Costs of Multiplicity in Public Health Supply Chains in Burundi

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Abstract

As the public health system in Burundi transitions from a mode of emergency humanitarian response to a sustainable operation, there is a significant opportunity to reduce costs by eliminating the duplication of functions served by multiple parties. Numerous multi-lateral agencies and NGOs play a significant role in the public health supply chain. Additionally, Burundi has several vertical programs focused on specific communicable diseases such as HIV/AIDS, malaria and tuberculosis, which have parallel distribution systems. This thesis assesses the costs of multiplicity in the public health supply chain in Burundi, focusing on identifying the factors contributing to multiplicity and evaluating their cost impacts. We specifically analyze the transportation and inventory costs under four different distribution scenarios in the context of a proposed health sector structural reform while using the current system as a baseline. The analysis also discusses several other relevant factors that affect the costs of multiplicity. The research suggests that the Ministry of Health in Burundi can reduce costs, and improve availability of drugs by shifting from a pickup mode to a delivery mode of distribution, sharing assets between the central procurement agency and vertical programs, and improving the cash flow in the system.

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List of Acronyms[1]

ACT	Artemisinin-based Combination Treatment
AIDS	Acquired Immune Deficiency Syndrome
ARV	Anti-retroviral
BDS	*Bureau District de Sante* or District Health Bureau
BPS	*Bureau Provincial de Sante* or Provincial Health Bureau
CAMEBU	*Central d'Achat des Médicaments de Burundi*
DPML	Department *of Pharmacies, Medicines and Laboratories or Direction Nationale de la Pharmacie, Médicaments et Laboratoires*
FBU	*Franc Burundais* or Burundian Francs
GAVI	Global Alliance for Vaccines and Immunization
GDP	Gross Domestic Product
HIV	Human Immunodeficiency Virus
IMR	Infant Mortality Rate
MDG	Millennium Development Goals
MOH	Ministry of Health
MSF	*Médecins sans Frontières*
NGO	Non-Governmental Organization
OCHA	United Nations Office for the Coordination of Humanitarian Affaires
PNLT	*Programme National de Lutte contre la Lèpre et la Tuberculose*
PSI	Population Services International
TB	Tuberculosis
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization

[1] *Italicized words are in French*

1 Introduction

Numerous African nations face significant challenges providing healthcare to the public. Increasing levels of the population infected with HIV/AIDS, malaria, tuberculosis and communicable illnesses, the lack of infrastructure and the high cost of pharmaceuticals are common problems inhibiting sufficient medical supply to patients. Many African Governments have sought external support from multiple non-governmental organizations (NGOs) to supply and distribute medical supplies. Ironically, this dependency on multiple parties to provide certain medical supply functions can inhibit the supply of drugs to patients due to inefficiencies resulting from redundancy. These inefficiencies, or costs of multiplicity, inflate the price of medical supply in Africa.

The Republic of Burundi has supplemented its medical supply function with the resources of multiple NGOs that work together to supply health care to over 8,000,000 citizens. Partnering with the Ministry of Health (MOH) of the Republic of Burundi, the United Kingdom's Department for International Development (DFID), and the World Health Organization (WHO), this study investigates the costs of multiplicity in public health supply chain in the Republic of Burundi. Specifically, this study quantifies the costs of multiplicity in distribution from the central medical store, and proposes recommendations that could decrease supply chain costs in the context of a proposed health sector structural reform.

1.1 Burundi Overview

The Republic of Burundi is a land-locked East African Nation bordered by Rwanda to the North, The Democratic Republic of Congo to the West, and Tanzania to the East and South as displayed in Figure 1 below. Burundi is divided into 17 provinces (see map in Appendix 1) and has a population of approximately 8,000,000 according to 2008 estimates.

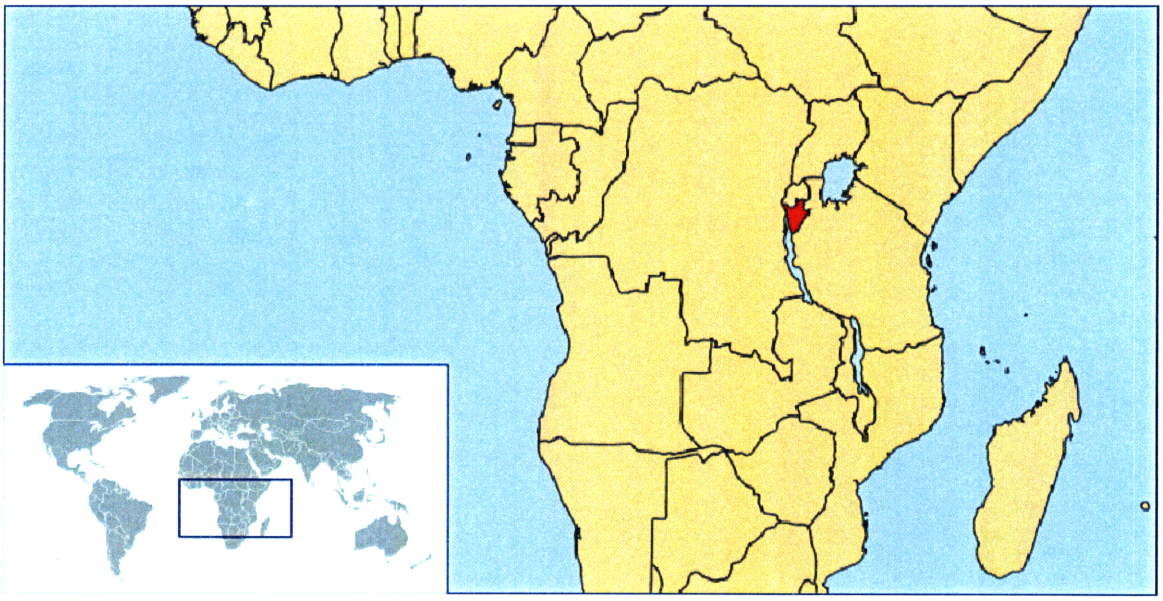

Figure 1. Location of Burundi

Politically, Burundi has been characterized by frequent conflicts since 1962; a civil war between two conflicting parties recently subsided with the election of Pierre Nkurunziza. However, the effect of multiple conflicts has left Burundi with a highly impoverished population, and health indicators reveal that average health levels are below Sub-Saharan averages (Word Bank 2001). Due to these issues, multiple NGOS, governments and multilateral agencies have intervened to supply

health services including drug distribution. In 2007, the WHO, in association with the Ministry of Health in Burundi created a mapping of the different stakeholders involved with financing, procurement, and distribution in the public health system in Burundi as illustrated in Appendix 2.

The combined efforts of these multiple organizations have sought to provide drugs mainly for communicable diseases such as Malaria, HIV/AIDS, and Tuberculosis which are the main causes of mortality in the region (World Bank 2001). Essential drugs are currently supplied through the Public Health system in Burundi.

1.2 Design of the Public Health System in Burundi

The public health system in Burundi is comprised of three levels. At the central level, is the Ministry of Health, which creates strategy, sets policy, and coordinates administration for the public health system. The Central Procurement Agency or *Central d'Achat des Médicaments de Burundi* (CAMEBU) is located in Bujumbura and is responsible for procuring drugs and supplies for the public sector. The intermediate level is composed of the Provincial Health Bureaus or Bureau *Provincial de Santé* (BPSs), who support the public health centers or *Centre de Santé* (CDSs) in their provinces. The level at which patients are served is made up of health centers and hospitals that interface with patients. The 3 levels of the public health system including what we define as the Primary Distribution Channel (PDC) –

which is comprised, of CAMEBU at the central level, BPSs at the province level and health centers at the service level – are illustrated in Figure 2 below.

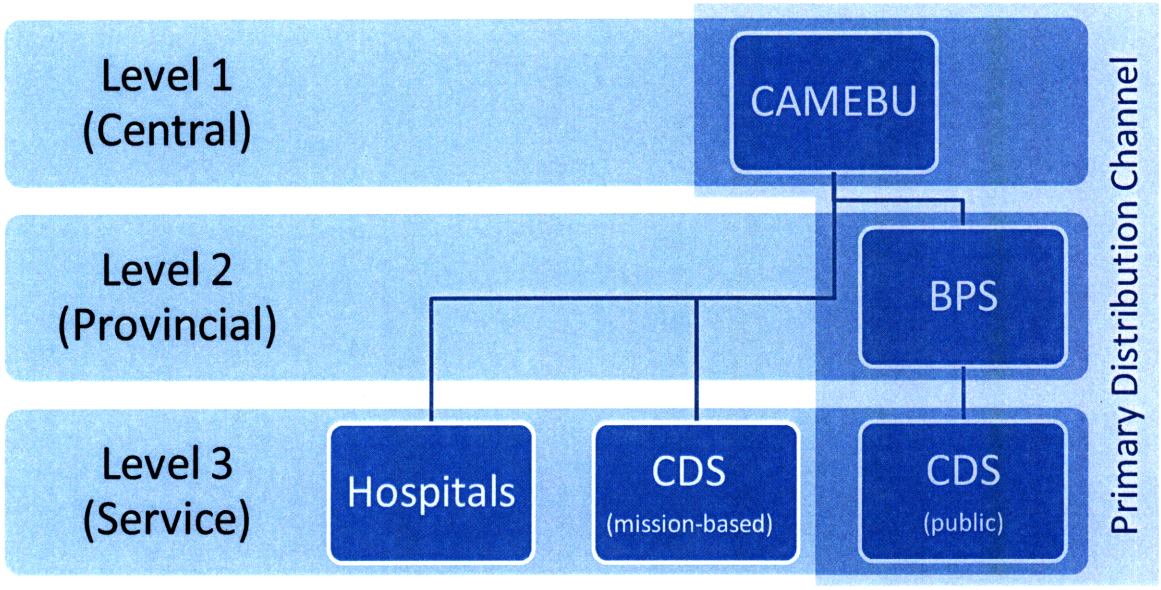

Figure 2. Structure of the province-based public health system in Burundi

Central Procurement Agency (CAMEBU)

CAMEBU procures and maintains a stock of essential medicines and supplies and also serves as a storage space for some of the vertical programs for specific diseases. CAMEBU does not deliver the drugs. Instead the BPSs and hospitals come to CAMEBU to pick up the drugs and supplies they need. CAMEBU recently installed an information technology system (Sage) to record transaction data for the sales of drugs and supplies whereas the other levels of the system still maintain paper-based records.

