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Evaluating the Impact of Microfranchising the Distribution of Anti-malaria Drugs in Kenya on Mortality and Morbidity

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

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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-difference to evaluate the effectiveness of the programme in increasing access to the drugs and hence on its impact on malaria morbidity and mortality. If effective, this system can be adopted 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 results show that the programme had significant positive impacts on malaria morbidity. The impact is, however, less when the patients have to walk longer distances to access the drugs. Further, the findings show that even without the free anti-malaria drugs, the outlets in themselves have had a significant negative impact on malaria morbidity. Programme impact on mortality is generally insignificant. The programme is therefore recommendable for replication.

Abbreviations and Acronyms

CFW	Child and Family Wellness
CIA	Conditional Independence Assumption
GPS	Global Positioning System
KEMSA	Kenya Medical Supplies Agency
KMPDB	Kenya Medical Practitioners and Dentists Board
MDGs	Millennium Development Goals
MOH	Ministry of Health
SHF	Sustainable Healthstore Foundation
WHO	World Health Organization

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1. Introduction

The severity of malaria cannot be over-emphasised. The World Health Organization (WHO) estimates that at least 40 per cent of the world population are 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). World Health Organization (2006) also estimates that malaria accounts for about 20 per cent of all childhood deaths. In Kenya, the United Nations Development Programme (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 64.7 per cent (Ministry of Health-MoH, 2001 and World Health Organization, 2008).

Recognizing its severity, the United Nations Millennium Development Goals (MDGs) explicitly put 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: use of treated bed nets, spraying of houses with insecticides, among others. Other than the preventive measures, curative measures are a major emphasis in containing the incidence of severe cases of malaria. One of the progress indicators towards achieving the eighth MDG on malaria is the proportion of population in malaria-risk areas using effective malaria prevention and treatment measures. This indicator recognizes 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 medicine among the rural poor is largely lacking. The World Health Organization (2006) notes that the burden of malaria is exuberated by the fact that barely half of the cases (53%) receive appropriate anti-malaria drugs from formal health facilities. The Ministry of Health (2001) estimates that only 2.2 per cent of the children with malaria receive the correct treatment within 24 hours of the onset of fever in the districts surveyed in Kenya.

Due to 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 in order to reach the often-neglected population, more so in rural areas with impassible roads and no government facilities.

The Government of Kenya in partnership with a local non-governmental organization, 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 programme, the medicines are provided for free by the government through the central procurement body, 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 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 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 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 into 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 MDG.

Other than addressing the MDGs, 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. The system has a great potential for replication in other African and Asian countries that experience similar health challenges. The question however is: Has the programme been effective in increasing access to the anti-malarial drugs? 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 programme with a view to recommend 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.

The study is organised as follows: Section two provides the details of the programme, and Section three gives the empirical strategy adopted, choice of variables and data used. Section four gives the empirical results, while Section five summarises, concludes and makes recommendations.

2. Programme Description

2.1 Structure of the Programme

In 1995, the Kenyan government 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 TB embarked on an innovative programme 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. As for anti-malaria drugs, the CFW shops get Coartem from the government for free through the SHF and give them out to 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 US$ 0.25 (the same screening fee is charged in government hospitals).

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 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 are sold. There is also a thorough training programme that ensures every operator knows how to diagnose the target conditions and accurately prescribe the correct medicine. 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 programme 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 Programme Unique?

The uniqueness of the programme is anchored on 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 people, ensures that more patients who could have otherwise not accessed the medicines, especially those far away from public health facilities, are catered 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. More so, it ensures prompt procurement due to reduced bureaucracy.

The shops provide prompt and effective services because 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 have been paid to the public hospitals. Also, effective and prompt service and reduced negligence are due to 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 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 Kiswahili or English can easily misunderstand the instructions given on the doses and this can sometimes be fatal.

3. Empirical Strategy

To evaluate the impact of the free malaria drugs, a question is asked: 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, a difference-in-difference methodology to assess the impacts of the programme on both morbidity and mortality is used. The key assumption underlying the difference-in-difference is that any selective differences between the treated and the untreated sub-locations are constant over time. Therefore, 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 $S = 1$ if a sub-location is treated, and $S = 1$ if the sub-location is a control sub-location so that;

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

Let us also define the average outcome (morbidity or mortality) in the treated sub-location as Y_1 and the average 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 $E(Y_1|S=1)$ and unobserved mean outcome under the condition of control $E(Y_0|S=1)$. Similarly, for the control sub-location, we have both unobserved mean under the condition of intervention $E(Y_1|S=0)$ and the observed mean under the condition of control $E(Y_0|S=0)$. The intermediate task is therefore to construct the counterfactual, given as $E(Y_0|S=1)$ 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 can estimate the counterfactuals from a simple D-in-D estimation using a fixed effects model without matching, provided we have identified a control group or we can estimate the D-in-D after

matching the control and the treated groups. One common way to match the control and the treated groups is by using the 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 very 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, one of the major assumptions underlying matching estimators, the conditional independence assumption (CIA), is very unlikely to have any plausibility in our study since the covariates (bed nets and health seeking behaviour) are likely to be correlated with the outcomes (morbidity and mortality). In other words, when it is true that increased bed-nets for instance would decrease malaria morbidity rates, increased morbidity rates may, on the other hand, lead the government to give out more bed nets. This means, therefore, that we cannot match. We instead use a simple D-in-D without matching to estimate the effect of the programme on the outcome indicators, mortality and morbidity.

3.2 Choice of Covariates

We choose control variables based on a review of health literature to determine what other factors, other than the introduction of the programme, 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 out to the sub-location per month. This data was obtained from the respective district government hospitals.
- Health-seeking behaviour 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 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 such as 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 uses 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. 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 the outlet in that sub-location started stocking the free medicines.

Since the programme is new and there are not yet many outlets running, we carry out an evaluation in all sub-locations in the five districts under study, which are: Kirinyaga, Embu, Mbeere, Thika and Nairobi. It is in these five districts that the programme 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 is divided 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 Treatment Condition

Different definitions of treatment condition are used to evaluate how the results change with the change in the treatment definitions.

3.4.1 When treatment condition is 5kms of reach

In the first 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 neighbouring 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 neighbouring 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 the field survey, which show 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. Ninety four (94) per cent of the respondents indicated that they were willing to walk for up to 30 minutes to access the free anti-malaria drugs. A walk of 30 minutes is roughly a 3.5kms distance walk. Four per cent indicated that they were willing to walk for up to one hour to access the drugs (around 6kms), and only one per cent were willing to walk for up to two hours (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 criterion, all the CFW-outlets are mapped using the global positioning system (GPS). From this mapping, the distance from all the points of the sub-location to their respective nearest outlet stocking free Coartem are measured. 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. The other definitions of treatment conditions used for sensitivity analysis are given in the section on empirical results.

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 both uncomplicated and severe malaria cases per sub-location per month. 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 includes: the number of bed nets given out to the sub-location per month and the number of immunizations per month. This data is 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 Appendix A Table 1. From the descriptive statistics, the average mortality cases in the sub-locations are 0.37 persons, while the average morbidity cases are 393 persons. The average distance of the sub-locations away from the nearest outlet is 13kms. The average number of children immunized is 29, while the average number of bednets given by the government is 43.

