introduction of the program, malaria morbidity significantly declined by about 247 cases on average or 6 per cent in the sub-locations with all their borders within 5kms of the nearest outlet providing free Coartem. Bed nets are found to have statistically insignificant impacts on malaria morbidity, an indication that the usage of bednets could be low in the areas under study. This calls

for efforts to sensitise the population probably through field days and home visits on the benefits of not just having the nets but of using them also. The results further show that the highest seasonal increase in malaria morbidity is experienced in the months of July and August. These apparently are the cold and wet months in the annual cycle when the weather is most conducive for mosquito breeding. We infer that these results are important for the timing of intervention measures in the prevention of malaria for instance by giving more bed nets between July and August when mosquitoes breed most.

Assuming that patients can walk for up to 10kms (and not more) to access the anti-malaria medicines , the magnitude of impact is smaller than when the distance the patients could walk was restricted to 5kms.The results imply that not many patients visit the outlets when the outlets are far away from where the patients live. Indeed the results from our field survey confirm the importance of distance on the program's impact. The results show that 94 per cent of the caregivers are willing to walk for up to 30 minutes (roughly a 3.5km distance walk) and not more to access the free drugs while only 1 per cent of the caregivers are willing to walk for up to 2 hrs (a distance of around 11kms) to access the free anti-malaria drugs. It may therefore be necessary to encourage efforts to set up more outlets nearer to the vulnerable populations.

The results further show that the program impacts are bigger when spillover effects to the neighboring sub-locations are accounted for than if they are ignored underlining the fact that the patients are only restricted by the distance traveled to access the anti-malaria drugs and not administrative boundaries. In fact assuming that the patients can only access the medicines if the outlets are in their own sub-locations, the impact of the program is found to be insignificant.

The results also show an increase in the program impact if the outlets that were selling the anti-malarial drugs are also considered as treated. This implies that even with the selling of the anti-malaria drugs, the presence of the outlets in the sub-locations in itself and the presence of other anti-malaria drugs in the outlets helped to reduce malaria morbidity since the drugs were now much nearer to the patients and therefore were used more when needed. Having more outlets whether selling or giving for free the anti-

malarial drug Coartem is therefore beneficial. The findings also show that the mere existence of the outlets has reduced malaria morbidity in the areas where they are located. This implies that even if the government were to stop providing the free Coartem, the outlets are still important in reducing malaria morbidity and construction of more outlets will be beneficial. The program impact on malaria mortality is found to be generally statistically insignificant with almost all the treatment definitions and therefore is not reported.

In general the program is found to have significantly increased access to the free anti-malaria drugs and hence reduced malaria mortality. The program is therefore recommendable for replication in the distribution of other essential drugs and for adoption in other African and Asian countries.

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Appendix A

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
morb	17753	393.7067	365.4954	0	3131
mort	17808	.3712376	2.605172	0	89
immun	17802	29.59123	62.80472	0	2934
bednets	17802	43.12369	419.252	0	14561
distance	17808	13.38561	9.995043	1	64
withal5km	17808	.0107817	.1032765	0	1
timeoutlet	17808	.0507075	.219406	0	1
outlet	17808	.0727763	.2597762	0	1
month	17808	6.5	3.452149	1	12
d1	17808	.0833333	.2763932	0	1
d2	17808	.0833333	.2763932	0	1
d3	17808	.0833333	.2763932	0	1
treatall	17808	.0056716	.0750983	0	1
treatoutlet	17808	.0507075	.219406	0	1
pop	17808	10087.1	11104.12	188	75290
morbrate	17753	.0837111	.1464375	0	3.515957
mortrate	17808	.0000811	.0005951	0	.0199283
JanFeb04	17808	.0416667	.1998319	0	1
MarApr04	17808	.0416667	.1998319	0	1
MayJun04	17808	.0208333	.1428301	0	1
lnmorb	16343	5.708572	.9381646	0	8.049108
lnmort	833	1.579912	1.010647	0	4.488636
treat1	17810	.0431218	.2031371	0	1
timeal1	17810	.0116788	.1074388	0	1
treat5km	17810	.0116788	.1074388	0	1
T1	17810	.0116788	.1074388	0	1
treat2	17810	.0727681	.2597628	0	1
timeal2	17810	.019708	.1389989	0	1
treat10km	17810	.019708	.1389989	0	1
allwithal	17810	.024256	.1538474	0	1
T2	17810	.019708	.1389989	0	1
timeal	17810	.0065693	.0807871	0	1
treat3	17810	.0065693	.0807871	0	1
T3	17810	.0065693	.0807871	0	1
T4	17810	.0145985	.1199426	0	1
T5	17810	.0186412	.1352581	0	1
sell	17810	.0107805	.1032707	0	1
timealsell	17810	.0040427	.0634551	0	1
selltreat	17810	.0040427	.0634551	0	1
FT1	17810	.0033689	.0579459	0	1
mmorb	17808	393.2385	279.8239	0	1716.125

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Table 2 - Main models with C1 as the comparison group