Provincial Health Bureau (BPS)

The BPSs pick-up drugs from CAMEBU and serve as an intermediate stocking point for the health centers in their province. They are scheduled to visit CAMEBU once per quarter. The BPSs estimate the demand for the health centers in their province and place their order at CAMEBU by filling out an order form displayed in Appendix 3. The BPSs pay the costs of hiring a vehicle for the trips to CAMEBU (if one is needed) while the MOH covers the cost of fuel. The BPSs are required to pay for the drugs they get from CAMEBU; however, they can get the materials on credit under the MOH account if they don't have money. In this case, the Ministry of Finance would reimburse CAMEBU for the amount of drugs given to the BPS on credit.

Health Center (CDS)

The public health centers pick up drugs and supplies from the BPSs on a monthly basis. They place their orders at the BPS using an order form similar to the one used by the BPSs and the order is supposed to be fulfilled from materials the BPS has in stock. The health centers typically hire a car or taxi for the trip and they have to bear the costs of hiring the vehicle. The health centers are supposed to pay the BPSs for the drugs and supplies within one month of the date of sale. The intent is to allow the health centers to recover the costs for the drugs and supplies by selling to their patients before having to pay the BPS for the materials. The mission-based health

centers are also permitted to procure materials through the public health system, however, they purchase drugs and supplies directly from CAMEBU as needed.

Hospitals

The hospitals in Burundi source their drugs and supplies from CAMEBU as well as private sector pharmacies. They operate autonomously and have the freedom to get materials through the private sector if they choose to since they regularly require drugs, which are not on the Essential Medicines List as well as specialty supplies. The hospitals typically use their own vehicles to pick up drugs and supplies as needed and they bear the full costs of transport.

1.3 Operation of the Public Health System in Burundi

Since the hospitals operate autonomously, our research is focused on what we describe as the Primary Distribution Channel (PDC) in the public health system. Through interviews with several people at different levels and observations during our visit to Burundi we learned that the PDC operates quite differently in practice than intended by design. The following discussion highlights these differences through a description of the system operation from an empirical and anecdotal perspective.

According to the several stakeholders we interviewed, frequent stock outs, and partial order fulfillments are a common occurrence. When health center's request

drugs, they are not always available at the BPS, so they occasionally purchase drugs from private pharmacies or return to the BPS more frequently than intended by design, to obtain partial replenishments of required drugs.

Similarly, the BPSs rarely get all the drugs and supplies they need from CAMEBU to fulfill the quarterly demand of the CDSs they serve, so they frequently return to CAMEBU to obtain portions of orders as drugs become available. In the event that drugs are not available at CAMEBU, BPSs often buy them from private sector wholesale pharmacies. In this case, the BPSs need to get permission from the Department of Pharmacies, Medicines and Laboratories or *Direction Nationale de la Pharmacie, Médicaments et Laboratoires* (DPML) to purchase drugs from the private sector. According to estimates received through interviews we conducted in Burundi, the BPSs regularly procure 30-70% of their requirements through private sector pharmacies. Also, some BPSs do not have the space to store a quarter's worth of drugs—this intensifies the need to frequently return to CAMEBU or private pharmacies to fulfill drug needs. On the BPS level, needs are also supplemented by private pharmacies.

Our empirical understanding of the public health system in Burundi is based on the receipts from CAMEBUs annual financial reports for 2006 and 2007. Based on information in these reports, the frequency of pick-ups at CAMEBU varied significantly between the BPSs from different provinces. The table below provides a summary of the number of trips made by each of the BPSs to CAMEBU.

Table 1. Number of trips made by the BPSs to CAMEBU in 2006 and 2007.

BPS		Trips	
No	**Name**	**2006**	**2007**
1	BPS Kirundo	1	3
2	BPS Cibitoke	1	no data
3	BPS Gitega	1	no data
4	BPS Cankuzo	2	2
5	BPS Ngozi	3	no data
6	BPS Kayanza	4	4
7	BPS Ruyigi	4	4
8	BPS Muyinga	4	no data
9	BPS Rutana	5	no data
10	BPS Bubanza	6	1
11	BPS Mwaro	7	1
12	BPS Makamba	no data	1
13	BPS Buja-Mairie	no data	6
14	BPS Buja Rural	no data	no data
15	BPS Bururi	no data	no data
16	BPS Karuzi	no data	no data
17	BPS Muramvya	no data	no data

The records above from CAMEBU's financial statements suggest that out of the 17 provinces in Burundi, only 11 BPSs picked up drugs from CAMEBU in 2006 and only 8 picked up drugs from CAMEBU in 2007. These low and declining numbers of BPSs that source drugs from CAMEBU is a concern. We suspect that the lack of data for the other provinces is due to transactions that were conducted on credit on the MOH account but this has not been confirmed. This is probably because CAMEBU's financial statements record transactions based on the payer and not the recipient of the drugs and supplies. Further investigation would help to understand the underlying reasons for this effect.

1.4 Proposed Health District Reform in Burundi

The proposed Public Health District Reform seeks to increase the efficiency of drug supply throughout Burundi by changing the structure and strategy of Burundi's public health supply chain. The reform would change Burundi's PDC from its current structure by replacing BPSs with District Health Bureaus (BDSs) as the intermediate stocking points as illustrated in Figure 2 below. In this new district-based-system, the BPSs would not hold any inventory, however, they would perform a management function where they would support, monitor and evaluate the performance of the BDSs in their province. Strategically, the reform would change the operation from the current pick-up mode of operation to a delivery mode.

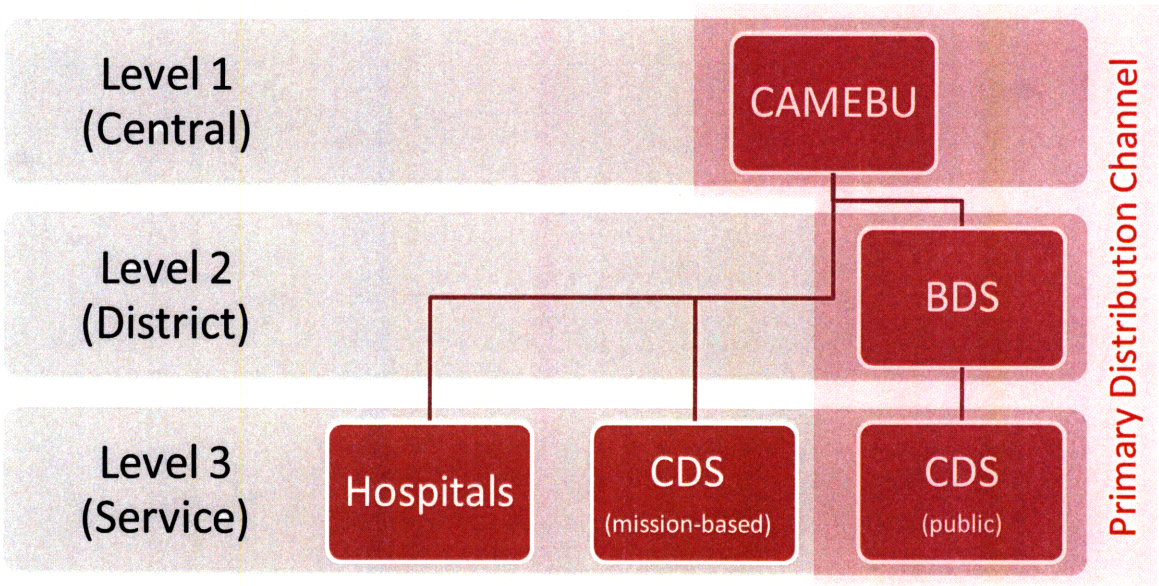

Figure 3. Structure of the province-based public health system in Burundi

The effects of multiplicity on the transportation and inventory costs would be impacted by the structure of the system. In the context of this reform, we evaluate 4

potential scenarios for the primary distribution channel in the public health system. The scenarios are combinations of the system structure (current province-based system or proposed district-based system) and the mode of distribution (pick-up or delivery) as follows:

1. Province-based structure operating in pick-up mode.
2. Province-based structure operating in delivery mode.
3. District-based structure operating in pick-up mode.
4. District-based structure operating in delivery mode.

Each alternative presents different transportation and inventory dynamics, with different cost-benefit tradeoffs.

1.5 Problem Definition

In light of the highly debated health district reform, we aim to provide an objective evaluation of the four different supply chain scenarios identified above. We assess the cost-benefit tradeoffs in each of the alternatives of the primary distribution channel in the public health system. In order to do so, we will address 3 main questions though our research –

1. What are the factors contributing to the costs of multiplicity in the public health supply chain in Burundi?
2. What is the impact of these costs?

3. What can be done to mitigate these costs?

By answering these questions objectively, we hope our research will help to guide the dialogue between the Ministry of Health and other stakeholders in their efforts to improve the effectiveness of health care delivery in Burundi.