4.2 Programme Impacts

4.2.1 Impact of treatment when distance is restricted to 5kms

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 *treat1=1* which 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-$\tilde{T}_1$ where *N=371* is the 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;

$$morb_{it} = \beta_{10} + \beta_{11}\left(bednets\right)_{it} + \beta_{12}\left(immun\right)_{it} + \beta_{13}\left(T_1\right) + \beta_{14}d_m + \beta_{15}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.1)$$

$$\ln morb_{it} = \alpha_{10} + \alpha_{11}\left(bednets\right)_{it} + \alpha_{12}\left(immun\right)_{it} + \alpha_{13}\left(T_1\right) + \alpha_{14}d_m + \alpha_{15}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.2)$$

where $morb_{it}$ are the malaria morbidity cases for sub-location *i* in time *t*, $lmorb_i$ is the natural log of morbidity for sub-location *i* in time *t*. $(bednets)_{it}$ and $(immune)_{it}$ are the number of bed nets and the number of children immunized (denoting the health seeking behaviour), respectively, of sub-location *i* in time *t*. 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 senting the adjacent month pairs (JanFeb, MarchApril, MayJune and so on), $y=2004,2005,2006,2007$. Therefore, $YD_{Jan\text{-}Feb,2004=1}$ if $\hat{m}=Jan\text{-}Feb$ pair and y=2004(for the months of January and February 2004) and zero otherwise. In the estimation results given in the Appendix, 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 programme on malaria mortality.

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 the Tables 2 (column T1C1-levels) in Appendix A. The results show that the introduction of the programme has had a negative and significant 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 natural logarithm of the morbidity as the dependent variable, the results given in Appendix A Table 2 (column T1C1-logs) show that following the introduction of the programme, malaria morbidity significantly reduced by 46 per cent in the sub-locations, with all their borders within 5kms to the nearest outlet providing free Coartem. The people's health seeking behaviour 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 0.0017 case. The average health seeking rate is 29.59 (see the descriptive statistics in Appendix A Table 1). This shows that the positive impact obtained is not substantially significant. Bed nets have statistically insignificant impacts on malaria morbidity.

This could probably be an indication that the people could have been given the nets but they do not use the nets as 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 in 2001 done in Kwale, Makueni, Kisii/Gucha and Bondo districts estimated the proportion as 4.6 per cent in the districts.

Except 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 significance 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 and the weather is the most conducive 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 for mosquito breeding. These findings are important for the timing of intervention measures in the prevention of malaria. It would be more beneficial to give more bed nets between July and August as this is when 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 reduce malaria morbidity compared to the other years. The results also show a significant reduction on mortality cases with an additional outlet providing free Coartem reducing mortality by approximately one case (0.59).

Therefore, provision of free anti-malarial drugs through the outlets reduces malaria morbidity in the sub-locations that can access the drugs within 5kms from where they live; the impacts of health-seeking behaviour of the people in these areas is substantially insignificant in reducing malaria morbidity; increasing bed nets has no significant impact on malaria morbidity probably due to low usage and/or wrong timing of provision of the nets and, finally; malaria morbidity is highest in the months of July and August and lowest between September and December. The results also show that malaria morbidity was lowest in 2004, followed by 2007 and highest in 2005 followed by 2006.

4.2.2 Impact of treatment when distance is restricted to 10kms

In this section, an analyzes of the impact of treatment is done under the condition of treatment T_2 where the assumption is that patients can walk for up to 10kms (and not more) to access the anti-malaria medicines. We construct the treatment condition T_2 by first defining the treatment variable *treat2,* which equals one if all of the sub-location's borders lie within 10kms to the nearest outlet distributing free Coartem and zero otherwise. A time dummy variable *timeal2* is then constructed denoting the time the sub-locations for which *treat2=1* started receiving free coartem. We then interact the treatment dummy and the time dummy to obtain the interaction term T_2, that is; T_2=*treat2*timeal2*. The comparison group is C_{12} where $C_{11} \neq C_{12} = N - \tilde{T}_2$ where *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* (see the definition of variables in Appendix B). In this sub-section, we estimate the models given as:

$$morb_{it} = \beta_{20} + \beta_{21}\left(bednets\right)_{it} + \beta_{22}\left(immun\right)_{it} + \beta_{23}\left(T_2\right) + \beta_{24}d_m + \beta_{25}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.3)$$

$$\ln morb_{it} = \alpha_{20} + \alpha_{21}\left(bednets\right)_{it} + \alpha_{22}\left(immun\right)_{it} + \alpha_{23}\left(T_2\right) + \alpha_{24}d_m + \alpha_{25}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.4)$$

where T_2 is the condition of treatment as defined at the beginning of this section. All the other variables are defined in section (4.2.1).

The results considering this treatment condition with the levels and natural log of morbidity as the outcome variables are given in Appendix A Table 2 (columns 4 and 5, T2C1-levels and T2C1-logs), respectively. 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 magnitude of impact is smaller than when the distance the patients could walk was restricted to 5kms. Using the natural log of malaria morbidity as the dependent variable, the results show that the programme has reduced malaria morbidity by 20 per cent in the areas up to 10kms around the outlets providing free Coartem. This is down from the 46 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 they 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 much smaller. The

treatment condition T_2 considers some patients who live far away from the shops 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. Again, over the annual seasonal cycle, highest seasonal increase in malaria morbidity is recorded in the months of July and August with the months of September to December recording the highest seasonal reductions in malaria morbidity. The results also show that malaria morbidity was higher in the years 2005 and 2006 compared to 2004 and 2007.

The impact of the programme on malaria mortality is statistically significant. According to the results, the coefficient is negative, implying that the shops have helped to reduce malaria mortality. However, the magnitude of the impact (0.32) is less than the average mortality of 0.37, implying that the magnitude may not be substantially significant. Given the insignificance of these results, the tables of the results are not provided here.

Generally, the results from this sub-section show that the further away the outlet providing free anti-malaria drugs is from the patients, the less likely it is that the patients will travel to the outlets to get medicine, and therefore the smaller is the impact of the programme. The impact of the programme therefore reduces as the distance to the outlets from the patient's home increases. 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 is restricted to 5kms.

4.2.3 Programme impact only in the sub-locations with outlets giving free Coartem

For comparison purposes, we consider an alternative treatment condition 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 $C_{11} \neq C_{12} = N - \tilde{T}_2$ where *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_3=*1* (see the definition of variables in Appendix B). In this section, we estimate the following model;

$$morb_{it} = \beta_{30} + \beta_{31}\left(bednets\right)_{it} + \beta_{32}\left(immun\right)_{it} + \beta_{33}\left(T_3\right) + \beta_{34}d_m + \beta_{35}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.5)$$

$$\ln morb_{it} = \alpha_{30} + \alpha_{31}\left(bednets\right)_{it} + \alpha_{32}\left(immun\right)_{it} + \alpha_{33}\left(T_3\right) + \alpha_{34}d_m + \alpha_{35}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.6)$$

where T_3 is the condition of treatment as defined at the beginning of this section. All the other variables are defined in section (4.2.1).

The estimation results with the levels and log of morbidity as the dependent variables are given in Appendix A Table 2 columns 6 and 7, T3C1-levels and T3C1-logs, respectively. The results using both levels and logs 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 programme 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 programme on morbidity, since the impact of the programme on mortality is consistently found to be insignificant.

The general conclusion here is that the patients do not use the outlets just because the outlets are in their own sub-locations, but they will consider the distance of the outlet to where they live before they can go there to access medicines. This calls for the establishment of more outlets where everyone in the sub-location can reach an outlet within 5kms from their homes.

4.2.4 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 we call it sell. *Sell=1* 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*. 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 models that are estimated in this sub-section are of the form:

$$morb_{it} = \beta_{50} + \beta_{51}(bednets)_{it} + \beta_{52}(immun)_{it} + \beta_{53}(T_5) + \beta_{54}d_m + \beta_{55}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.7)$$

$$\ln morb_{it} = \alpha_{50} + \alpha_{51}(bednets)_{it} + \alpha_{52}(immun)_{it} + \alpha_{53}(T_5) + \alpha_{54}d_m + \alpha_{55}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.8)$$

where T_5 is the condition of treatment as defined at the beginning of this section. All the other variables are defined in section (4.2.1).

