

WORLD BANK POLICY NOTE:
ENHANCING PUBLIC SUPPLY CHAIN MANAGEMENT IN ZAMBIA



This note represents the view of the World Bank (WB). The authors are appreciative for comments provided on an earlier draft by members of the Public Pilot Steering Committee. The views expressed in this document as well as any omissions are the sole responsibility of the World Bank.

1. Introduction

This policy note provides an overview of policy issues pertaining to the public supply chain of essential drugs in Zambia. It gives an overview of the main results of the Essential Drug Public Pilot Program and discusses supply chain policy issues that emerged during the implementation and evaluation of the program. The note is structured as follows; Section 2 provides a background to the Public Pilot Program and states the objective of the intervention; Section 3 presents the conclusions of the evaluation of the program, including a cost-effectiveness analysis, Section 4 gives the key recommendations emerging from the evaluation. The final section (Section 5) identifies areas of the supply chain where the World Bank recommends additional technical enhancements.

2. Background

Accessibility of essential drugs at the health facility level remains a bottleneck to health service delivery in Zambia. The Ministry of Health (MOH) and its partners have invested substantial amounts of money in the public sector supply chain in recent years. Despite these efforts, health facilities across Zambia continue to face difficulties accessing drugs and medical supplies in appropriate quantities. Several assessments that were done prior to the design of the pilot program including Beer (2007), Picazo (2006) and the baseline survey for the pilot program reported high stock-out rates, particularly at the health facility level.

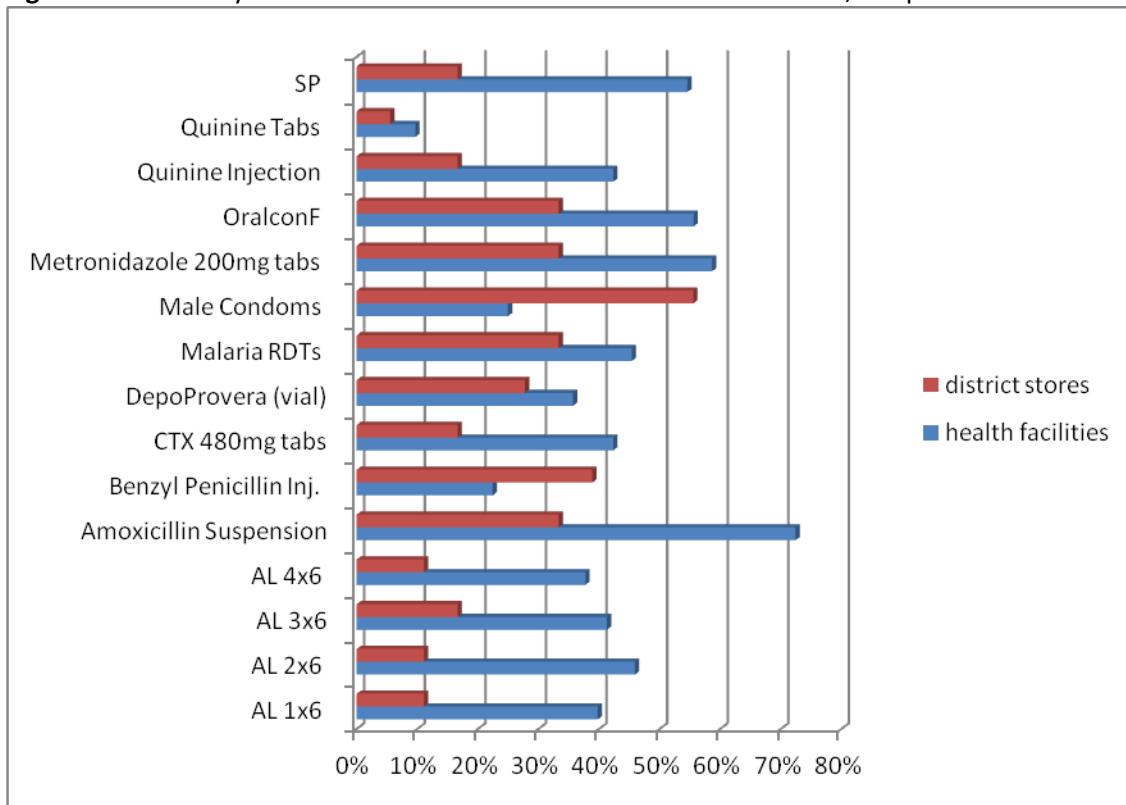
Primary distribution is handled by a para-statal agency and is largely reliable and effective. The receipt, storage and primary distribution of drugs and other health commodities from Lusaka to approximately 120 districts stores and hospitals are managed by a para-statal agency called Medical Stores Limited (MSL), currently under the management of Crown Agents. Improvements of MSL have been observed in recent years as a result of large capital investments and management reforms. Consequently, primary distribution is quite reliable and effective.

Secondary distribution is the responsibility of District Health Management Teams and remains a challenge. The distribution of commodities from district stores to approximately 1500 health facilities is the responsibility of District Health Management Teams (DHMTs) reporting to the MOH. Secondary distribution is currently ad-hoc and unreliable and the system's performance varies considerably across the country. Secondary distribution is particularly challenging in Zambia because typical loads to individual health facilities are very small, the destinations are geographically spread out, and the roads to reach health facilities often require specialist off-road vehicles. Significant problems in the secondary distribution include access to transport, lack of dedicated logistics staff at the district level, and challenges in communication throughout the supply chain.

Secondary distribution has been identified as the major bottleneck to accessibility of drugs at the health facility level. Figure 1 shows the probability of a stock-out for most commonly used drugs at health facilities and district stores. (Public Pilot Baseline Survey December 2008)For all drugs and

supplies except two (male condoms and Benzyl Penicillin), these data show much higher stock out rates at the health facility level compared to the district level and provide a clear indication that secondary distribution is the main constraint in the public sector supply chain system.

Figure 1: Probability of stock-outs at health facilities and district stores, 4th quarter 2008



Source: Baseline survey, Essential Drug Public Pilot Program (2008)

To address the challenges in the public sector supply chain, the Essential Drugs Public Pilot Program was launched in April 2009. Acknowledging the challenges in secondary distribution and the unavailability of drugs at the health facility level, the MOH, in collaboration with partners¹, launched the Essential Drugs Public Pilot program in April 2009. This was a bold initiative to improve access to essential drugs in the public sector in Zambia. The pilot program had the objective to evaluate the comparative cost-effectiveness of two alternative supply chain models as well as their operational effectiveness during a 12 month period (from April 2009 to April 2010).

Description of pilot program

¹ The pilot was funded by the World Bank, U.S. Government and DFID and implemented by Crown Agents, the USAID | DELIVER PROJECT and John Snow, Inc.

Two models focusing on improving logistics capacity at the district level and reducing number of stockholding points were designed. On grounds of potential cost-effectiveness and technical feasibility, the following two models to improve secondary distribution were agreed upon in consultations:²

Model A: The first pilot model *continues to hold stock at the district level*. Furthermore, this model introduces a Commodity Planner (CP) at the district level to enhance planning capacity. This CP is responsible for coordinating orders from the health facilities and stock management at the district. S/he also ensures that requisitions requests are sent every month by each health facility to the district store and performs picking and packing operations at the district level to fulfill the order requisitions of health facilities under that district. The CP also estimates the overall requirements and places orders to MSL for the stock needed to maintain the desired inventory level at the district store. Pharmacy technologists held the logistics responsibilities at the district level where this position was filled; while external CPs, hired directly under MSL, were contracted and trained in districts where the pharmacy technologist position was vacant.³

Model B: The second model *eliminates the intermediate storage of drugs at the district level*. The district store is converted into a “cross-dock”, i.e. point of transit, wherein it receives shipments from MSL that are pre-packed for individual health facilities. Under this option, the district does not carry any stock or perform any secondary picking and packing. This system has the potential to reduce the scope for pilferage and leakages as it enables better shipment tracking.⁴ However, it hinges on order requisitions from the health facilities being transmitted to MSL every month to allow for the assembling of packages to individual health facilities. As in Model A, a CP was added to the district store under this option and to ensure the smooth flow of order information from the health facilities to MSL.

For a graphic illustration of the two supply chain models please see Annex 1 Figures 1a and 1b.

To measure the effectiveness of the pilot, the program was accompanied by a rigorous impact evaluation. A thorough evaluation demands that any observed change in outcomes in pilot areas - such as the incidence and duration of stock-outs of essential drugs in pilot areas - is contrasted to outcomes in suitable comparison areas. To ensure this suitability, the districts where the intervention was implemented were selected on a randomized basis from a larger group of areas.⁵ The areas not selected serve as the comparison or “control”. More information about the design of the impact evaluation is available from the World Bank upon request.

² Many different designs to improve secondary distribution, such as direct distribution to health facilities, distribution through regional medical stores, contracting distribution/transport functions to private third party companies and enhancing planning capacity at various levels in the distribution system, were considered as potential interventions. Models A and B emerged from this deliberative process.

³ For the 16 intervention districts, there were 12 CPs recruited and the remaining 4 districts relied on pharmacy technologists.

⁴ An arrangement very similar to this is already in use in Zambia for the supply of ARVs and has resulted in eliminating stock-outs of ARVs at almost all ART sites.

⁵ Randomization of a sufficient number of study units assures that all units have an equal chance of control or treatment status and satisfies the conditions of a valid counterfactual comparison, namely that (1) all pre-intervention factors/characteristics will be on average equal between groups and (2) that the only difference in observed outcomes is due to the intervention and not to other observed or unobserved factors.