1.6 Literature Review

A diverse selection of literature was reviewed to understand the costs of multiplicity in the context of Burundi's Public Health supply chain. Sources outlining supply chain structure were used to understand the impact of changing structures on transportation and inventory dynamics. Literature on drug supply in African countries helped to frame our approach to the analysis. Specific studies in health supply chain strategy informed our recommendations.

S.D. Foster's "Improving the Supply and Use of Essential Drugs in Sub-Saharan Africa," discusses the fusion between the private and public supply chains in many African countries. She goes further to define parastatal organizations that duplicate functions in both sectors. To oppose issues of incorrect quantification of drug needs from multiple parties, Foster believes that centralization of public health supply chains is essential for proper public health supply chain management.

Effects of multiplicity are broached in Laverty and Lai's, "Improving Global Health Impact Through Tailored Supply Chains: A Case Study of Ghana" (2008). Segmentation is seen as a way to combat multiplicity in procurement and

distribution. Though specific costs of transportation, and inventories are not fully quantified, but the relative benefits of segmenting drugs are discussed extensively.

Anban Pillay's "The South African Experience: Access, Price, Regulation Towards National Health Insurance," details the fragmented nature of many African public health supply chains. His work provided baseline percentages of public versus private drug purchases in the space. Concerning cash flow issues up and down the supply chain Pillay provides innovative nationalized insurance alternatives that have been well received internationally.

John Snow Incorporated (JSI) has produced numerous documents detailing logistics system structures in African public health supply chains. JSI assessments have analyzed Ghana, Nigeria, and Kenya among other countries. This organization has also developed "Concepts of Logistics Systems Design," which is a manual detailing best practices in logistics system structural design for public health supply chains in Africa (Owens, 2003). Though some of JSI country assessments have touched on the impact of vertical programs, the costs associated with these programs have not been quantified.

Another JSI Article, "Decentralizing and Integrating Contraceptive Logistics Systems in Latin America and the Caribbean" provides a discussion of necessary differences in inventory policies for centralized and decentralized public health supply chains. This information, though not specific to Africa, or detailing costs, contributed to the qualitative inventory discussions.

2 Methods

We used a combination of qualitative and quantitative methods to analyze the costs of multiplicity in the distribution of the drugs and supplies through the public health supply chains in Burundi. Specifically, we used structured interviews to develop a qualitative understanding of the issues, which were complemented by surveys to gather transportation cost information. The data from the surveys were used to model transportation costs in the system to evaluate the current (province-based) and reformed (district-based) scenarios.

2.1 Current Province-Based System -

The Primary Distribution Channel of the public health system in Burundi is comprised of three levels as illustrated in Figure 4 below.

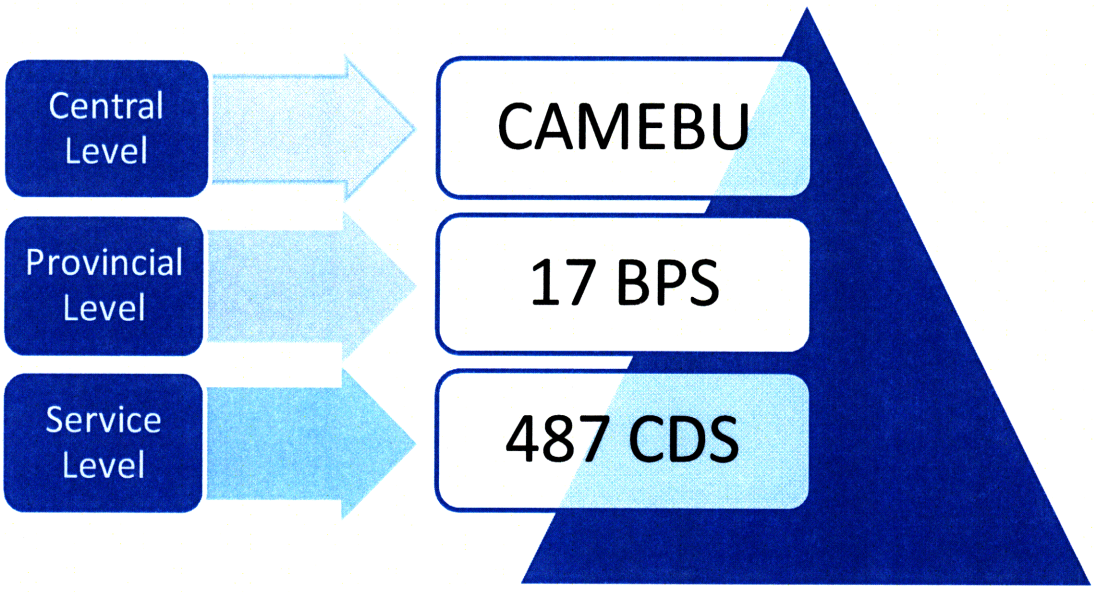

Figure 4. Structure of the province-based Primary Distribution Channel of the public health system in Burundi

Qualitative aspects were surveyed from respondents via structured interviews with stakeholders in the Central Procurement & Distribution Agency (CAMEBU), Provincial Distribution Centers (BPS), and at the Health Centers (CDS). These interviews provided the information pertaining to the ordering and transportation process, the types of vehicles used and also provided an initial range of estimates of the costs incurred. Multiple representatives at each of the three levels were interviewed to triangulate information and validate anecdotal estimates. A set of common questions was used consistently in most interviews to ensure that all necessary information was gathered. A complete list of questions and their responses can be found in Appendix 4.

2.1.1. Scenario 1: Pick-up Mode –

The current distribution system operates in a pick-up mode where the health centers pick up drugs and supplies from the provincial centers, which in turn pick up from the central store. Numerical data was obtained through a survey sent to the central procurement agency, and to provincial distribution centers, which solicited information about transportation costs, frequency of pick-ups, frequency of orders and other factors. A complete list of survey questions can be found in Appendix 5. The data from these surveys was used extensively to create the transportation cost model for the link between the central and provincial levels under the current system. Due to the lack of available data and challenges with implementing a similar survey for the health centers, the quantitative analysis was limited to link between the central and provincial levels.

2.1.2. Scenario 2: Delivery Mode –

In order to perform a quantitative comparison, we created a transportation cost model for a hypothetical scenario where the distribution system would operate in a push mode where CAMEBU would deliver drugs and supplies to the BPS. This would allow us to assess the transportation costs due to the multiplicity of pick-ups from CAMEBU. We used data from the UNDP invoices for the distribution of large quantities of medical supplies to all the BPSs to construct a model to calculate the transportation costs between CAMEBU and the different BPSs. Since the invoice data was only for distribution to the BPSs, our analysis was limited to distribution between the central and provincial levels.

2.2 Reformed District-Based System -

According to the proposed Health District reform, Burundi is transitioning to a health district system under which the 17 provincial distribution centers will be replaced by 44 district distribution centers. The reformed public health distribution system in Burundi will comprised of three levels as illustrated in Figure 4 below.

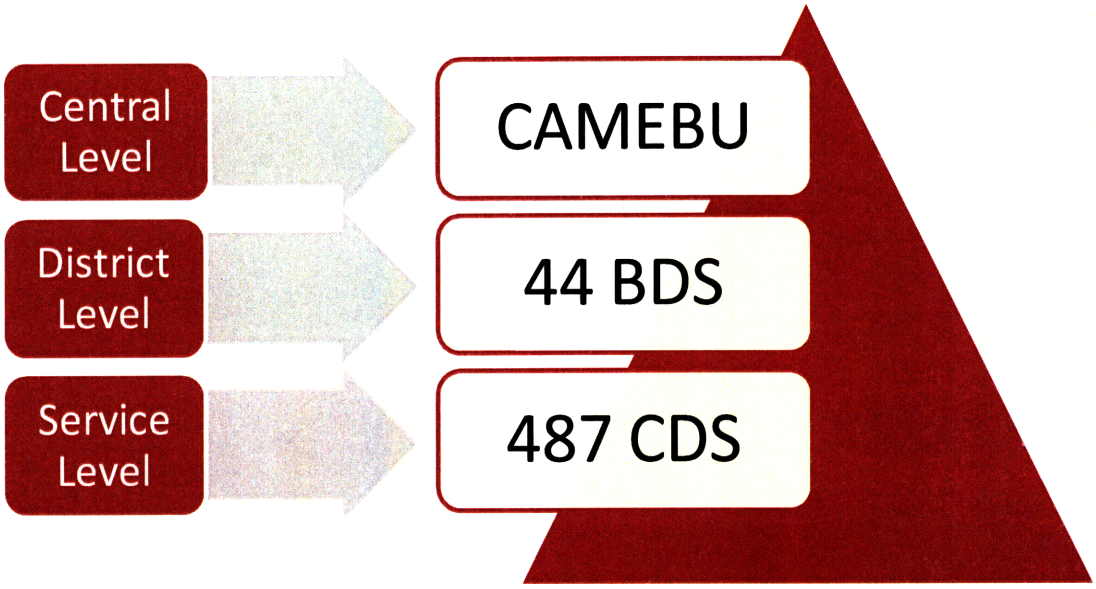

Figure 5. Structure of the district-based Primary Distribution Channel of the public health system in Burundi

The transportation cost models for both pick-up and push modes of operation were modified to assess the impact of the health reform of transitioning to the district distribution centers (BDS). These two cost models will help us evaluate the potential cost advantages of the hypothetical centralized distribution system over the current decentralized distribution system for both province level and district level distribution.

2.2.1. Scenario 3: Pick-up Mode –

The transportation cost model created based on the survey data was modified to quantify the costs that would be incurred in the reformed system for distribution between the central and district levels under the pick-up mode of operation. The 17

BPSs were replaced with 44 BDSs and transportation costs were extrapolated depending on the provinces to which the districts were a part of.