The results given in Appendix A Table 2 columns 10 and 11, T5C1-levels and T5C1-logs, respectively, show that the impact of the outlets that were selling coartem is still negative and statistically different from zero. The results show that the total effect *(*T_5*)* of outlets selling with *selltreat=1* and those with (*T_4=1 if T_3=1 or if T_1=1*), the results show that, with the levels of morbidity as the dependent variable, the programme introduction to an additional sub-location reduces morbidity by 147 cases and by 33 per cent when the log of morbidity is used. This is an improvement in the impact of the programme from the reduction of morbidity by 131 cases and 30 per cent (levels and logs, respectively) when the condition of treatment excludes the outlets that were selling Coartem. This implies that even with the selling of the anti-malaria drugs, the presence of the outlets 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 the patients and, therefore, access to anti-malaria drugs was increased. The results further show that the impact of the programme malaria mortality when the treatment condition is defined as T_5 is statistically insignificant.

Therefore, although the anti-malaria medicines were being sold, they were now much nearer the patients and were used more when needed, hence reducing malaria morbidity.

4.2.5 Effect of spillovers to the other sub-locations

In this section, 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* is analysed. The comparison group C_{2q} includes sub-locations C_{1q} 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 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 programme 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 that share a common border with the sub-locations in $\tilde{T}_q$. This is done in order to filter out the spill over effects of the programme to the neighbouring sub-locations. The model that we estimate here is given as:

$$morb_{jt} = \tilde{\beta}_{q0} + \tilde{\beta}_{q1}\left(bednets\right)_{jt} + \tilde{\beta}_{q2}\left(immun\right)_{jt} + \tilde{\beta}_{q3}\left(T_q\right) + \tilde{\beta}_{q4}d_m + \tilde{\beta}_{q5}YD_{\hat{m}y} + \varepsilon_{jt} \quad (4.9)$$

$$\ln morb_{jt} = \tilde{\alpha}_{q0} + \tilde{\alpha}_{q1}\left(bednets\right)_{jt} + \tilde{\alpha}_{q2}\left(immun\right)_{jt} + \tilde{\alpha}_{q3}\left(T_q\right) + \tilde{\alpha}_{q4}d_m + \tilde{\alpha}_{q5}YD_{\hat{m}y} + \varepsilon_{jt} \quad (4.10)$$

where T_q are the different conditions of treatment as defined in the previous sections with *q=1,2,3,4,5*. All the other variables are defined in section (4.2.1) and $i \neq j = \left(N - B_q\right)$.

The results from the estimations are summarised in Appendix A Table 4. The results show that when the distance of treatment is restricted to 5kms, the programme has a negative and statistically significant impact on malaria morbidity. An additional shop reduces malaria mortality by 243 cases (see Appendix A 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 section 4.2.1). The results using the log of morbidity as the dependent variable show that the distribution of the free anti-malaria drugs through the CFW shops has significantly reduced malaria morbidity by 45 per cent (Appendix A Table 4, column 3 – T1C2-logs), down from 46 per cent obtained with the whole sample. When the distance is restricted to 10kms, the impact of the programme 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). The results with the log of morbidity as the dependent variable and the treatment condition T_2 show that the programme has significantly reduced morbidity by 18 per cent (see Appendix A Table 4 column 5 – T2C2-logs), down from 20 per cent obtained with the inclusion of the sub-locations with common borders with $\tilde{T}_3$.

Considering the impacts of the programme 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 (Appendix A 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 log of morbidity as the dependent variable also return a statistically insignificant impact coefficient, confirming the earlier results that the programme 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 programme. The results show that morbidity reduces by 122 cases (Appendix A Table 4, column 8 – T4C2-levels). This again is lower than the impact of the programme when the spillover effects to the neighbouring sub-locations are considered. Analyzing the impacts of the programme 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 have had a statistically significant impact on malaria morbidity in the treated sub-locations. The programme has reduced malaria morbidity by 146 cases (Table 4 column 10 – T5C2-levels), down from 147 obtained with the whole sample.

In general, the finding shows that the programme impacts are larger when the spillover effects to the neighbouring sub-locations are accounted for than if they are ignored. This indicates that the programme has significant spillover effects to the neighbouring sub-locations.

4.2.6 Impact on morbidity of the outlets 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 model that we estimate here is given by:

$$morb_{it} = \beta_{60} + \beta_{61}\left(bednets\right)_{it} + \beta_{62}\left(immun\right)_{it} + \beta_{63}\left(treatoutlet\right) + \beta_{64}d_m + \beta_{65}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.11)$$

$$\ln morb_{it} = \alpha_{60} + \alpha_{61}\left(bednets\right)_{it} + \alpha_{62}\left(immun\right)_{it} + \alpha_{63}\left(treatoutlet\right) + \alpha_{64}d_m + \alpha_{65}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.12)$$

The results from this estimation with the levels and log of morbidity as the outcome variables are given in the Appendix A Table 5 (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 natural logs of morbidity as the dependent variable, the results show that the building of outlets in those sub-locations have reduced malaria morbidity by 36 per cent. This implies that the existence of the outlets in the sub-locations in itself have led to reduced malaria morbidity even without the free anti-malaria drugs. It 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.

4.2.7 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 models that we estimate in this sub-section are given as:

$$morb_{st} = \beta'_{q0} + \beta'_{q1}\left(bednets\right)_{st} + \beta'_{q2}\left(immun\right)_{st} + \beta'_{q3}\left(T_q\right) + \beta'_{q4}d_m + \beta'_{q5}YD_{\dot{m}y} + \varepsilon_{st} \qquad (4.13)$$

$$\ln morb_{st} = \alpha'_{q0} + \alpha'_{q1}\left(bednets\right)_{st} + \alpha'_{q2}\left(immun\right)_{st} + \alpha'_{q3}\left(T_q\right) + \alpha'_{q4}d_m + \alpha'_{q5}YD_{\dot{m}y} + \varepsilon_{st} \qquad (4.14)$$

The results from these estimations given in Appendix A Table 2 columns 12 and 13 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 (led to a reduction of morbidity by 141 cases) as can be seen from the coefficient of T_4 in Appendix A Table 2 (columns 12 FT1-levels). Using logs, 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 13 per cent, Tables 2 (columns 13 - FT1-logs) in the Appendix A. After the introduction of the programme, the treatment as defined by T_4 led to a reduction in malaria morbidity by 32 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).

4.2.8 Sensitivity analysis

This sub-section reports the results of the sensitivity analysis of the impacts of the programme on malaria morbidity and mortality. We leave out of this estimation the 20 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 80th 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 80th percentile. Assuming that the set of the 20 sub-locations (both treated

and comparisons) with highest average morbidity is represented by H_q for each treatment condition T_q=T_1,T_2,T_3,T_4,T_5, where *q=1,2,3,4,5*, the total sample after excluding the 20 then becomes (N-H_q), if the sub-locations with common borders to the ones in the sample $\tilde{T}_q$ are included in the estimation and *(N-*B_q*)-*H_q if the sub-locations with common borders to the ones in $\tilde{T}_q$ are excluded from the estimation. B_q and N are as defined in section (4.2.1). The models to be estimated in this section are given as:

$$morb_{it} = \beta_{70} + \beta_{71}\left(bednets\right)_{it} + \beta_{72}\left(immun\right)_{it} + \beta_{73}\left(TF1\right) + \beta_{74}T_4 + \beta_{75}d_m + \beta_{76}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.15)$$

$$\ln morb_{it} = \alpha_{70} + \alpha_{71}\left(bednets\right)_{it} + \alpha_{72}\left(immun\right)_{it} + \alpha_{73}\left(FT1\right) + \alpha_{74}T_4 + \beta_{75}d_m + \alpha_{76}YD_{\hat{m}y} + \varepsilon_{it} \quad (4.16)$$

where $s = \begin{cases} \left(N - H_q\right) & if \quad comparison\ sample\ is\ C_{1q} \\ \left(N - B_q\right) - H_q & if \quad compariron\ sample\ is\ C_{2q} \end{cases}$

with $s \neq i \neq j$ and all the other variables are as defined in section (4.2.1).