Variable	**In levels**			**In rates**		
Variable	Coefficient	Std. Err.	t-statistic	Coefficient	Std. Err.	t-statistic
bednets	0.0018	0.00	0.43	-3.03E-07	1.31E-06	-0.23
immun	0.43	0.04	11.27	0.0000928	0.0000121	7.67
T1	-247.97	18.85	-13.16	-0.0626881	0.006	-10.45
d1	43.97	13.19	3.33	0.0106743	0.004198	2.54
d2	47.56	13.17	3.61	0.0119684	0.0041931	2.85
d3	67.71	8.33	8.13	0.013459	0.0026522	5.07
d4	(dropped)			(dropped)		
d5	-5.67	17.85	-0.32	0.0082516	0.0056819	1.45
d6	-26.23	15.03	-1.74	0.0023093	0.0047859	0.48
d7	172.76	13.18	13.10	0.0414593	0.0041965	9.88
d8	114.82	13.18	8.71	0.026976	0.0041957	6.43
d9	-40.90	13.22	-3.09	-0.0032764	0.0042087	-0.78
d10	-53.29	13.23	-4.03	-0.0067189	0.0042107	-1.6
d11	-20.15	13.19	-1.53	-0.0048859	0.0041972	-1.16
d12	-32.38	13.19	-2.46	-0.0065658	0.0041987	-1.56
JanFeb04	-113.32	11.80	-9.60	-0.0217773	0.0037577	-5.8
MarApr04	-104.42	11.85	-8.81	-0.0167274	0.0037735	-4.43
MayJun04	-17.76	19.22	-0.92	-0.005231	0.0061179	-0.86
JulAug04	-76.47	11.78	-6.49	-0.0104826	0.0037483	-2.8
SepOct04	(dropped)			(dropped)		
NovDec04	-43.97	11.79	-3.73	-0.00588	0.0037545	-1.57
JanFeb05	56.48	11.78	4.79	0.0150143	0.0037502	4
MarApr05	48.78	11.79	4.14	0.0135372	0.0037518	3.61
MayJun05	80.93	15.23	5.31	0.008744	0.0048494	1.8
JulAug05	(dropped)			(dropped)		
SepOct05	97.56	11.79	8.28	0.0176831	0.0037516	4.71
NovDec05	16.23	11.80	1.38	0.005113	0.0037548	1.36
JanFeb06	(dropped)			(dropped)		
MarApr06	(dropped)			(dropped)		
MayJun06	128.77	15.20	8.47	0.0209231	0.0048389	4.32
JulAug06	-63.78	11.80	-5.41	-0.0159511	0.0037552	-4.25
SepOct06	73.70	11.81	6.24	0.0099459	0.0037595	2.65
NovDec06	(dropped)			(dropped)		
JanFeb07	11.97	11.82	1.01	0.0016436	0.0037621	0.44
MarApr07	-4.32	11.80	-0.37	0.0013443	0.003757	0.36
JulAug07	-118.09	11.80	-10.01	-0.0274515	0.0037567	-7.31
MayJun07	86.80	15.21	5.71	0.0116009	0.0048428	2.4
SepOct07	32.54	11.83	2.75	0.0022789	0.0037646	0.61
NovDec07	-24.05	11.79	-2.04	-0.0066919	0.0037534	-1.78
_cons	358.17	9.50	37.71	0.0738711	0.0030231	24.44