The pilot focused on peri-urban and rural areas and covered more than 22 percent of Zambia's 72 districts. A total of 16 out 50 peri-urban and rural districts⁶ were selected to implement one of the two supply chain models. Thus, the pilot was significant in scale covering almost one-quarter of Zambia's 72 districts. An additional eight districts with similar characteristics were selected to serve as controls i.e. they were included in the evaluation but did not receive any pilot intervention. Table 1 lists, and Annex 1 Figure 2 graphically depicts, the district selection by intervention.

Table 1: District Selection

Intervention A – District Store and Commodity Planner	Intervention B – Cross-Dock and Commodity Planner	Intervention C – Control Districts
Mwense* (Luapula)	Mkushi (Central)	Serenje (Central)
Milenge (Luapula)	Chama (Eastern)	Lundazi (Eastern)
Kafue* (Lusaka)	Kasama (Nothern)	Kaputa (Nothern)
Nakonde (Nothern)	Mungwi (Nothern)	Chinsali (Nothern)
Mufumbwe (Northwestern)	Chavuma (Northwestern)	Mazabuka (Southern)
Kabompo (Northwestern)	Mwinilunga (Northwestern)	Gwembe (Southern)
Choma* (Southern)	Mongu* (Western)	Namwala (Southern)
Shangombo (Western)	Kaoma (Western)	Lukulu (Western)

Note: Provinces in parentheses, *indicates that the district had a Pharmacy technologists rather than a Commodity Planner. Source: Authors

Two dedicated facility surveys, interviews with Commodity Planners, and an analysis of facility stockcards provided data to evaluate the program. The baseline data collection, covering 416 health centres, 23 hospitals and 18 District Health Offices, was conducted in Dec-Jan of 2008/09 prior to start of the pilot in April 2009.⁷ The follow up data collection was conducted during the same period in 2009/10, one year after the baseline survey and at the end of the pilot. Data on inventory and stock-out rates of fifteen tracer drugs were collected at both baseline and end-line. The end-line survey was more extensive in character and included supplementary information on stocking history and storage conditions. Furthermore, qualitative interviews with CPs were conducted. In addition, a team of experts in supply chain management from MIT collected stockcard data through digital cameras that were submitted through the CPs throughout the pilot period and entered into a database. These data were used for the analysis of the Inventory Control System (see Section 5).

3. Results

Results from the pilot program evaluation show remarkable improvement in access to essential drugs⁸ at the health facility level, particularly in districts where Model B was implemented.⁹ Figure 2 and 3

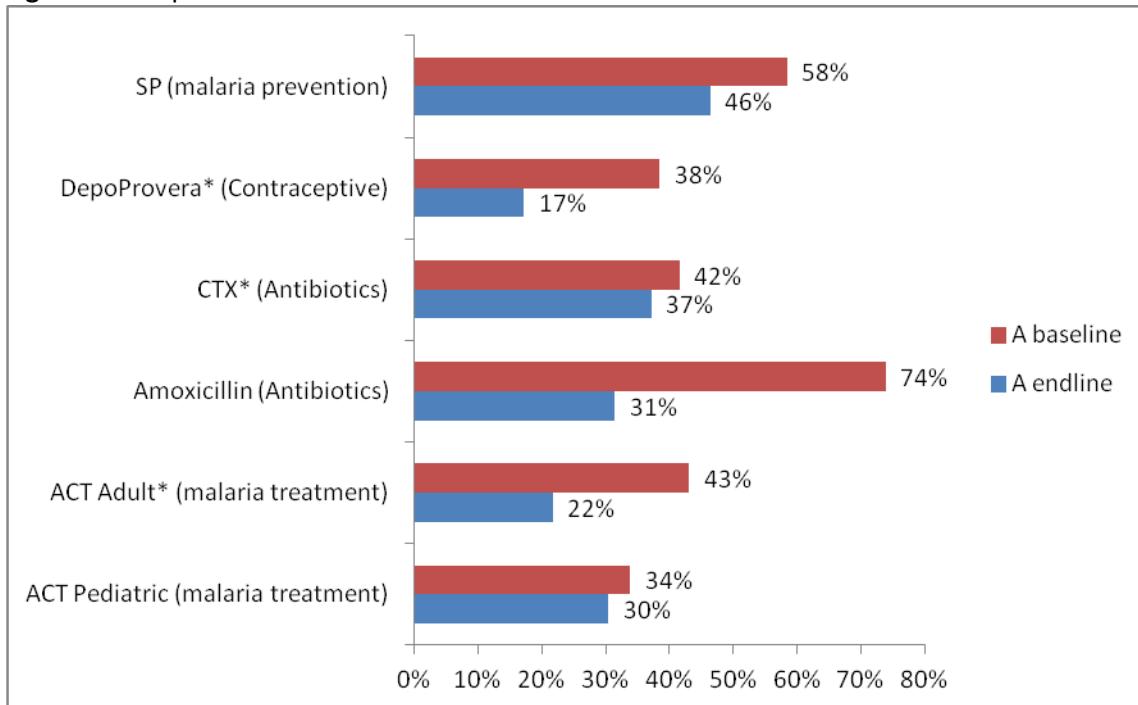
⁶ Urban districts were not included because of the relatively high performance of the health system in urban areas as well as relatively low malaria burden. A few rural and peri-urban districts were excluded on the basis that Churches Health Association of Zambia (CHAZ) was implementing supply chain interventions in those districts that could potentially distort the evaluation.

⁷ Health centers, health posts that carry pharmaceutical stock, as well as district hospitals were all included in the data collection efforts.

⁸ Given the unavailability of certain drugs at the central level due to bottlenecks in procurement, essential drugs in this study are represented by 15 tracer drugs which were available throughout the entire intervention period.

show the results of the impact evaluation of the pilot program for 6 selected drugs pre and post pilot implementation in A and B districts respectively. These 6 drugs are chosen for ease of display but the intervention had similar impacts on ***almost all*** essential drugs traced. Figure 2 indicates reduced stock outs in system A. For instance, in the baseline period 38 percent of health facilities were stocked out of DepoProvera, while the stock out rate in the follow up period was reduced to 17 percent. Reductions in the probability of stock out rates in the same magnitude are observed for Amoxicillin and ACT for adults. Although the reduction in stock out rates in A districts is promising, the gains are far less than those gains observed in B districts. Figure 3 shows dramatic decreases in stock out rates for the same 6 drugs; with decreases in stock out rates larger than 40 percentage points for SP, DepoProvera, Amoxicillin and ACT for adults. Overall these results show large performance improvements in the supply chain in B-districts whereas the A districts perform somewhat better with respect to baseline stock-out rates.

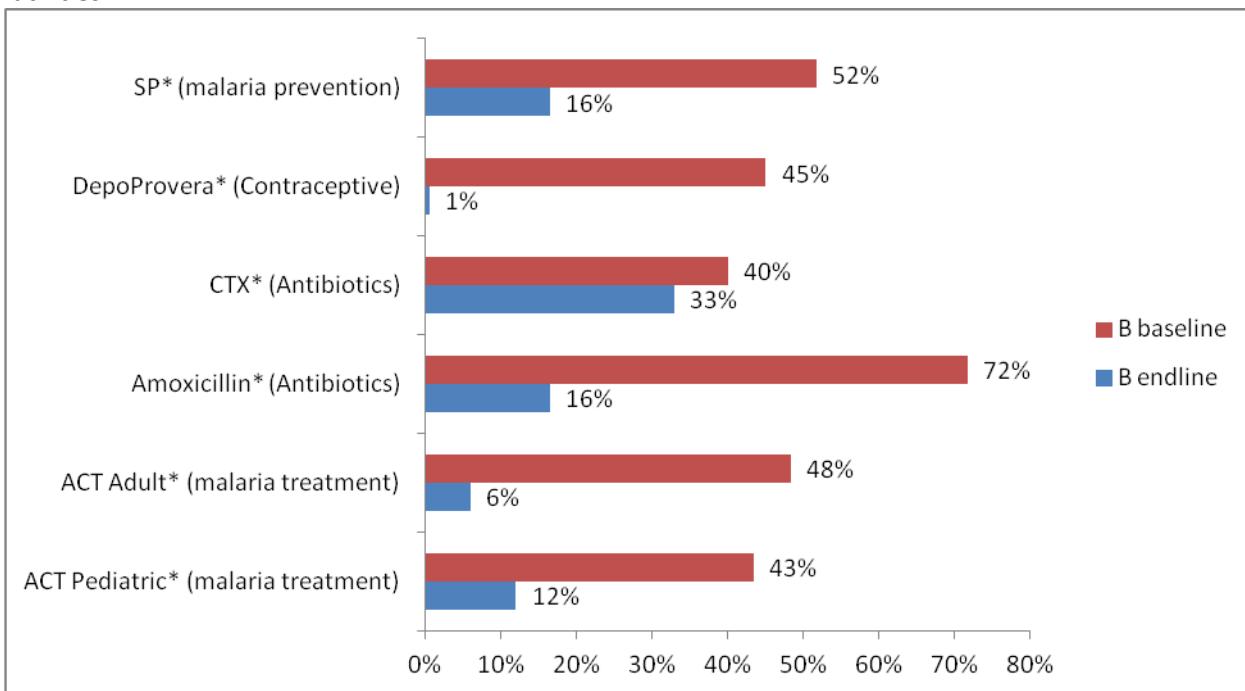
Figure 2: Comparison of baseline and endline stock-out rates in A district health facilities



Note: The Asterisk means that the reduction in stock-out rate is statistically significant with respect to any observed change in control districts, Source: Authors

⁹ An advanced statistical framework, termed a difference-in-difference regression analysis, presented in the Annex 2, confirms these results and shows that Model B performs significantly better in terms of availability of drugs and inventory levels.