The results from this estimation given in Table 3 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 (Appendix A Table 3 columns 2 - T1C1-levels). This impact is lower than the reduction by 247 cases obtained if the whole sample is included as $N = \left(\tilde{T}_1 + C_{12}\right)$ (as given in Appendix A Table 2 column 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 leaving out the 20 sub-locations with the highest average morbidity H_2, the impact of providing the free anti-malaria drugs through the outlets reduces morbidity by 71 (Appendix A Table 3 columns 4 T2C1-levels). 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 if the whole sample $N = \left(\tilde{T}_1 + C_{11}\right)$is considered (for the 10kms in Appendix A Table 2, column 4 T2C1-levels). This may be an indication that among the sub-locations with their entire boundaries within 10kms of the nearest outlet, the impact of the programme was less intense in the sub-locations with the highest average morbidity. Removing them from the sample, therefore, increased the impact of the programme. This is likely to be the opposite with the sub-locations that are within 5kms of reach to the nearest outlet as defined by T_1, where the impact reduced after filtering out the 20 per cent. The impact of the programme is likely to have been more intense on the excluded sub-locations than the ones below the 80th percentile of average morbidity. The impact of the programme 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 programme reduces the morbidity by 45 cases (Appendix A Table 3 column 6 T3C1-levels). This is an increase in the impact of the programme from a reduction by 24 cases obtained for the whole sample (Appendix A Table 2, column 6 T3C1-levels).

Surprisingly, the impact is now statistically different from zero, unlike in the previous cases when the 20 were included. This is a strong indication that including the 20 sub-locations with the highest average morbidity in this category understates the impact of the programme to the extent that the impact becomes insignificant. This implies that the impact of the programme 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 programme on morbidity considering 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, leads to a reduction in morbidity by 106 cases (Appendix A Table 10, column 6 T5C1-levels).

In all cases, the impact of the programme excluding the 20 sub-locations with the highest average morbidity of both treated and control sub-locations 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 outliers. In fact, in some cases, the outlier underrated the impact of the programme since it seemed that the programme impact was not very intense in the sub-locations with the highest average morbidity compared to the ones with lower average morbidity.

5. Summary, Conclusions and Recommendations

This study evaluates the effectiveness of an innovative anti-malarial distribution programme initiated between the Government of Kenya and the Sustainable Healthstore Foundation (SHF). The programme'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 franchise network. Under the franchise, small (privately-owned) shops, called Child and Family Wellness (CFW), 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 programme in increasing access of the 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 the programme's 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 results show that following the introduction of the programme, malaria morbidity significantly reduced by about 247 cases on average or 46 per cent in the sub-locations, with all their borders within 5kms to the nearest outlet providing free Coartem. The people's health seeking behaviour has a statistically significant and positive impact on malaria morbidity, but the impact is not substantially significant. Bed nets are found to have statistically insignificant impacts on malaria morbidity, an indication that the usage of bed nets 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 also using them. 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. 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 that helped to reduce malaria morbidity compared to the other years.

Assuming that patients can walk for up to 10kms (and not more) to access the anti-malaria medicines, the magnitude of the 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. It may therefore be necessary to encourage efforts to set up more outlets nearer the vulnerable populations. Additionally, incentives to keep the shops in business could be given in the areas where profits from the outlets are low. These could include posting at least one government-paid nurse to the outlets to defray the high costs of employing the nurses by the outlets. It is noteworthy that the results from our field survey indicate that some outlets closed down because the profits they got could not sustain the businesses.

The results further show that the programme impacts are bigger when spillover effects to the neighbouring sub-locations are accounted for than if they are ignored, underlining the fact that the patients are only restricted by the distance travelled to access the anti-malaria drugs and not administrative boundaries. The results show an increase in the programme impact when the outlets that were selling the anti-malarial drugs are also considered 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 nearer the patients and 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. Therefore, even if the government were to stop providing the free anti-malarial drugs, the outlets remain important in reducing malaria morbidity, and construction of more outlets will be beneficial. The programme impact on malaria mortality is generally statistically insignificant with almost all the treatment definitions and is therefore not reported here.

In general, the programme has significantly increased access to the free anti-malaria drugs, hence reduced malaria mortality. The programme 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