Table 3 – Alternative specifications of the main model

	T2C1-levels	T2C1-rates	T3C1-levels	T3C1-rates	T4C1-levels	T4C1-rates	T5C1-levels	T5C1-rates	FT1-levels	FT1-rates
bednets	0.0017(0.43)	-0.0000003(-0.23)	0.0017(0.43)	0.0000003(-0.2	0.0018(0.43)	0.0000003(-0.23	0.0017(0.43)	-0.0000003(-0.2	0.002(0.51)	-0.0000002(-0.18)
immun	0 .42(11.23)	0.0001(7.66)	0.42(11.23)	0.0001(7.66)	0.43(11.24)	0.00009(7.66)	0.43 (11.23)	0.00009(7.64)	0.43(11.23)	0.00009(7.66)
T1	-		-	-	-	-	-	-	-	-
T2	-58.85(-3.98)	-0.03(-5.67)	-	-	-	-	-	-	-	-
T3	-	-	-24.65(-0.99)	-0.009(-1.08)	-	-	-	-	-	-
T4	-	-	-	-	-131.6204(-7.75)	-0.039(-7.26)	-	-	-141.53(-8.22)	-0.041(-7.54)
T5	-	-	-	-	-		-147.14 (-9.61)	-0.038(-7.78)	-	-
TF1	-	-	-	-	-		-	-	-112.8(-3.59)	-0.023(-2.34)
d1	43.98(3.32)	0.01(2.54)	43.94(3.32)	0.011(2.53)	43.95(3.32)	0.011(2.54)	43.94(3.32))	0.011(2.54)	43.94(3.32)	0.011(2.54)
d2	47.64(3.60)	0.01(2.85)	47.65(3.60)	0.012(2.85)	47.60(3.60)	0.012(2.85)	47.58 (3.60)	0.012(2.85)	47.58(3.60)	0.012(2.85)
d3	67.73(8.09)	0.01(5.07)	67.73(8.09)	0.013(5.06)	67.73(8.10)	0.013(5.07)	67.73 (8.11)	0.013(5.07)	67.72(8.10)	0.013(5.07)
d4	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
d5	-5.66(-0.32)	0.01(1.45)	-5.66(-0.32)	0.008(1.45)	-5.67(-0.32)	0.008(1.45)	-5.68 (-0.32)	0.008(1.45)	-5.68(-0.32)	0.008(1.45)
d6	-26.20(-1.74)	0.002(0.48)	-26.20(-1.73)	0.0023(0.48)	-26.22(-1.74)	0.002(0.48)	-26.24(-1.74)	0.002(0.48)	-26.23(-1.74)	0.002(0.48)
d7	172.78(13.05)	0.04(9.86)	172.79(13.04)	0.04(9.85)	172.77(13.06)	0.041(9.86)	172.74(13.07)	0.041(9.87)	172.77(13.07)	0.041(9.87)
d8	114.84(8.67)	0.03(6.42)	114.85(8.67)	0.03(6.41)	114.83(8.68)	0.027(6.42)	114.81(8.69)	0.027(6.42)	114.8(8.69)	0.027(6.42)
d9	-40.87(-3.08)	-0.003(-0.78)	-40.85(-3.07)	-0.0033(-0.77)	-40.89(-3.08)	-0.003(-0.78)	-40.92 (-3.09)	-0.003(-0.78)	-40.93(-3.09)	-0.003(-0.78)
d10	-53.25(-4.01)	-0.01(-1.59)	-53.23(-4.00)	-0.007(-1.59)	-53.27(-4.01)	-0.007(-1.59)	-53.31(-4.02)	-0.007(-1.59)	-53.28(-4.02)	-0.007(-1.59)
d11	-22.39(-1.69)	-0.01(-1.22)	-23.75(-1.79)	-0.006(-1.37)	-21.40(-1.62)	-0.005(-1.21)	-19.52(-1.48)	-0.005(-1.12)	-17.41(-1.31)	-0.004(-1.01)
d12	-36.14(-2.73)	-0.01(-1.66)	-38.41(-2.90)	-0.008(-1.91)	-34.48(-2.61)	-0.007(-1.64)	-32.4(-2.45)	-0.007(-1.55)	-31.88(-2.41)	-0.006(-1.51)
JanFeb04	-113.34(-9.56)	-0.02(-5.79)	-113.32(-9.55)	-0.022(-5.78)	-113.32(-9.57)	-0.022(-5.79)	-113.33(-9.58)	-0.022(-5.79)	-113.32(-9.57)	-0.022(-5.79)
MarApr04	-104.38(-8.77)	-0.02(-4.42)	-104.36(-8.76)	-0.017(-4.42)	-104.4(-8.78)	-0.017(-4.43)	-104.44(-8.79)	-0.017(-4.43)	-104.43(-8.78)	-0.017(-4.43)
MayJun04	-17.73(-0.92)	-0.01(-0.85)	-17.72(-0.92)	-0.005(-0.85)	-17.748(-0.92)	-0.005(-0.85)	-17.76(-0.92)	-0.005(-0.85)	-17.75(-0.92)	-0.005(-0.85)