2.2.2. Scenario 4: Delivery Mode –

The transportation cost model based on the data from the UNDP invoices was modified to assess the projected costs that would be incurred in the reformed system for distribution between the central and district levels under the push mode of operation. The transportation costs for delivery to with 44 BDSs instead 17 BPSs from CAMEBU were extrapolated depending on the provinces to which the districts belong.

3 Analysis

Based on information gathered through our interviews in Burundi, we identified several factors contributing to the costs of multiplicity in the public health supply chain. The primary factors contributing to multiplicity in transportation are the pick-up mode of distribution and the constrained supply of drugs a CAMEBU. When operating in a pick-up mode there is the inherent multiplicity of each of the BPSs arranging their own transportation to pick up drugs and supplies from CAMEBU. The constrained supply at CAMEBU often results in only partial fulfillment of BPS orders which causes the BPSs to procure drugs from the private sector at higher prices or to return to CAMEBU more frequently. Both these factors result in higher transportation costs.

The primary factors contributing to multiplicity in inventory are the multiple stocks of some drugs at the same facility and the number of stocking locations. Several health centers are required to maintain separate stocks of drugs for sale and those which were donated to be given away to patients free of charge. Secondly, an increase in the number of stocking locations at the intermediate level would have an effect on the total system inventory.

Our analysis aims to discuss the factors contributing to the costs of multiplicity in the public health supply chain in Burundi and assess the cost impacts under different scenarios. First, we provide an analysis of the current province-based system with 17 provincial centers (BPS) as the intermediate stocking points between CAMEBU at the central level and the health centers at the service level.

Then we analyze the reformed district-based system in which 44 district centers (BDS) serve as the intermediate stocking points between the central and service levels. Each system structure is analyzed under two different modes of distribution: pick-up and delivery. In order to assess the impact of these factors on the transportation costs we develop two cost models; one quantifying the costs of pick-up by the BPSs or BDSs from CAMEBU and another quantifying the costs of delivery from CAMEBU to the BPSs or BDSs.

3.1 Cost Model for Pick-up mode –

The current distribution system operates in a pick-up mode where the health centers pick-up drugs and supplies from the provincial centers that go to CAMEBU to receive their stock. To analyze the transportation costs of pick-up between the BPS and CAMEBU we utilized data from surveys, which were administered to the directors of the BPS from the different provinces. An example of a completed survey can be found in Appendix 6. Survey responses were received only from 11 of the 17 BPSs. So we used the data from the 11 surveys to create a transportation cost model to estimate the transportation costs for the remaining 6 BPSs under the current system.

Based on the survey data we found a very high degree of variation in the number of trips made by the BPSs to pick-up drugs. By design, they are only intended to pick-up drugs once a quarter or 4 times per year. However, we found that amongst the BPSs who responded to the survey, they made an average of 9 trips per year to

CAMEBU ranging from as few as 4 trips to as many as 18 trips. These additional trips add significant expenses due to the high cost of transportation. The number of trips made by each of the provinces to CAMEBU and private sector pharmacies to pick-up drugs is illustrated in Figure 6 below.

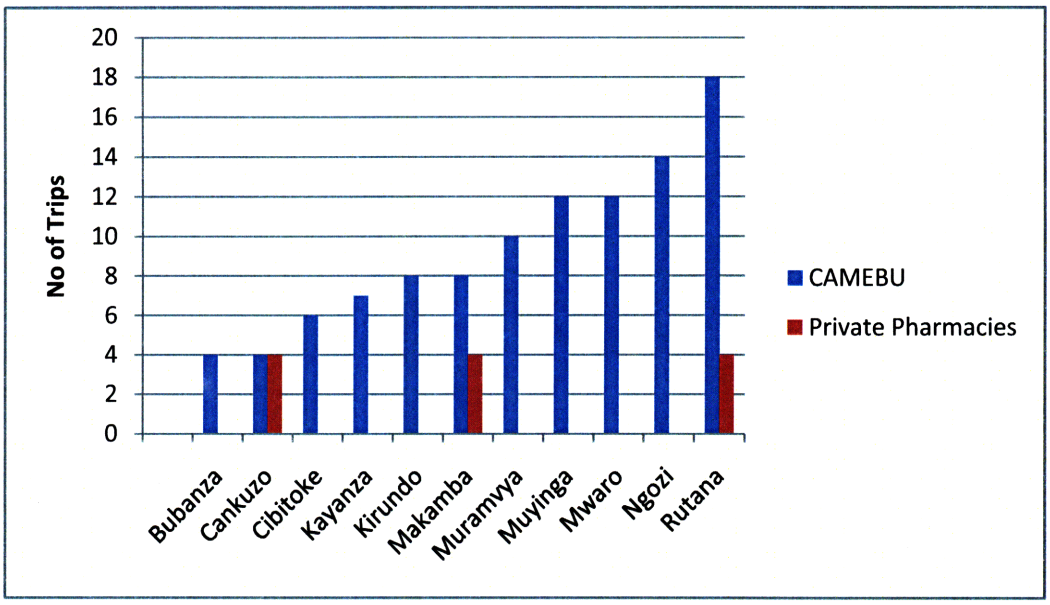

Figure 6. Number of trips for picking up drugs from CAMEBU and private pharmacies, by province.

The BPSs currently use several different modes of transport for picking up drugs. They primarily hire trucks for large shipments, use their own vehicle (if available) for smaller shipments, and occasionally hire taxis or motorcycles. The distribution of the number of trips by mode of transport used by the BPSs is shown in Figure 7 below. The other category primarily includes the vehicles owned by BPSs.

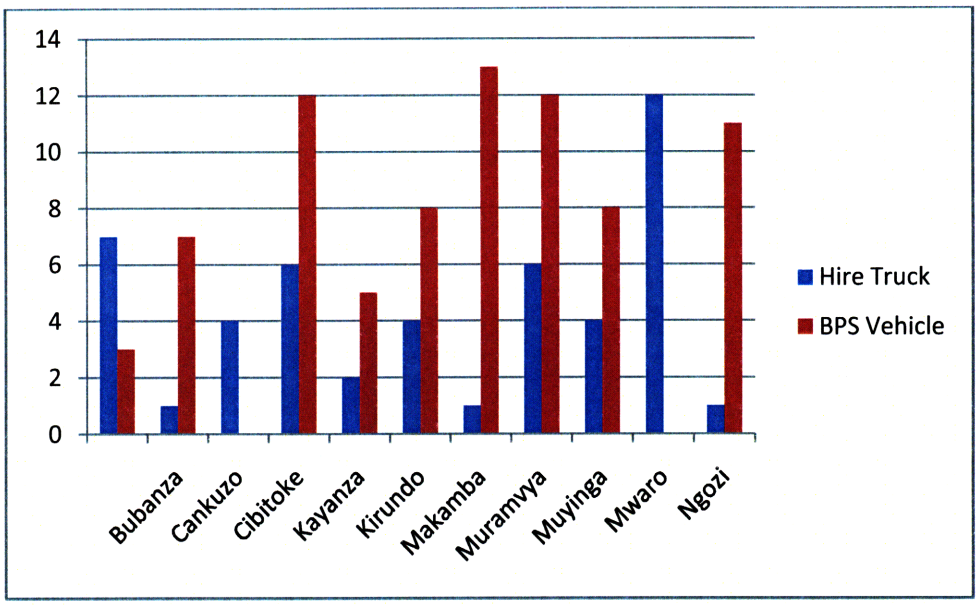

Figure 7. Trips by province using a hired truck or BPS vehicle

The actual transportation costs incurred by the BPSs as reported in the surveys are listed in Table 2 below. The trucks were hired for larger shipments whereas the BPS vehicles were used for smaller replenishments. It is evident that costs of hiring a truck dominate the total transportation costs.

Table 2. Transport costs by mode and province.

Province	Hire Truck		Truck Total (FBU)	BPS Vehicle		BPS Vehicle Total (FBU)	Total Cost (FBU)
	No of trips	Cost per trip		No of trips	Cost per trip		
Bubanza	7	80,000	560,000	3		0	560,000
Cankuzo	1	300,000	300,000	7		0	300,000
Cibitoke	4	200,000	800,000	0		0	800,000
Kayanza	6	300,000	1,800,000	12		0	1,800,000
Kirundo	2	380,000	760,000	5		0	760,000
Makamba	4	350,000	1,400,000	8	130,000	1,040,000	2,440,000
Muramvya	1	200,000	200,000	13	50,000	650,000	850,000
Muyinga	6	500,000	3,000,000	12	150,000	1,800,000	4,800,000
Mwaro	4	800,000	3,200,000	8	400,000	3,200,000	6,400,000
Ngozi	12	200,000	2,400,000			0	2,400,000
Rutana	1	300,000	300,000	11	130,000	1,430,000	1,730,000
TOTAL			**14,720,000**			**8,120,000**	**22,840,000**

The costs for hiring a truck vary significantly depending on location. The range of cost per trip for hiring a truck in each of the provinces is illustrated in Figure 8 below.