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

	T1C1-lev	T1C1-logs	T2C1-levels	T2C1-logs	T3C1-levels	T3C1-logs	T4C1-levels	T4C1-logs	T5C1-levels	T5C1-logs	FT1-levels	FT1-logs
bednets	0.002(0.43)	-0.000007(-0.66)	0.0017(0.43)	0.0000072(-0.66	0.0017(0.43)	-0.000007(-0.65)	0.0018(0.43)	-0.000007(-0.65)	0.0017(0.43)	-0.000007(-0.66)	0.002(0.51)	-0.0000069(-0.63)
immun	0.428(11.27)	0.0031(3.23)	0 .42(11.23)	0.00031(3.2)	0.42(11.23)	0.0003(3.22)	0.43(11.24)	0.0003(3.21)	0.43 (11.23)	0.0003(3.19)	0.43(11.23)	0.0003(3.21)
T1	-247.974(-13.16)	-0.47(-9.66)	-	-	-	-	-	-	-	-	-	-
T2	-	-	-58.85(-3.98)	-0.202(-5.23)	-	-	-	-	-	-	-	-
T3	-	-	-	-	-24.65(-0.99)	-0.08(-1.22)	-	-	-	-	-	-
T4	-	-	-	-	-	-	-131.6204(-7.75)	-0.31(-6.93)	-	-	-141.53(-8.22)	-0.32(-7.09)
T5	-	-	-	-	-	-	-	-	-147.14 (-9.61)	-0.33(-8.41)	-	-
TF1	-	-	-	-	-	-	-	-	-	-	-112.8(-3.59)	-0.13(-1.57)
d1	43.971(3.33)	0.18(5.04)	43.98(3.32)	0.17(5.02)	43.94(3.32)	0.18(5.03)	43.95(3.32)	0.18(5.02)	43.94(3.32))	0.18(5.01)	43.94(3.32)	0.18(5.02)
d2	47.559(3.61)	0.17(4.90)	47.64(3.60)	0.17(4.88)	47.65(3.60)	0.17(4.90)	47.60(3.60)	0.17(4.88)	47.58(3.60)	0.17(4.88)	47.58(3.60)	0.17(4.88)
d3	67.714(8.13)	0.26(7.51)	67.73(8.09)	0.26(7.64)	67.73(8.09)	0.28(8.05)	67.73(8.10)	0.27(7.60)	67.73 (8.11)	0.26(7.45)	67.72(8.10)	0.27(7.59)
d4	(dropped)	0.07(2.07)	(dropped)	0.078(2.23)	(dropped)	0.091(2.62)	(dropped)	0.076(2.18)	(dropped)	0.07(2.02)	(dropped)	0.076(2.16)
d5	-5.665(-0.32)	0.20(4.06)	-5.66(-0.32)	0.20(4.2)	-5.66(-0.32)	0.21(4.47)	-5.67(-0.32)	0.20(4.15)	-5.68 (-0.32)	0.19(4.03)	-5.68(-0.32)	0.2(4.13)
d6	-26.227(-1.74)	0.16(3.86)	-26.20(-1.74)	0.16(4.03)	-26.20(-1.73)	0.18(4.35)	-26.22(-1.74)	0.16(3.97)	-26.24(-1.74)	0.16(3.83)	-26.23(-1.74)	0.16(3.95)
d7	172.758(13.10)	0.12(3.32)	172.78(13.05)	0.11(3.31)	172.79(13.04)	0.11(3.31)	172.77(13.06)	0.11(3.32)	172.74(13.07)	0.12(3.32)	172.77(13.07)	0.12(3.32)
d8	114.823(8.71)	0.0015(0.04)	114.84(8.67)	0.001(0.04)	114.85(8.67)	0.0012(0.04)	114.83(8.68)	0.0013(0.04)	114.81(8.69)	0.0013(0.04)	114.8(8.69)	0.0013(0.04)
d9	-40.903(-3.09)	(dropped)	-40.87(-3.08)	(dropped)	-40.85(-3.07)	(dropped)	-40.89(-3.08)	(dropped)	-40.92 (-3.09)	(dropped)	-40.93(-3.09)	(dropped)
d10	-53.288(-4.03)	-0.03(-1.37)	-53.25(-4.01)	-0.03(-1.36)	-53.23(-4.00)	-0.03(-1.36)	-53.27(-4.01)	-0.03(-1.37)	-53.31(-4.02)	-0.031(-1.37)	-53.28(-4.02)	-0.03(-1.36)
d11	-20.148(-1.53)	-0.13(-3.61)	-22.39(-1.69)	-0.126(-3.59)	-23.75(-1.79)	-0.12(-3.53)	-21.40(-1.62)	-0.13(-3.60)	-19.52(-1.48)	-0.13(-3.61)	-17.41(-1.31)	-0.13(-3.57)
d12	-32.383(-2.46)	-0.17(-4.83)	-36.14(-2.73)	-0.172(-4.86)	-38.41(-2.90)	-0.17(-4.90)	-34.48(-2.61)	-0.17(-4.86)	-32.4(-2.45)	-0.17(-4.85)	-31.88(-2.41)	-0.17(-4.88)
JanFebo4	-113.323(-9.60)	-0.13(-4.02)	-113.34(-9.56)	-0.122(3.77)	-113.32(-9.55)	-0.11(-3.39)	-113.32(-9.57)	-0.12(-3.85)	-113.33(-9.58)	-0.13(-4.02)	-113.32(-9.57)	-0.13(-3.87)
MarApro4	-104.420(-8.81)	-0.16(-4.97)	-104.38(-8.77)	-0.158(-4.9)	-104.36(-8.76)	-0.15(-4.91)	-104.4(-8.78)	-0.169(-4.92)	-104.44(-8.79)	-0.16(-4.94)	-104.43(-8.78)	-0.16(-4.92)
MayJuno4	-17.761(-0.92)	-0.02(-0.47)	-17.73(-0.92)	-0.024(-0.46)	-17.72(-0.92)	-0.024(	-17.748(-0.92)	-0.024(-0.46)	-17.76(-0.92)	-0.02(-0.46)	-17.75(-0.92)	-0.02(-0.46)
JulAugo4	-76.471(-6.49)	0.32(9.92)	-76.47(-6.47)	0.32(10.13)	-76.47(-6.46)	0.34(10.56)	-76.47(-6.47)	0.32(10.07)	-76.48(-6.48)	0.32(9.89)	-76.48(-6.48)	0.32(10.05)
SeptOcto4	(dropped)	0.11(3.37)	(dropped)	0.117(3.59)	(dropped)	0.13(4.00)	(dropped)	0.11(3.52)	(dropped)	0.11(3.34)	(dropped)	0.11(3.50)
NovDeco4	-43.965(-3.73)	0.11(3.29)	-40.93(-3.45)	-0.115(-3.52)	-39.11(-3.30)	0.13(3.93)	-42.27(-3.57)	0.113(3.45)	-44.29(-3.74)	0.107(3.27)	-45.6(-3.84)	0.11(3.43)
JanFebo5	56.481(4.79)	0.15(4.83)	56.45(4.77)	0.155(5.02)	56.47(4.77)	0.17(5.44)	56.477(4.78)	0.15(4.97)	56.47(4.78)	0.15(4.80)	56.48(4.78)	0.15(4.95)
MarApro5	48.776(4.14)	0.10(3.39)	48.71(4.11)	0.104(3.38)	48.71(4.11)	0.10(3.37)	48.74(4.12)	0.104(3.38)	48.72(4.12)	0.104(3.38)	48.74(4.12)	0.104(3.38)
MayJuno5	80.934(5.31)	0.05(1.13)	80.96(5.29)	0.045(1.08)	80.98(5.29)	0.045(1.10)	80.95(5.30)	0.046(1.10)	80.95(5.30)	0.046(1.11)	80.95(5.30)	0.05(1.10)
JulAugo5	(dropped)	0.34(11.06)	(dropped)	0.35(11.21)	(dropped)	0.36(11.68)	(dropped)	0.35(11.18)	(dropped)	0.34(11.00)	(dropped)	0.35(11.16)
SeptOcto5	97.555(8.28)	0.25(7.93)	97.54(8.24)	0.25(8.09)	97.53(8.23)	0.27(8.54)	97.55(8.25)	0.25(8.05)	97.56(8.26)	0.24(7.87)	97.56(8.25)	0.25(8.02)
NovDeco4	16.227(1.38)	0.21(6.56)	19.26(1.62)	0.21(6.74)	21.08(1.78)	0.23(7.18)	17.92(1.51)	0.21(6.69)	15.91(1.35)	0.21(6.52)	14.59(1.23)	0.21(6.67)
JanFebo6	(dropped)	0.06(1.81)	(dropped)	0.061(2.00)	(dropped)	0.075(2.42)	(dropped)	0.06(1.95)	(dropped)	0.055(1.78)	(dropped)	0.06(1.93)
MarApro6	(dropped)	(dropped)	(dropped)	dropped	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MayJuno6	128.770(8.47)	0.15(3.72)	128.77(8.43)	0.15(3.67)	128.78(8.43)	0.15(3.68)	128.78(8.44)	0.153(3.69)	128.78(8.45)	0.15(3.70)	128.78(8.45)	0.15(3.69)
JulAugo6	-63.785(-5.41)	0.19(6.10)	-63.78(-5.38)	0.19(6.26)	-63.79(-5.38)	0.21(6.72)	-63.79(-5.39)	0.19(6.21)	-62.19(-5.26)	0.19(6.17)	-63.83(-5.40)	0.19(6.19)
SeptOcto6	73.704(6.24)	0.13(4.31)	73.69(6.21)	0.13(4.47)	73.68(6.21)	0.15(4.92)	73.7(6.22)	0.138(4.43)	75.31(6.36)	0.14(4.38)	79.77(6.67)	0.14(4.59)
NovDeco6	(dropped)	0.13(4.13)	(dropped)	0.13(4.23)	(dropped)	0.14(4.46)	(dropped)	0.13(4.20)	(dropped)	0.13(4.17)	(dropped)	0.13(4.30)
JanFebo7	11.973(1.01)	(dropped)	5.69(0.48)	(dropped)	2.06(0.17)	(dropped)	8.47(0.71)	(dropped)	10.89(0.92)	(dropped)	9.02(0.76)	(dropped)
MarApro6	-4.321(-0.37)	-0.10(-3.15)	-10.74(-0.90)	-0.102(-3.33)	-14.43(-1.22)	-0.12(-3.77)	-7.93(-0.67)	-0.10(-3.27)	-5.51(-0.47)	-0.096(-3.10)	-7.41(-0.63)	-0.1(-3.25)
MayJuno7	-118.087(-10.01)	(dropped)	-124.51(-10.48)	-0.024(-0.58)	-128.20(-10.82)	(dropped)	-121.7(-10.27)	(dropped)	-119.2(-10.07	(dropped)	-121.2(-10.23)	(dropped)
JulAugo7	86.804(5.71)	-0.02(-0.41)	80.39(5.26)	dropped	76.71(5.02)	-0.04(-0.89)	83.21(5.45)	-0.02(-0.52)	85.64(5.61)	-.016(-0.38)	83.7(5.49)	-0.02(-0.50)
SeptOcto7	32.542(2.75)	(dropped)	26.09(2.19)	dropped	22.39(1.89)	(dropped)	28.93(2.44)	(dropped)	31.37(2.64)	(dropped)	29.47(2.48)	(dropped)
NovDeco7	-24.053(-2.04)	(dropped)	-27.46(-2.32)	dropped	-29.34(-2.48)	(dropped)	-25.98(-2.20)	(dropped)	-25.5(-2.16)	(dropped)	-28.75(-2.43)	(dropped)
Constant	358.173(37.71)	5.53(220.09)	358.14(37.54)	5.54(218.73)	358.13(37.52)	5.53(219.05)	358.16(37.59)	5.53(219.37)	358.2(37.63)	5.56(219.55)	358.18(37.61)	5.5(219.3)