JulAug04	-76.47(-6.47)	-0.01(-2.79)	-76.47(-6.46)	-0.010(-2.79)	-76.47(-6.47)	-0.010(-2.79)	-76.48(-6.48)	-0.010(-2.79)	-76.48(-6.48)	-0.010(-2.79)
SeptOct04	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
NovDec04	-40.93(-3.45)	-0.01(-1.47)	-39.11(-3.30)	-0.0047(-1.24)	-42.27(-3.57)	-0.006(-1.49)	-44.29(-3.74)	-0.006(-1.59)	-45.6(-3.84)	-0.006(-1.67)
JanFeb05	56.45(4.77)	0.02(3.99)	56.47(4.77)	0.015(3.99)	56.477(4.78)	0.015(4.00)	56.47(4.78)	0.015(4.00)	56.48(4.78)	0.015(4.00)
MarApr05	48.71(4.11)	0.01(3.60)	48.71(4.11)	0.014(3.59)	48.74(4.12)	0.014(3.60)	48.72(4.12)	0.014(3.6)	48.74(4.12)	0.014(3.6)
MayJun05	80.96(5.29)	0.01(1.80)	80.98(5.29)	0.009(1.80)	80.95(5.30)	0.009(1.80)	80.95(5.30)	0.009(1.8)	80.95(5.30)	0.009(1.8)
JulAug05	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
SeptOct05	97.54(8.24)	0.02(4.70)	97.53(8.23)	0.018(4.70)	97.55(8.25)	0.018(4.71)	97.56(8.26)	0.018(4.71)	97.56(8.25)	0.018(4.71)
NovDec04	19.26(1.62)	0.01(1.45)	21.08(1.78)	0.006(1.68)	17.92(1.51)	0.005(1.43)	15.91(1.35)	0.005(1.33)	14.59(1.23)	0.005(1.25)
JanFeb06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MarApr06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MayJun06	128.77(8.43)	0.02(4.31)	128.78(8.43)	0.021(4.31)	128.78(8.44)	0.021(4.32)	128.78(8.45)	0.021(4.32)	128.78(8.45)	0.021(4.32)
JulAug06	-63.78(-5.38)	-0.02(-4.24)	-63.79(-5.38)	-0.016(-4.24)	-63.79(-5.39)	-0.016(-4.24)	-62.19(-5.26)	-0.016(-4.13)	-63.83(-5.40)	-0.016(-4.24)
SeptOct06	73.69(6.21)	0.01(2.64)	73.68(6.21)	0.010(2.64)	73.7(6.22)	0.010(2.64)	75.31(6.36)	0.010(2.75)	79.77(6.67)	0.011(2.94)
NovDec06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
JanFeb07	5.69(0.48)	0.0009(0.24)	2.06(0.17)	-0.0008(-0.21)	8.47(0.71)	0.001(0.28)	10.89(0.92)	0.001(0.37)	9.02(0.76)	0.001(0.31)
MarApr06	-10.74(-0.90)	0.0006(0.15)	-14.43(-1.22)	-0.0012(-0.31)	-7.93(-0.67)	0.001(0.20)	-5.51(-0.47)	0.001(0.29)	-7.41(-0.63)	0.001(0.23)
MayJun07	-124.51(-10.48)	-0.03(-7.48)	-128.20(-10.82)	-0.03(-7.96)	-121.7(-10.27)	-0.028(-7.45)	-119.2(-10.07	-0.028(-7.36)	-121.2(-10.23)	-0.028(-7.42)
JulAug07	80.39(5.26)	0.01(2.23)	76.71(5.02)	0.01(1.88)	83.21(5.45)	0.011(2.27)	85.64(5.61)	0.011(2.34)	83.7(5.49)	0.011(2.29)
SeptOct07	26.09(2.19)	0.0015(0.40)	22.39(1.89)	-0.0002(-0.06)	28.93(2.44)	0.002(0.45)	31.37(2.64)	0.002(0.54)	29.47(2.48)	0.002(0.48)
NovDec07	-27.46(-2.32)	-0.01(-1.89)	-29.34(-2.48)	-0.01(-2.13)	-25.98(-2.20)	-0.007(-1.86)	-25.5(-2.16)	-0.007(-1.88)	-28.75(-2.43)	-0.008(-2.01)
Constant	358.14(37.54)	0.07(24.38)	358.13(37.52)	0.07(24.36)	358.16(37.59)	0.074(24.40)	358.2(37.63)	0.074(24.4)	358.18(37.61)	0.074(24.4)