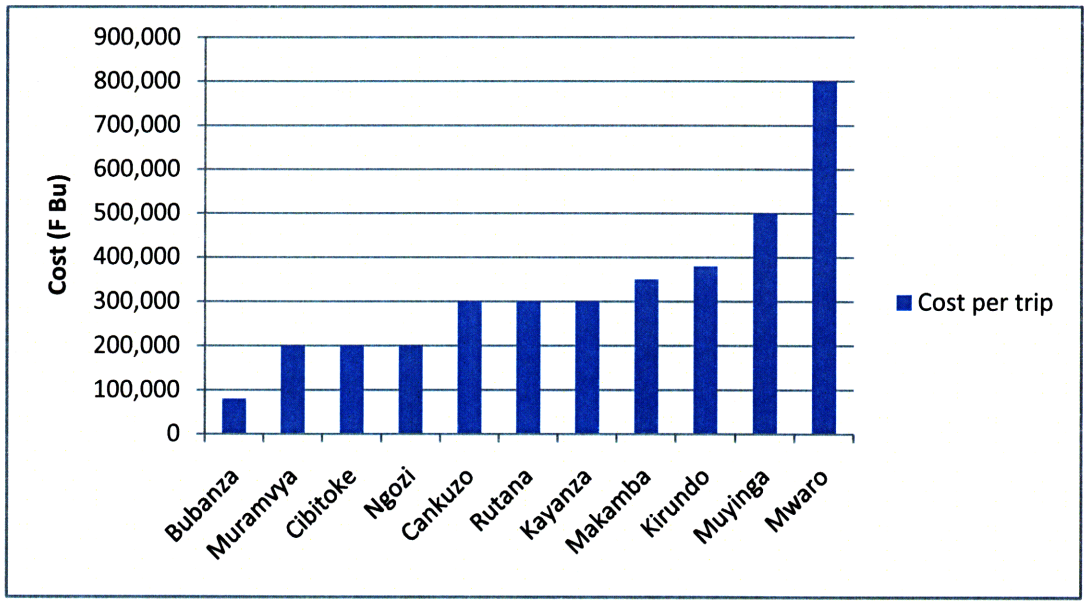

Figure 8. Costs for hiring a truck

To estimate the total transportation costs between the central and provincial levels we created a model based on the survey data. We assumed a quarterly pick-up routine, which is the intended replenishment frequency by design of the current system. Since the reduced pick-up frequency would result in larger shipments on average we used the costs of hiring trucks to build the transportation cost model. In order to estimate the vehicle costs as a function of distance, we created a scatter plot of the truck rental costs against the distance for each trip as illustrated in Figure 9 and performed a regression. It is evident that one clearly outlying data point is causing a very poor fit as indicated by the very low R^2 value.

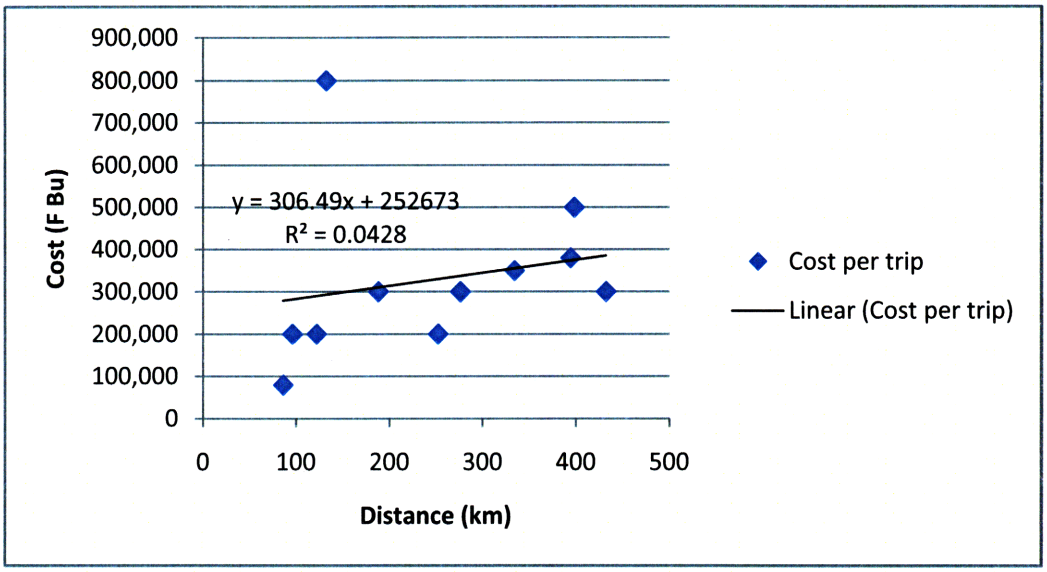

Figure 9. Preliminary regression of vehicle costs as a function of distance.

In order to get a better estimate of the vehicle costs as a function of distance, we created another scatter plot after removing the outlying data point as illustrated in Figure 10. The regression on this set of data points resulted in a much better fit as indicated by the significantly higher R^2 value.

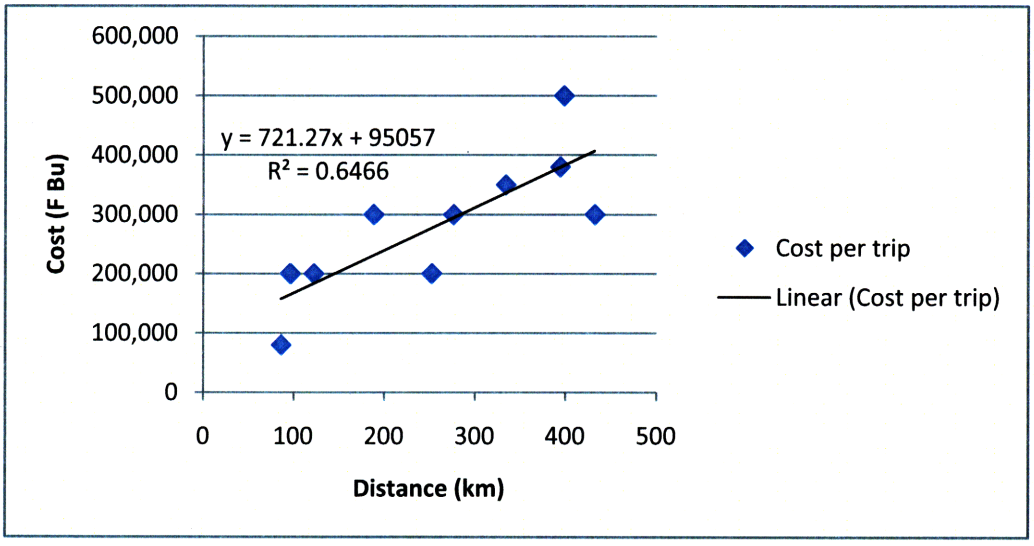

Figure 10. Revised regression vehicle costs as a function of distance.

To allow a comparison between the vehicle costs in the pick-up and delivery modes, we needed to ensure consistency between models. The vehicle costs in the delivery mode are accounted for completely as a variable cost with respect to distance. Therefore, we performed another regression on the data set to eliminate the fixed cost component by forcing a zero intercept as displayed in Figure 11 below.

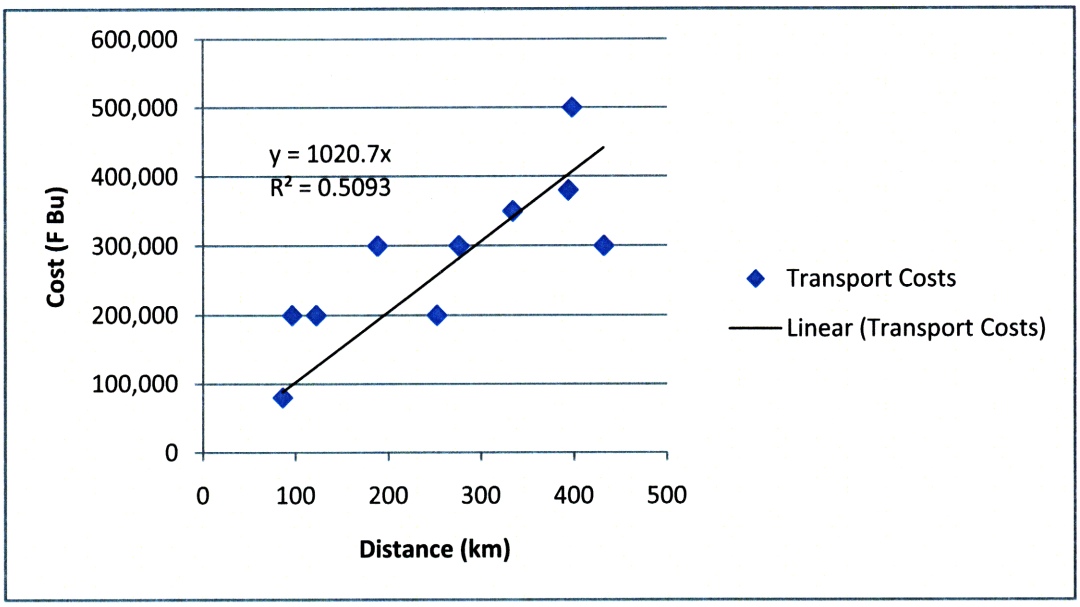

Figure 11. Vehicle costs as a function of distance.

The total vehicle costs, between the central and provincial levels in the pick-up mode, can be estimated as a function of distance using the variable cost of 1020.7 FBU per kilometer travelled as derived from the regression. The table of distances between the provinces provided by the Burundi tourism department (Appendix 7) can then be used calculate round-trip tour distances for pick-ups from CAMEBU to compute the appropriate vehicle costs for each of the tours.

3.2 Delivery Cost Model -

The delivery mode evaluation is based on a proposed scenario in which the central level would deliver drugs and supplies to the provincial level instead of the BPSs picking up from CAMEBU as they do in the current system. To analyze the transportation costs of delivery between CAMEBU and the BPSs we utilized the receipts of transportation costs for a joint distribution effort of supplies by CAMEBU and the United Nations Development Program (UNDP) to the provinces. A summary of the delivery costs is provided in Table 3 below.

Table 3. Transportation costs of UNDP deliveries.