Table 3: Sensitivity analysis with the 20 per cent of both treated and controls with highest average morbidity left out

	T1C1-levels	T1C1-logs	T2C1-levels	T2C1-logs	T3C1-levels	T3C1-logs	T4C1-levels	T4C1-logs	T5C1-levels	T5C1-logs
bednets	0.0012(-0.40)	0.000014(-1.23)	-0.0012(-0.39)	-0.000014(-1.22)	-0.0012(-0.39)	-0.000014(-1.21)	-0.0013(-0.39)	-0.000014(-1.22)	-0.0012(-0.39)	-0.000014(-1.22)
immun	0.09(2.84)	0.000054(0.52)	0.09(2.85)	0.00005(0.52)	0.09(2.86)	0.00006(0.54)	0.09(2.84)	0.00005(0.52)	0.08(2.82)	0.00005(0.51)
T1	-158.12(-9.66)	-0.52(-8.94)	-	-	-	-	-	-	-	-
T2	-	-	-71.52(-5.52)	-0.29(-6.21)	-	-	-	-	-	-
T3	-	-	-	-	-45.74(-2.07)	-0.14(-1.7)	-	-	-	-
T4	-	-	-	-	-	-	-109.85(-7.26)	-0.38(-7.01)	-	-
T5	-	-	-	-	-	-	-	-	-106.18(-7.91)	-0.35(-7.43)
TF1	-	-	-	-	-	-	-	-	-	-
d1	120.50(11.26)	0.17(4.32)	120.52(11.24)	0.17(4.2)	120.44(11.22)	0.15(3.78)	120.49(11.24)	0.17(4.19)	120.50(11.25)	0.17(4.27)
d2	118.01(11.04)	0.18(4.39)	118.06(11.02)	0.17(4.28)	118.04(11.01)	0.16(3.87)	118.03(11.03)	0.17(4.27)	118.04(11.04)	0.17(4.35)
d3	57.43(8.52)	0.15(3.67)	57.45(8.51)	0.14(3.56)	57.45(8.5)	0.13(3.13)	57.44(8.51)	0.14(3.56)	57.44(8.51)	0.15(3.64)
d4	(dropped)	-0.05(-1.36)	(dropped)	-0.06(-1.45)	(dropped)	-0.08(-1.89)	(dropped)	-0.06(-1.45)	(dropped)	-0.06(-1.38)
d5	79.32(5.49)	0.21(3.82)	79.32(5.48)	0.21(3.8)	79.29(5.47)	0.20(3.75)	79.31(5.49)	0.21(3.8)	79.32(5.49)	0.21(3.8)
d6	66.16(5.44)	0.17(3.7)	66.17(5.43)	0.17(3.68)	66.15(5.42)	0.17(3.63)	66.16(5.43)	0.17(3.68)	66.17(5.44)	0.17(3.68)
d7	217.52(20.35)	0.11(2.69)	217.53(20.31)	0.10(2.58)	217.52(20.29)	0.09(2.14)	217.53(20.32)	0.10(2.59)	217.53(20.33)	0.11(2.66)
d8	173.82(16.27)	0.0041(-0.1)	173.82(16.23)	-0.01(-0.2)	173.80(16.22)	-0.03(-0.65)	173.82(16.25)	-0.01(-0.2)	173.83(16.25)	-0.01(-0.13)
d9	46.96(4.39)	0.13(3.19)	46.96(4.38)	0.13(3.18)	46.96(4.38)	0.13(3.12)	46.96(4.39)	0.13(3.18)	46.96(4.39)	0.13(3.17)
d10	37.31(3.49)	0.09(2.19)	37.32(3.48)	0.09(2.17)	37.32(3.48)	0.09(2.12)	37.32(3.48)	0.09(2.17)	37.32(3.49)	0.09(2.17)
d11	53.30(4.98)	(dropped)	52.81(4.93)	(dropped)	51.52(4.8)	(dropped)	52.95(4.94)	(dropped)	53.99(5.04)	(dropped)
d12	42.03(3.93)	-0.05(-2.15)	41.21(3.84)	-0.05(-2.18)	39.07(3.64)	-0.06(-2.34)	41.45(3.87)	-0.05(-2.18)	42.44(3.96)	-0.05(-2.19)
JanFeb04	-78.44(-8.22)	-0.08(-2.36)	-78.47(-8.21)	-0.08(-2.24)	-78.44(-8.2)	-0.07(-1.83)	-78.44(-8.21)	-0.08(-2.23)	-78.45(-8.22)	-0.08(-2.32)
MarApr04	(dropped)	-0.02(-0.65)	(dropped)	-0.02(-0.55)	(dropped)	0.004(-0.13)	(dropped)	-0.02(-0.56)	(dropped)	-0.02(-0.64)
MayJun04	-8.37(-0.54)	-0.01(-0.13)	-8.36(-0.54)	-0.01(-0.12)	-8.35(-0.54)	-0.01(-0.12)	-8.37(-0.54)	-0.01(-0.12)	-8.37(-0.54)	-0.01(-0.13)
JulAug04	-63.62(-6.68)	0.33(9.21)	-63.62(-6.67)	0.33(9.28)	-63.62(-6.66)	0.35(9.72)	-63.62(-6.67)	0.33(9.29)	-63.62(-6.67)	0.33(9.2)
SeptOct04	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
NovDec04	-33.16(-3.48)	(dropped)	-32.50(-3.4)	(dropped)	-30.80(-3.22)	(dropped)	-32.69(-3.42)	(dropped)	-33.71(-3.53)	(dropped)
JanFeb05	36.77(3.86)	0.17(5.07)	36.74(3.85)	0.18(5.14)	36.77(3.85)	0.19(5.57)	36.77(3.85)	0.18(5.17)	36.77(3.85)	0.18(5.09)
MarApr05	109.60(11.48)	0.24(6.91)	109.55(11.45)	0.24(6.94)	109.53(11.44)	0.25(7.41)	109.58(11.46)	0.24(6.98)	109.58(11.47)	0.24(6.9)
MayJun05	53.96(4.38)	0.06(1.34)	53.96(4.37)	0.06(1.3)	53.98(4.37)	0.06(1.32)	53.96(4.37)	0.06(1.32)	53.96(4.37)	0.06(1.33)
JulAug05	(dropped)	0.37(10.84)	(dropped)	0.38(10.86)	(dropped)	0.39(11.34)	(dropped)	0.38(10.9)	(dropped)	0.37(10.82)
SeptOct05	79.40(8.33)	0.16(4.51)	79.39(8.31)	0.16(4.46)	79.38(8.3)	0.16(4.47)	79.40(8.32)	0.16(4.49)	79.40(8.32)	0.16(4.5)
NovDec04	26.63(2.79)	0.11(2.97)	27.29(2.85)	0.10(2.92)	28.99(3.03)	0.11(2.93)	27.10(2.83)	0.11(2.96)	26.09(2.73)	0.11(2.97)
JanFeb06	(dropped)	0.07(2.12)	(dropped)	0.07(2.18)	(dropped)	0.09(2.61)	(dropped)	0.08(2.22)	(dropped)	0.07(2.13)
MarApr06	69.04(7.21)	0.12(3.5)	69.03(7.19)	0.12(3.54)	69.00(7.18)	0.14(4.00)	69.04(7.2)	0.12(3.57)	69.06(7.2)	0.12(3.49)
MayJun06	82.00(6.67)	0.15(3.21)	82.00(6.66)	0.15(3.17)	82.00(6.65)	0.15(3.18)	82.00(6.66)	0.15(3.19)	82.00(6.66)	0.15(3.2)
JulAug06	-58.17(-6.10)	0.20(5.88)	-58.18(-6.08)	0.21(5.91)	-58.18(-6.08)	0.22(6.39)	-58.18(-6.09)	0.21(5.95)	-57.09(-5.97)	0.21(5.99)
SeptOct06	49.35(5.17)	0.004(0.12)	49.35(5.16)	0.0024(0.07)	49.33(5.15)	0.0028(0.08)	49.35(5.16)	0.0035(0.1)	50.44(5.28)	0.01(0.21)
NovDec06	(dropped)	0.001(-0.03)	(dropped)	0.0035(-0.1)	(dropped)	-0.01(-0.3)	(dropped)	0.003(-0.09)	(dropped)	0.0005(0.01)
JanFeb07	-8.80(-0.92)	(dropped)	-10.27(-1.07)	(dropped)	-13.60(-1.42)	(dropped)	-9.80(-1.02)	(dropped)	-8.87(-0.93)	(dropped)
MarApr07	47.37(4.95)	(dropped)	45.83(4.77)	(dropped)	42.37(4.42)	(dropped)	46.31(4.83)	(dropped)	47.24(4.93)	(dropped)
MayJun07	37.82(3.08)	-0.03(-0.7)	36.29(2.94)	-0.04(-0.78)	32.85(2.66)	-0.05(-1.1)	36.77(2.99)	-0.04(-0.78)	37.69(3.06)	-0.03(-0.71)
JulAug07	-115.64(-12.12)	(dropped)	-117.17(-12.23)	(dropped)	-120.62(-12.61)	(dropped)	-116.69(-12.2)	(dropped)	-115.77(-12.11)	(dropped)
SeptOct07	24.29(2.54)	-0.11(-3.12)	22.75(2.37)	-0.12(-3.21)	19.29(2.01)	-0.13(-3.64)	23.23(2.43)	-0.12(-3.21)	24.16(2.52)	-0.11(-3.12)
NovDec07	-9.13(-0.96)	-0.10(-2.64)	-10.01(-1.05)	-0.10(-2.74)	-11.77(-1.23)	-0.12(-3.16)	-9.72(-1.02)	-0.10(-2.74)	-9.81(-1.03)	-0.10(-2.65)
Constant	186.30(24.54)	5.311(80.62)	186.29(24.48)	5.31(180.4)	186.30(24.46	5.32(180.21)	186.30(24.5)	5.31(180.44)	186.30(24.51)	5.31(180.48)