The figures in the parenthesis are the t-statistics

Table 4: Spillover Effects with C2 as the comparison group

	T1C2-levels	T1C2-rates	T2C2-levels	T2C2-rates	T3C2-levels	T3C2-rates	T4C2-levels	T4C2-rates	T5C2-levels	T5C2-rates
bednets	0.0017(0.43)	-0.0000003(-0.24)	0.0018(0.43)	-0.0000003(-0.2	0.002(0.43)	-0.0000003(-0.2	0.0018(0.43)	-0.0000003(-0.24	0.0018(0.43)	-0.0000003(-0.23
immun	0.42(11.24)	0.00009(7.64)	0.43(11.19)	0.00009(7.62)	0.427(11.19)	0.00009(7.62)	0.427(11.2)	0.00009(7.62)	0.43(11.2)	0.00009(7.63)
T1	-243.4(-12.51)	-0.055(-8.9)	-	-	-	-	-	-	-	-
T2	-	-	-49.18(-3.27)	-0.021(-4.36)	-	-	-	-	-	-
T3	-	-	-	-	-25.477(-1.02)	-0.009(-1.14)	-	-	-	-
T4	-	-	-	-	-	-	-122.067(-7.00)	-0.032(-5.78)	-	-
T5	-	-	-	-	-	-	-	-	-146.98(-9.59)	-0.038(-7.76)
TF1	-	-	-	-	-	-	-	-	-	-
d1	70.8(4.70)	0.009(1.8)	70.81(4.68)	0.009(1.8)	70.775(4.68)	0.009(1.8)	70.795(4.69)	0.009(1.80)	70.76(4.69)	0.008(1.76)
d2	74.49(4.95)	0.010(2.09)	74.56(4.94)	0.010(2.08)	74.561(4.94)	0.010(2.08)	74.525(4.94)	0.010(2.08)	74.40(4.93)	0.010(2.03)
d3	94.6(6.28)	0.011(2.39)	94.63(6.26)	0.011(2.38)	94.63(6.26)	0.011(2.38)	94.630(6.27)	0.011(2.38)	94.65(6.27)	0.011(2.34)
d4	27.37(1.82)	-0.002(-0.36)	27.36(1.81)	-0.002(-0.36)	27.362(1.81)	-0.002(-0.36)	27.366(1.81)	-0.002(-0.36)	26.75(1.77)	-0.002(-0.47)
d5	20.42(2.12)	0.006(1.91)	20.40(2.11)	0.006(1.91)	20.397(2.11)	0.006(1.9)	20.412(2.11)	0.006(1.91)	20.62(2.13)	0.006(1.94)
d6	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
d7	199.2(13.25)	0.039(8.18)	199.24(13.20)	0.039(8.17)	199.249(13.19)	0.039(8.16)	199.240(13.21)	0.039(8.17)	199.83(13.25)	0.039(8.20)
d8	141.8(9.43)	0.025(5.22)	141.82(9.40)	0.025(5.21)	141.823(9.39)	0.025(5.21)	141.819(9.41)	0.025(5.22)	141.74(9.4)	0.025(5.17)
d9	-14.39(-0.96)	-0.005(-1.13)	-14.37(-0.95)	-0.005(-1.13)	-14.37(-0.95)	-0.005(-1.13)	-14.381(-0.95)	-0.005(-1.13)	-14.36(-0.95)	-0.006(-1.16)
d10	-26.8(-1.78)	-0.009(-1.86)	-26.80(-1.77)	-0.009(-1.85)	-26.792(-1.77)	-0.009(-1.85)	-26.804(-1.78)	-0.009(-1.85)	-26.74(-1.77)	-0.009(-1.87)
d11	6.7(0.45)	-0.007(-1.44)	4.44(0.29)	-0.007(-1.49)	3.394(0.22)	-0.008(-1.59)	5.444(0.36)	-0.007(-1.48)	7.08(0.47)	-0.007(-1.45)
d12	-5.6(-0.37)	-0.009(-1.8)	-9.39(-0.62)	-0.009(-1.88)	-11.141(-0.74)	-0.010(-2.04)	-7.720(-0.51)	-0.009(-1.87)	-5.81(-0.38)	-0.009(-1.83)
JanFeb04	-113.6(-9.6)	-0.022(-5.8)	-113.62(-9.56)	-0.022(-5.8)	-113.603(-9.56)	-0.022(-5.79)	-113.599(-9.57)	-0.022(-5.80)	-113.70(-9.58)	-0.022(-5.79)
MarApr04	-104.9(-8.83)	-0.017(-4.47)	-104.90(-8.79)	-0.017(-4.47)	-104.887(-8.79)	-0.017(-4.46)	-104.91(-8.8)	-0.017(-4.47)	-104.79(-8.8)	-0.017(-4.43)
MayJun04	-17.5(-0.91)	-0.005(-0.83)	-17.52(-0.91)	-0.005(-0.83)	-17.512(-0.91)	-0.005(-0.83)	-17.533(-0.91)	-0.005(-0.83)	-17.59(-0.91)	-0.005(-0.85)