Dates	No of Days	Distance (km)	No of People from CAMEBU	Per Diems (FBU)	Rate (FBU/ tonne-km)	Vehicle Costs (FBU)	Total Cost (FBU)
Le 02/12/2008	1	35	1	0	425	104,125	104,125
Du 10 au 10/09/2008	1	45	1	0	425	133,875	133,875
Le 11/11/2008	1	69	2	70,000	425	205,275	275,275
Le 17/10/2008	1	83	2	35,000	425	246,925	281,925
Le 25/09/2008	1	87	2	35,000	425	258,825	293,825
Du 24 au 25/09/2008	2	171	2	70,000	425	508,725	578,725
Du 03 au 04/09/2008	2	185	2	70,000	425	550,375	620,375
Du 31/10 au1/11/2008	2	190	2	70,000	425	565,250	635,250
Du 28 au 29/10/2008	2	209	2	70,000	425	621,775	691,775
Du 26 au 27/09/2008	2	225	2	70,000	425	669,375	739,375
Du 04 au 05/09/2008	2	227	2	70,000	425	675,325	745,325
Du 18 au 19/11/2008	2	228	2	70,000	425	678,300	748,300
Du 09 au 10/10/2008	2	245	2	70,000	425	728,875	798,875
Du 14 au 15/10/2008	2	248	2	70,000	425	737,800	807,800
Du 29 au 30/09/2008	2	263	2	70,000	425	782,425	852,425
Du 05 au 06/1112008	2	272	2	70,000	425	809,200	879,200
Du 20 au 21/11/2008	2	284	2	70,000	425	844,900	914,900
Du 02 au 03/10/2008	2	300	2	70,000	425	892,500	962,500
Du 01 au 02/09/2008	2	386	2	70,000	425	1,148,350	1,218,350
Du 22 au 23/10/2008	2	388	2	70,000	425	1,154,300	1,224,300
Du 06 au 071110/2008	2	424	2	70,000	425	1,261,400	1,331,400
Du 08 au 10/09/2008	3	351	2	105,000	425	1,044,225	1,149,225
Du 13 au 15/11/2008	3	566	2	70,000	425	1,683,850	1,753,850
Du 25 au 28/11/2008	4	510	2	140,000	425	1,517,250	1,657,250
TOTAL	**47**	**5,991**		**1,575,000**		**17,823,225**	**19,398,225**

The UNDP receipts data was used to create a cost model to characterize the vehicle costs as a function of distance and the per diem costs as a function of trip duration in days. The UNDP data was utilized for building the cost model, as it was

the only series of delivery trips made from CAMEBU to the provinces for which cost data was available.

In order to calculate total transportation costs as a function of distance, we needed to estimate the trip duration in days as a function of distance to compute per diem costs. In order to do so we created a scatter plot of the trip distance against the duration is illustrated in Figure 12 below. Based on the receipt data, the per diem rate were fairly consistent for all the delivery trips and determined to be 17,500 FBU per person-day.

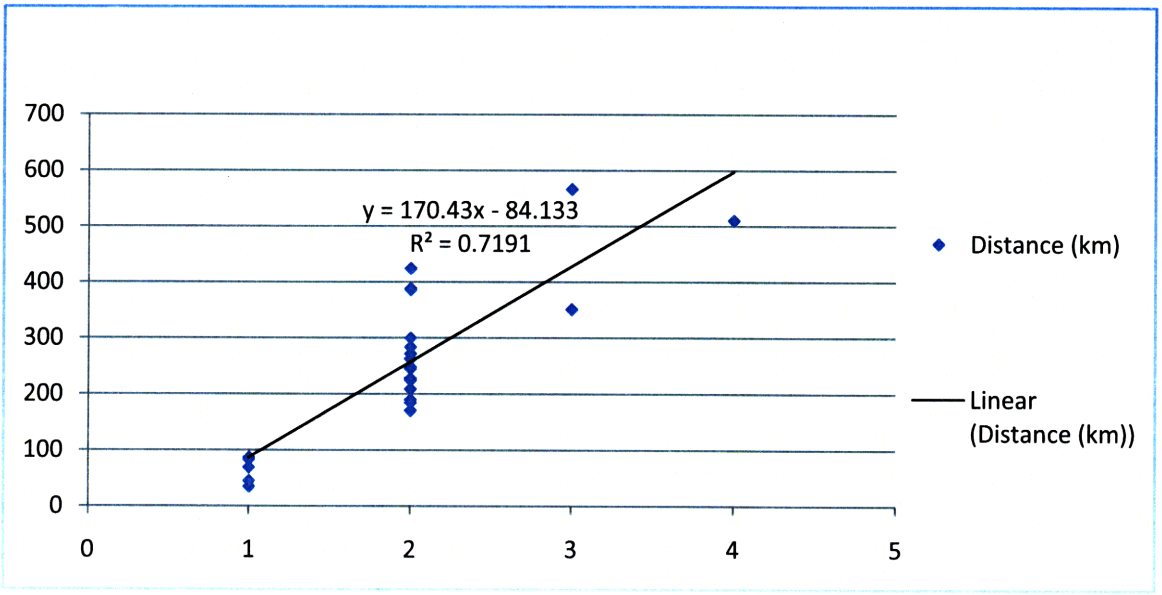

Figure 12. Correlation between Trip Distance and Duration

We performed a linear regression analysis to establish a correlation between the tour distance and the duration of the trips. This would enable estimation of per diem costs based on a trip distance. The range of distances and corresponding trip durations based on the regression are displayed in Table 4 below.

Table 4. Range of trip distances and corresponding duration.

From Cost Model	Distance (in km)			Duration (Days)
	Range_Low	Range_Nom	Range_High	
	2	86	171	1
	172	257	341	2
	342	427	512	3
	513	598	682	4

The correlation between trip distance and duration allows us to estimate total trip costs based solely on distance. First, the vehicle cost component is directly a function of distance. Second, the per diem cost component, which is a function of people and duration, is calculated assuming two people per trip. Further, using the results of the distance-duration regression in Table 4 we estimate the number of days needed for the trip based on the tour distance thereby allowing us to calculate total trip costs of delivery solely based on distance. Thus the total cost function is comprised of a vehicle cost component which is linear with respect to the trip distance and a per diem cost component which is a step function with respect to the trip duration as illustrated in Figure 13 below.

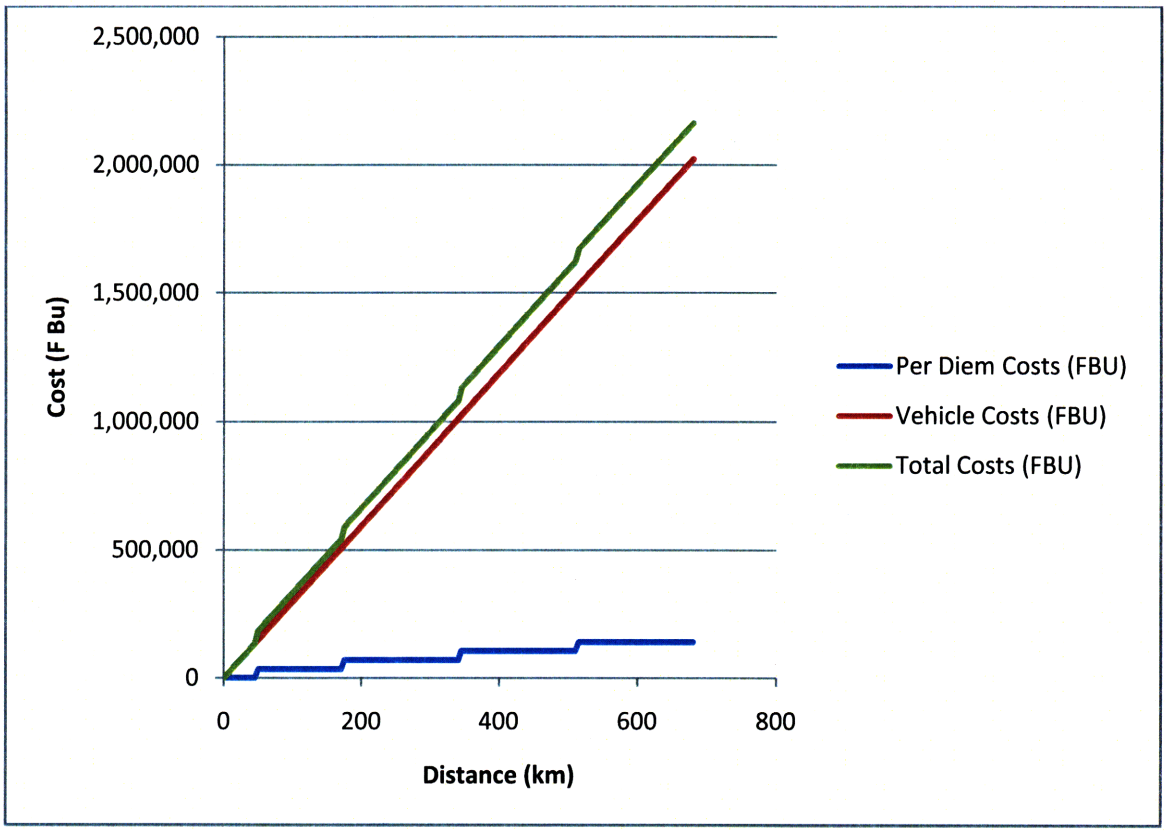

Figure 13. Components of the delivery cost model.