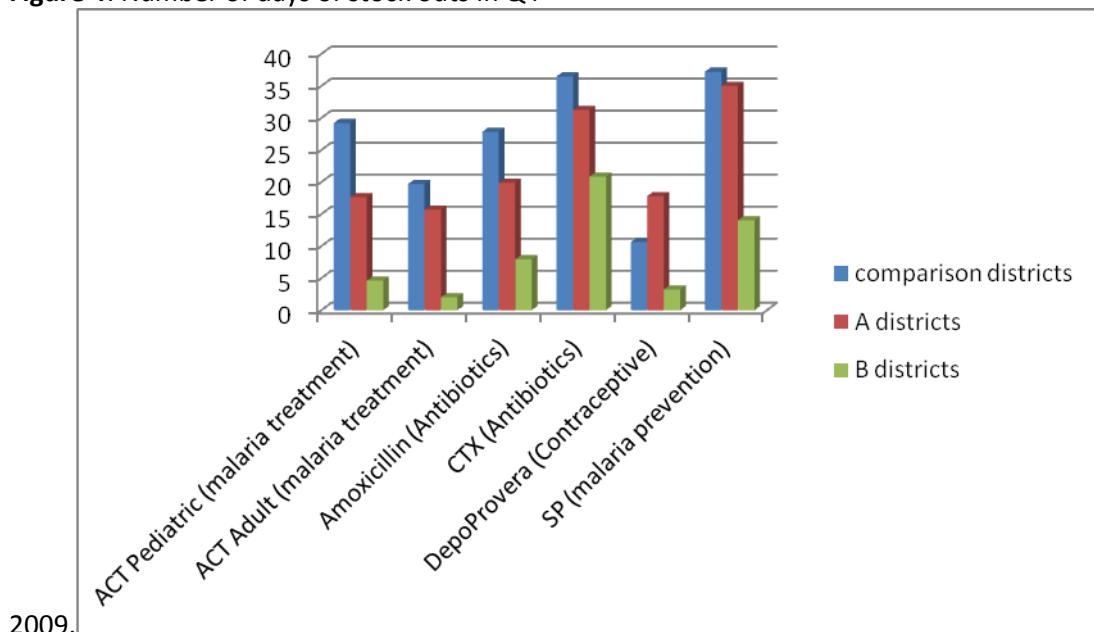
Figure 3: Comparison of baseline and endline stock-out rates in B district health facilities



Note: The Asterisk means that the reduction in stock-out rate is statistically significant with respect to any observed change in control districts, Source: Authors.

Considering the duration of stock-outs, B districts showed large improvements while A districts performed only marginally better than comparison districts. Figure 4 shows the average number of days of stocks outs of drugs in health facilities for the fourth quarter of 2009 by the different categories of districts (A, B and comparison). For pediatric ACTs, the drugs were stocked out an average of 29 days out of a maximum of 92 days in comparison districts (where no changes were made in the supply chain) while this number was reduced to 18 days in districts with Model A and 5 days in districts with Model B. A similar pattern occurs for ACT for adults, Amoxicillin and CTX. Districts where Model A were implemented had more days of stock outs compared to comparison district for DepoProvera, and the difference between comparison districts (37 days) and A districts (35 days) for SP is negligible.

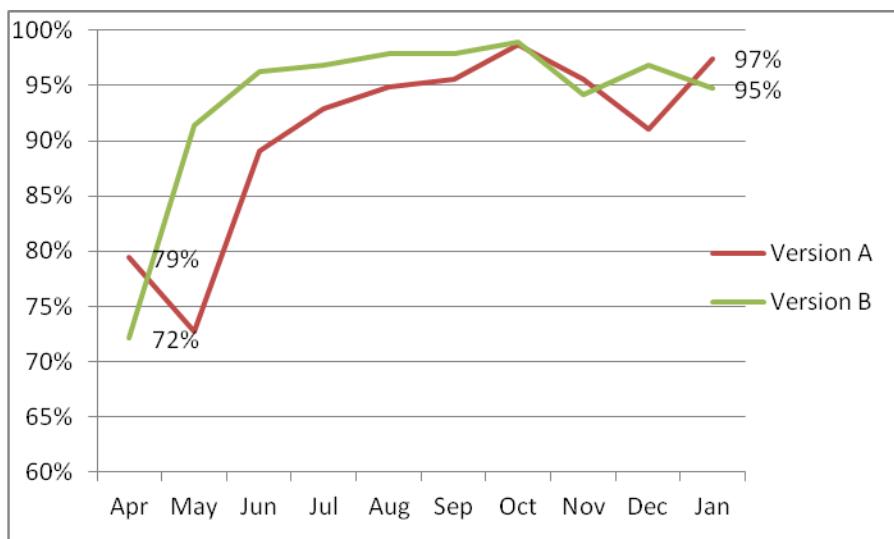
Figure 4: Number of days of stock outs in Q4



Source: Authors

Storage conditions and other measures of effectiveness of the supply chain also improved in both A and B districts. In addition to the increased availability of drugs, various measures of effectiveness of the supply chain, e.g. storage conditions, improved in the pilot districts. Figure 5 provides one example with an overview of the development in reporting rates to MSL in A and B districts respectively. It shows that reporting rates went from 79 percent and 72 percent in A and B districts respectively, to 97 percent to 95 percent 10 months later. The importance of reporting for the delivery of drugs was emphasized to MOH staff during intervention training. Supervision, conducted by CPs, was also intensified in treatment areas. These measures seem to have helped to increase reporting rates in both A and B districts.

Figure 5: Average reporting rate to MSL by A and B districts.



Source: Data from MSL

Through in-depth interviews, Commodity Planners unanimously confirmed the success of the program at the district and community levels. In addition to collecting and analyzing quantitative data, the research team also conducted structured interviews with the CPs.¹⁰ Reflecting the results of the quantitative analysis, all CPs provided ample anecdotal evidence that the program was succeeding in significantly reducing stock-outs of essential drugs at health facilities in their districts. The CPs generally reported that health facilities have been exceedingly cooperative and added that support throughout the communities has been wide-spread.

Most CPs faced considerable challenges in terms of ensuring transportation, storage space and communication. A key constraint faced by all CPs was transportation. CPs had to rely on vehicles from the district health office and fuel to deliver the drugs to the health facilities. According to the interviewees, they had to “compete” with other programs and priorities for transportation resources, and did not always receive the requisite support from the DHMTs. However as time went by and the district managers became more familiar with the program, some CPs saw a marked improvement in their relationship with the DHMTs. Dedicated storage space, at both the district and health facility level, was a second major challenge. A number of CPs stressed the need to survey the storage facilities at all the districts stores and health facilities prior to scaling up the program, and where necessary to invest in upgrading or expanding the storage rooms. Finally, communication constraints emerged as another clear theme. Most health facilities have very limited mobile phone access and rely mostly on two-way radio. This made it difficult for the CPs to communicate with the health facilities on a regular basis. Furthermore, some CPs reported a heavy workload, long hours, and hardship from living in remote and rural areas. Considering the pivotal role of a cadre, such as the CPs or Pharmacy Technologies, that coordinates logistics at the district level, it will be important to develop a human resource strategy that is both affordable and capable of attracting and retaining high quality logistics staff at the district level.

The impact of reduced stock-out rates on health outcomes

A decision tree framework was used to estimate the impact on mortality and morbidity of reduced stock-outs rates of the first-line malaria treatment in A, B and comparison districts. There is no standard methodology for estimating the health outcome impact of stock outs. We used a patient centered decision-tree framework to describe the decision alternatives that may be chosen by a patient/care giver who encounters a stock out in a public health facility. We then measured the consequences for each pathway the patient can take in terms of full recovery, partial recovery, deaths and days of illness. The estimates presented focus only on the health outcome improvements from reduction in the stock outs of Artemether Lumefantrine (ACT) used for the treatment of uncomplicated malaria.¹¹ Because the pilot program had a positive impact on the access to all essential drugs that are

¹⁰ 10 out of 12 CPs involved in the pilot were interviewed. These interviews were conducted by telephone between 04/01 and 04/14, 2010 and on average lasted about 80 minutes. The questions focused on the training the CPs received, the nature of the relationships between the CPs and the other partners in the project, the overall logistics of the program, as well as remuneration and benefits. Finally, the CPs were asked to share their views on how the entire system can be improved – both in terms of overall efficiency and cost-effectiveness – with an eye to the potential scale-up of the project.

¹¹ We assume full substitutability between the 4 different weight bands for Artemether Lumefantrine for under-five patients implying that a health facility will dispense fewer tablets from a strip of 24 , 18 or 12 tabs rather than not fulfilling the demand for a strip of 6 for a children less than five years old. Admittedly, some health facilities may not engage in such a practice but this assumption allows us to obtain the most conservative estimates for the reduction in mortality and morbidity.

supplied to the health facilities, these estimated health gains are highly conservative. There is no attempt to estimate health gains from increased availability of the 52 medicines and medical supplies in the Primary Health Center (PHC) Kit and over 50 other medicines in various pack forms that are available in the MSL catalogue and are ordered by health facilities.

A conservative estimate shows that if Model B were scaled-up nationwide under-five and over-five mortality due to malaria would decrease by 21 percent and 25 percent respectively. Under Model B the probability that not one of the ACT packages are available at a given clinic is only 1 percent. Given that stock outs are substantially higher in A and control districts, the health gains should be significant. Table 2 presents a comparison of the current system (as-is), Model A and Model B in terms of actual cases of uncured malaria, severe malaria and deaths due to malaria for under-five and over-five children respectively should these different models be scaled up nationwide. Translating the information in the table to averted deaths, it is seen that if Model B were scaled up nationwide, an additional 3,320 under-five deaths and 448 over-five deaths due to malaria would be averted each year (Table 3). This implies a reduction of 21.4 percent and 25.4 percent in under-five and over-five mortality attributable to malaria respectively.