JulAug04	-77.02(-6.53)	-0.011(-2.85)	-77.03(-6.50)	-0.011(-2.85)	-77.029(-6.5)	-0.011(-2.85)	-77.023(-6.51)	-0.011(-2.85)	-76.71(-6.48)	-0.011(-2.79)
SeptOct04	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
NovDec04	-43.95(-3.72)	-0.006(-1.55)	-40.93(-3.45)	-0.005(-1.45)	-39.531(-3.33)	-0.005(-1.29)	-42.270(-3.56)	-0.006(-1.48)	-44.41(-3.74)	-0.006(-1.59)
JanFeb05	56.24(4.76)	0.015(3.95)	56.21(4.74)	0.015(3.94)	56.224(4.74)	0.015(3.94)	56.231(4.75)	0.015(3.95)	56.65(4.79)	0.015(4.00)
MarApr05	48.32(4.09)	0.013(3.53)	48.25(4.07)	0.013(3.52)	48.240(4.07)	0.013(3.52)	48.270(4.07)	0.013(3.52)	48.73(4.11)	0.014(3.59)
MayJun05	81.18(5.32)	0.009(1.81)	81.22(5.30)	0.009(1.81)	81.234(5.3)	0.009(1.81)	81.205(5.3)	0.009(1.81)	81.47(5.32)	0.009(1.81)
JulAug05	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
SeptOct05	97.7(8.27)	0.018(4.71)	97.69(8.24)	0.018(4.7)	97.684(8.23)	0.018(4.69)	97.694(8.25)	0.018(4.70)	97.81(8.26)	0.018(4.71)
NovDec04	16.4(1.39)	0.005(1.38)	19.43(1.64)	0.006(1.47)	20.830(1.75)	0.006(1.64)	18.087(1.53)	0.005(1.45)	15.97(1.35)	0.005(1.33)
JanFeb06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MarApr06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MayJun06	129.9(8.53)	0.021(4.43)	129.96(8.49)	0.021(4.42)	129.961(8.49)	0.021(4.42)	129.95(8.5)	0.021(4.42)	129.50(8.48)	0.021(4.33)
JulAug06	-63.57(-5.38)	-0.016(-4.2)	-63.57(-5.35)	-0.016(-4.19)	-63.571(-5.35)	-0.016(-4.19)	-63.569(-5.36)	-0.016(-4.19)	-62.24(-5.25)	-0.016(-4.13)
SeptOct06	74.17(6.27)	0.010(2.69)	74.17(6.24)	0.010(2.69)	74.163(6.24)	0.010(2.68)	74.171(6.25)	0.010(2.69)	75.53(6.36)	0.010(2.75)
NovDec06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
JanFeb07	11.75(0.99)	0.002(0.4)	5.48(0.46)	0.001(0.2)	2.697(0.23)	-0.0004(-0.12)	8.255(0.69)	0.001(0.25)	10.74(0.9)	0.001(0.37)
MarApr07	-4.58(-0.39)	0.001(0.32)	-11.01(-0.93)	0.0007(0.11)	-13.854(-1.17)	-0.001(-0.22)	-8.195(-0.69)	0.001(0.16)	-5.67(-0.48)	0.001(0.28)
MayJun07	-118.27(-10.00)	-0.027(-7.31)	-124.69(-10.48)	-0.028(-7.48)	-127.54(-10.75)	-0.029(-7.83)	-121.8(10.27)	-0.028(-7.45)	-119.79(-10.09)	-0.028(-7.37)
JulAug07	87.42(5.73)	0.012(2.44)	81.02(5.29)	0.011(2.28)	78.19(5.11)	0.010(2.03)	83.826(5.48)	0.011(2.32)	85.95(5.62)	0.011(2.34)
SeptOct07	32.79(2.77)	0.002(0.63)	26.36(2.21)	0.002(0.42)	23.507(1.98)	0.0003(0.09)	29.181(2.45)	0.002(0.47)	31.31(2.63)	0.002(0.53)
NovDec07	-24.04(-2.03)	-0.007(-1.78)	-27.46(-2.31)	-0.007(-1.89)	-28.91(-2.44)	-0.008(-2.06)	-25.977(-2.19)	-0.007(-1.86)	-25.65(-2.16)	-0.007(-1.88)
Constant	330.97(28.04)	0.075(20.09)	330.97(27.92	0.075(20.06)	330.97(27.91	0.075(20.04)	330.975(27.95)	0.075(20.06)	332.29(28.08)	0.076(20.27)