The total vehicle costs, between the central and provincial levels in the delivery mode, can be estimated as a function of distance using the variable cost of 425 FBU per ton-kilometer as derived from the model. The table of distances between the provinces provided by the Burundi tourism department (Appendix 7) can then be used calculate tour distances for delivery from CAMEBU to the BPSs to compute the appropriate vehicle costs for each of the tours. The total per diem costs can also be calculated as a function of distance by estimating the number of days for the trip based on Table 4 and then calculating the per diem costs based on the rate of 17,500 FBU per person-day.

3.3 Analyzing transportation costs for 4 scenarios:

Our evaluation of transportation is focused on the vehicle and per diem costs in all four scenarios, which would vary significantly depending on the system structure and distribution strategy. The quantitative assessment of the transportation costs is limited to the link between the central and intermediate levels (province or district) due to the lack of data to develop a cost model between the intermediate and service levels. However, we provide a framework for extending the analysis to evaluate transportation costs the intermediate and service levels.

3.4 Analysis of Current System -

We analyzed the current 3-level system under two scenarios. First, as the system is currently operating in pick-up mode where the province level picks up drugs and supplies from the central level. Second, as the system would operate in a hypothetical delivery mode where drugs and supplies would be delivered from CAMEBU to the BPSs.

3.4.1. Scenario 1: Pick-up Mode –

The first scenario is an assessment of how the current system is designed to operate. A representative from the BPSs in each of the 17 provinces goes to CAMEBU once every 3 months to pick up drugs and supplies.

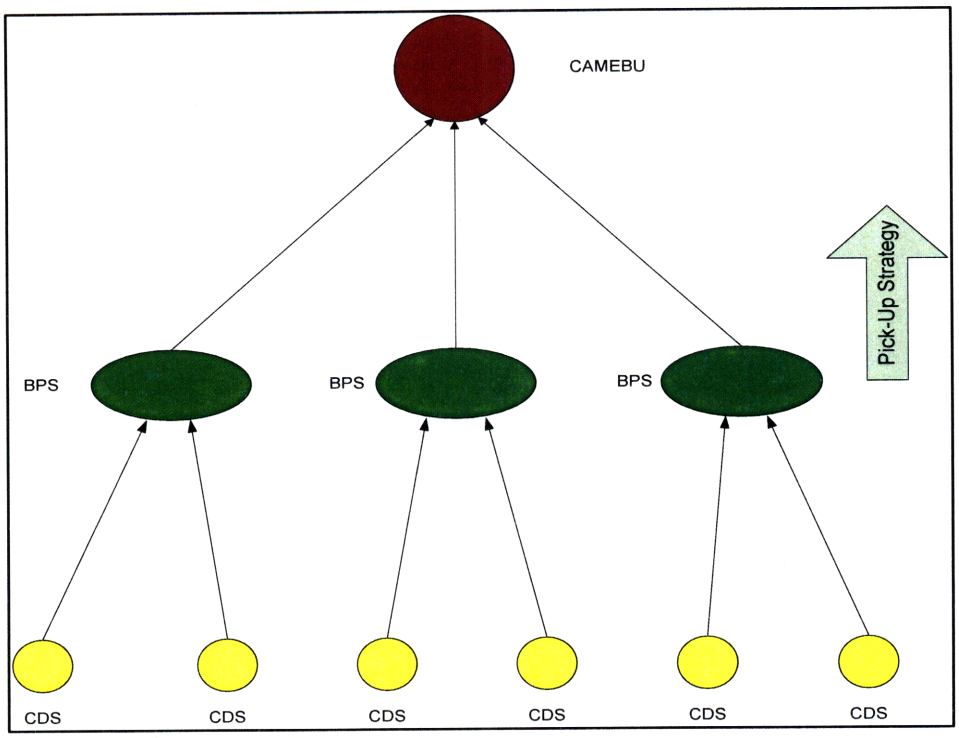

Figure 14. Province Based System with Pick-Up Strategy

To estimate the total cost of transportation as a function of distance, between the central and provincial levels in the pick-up mode, we used a table of distances between the provinces (provided in Appendix 7). Then the variable cost of 1020.7 FBU per kilometer travelled as derived in the pick-up cost model was used to calculate the appropriate costs for each of the tours. In order to calculate the per diem costs we used the range of trip distances and corresponding duration in Table 4 to estimate the number of days for each pick-up trip. The per diem costs were then calculated using a rate of 17,500 FBU per person-day (as derived from the delivery cost model) and assuming that two people from the BPS travel for each trip to CAMEBU. According to the cost model, no per diem is paid for trips shorter than 50 kilometers, which is consistent with the data that was used to create the model. We

assumed a quarterly pick-up schedule or frequency of 4 trips per year as intended by design of the system to allow a comparison with the hypothetical delivery mode, which is discussed Scenario 2. The total annual costs of pick-up incurred by the BPSs are as shown in Table 5 below.

Table 5. Total annual costs of pick-up from CAMEBU in the current system.

Province	Distance (km)	Duration (days)	Transport Costs (F Bu)	Perdiem Cost (F Bu)	Frequency (Trips/year)	Annual Cost (F Bu)
Buja mairie	4	1	4,083	0	4	16,331
Buja rural	40	1	40,828	0	4	163,312
Bururi	212	2	216,388	70,000	4	1,145,554
Gitega	200	2	204,140	70,000	4	1,096,560
Karuzi	316	2	322,541	70,000	4	1,570,165
Ruyigi	340	2	347,038	70,000	4	1,668,152
Bubanza	86	1	87,780	35,000	4	491,121
Cankuzo	432	3	440,942	105,000	4	2,183,770
Cibitoke	122	1	124,525	35,000	4	638,102
Kayanza	188	2	191,892	70,000	4	1,047,566
Kirundo	394	3	402,156	105,000	4	2,028,623
Makamba	334	2	340,914	70,000	4	1,643,655
Muramvya	96	1	97,987	35,000	4	531,949
Muyinga	398	3	406,239	105,000	4	2,044,954
Mwaro	132	1	134,732	35,000	4	678,930
Ngozi	252	2	257,216	70,000	4	1,308,866
Rutana	276	2	281,713	70,000	4	1,406,853
Total	**3,822**	**31**	**3,901,115**	**1,015,000**		**19,664,462**

3.4.2. Scenario 2: Delivery Mode –

The second scenario is an assessment of the current system structure operating in a hypothetical delivery mode. In this case, CAMEBU would deliver drugs and supplies to each of the 17 BPSs once every 3 months.

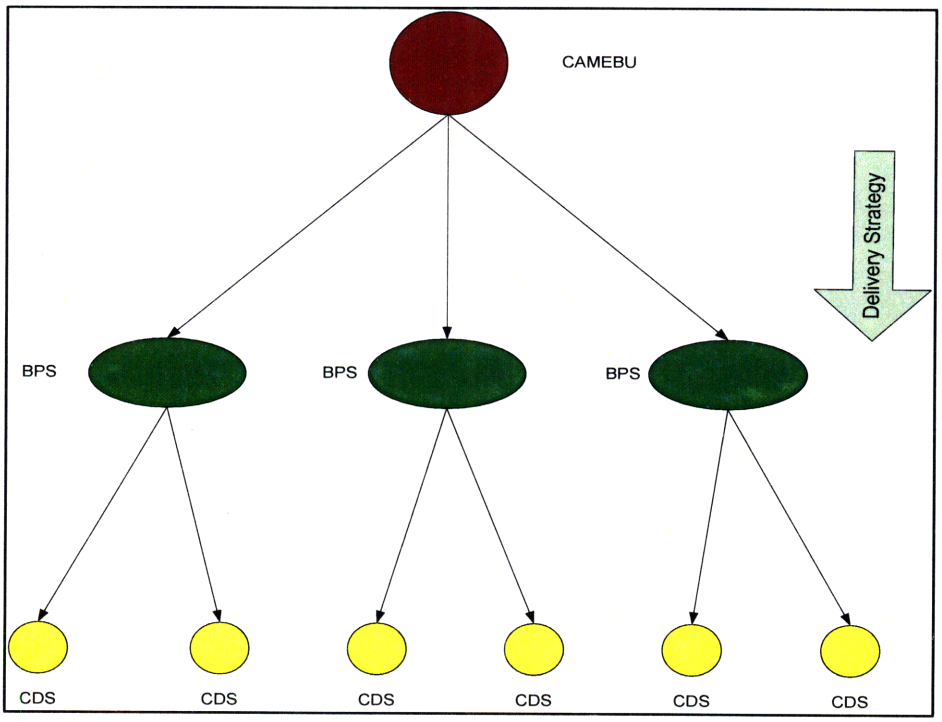

Figure 15. Province Based Structure with Delivery Strategy

The fundamental advantage of the delivery mode over the pick-up mode is the ability to make multi-stop shipments or what is referred to as 'milk runs'. This provides significant cost efficiency by reducing the number of trips made assuming that the shipments are not constrained by capacity. To plan the delivery routes from CAMEBU, the provinces have been grouped into clusters considering geographic proximity and trying to keep the demand amongst clusters comparable. The total population of the provinces in each cluster was used as an indication of the level of demand of drugs and supplies. The 17 provinces were divided into clusters of two or three as depicted in Table 6 below, to illustrate the potential cost savings of multi-stop deliveries compared to individual pick-ups.

Table 6. Clusters of provinces for delivery to BPS.