Table 2: Estimates of annual cases of uncured malaria cases, severe malaria cases and deaths by population groups for as-is (the current system), Option A and Option B (assuming nationwide coverage of each system)

	Under-five population			Over-five population (1)	
	As-is	Option A	Option B	As-is	Option B
Uncured malaria cases	621,526	614,885	488,711	706,242	527,043
Severe malaria cases	31,076	30,744	24,436	7,062	5,270
Deaths	15,538	15,372	12,218	1,766	1,318

Note: (1) Only the results of Option B are presented because in this case Option A leads to a slight increase in the probability of stock out as compared to the “as-is” case. As before, this increase is however statistically insignificant and therefore not included in the table.

The aggregate household income loss averted due to a national scale-up of model B is estimated to be more than US\$1.6 million/year. An episode of illness also has a significant economic cost to the household due to the productive time lost per episode for a sick adult and also for an adult caring for sick children. Often times, the economic burden of an illness episode on a household can be devastating enough to bring a household into extreme poverty, debt and the sale of assets, which jeopardizes a household’s future earnings potential. Again with a focus on untreated or ineffectively treated malaria, and using the concept of foregone income (i.e. calculating the value of lost workdays as a result of malaria based on estimated wages) a national scale-up of model B should result average direct savings of over \$ 1,629,312.¹² Table 3 summarizes the benefit from national scale-up of Model.

¹² We assume the average additional time lost per episode of malaria that is not effectively treated to be 2 days for a sick adult and also 2 days for an adult caring for sick children. Admittedly, apart from the direct short term economic consequences due to wages lost, there are also likely to be significant indirect effects and long term effects such as income lost due to death/increased mortality and cognitive loss due to malaria related anemia in young children. The estimation of such long term consequences of treating a larger fraction of the population with effective drugs is beyond the scope of this study.

Table 3: Annual benefits from national scale-up of Model B at-a-glance (compared to the current system)

Reduction in uncured malaria cases per year	312,014
Reduction in Severe malaria cases per year	8,433
Under 5 Deaths averted per year	3,320
Over 5 Deaths averted per year	448
Total deaths averted	3,768
Aggregate average direct household income loss saved	\$ 1,629,312

Source: Authors

Cost-effectiveness analysis

Alongside the impact evaluation data collection, a cost-effectiveness analysis was conducted. Comprehensive cost categories include recurrent costs such as salaries and transport as well as fixed initial costs such as staff recruitment and training. A per district average monthly cost was estimated by distributing the fixed initial cost over a 5 year period. As costs will be compared across versions A, B, and control areas, we do not discount future costs or adjust for expected inflation (this is equivalent to setting the discount rate to equal the expected inflation rate). All costs were measured in Kwacha and cost aggregates then converted to US dollars at an exchange rate of 4500 Kwacha to one dollar.

Model B has a higher additional cost than Model A, but given its superior performance may well be worth the investment. The estimated additional costs to the supply chain per district per month for intervention A is \$3479 and for B it is \$3971 (including recurrent costs and fixed costs). The monthly recurrent costs for Model A and Model B are \$2832 and \$3325 respectively. A breakdown of cost categories is presented in Table 4. The cost difference between the two interventions is due to the additional transport costs captured under B as well as higher personnel costs at central stores for picking and packing activities. The estimate cost differential implies that the additional cost of B is 17 percent greater than the additional cost of A. Given the relative performance of version B, this cost differential may well be worth the investment.

When comparing the average distribution cost in pilot areas to the equivalent for the average district in Zambia, it is important to keep in mind that the pilot was implemented in remote districts with higher transportation costs. In many ways the most pertinent cost comparison is with regards to the per district monthly cost of the existing distribution system. This cost, determined by dividing the total system cost by the number of districts in Zambia, is \$3878.¹³ This cost estimate includes the distribution of all drugs, not only essential medicines, although essential medicines make up the vast majority of staff time, storage space, picking activity, and transport volumes. This estimate is the average for all districts in Zambia, including centrally located and relatively accessible districts, where the average cost is undoubtedly lower due to lower transport costs. Hence a comparison of the additional costs of A or B,

¹³ This value is estimated based on current MOH salaries.

which have been measured in the more remote districts of Zambia, against the distributional costs in an average Zambian district may somewhat overstate the cost differential and this should be born in mind when comparing the relative costs of various delivery options.

Table 4. Estimated district average monthly incremental costs of Versions A and B, by cost category

Cost category	A	B
<i>Recurrent cost - staff related</i>		
Salaries	1693	1867
Travel Expenses by CPs, Project Manager, Supervisors etc to Piloted Districts	87	87
Telephone/C cellphone Accessories and Expenses	106	106
Staff Welfare expenses-Accommodation for CPs, Refreshments etc	90	90
Group Life Assurance Premium	8	8
Gratuities	476	537
Medical Expenses	8	8
<i>Recurrent cost - other categories</i>		
Packaging Material for Repackaging of Drugs	8	33
Fuel & Lubricants - Travel by Project Manager to Piloted Districts & Entitlements	33	33
Extra fuel for distribution trips	78	311
Canteen Expenses	96	96
Stationery & office Supplies	87	87
Bank Charges	14	14
Postage	4	4
Repairs & Maintenance General-Computers	44	44
<i>Fixed cost</i>		
Recruitment Expenses	11	11
Subscription & Licenses (Medical Council of Zambia - Pharmacist CP's)	1	1
Protective Clothing for Warehouse WBP Staff	0	0
Computer & Computer Accessories	26	26
Pallet Jacks for Warehouse	6	6
Office Equipment-Aircon, Solar Panels etc	3	3
Furniture,Fixture & Fittings	5	5
Computer Software-Accpac and Microsoft Windows 2007 Application	7	7
Training Materials - MSL	65	65
District Personnel Training Costs - JSI	454	454
Monitoring and Evaluation Costs - JSI	67	67
Total	3,479	3,971
Note: Exchange rate = 4500 Kwacha/dollar		

Source: Authors, based on data from MSL

Regarding cost-effectiveness, System B is almost four times as cost-effective as System A with regards to stock availability. How do these intervention costs relate to the gains observed by models A and B? Cost-effectiveness interventions of the two models are presented in two ways – first in terms of the cost per day of essential medicine stock-out averted (weighting all tracer drugs equally) and then in terms of cost per Year of Life Lost (YLL) averted as a result of the increased availability of one essential anti-malarial drug, ACT. To estimate the cost per stock-out day averted, we take a district of average size with 18 health facilities. The evaluation results suggest that in the fourth quarter of 2009 there was an average of 1704 stock-out days per month across all 15 tracer drugs in the control districts. This total reduces to 1464 in Model A and 756 in Model B. Thus by this metric, Model A reduces a stock-out day of one tracer drug at a cost of \$14.5 in additional operating costs. Model B, on the other hand, achieves

the same stock-out reduction at a cost of \$4.2. With regards to this particular measure of stock availability, Model B is three and a half times as cost-effective as Model A.

Considering malaria related deaths alone, a scale up of Model B would translate into more than 770 000 Years of Life Lost (YLL) averted during a 5 year period. If we wish to express the cost-effectiveness in terms of health gains, we again focus on malaria deaths averted due to increase availability of ACT at the facility level. As expressed earlier, a national scale-up of Model B may result in 3320 fewer under-five deaths and 448 over-five deaths annually. In 2008, the life expectancy in Zambia (World Bank WDI, 2008) was estimated at 45.4 years. In terms of years of life lost averted, this translates into 720,440 YLLs averted from the reduction in under-five deaths, and 50,175 from the reduction in over five deaths (assuming the median age of Zambians over 5 is 22 years as per CIA World Factbook). This implies a monetary value of \$22 per YLL averted for a national scale-up of Version B operating over a 5 year period. It is difficult to find benchmark comparisons for this estimate of cost-effectiveness since it is a marginal investment into an active health system. However one contextual comparison is the estimated cost-effectiveness of antiretroviral therapy where one estimate for Sub-Saharan Africa stands at \$350/DALY averted (Marseille et al. 2002).¹⁴ This comparison cost-effectiveness includes additional inputs such as medical staff as well as pharmaceutical costs. Other benchmarks include the cost-effectiveness of a global ACT subsidy at approximately \$43/YLL averted (assuming full subsidy of one dollar per treatment course of ACT and the life expectancy for Zambia) (Laxminarayan et al. 2006) and the cost effectiveness of intermittent preventive treatment for malaria in pregnant women with Sulfadoxine-Pyrimethamine (SP) of \$19/DALY averted (Yadav, 2010). Whichever benchmark that is being used, it is clear from this analysis that investments in the supply chain are cost-effective compared to other common public health interventions. In addition, this supply chain estimate only concerns malaria deaths averted and not the possible other numerous health benefits from increased availability of other essential drugs.

Zambia is currently under-investing in its supply chain and the cost for scaling up Model B would still keep distribution costs below benchmarks in countries with similar level of development. While the additional cost of A or B is large in proportional terms – a national scale up of Model B would increase the supply chain operational cost from 4.1 percent to 8.5 percent of the total pharmaceutical budget – the cost implications should be understood in light of international comparisons. Benchmarks show that the equivalent number for less-developed and geographically challenged states (e.g. Tanzania, Malawi and Rwanda) is between 20-25 percent and for more developed states between 12-20 percent (USAID, 2009). The equivalent number for the ARV system in Zambia is about 10 percent in urban areas and 16 percent in rural areas (*ibid*). In general, logistics costs tend to decline with increased efficiency in the economy (e.g. improved infrastructure). Therefore distribution costs are generally higher in developing countries compared to developed countries. The current distribution cost of 4.1 percent in Zambia is even lower than typical logistic costs of US pharmaceutical companies which are around 4.5 percent (*ibid*). These data and the poor performance of the supply chain system clearly show that Zambia is currently under-investing in its supply chain.