The figures in the parenthesis are the t-statistics

Table 5: Sensitivity Analysis with the 20 per cent of both treated and controls with highest average morbidity left out

	T1C1-levels	T1C1-rates	T2C1-levels	T2C1-rates	T3C1-levels	T3C1-rates	T4C1-levels	T4C1-rates	T5C1-levels	T5C1-rates
bednets	0.0012(-0.40)	-0.0000007(-0.57)	-0.0012(-0.39)	-0.0000007(-0.5	-0.0012(-0.39)	-0.0000007(-0.5	-0.0013(-0.39)	-0.0000007(-0.56	-0.0012(-0.39)	-0.0000007(-0.56
immun	0.09(2.84)	0.000018(1.66)	0.09(2.85)	0.00002(1.66)	0.09(2.86)	0.00002(1.68)	0.09(2.84)	0.00002(1.66)	0.08(2.82)	0.00002(1.65)
T1	-158.12(-9.66)	-0.040(-6.71)	-	-	-	-	-	-	-	-
T2	-	-	-71.52(-5.52)	-0.021(-4.39)	-	-	-	-	-	-
T3	-	-	-	-	-45.74(-2.07)	-0.008(-1.01)	-	-	-	-
T4	-	-	-	-	-	-	-109.85(-7.26)	-0.027(-4.92)	-	-
T5	-	-	-	-	-	-	-	-	-106.18(-7.91)	-0.026(-5.25)
TF1	-	-	-	-	-	-	-	-	-	-
d1	120.50(11.26)	0.020(5.16)	120.52(11.24)	0.020(5.16)	120.44(11.22)	0.020(5.15)	120.49(11.24)	0.020(5.16)	120.50(11.25)	0.020(5.16)
d2	118.01(11.04)	0.021(5.24)	118.06(11.02)	0.021(5.24)	118.04(11.01)	0.021(5.24)	118.03(11.03)	0.021(5.24)	118.04(11.04)	0.021(5.24)
d3	57.43(8.52)	0.012(4.83)	57.45(8.51)	0.012(4.83)	57.45(8.5)	0.012(4.82)	57.44(8.51)	0.012(4.83)	57.44(8.51)	0.012(4.83)
d4	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
d5	79.32(5.49)	0.021(3.86)	79.32(5.48)	0.021(3.86)	79.29(5.47)	0.021(3.85)	79.31(5.49)	0.021(3.86)	79.32(5.49)	0.021(3.86)
d6	66.16(5.44)	0.016(3.68)	66.17(5.43)	0.016(3.68)	66.15(5.42)	0.016(3.68)	66.16(5.43)	0.016(3.68)	66.17(5.44)	0.016(3.68)
d7	217.52(20.35)	0.045(11.36)	217.53(20.31)	0.045(11.35)	217.52(20.29)	0.045(11.35)	217.53(20.32)	0.045(11.36)	217.53(20.33)	0.045(11.36)
d8	173.82(16.27)	0.033(8.34)	173.82(16.23)	0.033(8.33)	173.80(16.22)	0.033(8.33)	173.82(16.25)	0.033(8.33)	173.83(16.25)	0.033(8.34)
d9	46.96(4.39)	0.008(2.15)	46.96(4.38)	0.008(2.15)	46.96(4.38)	0.008(2.15)	46.96(4.39)	0.008(2.15)	46.96(4.39)	0.008(2.15)
d10	37.31(3.49)	0.006(1.60)	37.32(3.48)	0.006(1.59)	37.32(3.48)	0.006(1.59)	37.32(3.48)	0.006(1.59)	37.32(3.49)	0.006(1.6)
d11	53.30(4.98)	0.005(1.37)	52.81(4.93)	0.005(1.36)	51.52(4.8)	0.005(1.25)	52.95(4.94)	0.005(1.35)	53.99(5.04)	0.006(1.41)
d12	42.03(3.93)	0.004(0.99)	41.21(3.84)	0.004(0.96)	39.07(3.64)	0.003(0.79)	41.45(3.87)	0.004(0.95)	42.44(3.96)	0.004(1.01)
JanFeb04	-78.44(-8.22)	-0.014(-3.94)	-78.47(-8.21)	-0.014(-3.94)	-78.44(-8.2)	-0.014(-3.93)	-78.44(-8.21)	-0.014(-3.94)	-78.45(-8.22)	-0.014(-3.94)
MarApr04	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MayJun04	-8.37(-0.54)	-0.002(-0.41)	-8.36(-0.54)	-0.002(-0.41)	-8.35(-0.54)	-0.002(-0.41)	-8.37(-0.54)	-0.002(-0.41)	-8.37(-0.54)	-0.002(-0.41)
JulAug04	-63.62(-6.68)	-0.009(-2.47)	-63.62(-6.67)	-0.009(-2.46)	-63.62(-6.66)	-0.009(-2.46)	-63.62(-6.67)	-0.009(-2.47)	-63.62(-6.67)	-0.009(-2.47)
SeptOct04	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
NovDec04	-33.16(-3.48)	-0.006(-1.72)	-32.50(-3.4)	-0.006(-1.69)	-30.80(-3.22)	-0.005(-1.54)	-32.69(-3.42)	-0.006(-1.68)	-33.71(-3.53)	-0.006(-1.75)
JanFeb05	36.77(3.86)	0.009(2.54)	36.74(3.85)	0.009(2.54)	36.77(3.85)	0.009(2.54)	36.77(3.85)	0.009(2.54)	36.77(3.85)	0.009(2.54)
MarApr05	109.60(11.48)	0.017(4.77)	109.55(11.45)	0.017(4.77)	109.53(11.44)	0.017(4.76)	109.58(11.46)	0.017(4.77)	109.58(11.47)	0.017(4.77)
MayJun05	53.96(4.38)	0.002(0.37)	53.96(4.37)	0.002(0.37)	53.98(4.37)	0.002(0.37)	53.96(4.37)	0.002(0.37)	53.96(4.37)	0.002(0.37)
JulAug05	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
SeptOct05	79.40(8.33)	0.014(4.06)	79.39(8.31)	0.014(4.05)	79.38(8.3)	0.014(4.05)	79.40(8.32)	0.014(4.05)	79.40(8.32)	0.014(4.05)
NovDec04	26.63(2.79)	0.006(1.73)	27.29(2.85)	0.006(1.76)	28.99(3.03)	0.007(1.91)	27.10(2.83)	0.006(1.77)	26.09(2.73)	0.006(1.7)
JanFeb06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MarApr06	69.04(7.21)	0.009(2.61)	69.03(7.19)	0.009(2.60)	69.00(7.18)	0.009(2.6)	69.04(7.2)	0.009(2.61)	69.06(7.2)	0.009(2.61)
MayJun06	82.00(6.67)	0.011(2.36)	82.00(6.66)	0.011(2.36)	82.00(6.65)	0.011(2.36)	82.00(6.66)	0.011(2.36)	82.00(6.66)	0.011(2.36)
JulAug06	-58.17(-6.10)	-0.014(-4.00)	-58.18(-6.08)	-0.014(-4.00)	-58.18(-6.08)	-0.014(-3.99)	-58.18(-6.09)	-0.014(-4.00)	-57.09(-5.97)	-0.014(-3.92)
SeptOct06	49.35(5.17)	0.006(1.71)	49.35(5.16)	0.006(1.71)	49.33(5.15)	0.006(1.71)	49.35(5.16)	0.006(1.71)	50.44(5.28)	0.006(1.79)
NovDec06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
JanFeb07	-8.80(-0.92)	-0.002(-0.49)	-10.27(-1.07)	-0.002(-0.55)	-13.60(-1.42)	-0.003(-0.86)	-9.80(-1.02)	-0.002(-0.58)	-8.87(-0.93)	-0.002(-0.52)
MarApr07	47.37(4.95)	0.005(1.55)	45.83(4.77)	0.005(1.48)	42.37(4.42)	0.004(1.17)	46.31(4.83)	0.005(1.47)	47.24(4.93)	0.005(1.52)
MayJun07	37.82(3.08)	-0.001(-0.17)	36.29(2.94)	-0.001(-0.22)	32.85(2.66)	-0.002(-0.46)	36.77(2.99)	-0.001(-0.23)	37.69(3.06)	-0.001(-0.19)
JulAug07	-115.64(-12.12)	-0.028(-7.90)	-117.17(-12.23)	-0.028(-7.95)	-120.62(-12.61)	-0.029(-8.28)	-116.69(-12.2)	-0.028(-7.98)	-115.77(-12.11)	-0.03(-7.92)
SeptOct07	24.29(2.54)	0.000(-0.08)	22.75(2.37)	-0.0009(-0.14)	19.29(2.01)	-0.002(-0.46)	23.23(2.43)	-0.001(-0.16)	24.16(2.52)	-0.0004(-0.1)
NovDec07	-9.13(-0.96)	-0.004(-1.20)	-10.01(-1.05)	-0.004(-1.24)	-11.77(-1.23)	-0.005(-1.4)	-9.72(-1.02)	-0.004(-1.25)	-9.81(-1.03)	-0.004(-1.26)
Constant	186.30(24.54)	0.043(15.54)	186.29(24.48)	0.043(15.52)	186.30(24.46	0.043(15.51)	186.30(24.5)	0.043(15.53)	186.30(24.51)	0.043(15.53)