Table 4: Spillover effects with C2 as the comparison group

	T1C2-levels	T1C2-logs	T2C2-levels	T2C2-logs	T3C2-levels	T3C2-logs	T4C2-levels	T4C2-logs	T5C2-levels	T5C2-logs
bednets	0.0017(0.43)	-0.0000073(-0	0.0018(0.43)	0.0000073(-0.0	0.002(0.43)	-0.0000072(-0	0.0018(0.43)	-0.0000072(-0.0	0.0018(0.43)	-0.0000072(-0.66)
immun	0.42(11.24)	0.00031(3.20)	0.43(11.19)	0.00031(3.18)	0.427(11.19)	0.00031(3.18)	0.427(11.2)	0.00031(3.18)	0.43(11.2)	0.00031(3.19)
T1	-243.4(-12.51)	-0.45(-8.98)	-	-	-	-	-	-	-	-
T2	-	-	-49.18(-3.27)	-0.181(-4.58)	-	-	-	-	-	-
T3	-	-	-	-	-25.477(-1.02)	-0.083(-1.26)	-	-	-	-
T4	-	-	-	-	-	-	-122.067(-7.00)	-0.283(-6.22)		
T5	-	-	-	-	-	-	-	-	-146.98(-9.59)	-0.333(-8.37)
TF1	-	-	-	-	-	-	-	-	-	-
d1	70.8(4.70)	0.17(5.00)	70.81(4.68)	0.175(4.98)	70.775(4.68)	0.175(5.00)	70.795(4.69)	0.174(4.98)	70.76(4.69)	0.176(5.02)
d2	74.49(4.95)	0.17(4.86)	74.56(4.94)	0.170(4.85)	74.561(4.94)	0.171(4.87)	74.525(4.94)	0.17(4.85)	74.40(4.93)	0.171(4.88)
d3	94.6(6.28)	0.26(7.51)	94.63(6.26)	0.269(7.65)	94.63(6.26)	0.280(7.99)	94.630(6.27)	0.267(7.61)	94.65(6.27)	0.264(7.52)
d4	27.37(1.82)	0.07(2.13)	27.36(1.81)	0.081(2.29)	27.362(1.81)	0.092(2.62)	27.366(1.81)	0.079(2.24)	26.75(1.77)	0.074(2.10)
d5	20.42(2.12)	0.19(4.02)	20.40(2.11)	0.202(4.16)	20.397(2.11)	0.213(4.38)	20.412(2.11)	0.199(4.11)	20.62(2.13)	0.194(4.00)
d6	(dropped)	0.16(3.82)	(dropped)	0.166(3.98)	(dropped)	0.176(4.25)	(dropped)	0.163(3.93)	(dropped)	0.157(3.79)
d7	199.2(13.25)	0.11(3.28)	199.24(13.20)	0.115(3.26)	199.249(13.19)	0.115(3.26)	199.240(13.21)	0.115(3.27)	199.83(13.25)	0.115(3.29)
d8	141.8(9.43)	0.0013(0.04)	141.82(9.40)	0.001(0.03)	141.823(9.39)	0.001(0.03)	141.819(9.41)	0.001(0.03)	141.74(9.4)	0.0004(0.01)
d9	-14.39(-0.96)	(dropped)	-14.37(-0.95)	(dropped)	-14.37(-0.95)	(dropped)	-14.381(-0.95)	(dropped)	-14.36(-0.95)	(dropped)
d10	-26.8(-1.78)	-0.03(-1.38)	-26.80(-1.77)	-0.031(-1.37)	-26.792(-1.77)	-0.031(-1.37)	-26.804(-1.78)	-0.031(-1.38)	-26.74(-1.77)	-0.030(-1.36)
d11	6.7(0.45)	-0.019(-0.54)	4.44(0.29)	-0.011(-0.30)	3.394(0.22)	0.001(0.04)	5.444(0.36)	-0.014(-0.38)	7.08(0.47)	-0.019(-0.51)
d12	-5.6(-0.37)	-0.06(-1.74)	-9.39(-0.62)	-0.056(-1.55)	-11.141(-0.74)	-0.047(-1.29)	-7.720(-0.51)	-0.059(-1.62)	-5.81(-0.38)	-0.063(-1.73)
JanFeb04	-113.6(-9.6)	-0.13(-4.01)	-113.62(-9.56)	-0.122(-3.76)	-113.603(-9.56)	-0.112(-3.44)	-113.599(-9.57)	-0.124(-3.83)	-113.70(-9.58)	-0.129(-3.99)
MarApr04	-104.9(-8.83)	-0.16(-5.02)	-104.90(-8.79)	-0.161(-4.96)	-104.887(-8.79)	-0.161(-4.97)	-104.91(-8.8)	-0.161(-4.98)	-104.79(-8.8)	-0.161(-4.96)
MayJun04	-17.5(-0.91)	-0.025(-0.46)	-17.52(-0.91)	-0.024(-0.46)	-17.512(-0.91)	-0.024(-0.46)	-17.533(-0.91)	-0.024(-0.45)	-17.59(-0.91)	-0.023(-0.43)
JulAug04	-77.02(-6.53)	0.32(9.90)	-77.03(-6.50)	0.326(10.10)	-77.029(-6.5)	0.337(10.46)	-77.023(-6.51)	0.324(10.04)	-76.71(-6.48)	0.321(9.94)
SeptOct04	(dropped)	0.11(3.34)	(dropped)	0.116(3.56)	(dropped)	0.127(3.9)	(dropped)	0.114(3.49)	(dropped)	0.111(3.40)
NovDec04	-43.95(-3.72)	(dropped)	-40.93(-3.45)	(dropped)	-39.531(-3.33)	(dropped)	-42.270(-3.56)	(dropped)	-44.41(-3.74)	(dropped)
JanFeb05	56.24(4.76)	0.15(4.83)	56.21(4.74)	0.156(5.02)	56.224(4.74)	0.167(5.37)	56.231(4.75)	0.154(4.97)	56.65(4.79)	0.151(4.87)
MarApr05	48.32(4.09)	0.102(3.31)	48.25(4.07)	0.102(3.30)	48.240(4.07)	0.102(3.3)	48.270(4.07)	0.102(3.31)	48.73(4.11)	0.103(3.34)
MayJun05	81.18(5.32)	0.047(1.13)	81.22(5.30)	0.046(1.09)	81.234(5.3)	0.046(1.11)	81.205(5.3)	0.046(1.11)	81.47(5.32)	0.049(1.17)
JulAug05	(dropped)	0.34(11.05)	(dropped)	0.351(11.21)	(dropped)	0.362(11.6)	(dropped)	0.349(11.17)	(dropped)	0.345(11.06)
SeptOct05	97.7(8.27)	0.25(7.90)	97.69(8.24)	0.256(8.06)	97.684(8.23)	0.267(8.44)	97.694(8.25)	0.254(8.01)	97.81(8.26)	0.251(7.92)
NovDec04	16.4(1.39)	0.099(3.04)	19.43(1.64)	0.097(2.99)	20.830(1.75)	0.097(3.00)	18.087(1.53)	0.098(3.02)	15.97(1.35)	0.099(3.04)