¹⁴ In the case of malaria DALY and YLL are not equal but similar given that effects of malaria on disability are small. Correspondingly, the bulk of HIV related DALYs derive from YLLs.

Some net savings in B districts are not included in the estimates above and if included the additional cost for Model B is likely to decrease. The cost estimates above do not take into account possible savings such as the discontinuation of picking and packing services at the district level, or the saved local transport costs from the district store to the facility. Additionally, a scale-up may also involve further savings such as the ability to reassign the district-level store keeper to other duties as that position is no longer necessary. If we wish to include these savings, the net additional monthly operating costs of B falls to a maximum of \$2992 and perhaps even less depending on the current transport costs incurred at the district level.

4. Recommendations

Given Model B's superior performance, we recommend that Model A districts are immediately converted into Model B districts as a first step towards the goal of scaling up Model B nation-wide. Scaling up Model B nation-wide should be given high priority by the Government and cooperating partners. The evidence presented in Section 3 clearly shows that Model B performed very well during the pilot period. Its performances is superior to model A and comparison districts on a number of metrics including probability of stock-outs at the health facility level, duration of stock-outs and inventory levels. Furthermore, the cost-effectiveness analysis concludes that although Model B has a slightly higher additional cost than both Model A and the current system, it is almost 4 times as cost-effective as Model A given its ability to get the drugs to the end patient and thereby save lives. Moreover, the analysis shows that the distribution cost for scaling up Model B nationally is still low compared to benchmarks of distribution cost/total budget for pharmaceuticals reported in the private sector and similar settings in Sub-Saharan Africa. Based on the findings, we recommend that Model A districts are converted into Model B districts as soon as possible. This is the first step in the national-scale up of Model B.

Given the substantial impact on health outcomes financing for national scale-up of Model B should be raised urgently. The analysis of the results of the public pilot has shown that, based on conservative estimates, if Model B were scaled-up nationwide under-five and over-five mortality due to malaria would decrease by 21 percent and 25 percent respectively. This only reflects the effect of increased availability of malaria drugs, the overall effect on health outcomes is expected to be much larger because of the increased availability of other essential drugs as well. Additionally, Model B is highly cost-effective and the analysis shows that investments in the supply chain are highly cost-effective compared to other common public health interventions. We therefore recommend that scaling-up Model B nationally should take place as soon as possible.

5. Further Technical Enhancements of the Supply Chain

While starting the implementation of national scale-up of Model B, it is recommended that certain additional technical enhancements are developed and implemented to optimize the supply chain. The areas where there is scope for improvements, which were identified during the implementation of the pilot program as well as through additional analysis, will be discussed in detail in the subsequent section.

The Inventory Control System

An analysis of health facility stock cards that was made possible through the pilot program shows that faults in the inventory control system contributes to stock outs of drugs across health facilities.

During the pilot program a research team affiliated with MIT Zaragoza Logistics Program collected detailed stock card data from CPs that have never before been collected systematically in Zambia.¹⁵

These data are very rich and show that the inventory control system¹⁶, namely the system for deciding how much of which supply to ship to which destination at a given point, has a number of weaknesses.

According to the study, some of the issues identified in the current inventory control system include:

- *Its reliance on the average monthly consumption of drugs over the past three months as a forecast of future demand.* As a result, stock-outs occurring in the recent past reduce the quantity of drugs to be shipped next, potentially sustaining a stock-out situation over multiple months. In addition, the system fails to anticipate any upcoming predictable changes in demand, for example during the rainy season when it is known that demand for malaria and diarrhea-related commodities drastically increase;
- *Its failure to systematically anticipate any upcoming predictable changes in delivery lead-times, even though those changes should substantially affect shipment quantities.* For example, in the current system increases in shipments to health facilities that are cut-off by flooding during the rainy season are at the discretion of the health facility manager. There is no formal system in place to make sure that health facilities are accurately supplied when lead-times change, even though the annual timing of cut-offs and other obstacles affecting lead-times can be predicted with a fairly high degree of certainty;
- *Its ad-hoc and subjective manner of allocating stocks to health facilities when inventory levels at MSL are not sufficient to cover all orders.*

Simulations conducted based on the stock card data show that relatively small and low-cost investments in the inventory control system would yield high benefits in terms of access to drugs. Potential benefits associated with a new inventory control system include: increased availability of drugs to patients; reduced inventory holding costs and waste due to drug expiry; fairness and full rationality in drug rationing situations; and elimination of need for health center workers to perform order calculations and for MSL staff to check the arithmetic of these orders. Based on the above, the World Bank recommends that the MOH pilots an alternative optimization-based inventory control system, which computes all shipments to health centers in a scientific manner in order to minimize country-wide unmet drug needs of patients at all times and under all scenarios of inventory availability, storage capacity and all other relevant practical constraints. The first phase of such pilot will develop and implement an operational version of the optimization-based inventory control system defined by the three modules: Shipment optimization, Forecasting, and Information System. The second phase will test its scalability.

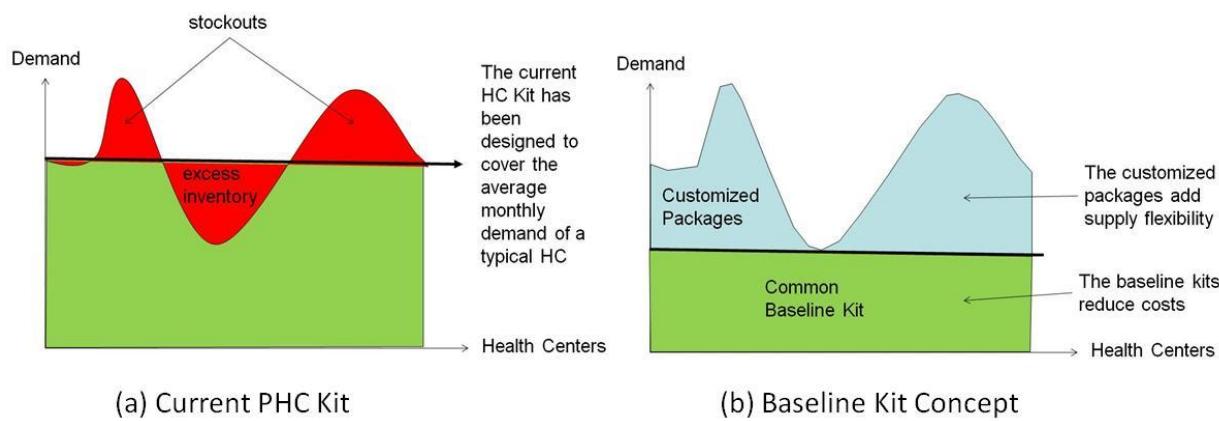
Public Health Centre Kit System

¹⁵ For a more thorough explanation of the challenges with the current inventory control system in Zambia, please see Gallien and Yadav (2010).

¹⁶ The current inventory control system relies on the so-called “min/max rule” and is implemented in part through a software known as “supply-chain manager”.

The evaluation of the pilot program indicates that it could be beneficial to replace the kit with custom made deliveries to health centers. The pilot did not set out to make a judgment on the PHC kit, however, both models evaluated in the pilot supplied the requested quantities of individual drugs to the health facilities instead of supplying the PHC kit. A system with a standardized PHC kit as the lowest unit for ordering and distribution leads to excess inventory of some medicines and shortages of others as the disease patterns and therefore demand across health centers has considerable heterogeneity. In the case of Zambia, the content of the kit has not been updated to current disease patterns and it lacks several important drugs such as RDTs and ACTs. Having said this, the kit system has several advantages: distribution of kits instead of individual medicines has proven beneficial in terms of easier flow through the supply system; lower burden of procurement; fewer data needs in the supply chain; and robustness in the stock availability of medicines in the event that health facilities do not place orders routinely and systematically. Furthermore, kits considerably reduce the order picking and packing workload at MSL and more importantly at the district health offices. Similarly, ordering a large number of individual drugs can over burden the skeletal human resource capacity at health centers; resulting in non-ordering and thus poor availability.

Figure 6: The Existing Primary Health Center Kit (a) and the Alternative Baseline Kit Concept (b).



Source: Authors

As Model B is scaled up nation-wide, it will be important to for the MOH to carefully consider the most appropriate way forward for Zambia in terms of keeping, altering or abolishing the health centre kit. To investigate the trade-offs with the kit in detail and understand the most appropriate system for the Zambia National Supply Chain, the World Bank recommends that the MOH commissions a specific study on the design of physical flows in Zambia's distribution system, including the design of an alternative kit system combining inventory flexibility of individual ordering with the cost and robustness benefits of the current PHC kit system. In particular, this study needs to take the current capacity of the Procurement Unit at the MOH into account. Furthermore, it is recommended that it explores the concept of a baseline kit inspired from common practices in the production of electricity: instead of using a kit designed to cover the expected monthly needs of a typical health center (average demand kit) as is currently done, this concept involves using a kit designed to cover only a fraction of the expected need of a typical health facility (e.g., 30 percent or 40 percent demand kit), and at the same time send another customized shipment to each health facility containing supplemental customized

quantities of the kit drugs as well as other drugs not included in the kit (see Figure 6 for illustration). Ideally, the quantities of drugs included in the kit are such that the extent of additional individual ordering of the same drug is minimized.