The figures in the parenthesis are the t-statistics

Table 6: Impacts of the CWF-shops on malaria morbidity

	levels	**rates**
bednets	0.00179(0.43)	-0.0000003(-0.23)
immun	0.43(11.19)	0.00009(7.64)
timeotlet	-121.56(-6.21)	-0.018(-2.94)
d1	43.47(3.28)	0.011(2.52)
d2	47.25(3.57)	0.012(2.84)
d3	67.56(8.08)	0.013(5.05)
d4	(dropped)	(dropped)
d5	-8.42(-0.47)	0.008(1.37)
d6	-28.97(-1.92)	0.002(0.4)
d7	170.62(12.89)	0.041(9.77)
d8	112.84(8.53)	0.027(6.34)
d9	-43.64(-3.29)	-0.004(-0.87)
d10	-56.02(-4.22)	-0.007(-1.69)
d11	-23.42(-1.77)	-0.006(-1.37)
d12	-38.21(-2.89)	-0.008(-1.92)
JanFeb04	-115.66(-9.76)	-0.022(-5.87)
MarApr04	-107.07(-8.99)	-0.017(-4.52)
MayJun04	-17.75(-0.92)	-0.005(-0.85)
JulAug04	-77.15(-6.53)	-0.011(-2.82)
SeptOct04	(dropped)	(dropped)
NovDec04	-42.16(-3.56)	-0.005(-1.35)
JanFeb05	54.16(4.58)	0.015(3.9)
MarApr05	46.40(3.92)	0.013(3.5)
MayJun05	81.31(5.32)	0.009(1.81)
JulAug05	(dropped)	(dropped)
SeptOct05	98.88(8.36)	0.018(4.75)
NovDec04	19.37(1.64)	0.006(1.62)
JanFeb06	(dropped)	(dropped)
MarApr06	(dropped)	(dropped)
MayJun06	131.76(8.63)	0.021(4.4)
JulAug06	-61.48(-5.19)	-0.016(-4.14)
SeptOct06	76.68(6.46)	0.010(2.75)
NovDec06	(dropped)	(dropped)
JanFeb07	2.62(0.22)	-0.001(-0.22)
MarApr07	-13.41(-1.13)	-0.001(-0.3)
MayJun07	-125.19(-10.58)	-0.030(-7.87)
JulAug07	80.40(5.27)	0.010(1.97)
SeptOct07	26.11(2.2)	0.0002(0.06)
NovDec07	-28.69(-2.42)	-0.008(-2.12)
Constant	365.22(38.04)	0.075(24.54)

The figures in the parenthesis are the t-statistics

Appendix B - Definition of variables

Outcomes

Malaria Morbidity: Number of severe cases of malaria per sub-location per month
Malaria Mortality: Number of malaria deaths per sub-location per month

Treatment groups

treat1=1 - If all of the sub-location's borders lie within 5 kms to the nearest outlet distributing free Coartem.

timeal1 - The time the sub-locations for which treat1=1 started providing free Coartem

T_1 - is the interaction term between timeal1 and treat1 i.e. T_1=treat1*timeal1

treat2=1 - If a sub-location is entirely within 10 kms to an outlet giving free Coartem.

timeal2 - The time the sub-locations for which treat2=1 started providing free Coartem

T_2 - is the interaction term between timeal2 and treat2 i.e. T_2=*treat2*timeal2*

allwithal=1 - If a sub-location had an outlet that was providing free Coartem in that month. Does not include any neighbors without an outlet providing free Coartem.

timeal - Denotes the time the outlets with *allwithal=1* started providing free Coartem

T_3 - is the interaction term between *timeal* and *allwithal* i.e. T_3=*allwithal*timeal*

T_4 - T_4=1 if T_3=1 or if T_1=1

T_5 - T_5=1 if T_4=1 of if T_4 would equal one except for the fact that the shop was charging for Coartem in a particular month than giving it for free.

sell -equals one for sub-location with outlets that were selling Coartem and zero otherwise.

timesell -Is a time dummy variable denoting the time the outlets started selling Coartem

selltreat - Is an interaction term between *sell* and *timesell*

Comparison groups

C_{11} - All sub-locations not included in T_1

C_{12} - All sub-locations not included in T_2

C_{13} - All sub-locations not included in T_3

C_{14} - All sub-locations not included in T_4

C_{15} - All sub-locations not included in T_5

C_{21} - All sub-locations in group C_{11} which do not share a common border with the sub-location in T_1

C_{22} - All sub-locations in group C_{12} which do not share a common border with the sub-location in T_2

C_{23} - All sub-locations in group C_{13} which do not share a common border with the sub-location in T_3

C_{24} - All sub-locations in group C_{14} which do not share a common border with the sub-location in T_4

C_{25} - All sub-locations in group C_{15} which do not share a common border with the sub-location in T_5

Seasonal Monthly Dummies

d_1 - represents the month of January (equals to one if month is January and zero otherwise)

d_2 - represents the month of February (equals to one if month is February and zero otherwise)

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d_{12} - represents the month of December (equals to one if month is December and zero otherwise)

morbrate- morbidity rate – number of sub-location morbidity cases divided by sub-location population.

TF1 -*FT1=1* (for sub-locations that are treated in at least one month under definition T_4) in the three months prior to the first month in which $T_4 = 1$ and zero in all other months and sub-locations where $T_4 = 0$

outlet=1 - If a sub-location had an outlet in that month, whether stocking Coartem or not.

timeoutlet - Denotes the time the outlets was built.

treatoutlet - is the interaction term between outlet and timeoutlet i.e. treatoutlet=outlet*timeoutlet