JanFeb06	(dropped)	0.057(1.83)	(dropped)	0.063(2.02)	(dropped)	0.074(2.37)	(dropped)	0.061(1.97)	(dropped)	0.057(1.84)
MarApr06	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
MayJun06	129.9(8.53)	0.16(3.76)	129.96(8.49)	0.155(3.72)	129.961(8.49)	0.155(3.73)	129.95(8.5)	0.155(3.73)	129.50(8.48)	0.157(3.78)
JulAug06	-63.57(-5.38)	0.19(6.11)	-63.57(-5.35)	0.196(6.28)	-63.571(-5.35)	0.208(6.66)	-63.569(-5.36)	0.194(6.22)	-62.24(-5.25)	0.195(6.27)
SeptOct06	74.17(6.27)	0.13(4.3)	74.17(6.24)	0.140(4.47)	74.163(6.24)	0.151(4.84)	74.171(6.25)	0.138(4.42)	75.53(6.36)	0.139(4.44)
NovDec06	(dropped)	0.02(0.65)	(dropped)	0.016(0.51)	(dropped)	0.011(0.35)	(dropped)	0.018(0.55)	(dropped)	0.023(0.72)
JanFeb07	11.75(0.99)	(dropped)	5.48(0.46)	(dropped)	2.697(0.23)	(dropped)	8.255(0.69)	(dropped)	10.74(0.9)	(dropped)
MarApr07	-4.58(-0.39)	-0.099(-3.19)	-11.01(-0.93)	-0.104(-3.36)	-13.854(-1.17)	-0.116(-3.73)	-8.195(-0.69)	-0.102(-3.31)	-5.67(-0.48)	-0.098(-3.16)
MayJun07	-118.27(-10.00)	(dropped)	-124.69(-10.48)	(dropped)	-127.54(-10.75)	(dropped)	-121.8(10.27)	(dropped)	-119.79(-10.09)	(dropped)
JulAug07	87.42(5.73)	-0.016(-0.39)	81.02(5.29)	-0.023(-0.56)	78.19(5.11)	-0.034(-0.82)	83.826(5.48)	-0.021(-0.5)	85.95(5.62)	-0.015(-0.37)
SeptOct07	32.79(2.77)	(dropped)	26.36(2.21)	(dropped)	23.507(1.98)	(dropped)	29.181(2.45)	(dropped)	31.31(2.63)	(dropped)
NovDec07	-24.04(-2.03)	-0.107(-3.26)	-27.46(-2.31)	-0.115(-3.49)	-28.91(-2.44)	-0.126(-3.83)	-25.977(-2.19)	-0.112(-3.42)	-25.65(-2.16)	-0.108(-3.28)
Constant	330.97(28.04)	5.55(219.58)	330.97(27.92	5.547(218.26)	330.97(27.91	5.536(218.65)	330.975(27.95)	5.55(218.88)	332.29(28.08)	5.558(219.10)

Table 5: Impacts of the CWF shops on malaria morbidity

	levels l	ogs
bednets	0.00179(0.43)	-0.000007(-0.66)
immun	0.43(11.19)0	.0003(3.17)
timeotlet	-121.56(-6.21)	-0.37(-7.21)
d1	43.47(3.28)0	.173(4.95)
d2	47.25(3.57)0	.169(4.83)
d3	67.56(8.08)0	.278(7.96)
d4	(dropped)0	.089(2.54)
d5	-8.42(-0.47)	0.205(4.23)
d6	-28.97(-1.92)0	.168(4.07)
d7	170.62(12.89)0	.116(3.31)
d8	112.84(8.53)0	.001(0.04)
d9	-43.64(-3.29)(	dropped)
d10	-56.02(-4.22)-	0.030(-1.36)
d11	-23.42(-1.77)-	0.125(-3.54)
d12	-38.21(-2.89)-	0.174(-4.92)
JanFeb04	-115.66(-9.76)	-0.119(-3.68)
MarApr04	-107.07(-8.99)	-0.168(-5.19)
MayJun04	-17.75(-0.92)-	0.025(-0.47)
JulAug04	-77.15(-6.53)0	.328(10.2)
SeptOct04	(dropped)0	.118(3.63)
NovDec04	-42.16(-3.56)0	.117(3.57)
JanFeb05	54.16(4.58)0	.160(5.17)
MarApr05	46.40(3.92)0	.097(3.15)
MayJun05	81.31(5.32)0	.047(1.12)
JulAug05	(dropped)0	.354(11.38)
SeptOct05	98.88(8.36)0	.262(8.31)
NovDec04	19.37(1.64)0	.218(6.96)
JanFeb06	(dropped)0	.073(2.38)
MarApr06	(dropped)(	dropped)
MayJun06	131.76(8.63)	0.162(3.92)
JulAug06	-61.48(-5.19)0	.207(6.66)
SeptOct06	76.68(6.46)0	.151(4.85)
NovDec06	(dropped)0	.137(4.4)
JanFeb07	2.62(0.22)	(dropped)
MarApr07	-13.41(-1.13)-	0.113(-3.68)
MayJun07	-125.19(-10.58)(	dropped)
JulAug07	80.40(5.27)-	0.025(-0.61)
SeptOct07	26.11(2.2)	(dropped)
NovDec07	-28.69(-2.42)(	dropped)
Constant	365.22(38.04)5	.561(218.38)

Appendix B

Treatment groups

treat1=1	If all of the sub-location's borders lie within 5kms 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 10kms 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 neighbours 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_{24}, 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_2	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)
d_{12}	represents the month of December (equals to one if month is December and zero otherwise)
lnmorb	the natural log of morbidity
TF1	*FT1=1* (for sub-locations that are treated in at least one month under definition) 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

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