The Information System

A move from a paper-based to a digital supply chain information system has the potential to improve visibility of the supply chain as well as its performance. It was noticed during the pilot that the paper-based supply chain information system does not collect sufficient information to establish accurate and real-time information on patient needs for drugs at the health facility level and inventory positions in all storage locations. Furthermore, it is also relatively costly both in terms of manpower employed at the central level for data entry and in its sensitivity to human errors. The MOH already has experience with electronic based communication system, namely Smartcare technology, which is in service in a number of health facilities for the HIV and AIDS program. In the context of the supply chain, a computerized information system has the potential to: reduce stock-outs and inventory costs caused by long and unreliable paper-based transmission of inventory information; reduce the time spent by health workers recording inventory transactions; improve patient demand visibility and tracking for distribution, procurement and epidemiological monitoring purposes; enhance visibility and tracking of delivery lead-times for performance monitoring, shipment optimization and transportation capacity allocation purposes; and reduce manual data-entry costs at MSL.

A feasibility assessment of the digitalization of the information system in Zambia could answer important questions regarding the use of mobile technologies to improve the performance of the national supply chain. The potential to use mobile technologies to improve pharmaceutical supply chains in Africa is well-demonstrated (e.g. through initiatives implemented by SMS for Life and RapidSMS).¹⁷ However, there is little information available to date on the feasibility of using mobile technology for improving supply chains on a large scale and when numerous essential drugs are involved (pilots to date have been small in scale and disease specific). Furthermore, it is unknown if and what kind of digital solution that would best fit the Zambian context. To understand these aspects, the World Bank recommends to set-up a field-lab to systematically field test recent and potentially high-impact technologies (e.g., inexpensive smart phone with integrated bar-code scanner running custom client applications) for the handling of a large number of essential drugs. The first phase of this study could have the objective to identify and evaluate one or several joint technology and process solutions forming the architecture of a digital information system adapted to the field challenges of Zambia's national supply chain. The second phase should identify and resolve issues pertaining to large-scale deployment of the selected technological solution.

References

Arrow K. J., C. Panosian, and H. Gelband, 2004, editors. Saving lives, buying time: economics of malaria drugs in an age of resistance, National Academies Press, Washington, DC

Beer, K. (2007), "Zambia Malaria Commodity Security Assessment", unpublished report to the World Bank.

¹⁷ For description of case studies see <http://www.rapidsms.org> and <http://www.rbm.who.int/globaladvocacy/pr2010-04-21.html#note1>

Chanda , P., F. Masiye , B. M Chitah , N. Sipilanyambe , M.Hawela , P. Banda and T. Okorosobo . A cost-effectiveness analysis of artemether lumefantrine for treatment of uncomplicated malaria in Zambia., *Malaria Journal* 2007 6:21

Gallien J. and P. Yadav (2010) "Inventory Control for the Public Distribution of Essential Drugs in Zambia: Analysis of Existing System and Alternative Proposal", unpublished report to the World Bank.

Laxminarayan R, Over M, Smith DL (2006) : Will a global subsidy of new antimalarials delay the emergence of resistance and save lives? *Health Aff* 2006 , 25:325-336.

Marseille, E. P.B. Hofmann, and J.G. Khan (2002), "HIV Prevention before HAART in Sub-Saharan Africa" Lancet 359 (9320): 1851-56.Marsh, D. R., K E Gilroy, R. Van de Weerdt, E. Wansi, S.Qazi .Community case management of pneumonia: at a tipping point? *Bulletin of the World Health Organization*. Volume 86, Number 5, May 2008, 381-389

Picazo, O and F. Zhao (2008). Zambia Health Sector Public Expenditure Review. Washington, DC: The World Bank Group.

USAID (2009) Estimating the Global In-Country Supply Chain Costs of Meeting the MDGs by 2015 Technical Brief, available at http://pdf.usaid.gov/pdf_docs/PNADP080.pdf

World Bank (2008). World Development Indicators.

Yadav, P. (2010). "Improving Public Health in Developing Countries through Operations Research", Wiley Encyclopedia of Operations Research and Management Science. John Wiley & Sons.

Annex 1

Figure 1a: Model A, Commodity Planner

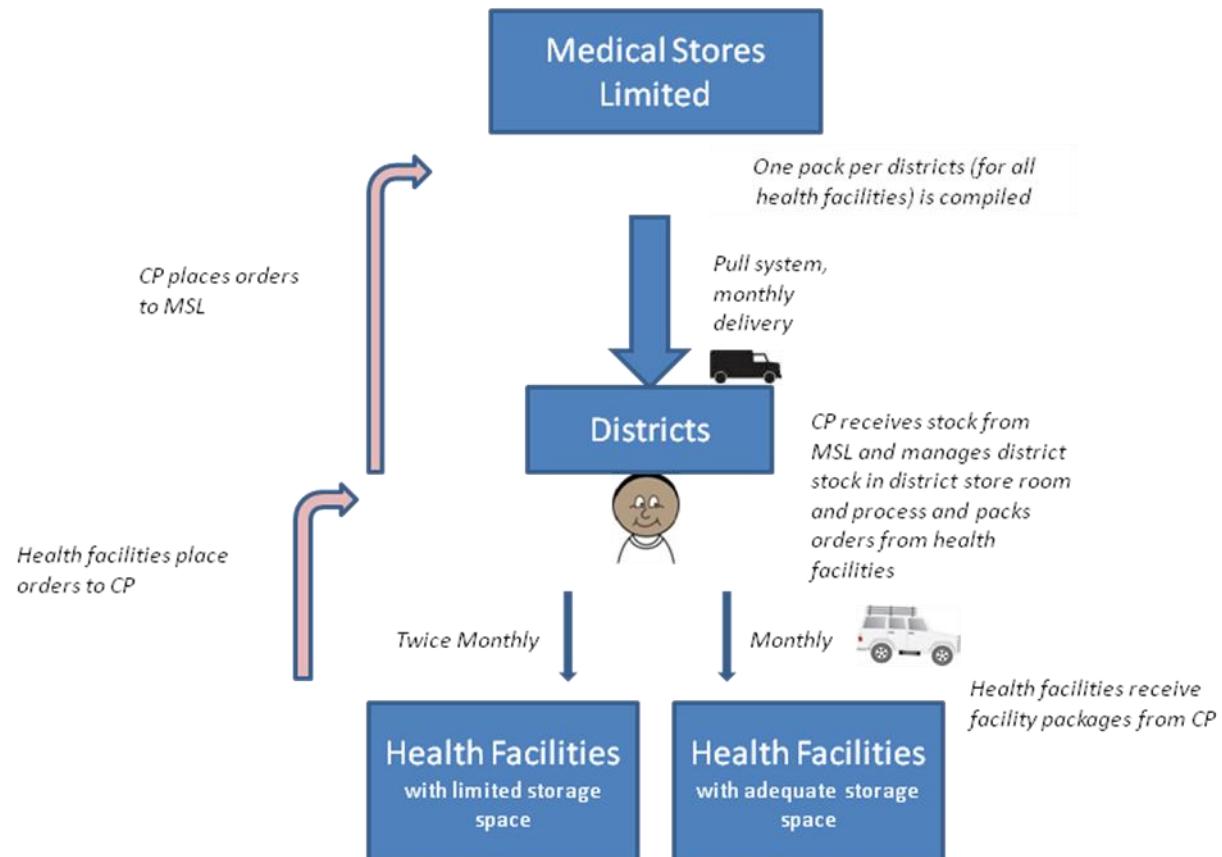


Figure 1b: Model B, Commodity Planner and Cross-Dock

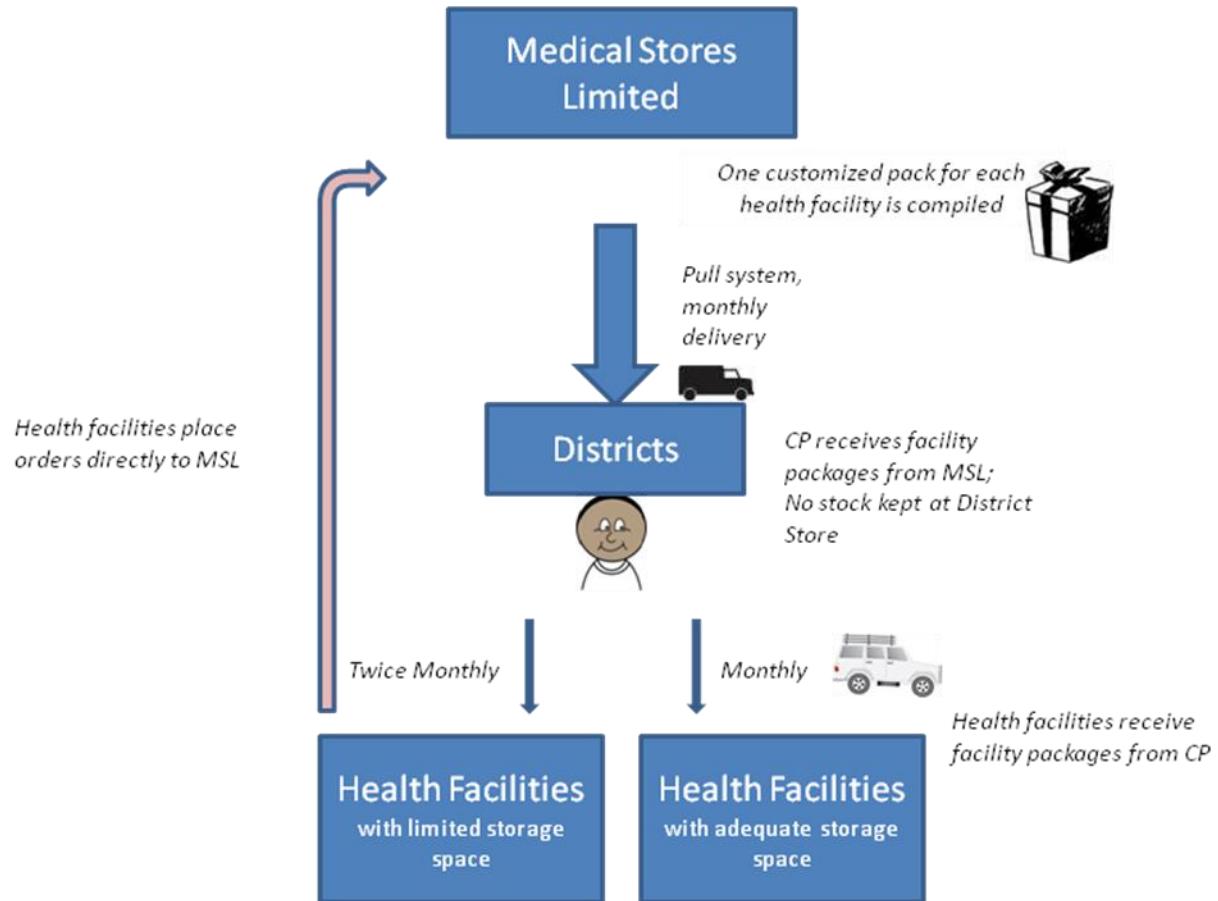
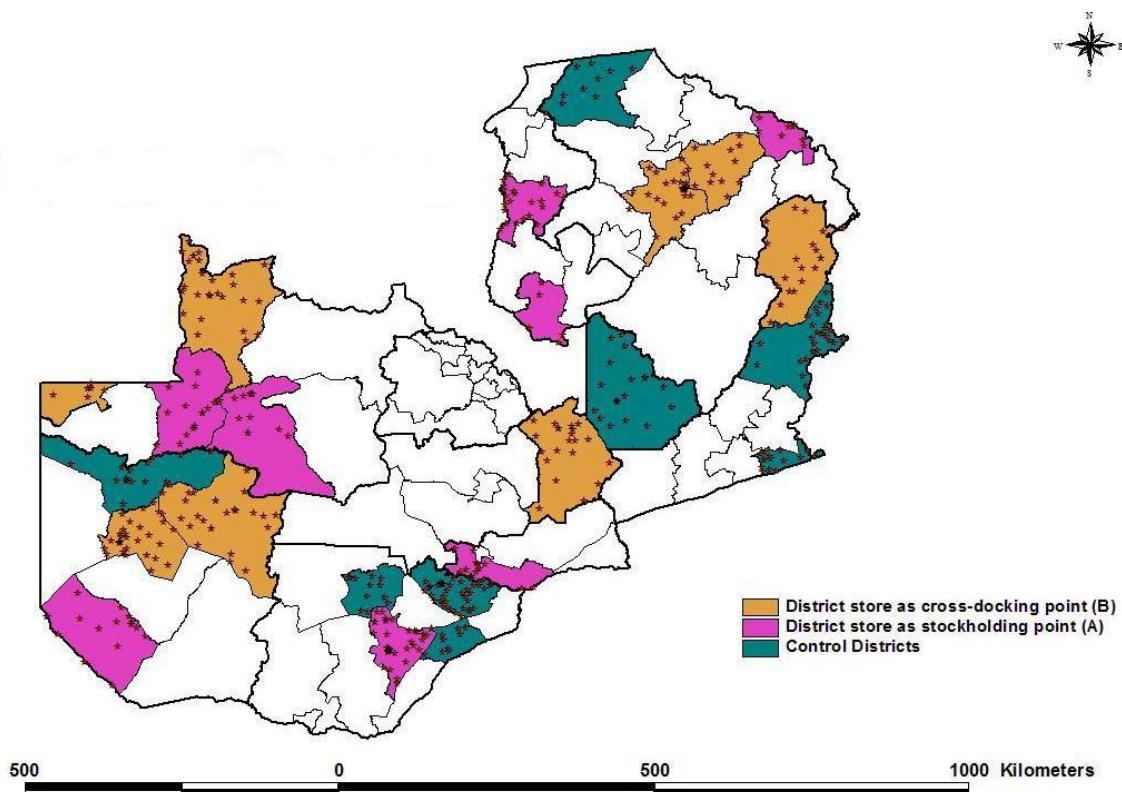


Figure 2: Districts by A and B interventions and control areas



Annex 2

Tables 1 and 2 of Annex 2 present a comprehensive overview of the results for all 15 tracer drugs that takes into account the relative difference between baseline and endline values in both the treatment and control areas through a “difference-in-difference” regression specification. This specification is given in the equation below, where O is the outcome of interest at facility f in district d . A and B are indicators for A and B districts, respectively, while $I(t=1)$ is an indicator for the follow-up period.

$$O_{fd} = \gamma_0 + \gamma_{A0} * A_{fd} + \gamma_{B0} * B_{fd} + \gamma_1 * I(t=1) + \gamma_{A1} * A_{fd} * I(t=1) + \gamma_{B1} * B_{fd} * I(t=1) + \varepsilon_{fd}$$

The coefficients of interest, those that identify the causal impact of Models A and B, are given by γ_{A1} and γ_{B1} . Standard errors are clustered at the district level to account for any observational dependence within districts since the intervention is by design a district-level intervention.

Annex 2 Table 1 reports the difference-in-differences in the probability of stock-outs for Model A and B. The table indicates that the B model has a negative and statistically significant effect on the likelihood of stock-outs for 11 out of the 15 tracer drugs. The A model has a negative and statistically significant effect for only 5 out of 15 drugs. A similar analysis looking at the inventory level was conducted (Table 2) and the same pattern occurs with higher inventory levels for most drugs (9 out of 15) in Model B districts compared to Model A districts (2 out of 15) and control districts. In summary, these statistically significant results show that Model B performs substantively better in terms of availability of drugs and inventory levels

Table 1. Difference-in-difference estimates of intervention effect on probability of stock-out in health facilities

Drug type	Constant	p-value	A districts	p-value	B districts	p-value	Follow-up period	p-value	A districts * follow-up	p-value	B districts * follow-up	p-value	N	Adjusted R-square
AL 1x6	0.423***	0.001	-0.084	0.524	0.011	0.938	0.064	0.303	-0.098	0.209	-0.378***	0.007	406	0.052
AL 2x6	0.380***	0.000	0.081	0.474	0.170	0.117	0.033	0.675	-0.248*	0.051	-0.508***	0.000	407	0.090
AL 3x6	0.338***	0.000	0.093	0.405	0.145	0.172	0.162**	0.025	0.375***	0.001	-0.586***	0.000	406	0.099
AL 4x6	0.338***	0.000	0.062	0.455	0.062	0.496	0.210*	0.097	-0.204	0.175	-0.491***	0.006	405	0.060
Amoxicillin Suspension	0.718***	0.000	0.020	0.881	-0.002	0.989	-0.205*	0.065	-0.219	0.106	-0.348**	0.021	407	0.184
Benzyl Penicillin Inj.	0.225**	0.030	0.021	0.849	-0.025	0.816	-0.198**	0.031	-0.005	0.961	0.043	0.677	407	0.068
CTX 480mg tabs	0.451***	0.000	-0.035	0.708	-0.051	0.600	0.293***	0.002	-0.336**	0.023	-0.364**	0.030	407	0.068
DepoProvera (vial)	0.254***	0.000	0.131	0.198	0.196	0.120	0.138	0.197	-0.352**	0.028	-0.588***	0.001	407	0.106
Malaria RDTs	0.465***	0.000	-0.003	0.979	-0.031	0.825	-0.086	0.519	-0.189	0.236	-0.168	0.397	407	0.054
Male Condoms	0.183***	0.003	0.078	0.389	0.134	0.127	-0.075	0.163	-0.058	0.564	-0.182**	0.042	407	0.041
Metronidazole 200mg tabs	0.606***	0.000	0.010	0.928	-0.072	0.628	-0.173*	0.100	0.001	0.996	0.058	0.653	407	0.015
OralconF	0.408***	0.000	0.176	0.177	0.292**	0.032	-0.071	0.651	-0.357*	0.070	-0.555***	0.004	407	0.188
Quinine Injection	0.338***	0.001	0.139	0.252	0.129	0.360	-0.162	0.127	-0.157	0.212	-0.274*	0.078	407	0.125
Quinine Tabs	0.085**	0.019	-0.054	0.181	0.099	0.206	0.145	0.152	-0.105	0.314	-0.209	0.128	407	0.032
SP	0.535***	0.000	0.049	0.645	-0.019	0.858	0.073	0.548	-0.194	0.273	-0.425**	0.019	406	0.077

Note: Robust standard errors adjusted for design effect at district level. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors

Table 2. Difference-in-difference estimates of intervention effect on quantity stocked in health facilities

Drug type	Constant	p-value	A districts	p-value	B districts	p-value	Follow-up period	p-value	A districts * follow-up	p-value	B districts * follow-up	p-value	N	Adjusted R-square
AL 1x6	48.718*** 0.004		-9.764 0.619		-2.385 0.906		18.056 0.599		16.813 0.666		90.088** 0.042		402	0.079
AL 2x6	34.803*** 0.000		1.705 0.896		-2.153 0.835		60.197 0.165		-15.690 0.722		102.765** 0.043		402	0.140
AL 3x6	48.572*** 0.000		-1.572 0.933		-3.355 0.832		38.442 0.396		-9.707 0.842		72.311 0.145		403	0.078
AL 4x6	39.451*** 0.000		15.272 0.470		-4.101 0.735		21.169 0.608		-21.142 0.653		120.197** 0.026		402	0.096
Amoxicillin Suspension	1.606** 0.021		4.902 0.238		1.261 0.326		7.175** 0.032		13.810 0.118		60.125*** 0.004		404	0.176
Benzyl Penicillin Inj.	27.183*** 0.001		5.723 0.524		-4.000 0.593		20.529* 0.081		-11.117 0.524		25.681 0.163		403	0.047
CTX 480mg tabs	1.880*** 0.000		-0.296 0.574		1.163 0.489		-0.491 0.687		3.347* 0.100		2.154 0.271		406	0.014
DepoProvera (vial)	55.352*** 0.000		-22.243 0.157		-20.069 0.195		-8.310 0.699		68.816* 0.056		248.297*** 0.000		395	0.246
Malaria RDTs	4.099*** 0.001		13.963** 0.039		0.701 0.711		9.554 0.181		19.543* 0.053		-4.712 0.523		404	0.005
Male Condoms	13.986** 0.025		-5.878 0.337		-5.403 0.394		18.084 0.135		-14.177 0.255		0.708 0.960		400	0.040
Metronidazole 200mg tabs	0.632*** 0.000		0.352 0.329		0.334 0.281		0.580* 0.072		0.885 0.189		0.827* 0.075		405	0.075
OralconF	118.930*** 0.005		-78.758* 0.072		82.613* 0.061		21.084 0.792		313.289 0.163		217.583* 0.097		396	0.026
Quinine Injection	73.575** 0.035		-17.928 0.700		-51.991 0.135		1.854 0.942		-18.355 0.609		133.481*** 0.005		382	0.056
Quinine Tabs	2.243*** 0.000		1.705 0.133		0.404 0.740		46.387 0.277		-46.758 0.274		-43.917 0.303		405	-0.002
SP	0.587*** 0.000		0.028 0.878		0.046 0.771		-0.120 0.525		0.534 0.234		1.721*** 0.002		405	0.099

Note: Robust standard errors adjusted for design effect at district level. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors

Annex 3

Methodology and assumptions used to estimate the impact of reduced stock-outs of ACTs on under- and over-five mortality in Zambia.

1,508,448 cases of malaria were reported amongst children less than 5 years old in Zambia in 2008 (World Malaria report 2009). Of these, approximately 61.8 percent (LCMS 2006) sought any form of formal consultation for malaria like fevers. Approximately 28.6 percent self administered medicines purchased primarily (95 percent) in non public sector sources. Among those who sought formal consultation, 93 percent seek care at a public sector facility and 62 percent of those who use drugs for the treatment of malaria like fevers obtain them in a public sector facility.

We estimate the market share of ACTs in the non public sector to be 8.0 percent based on multiple earlier studies on the private anti-malarial market in Zambia. The remaining 92 percent of those who obtain drugs in the private sector use primarily SP (Fansidar).

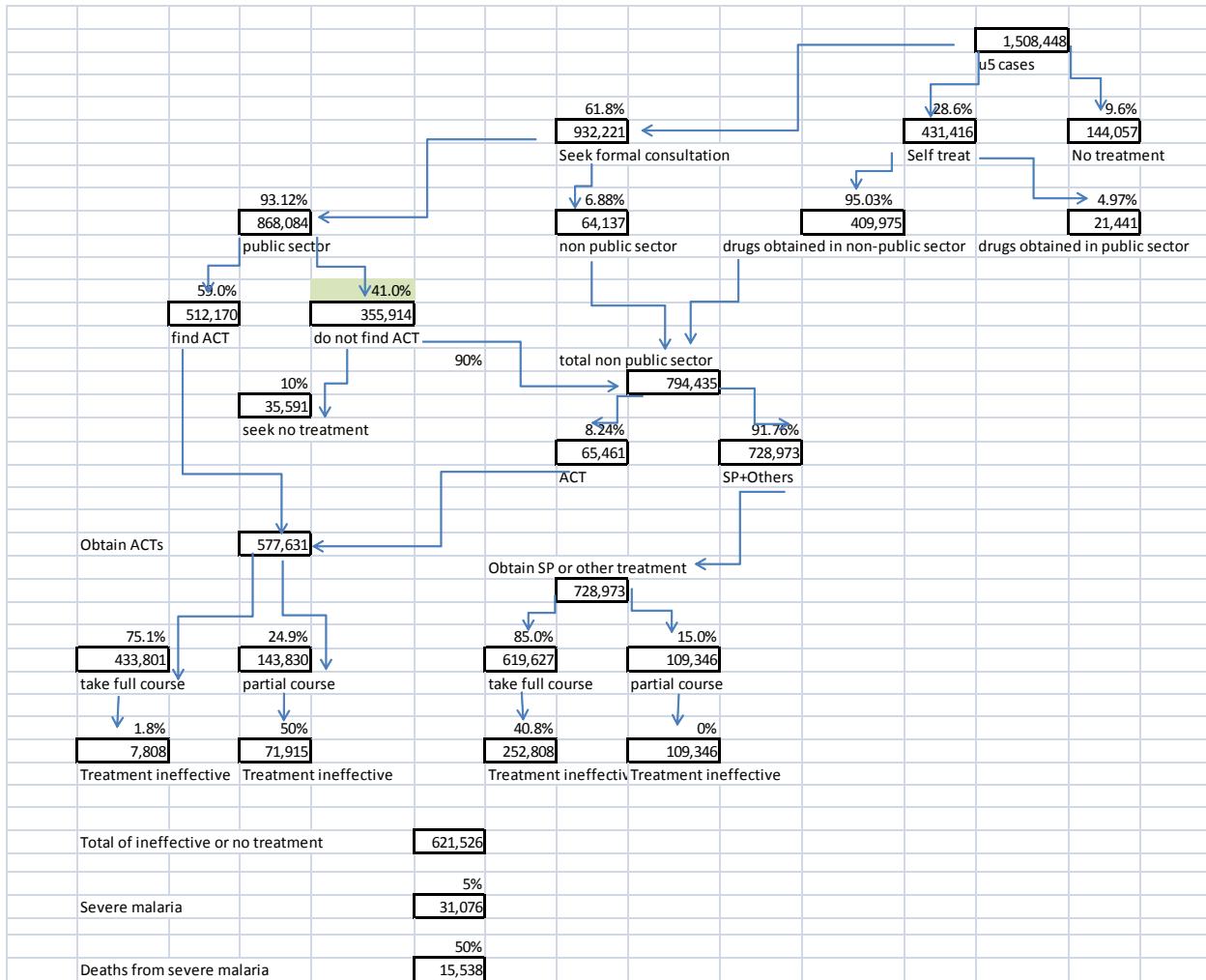
As in Chanda et al. 2007 (Malaria Journal 2007 6:21) we assume the current efficacy of AL is 98.2 percent as compared to 68.4 percent for SP. We also include estimates of compliance/full dosing for each drug based on the length and complexity of SP and AL treatment. In accordance with the longer length of ACT treatment relative to SP/Fansidar we set the compliance of ACTs to be 75.2 percent and of SP to be 85 percent. These figures are also from Chanda et al. 2007 but tie closely with other studies on malaria interventions notably (Saving Lives Buying Time, Arrow et al, IOM 2004). In our model we assume that 50 percent of patients who do not comply with the complete dosage of AL are still cured whereas non compliance with SP full dosage leads to a 0 percent cure rate. This assumption is also widely accepted in numerous cost-effectiveness studies on malaria treatment due to the shorter treatment course of SP and its mechanism of parasite elimination.

Currently those who seek treatment in the public sector health facilities find any dosage form of artemether lumefantrine available only 59 percent of the time. Upon encountering a stock out, the caregivers have to resort to seeking treatment in the non public sector where the share of ACTs is extremely low. We assume that in some cases (10 percent) they do not seek any formal treatment at all once they cannot find drugs in the public sector health facility. The result being that a larger number of care givers obtain ineffective SP treatment in the private sector. This translates into 621,526 of the total 1,508,448 under five malaria cases not being effectively treated. 5 percent of these ineffectively treated cases translate into severe malaria with a 50 percent chance of death resulting from it.

One caveat is that those presenting for consultation at a public sector clinic and encountering a stock out might in some cases travel to other health facilities. However, given the acute nature of malaria symptoms for children under 5 and the lack of patient transport systems in most primary care health centers, such instances are not very many to be a significant effect. Also, when stock outs occur their duration is several days (average duration in the current as-is system is 22 days for all forms of Artemether Lumefantrine) thereby not allowing repeat visits to the health facility.

The decision and flow pathway which brought about the numbers quoted in Policy Note is illustrated in Figure 1 below.

Figure 1. A model of patient flow and treatment seeking to estimate the impact of stock out reduction in U5



The reduction in ineffectively treated cases, complicated cases and mortality for patients over 5 years or older is estimated using a similar approach as described above. The only significant difference in the computation is the proportion of those who seek any form of treatment is slightly lower for the over 5 population. Also, we assume that 30 percent of those over 5 years old who seek treatment in the public sector health facilities and encounter a drug stock out on the day of their visit do not obtain any treatment at all. This fraction is higher as compared to the 10 percent for U5. Multiple earlier studies have documented such behavior among adults with malaria. The higher developed immunity in the population over 5 leads to fewer cases of complicated malaria (1 percent) and fewer of the complicated cases resulting in death (25 percent) even when malaria was not treated effectively. Figure 2 below depicts the decision and flow pathway for the over 5 population.

Figure 2: A model of patient flow and treatment seeking to estimate the impact of stock out reduction in over

5