CLUSTER 1		
No	Province Name	POPULATION
1	BUBANZA	348,188
2	CIBITOKE	460,626
3	KAYANZA	586,096
	Total	1,394,910

CLUSTER 2		
No	Province Name	POPULATION
1	KIRUNDO	636,298
2	MUYINGA	632,346
	-	-
	Total	1,268,644

CLUSTER 3		
No	Province Name	POPULATION
1	NGOZI	661,310
2	KARUZI	433,061
3	MURAMVYA	294,891
	Total	1,389,262

CLUSTER 4		
No	Province Name	POPULATION
1	BURURI	570,929
2	MAKAMBA	428,917
3	RUTANA	336,394
	Total	1,336,240

CLUSTER 5		
No	Province Name	POPULATION
1	Buja Mairie	478,155
2	Buja Rural	565,070
3	MWARO	269,048
	Total	1,312,273

CLUSTER 6		
No	Province Name	POPULATION
1	GITEGA	715,080
2	CANKUZO	221,391
3	RUYIGI	400,818
	Total	1,337,289

Using the table of the distances between the provinces (Appendix 7) we estimated the tour distance for delivering to each cluster. The transport cost component was calculated directly as a function of the distance using the rate of 425 FBU per ton-km based on the model. The trip duration was assessed using the distance-duration regression (Table 4), which was then used to compute the per diem costs.

Table 7. Total annual costs of delivery in the current system using UNDP rates.

Cluster	Distance (km)	Duration (days)	Transport Cost (FBU)	Per Diem Cost (FBU)	Total (FBU)	Frequency (trips/year)	Annual Cost (FBU)
1	271	2	806,225	70,000	876,225	4	3,504,900
2	460	3	1,368,500	105,000	1,473,500	4	5,894,000
3	435	3	1,294,125	105,000	1,399,125	4	5,596,500
4	332	2	987,700	70,000	1,057,700	4	4,230,800
5	142	1	422,450	35,000	457,450	4	1,829,800
6	370	3	1,100,750	105,000	1,205,750	4	4,823,000
Total	**2,010**	**14**	**5,979,750**	**490,000**	**6,469,750**		**25,879,000**

The transportation costs in Table 7 above were calculated using a rate of 425 FBU per ton-kilometer and a shipment size of 7 tons, which was based on the delivery cost model using the UNDP receipts data. These deliveries included

transport of bulky items, which were transported in large trucks with capacities of 20 cubic meters. However, for the delivery of significantly lighter loads comprised of drugs and supplies, a smaller delivery truck comparable to the trucks hired by the BPSs for pick-up would be used. Therefore, we computed the costs of delivery using the same rate of 1020.7 FBU per kilometer, which are summarized in Table 8 below. This rate translates to an equivalent average shipment weight of 2.4 tons instead of 7 tons, which is a more realistic for the relatively light weight drugs and supplies.

Cluster	Distance (km)	Duration (days)	Transport Cost (FBU)	Per Diem Cost (FBU)	Total (FBU)	Frequency (trips/year)	Annual Cost (FBU)
1	271	2	276,610	70,000	346,610	4	1,386,439
2	460	3	469,522	105,000	574,522	4	2,298,088
3	435	3	444,005	105,000	549,005	4	2,196,018
4	332	2	338,872	70,000	408,872	4	1,635,490
5	142	1	144,939	35,000	179,939	4	719,758
6	370	3	377,659	105,000	482,659	4	1,930,636
Total	**2,010**	**14**	**2,051,607**	**490,000**	**2,541,607**		**10,166,428**

Table 8. Total annual costs of delivery in the current system.

Considering the variation in transportation rates and the lack of information about truck capacity constraints we performed a sensitivity analysis to gauge the impact of a range of transport rates on the total annual costs of delivery. Given the rate from the pick-up cost model was 1020.7 FBU per kilometer and the rate from the UNDP delivery cost model was equivalent to 2975 FBU per kilometer (425 FBU per ton-kilometer x 7 tons) we selected a range of 400 to 4000 FBU per kilometer. This range in vehicle rates captures the variation due to a range of vehicle sizes an capacities. The variation of the total annual costs of delivery with a change in the

transport rate is illustrated in Figure 16 below. Vehicle costs accounted for 62-94% of total costs over the range of transportation rates.

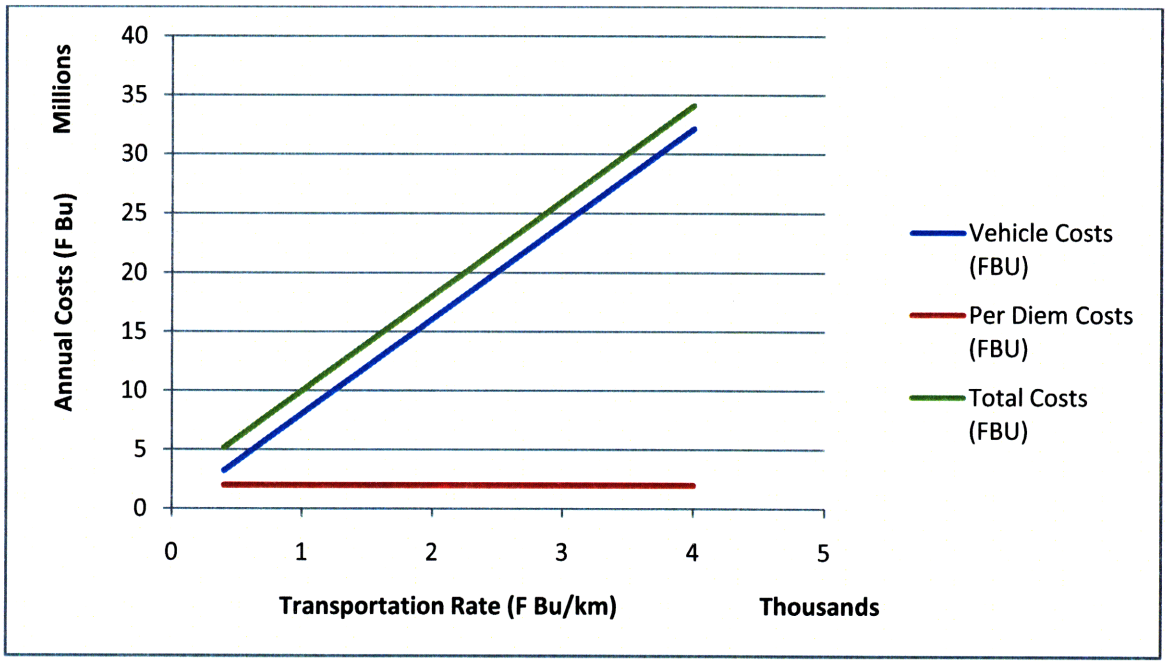

Figure 16. Variation of the total annual costs of delivery with a change in transportation rate.

Given the variation in per diem rates we performed a sensitivity analysis to gauge the impact of a range of per diem rates on the total annual costs of delivery. According to the Ministry of Health guidelines, per diem rates should range from 15,000 to 25,000 FBU per day. However, since we had received anecdotal estimates of per diems as high as 40,000 FBU through our interviews in Burundi, we selected a range of 15,000 to 40,000 FBU per day-person for the sensitivity analysis. Even though the high-end per diem rate exceeds current MOH guidelines, it reflects costs, which might actually be paid in the case of policy violation and might be beneficial in case the MOH was potentially considering increasing per diem rates. The

variation of the total annual costs of delivery with a change the per diem rate is illustrated in Figure 16 below. Per diem costs accounted for 17-35% of total costs over the range of per diem rates. The vehicle costs in this sensitivity analysis are constant since they do not vary as a function of the per diem rate.

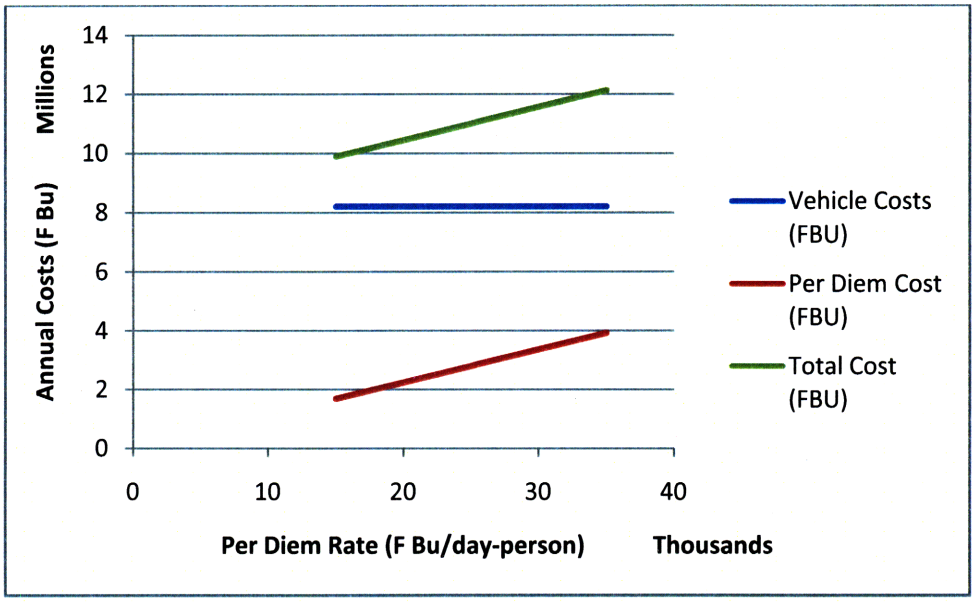

Figure 17. Variation of total annual costs of delivery with a change in per diem rate.

3.5 Analysis of Reformed System -

According to the proposed health sector reform, Burundi will potentially be transitioning to a health district system under which the 17 provincial distribution centers will be replaced by 44 district distribution centers as the intermediate stocking points for drugs in the public health distribution system. We analyzed the impact of this reform on the system-wide transportation costs in the pick-up mode as well as the hypothetical delivery mode.

3.5.1. Scenario 3: Pick-up Mode –

The third scenario is an assessment of district-based system operating in a pick-up mode. The BDSs from each of the 44 districts would go to CAMEBU one per quarter to pick up the drugs and supplies they needed.

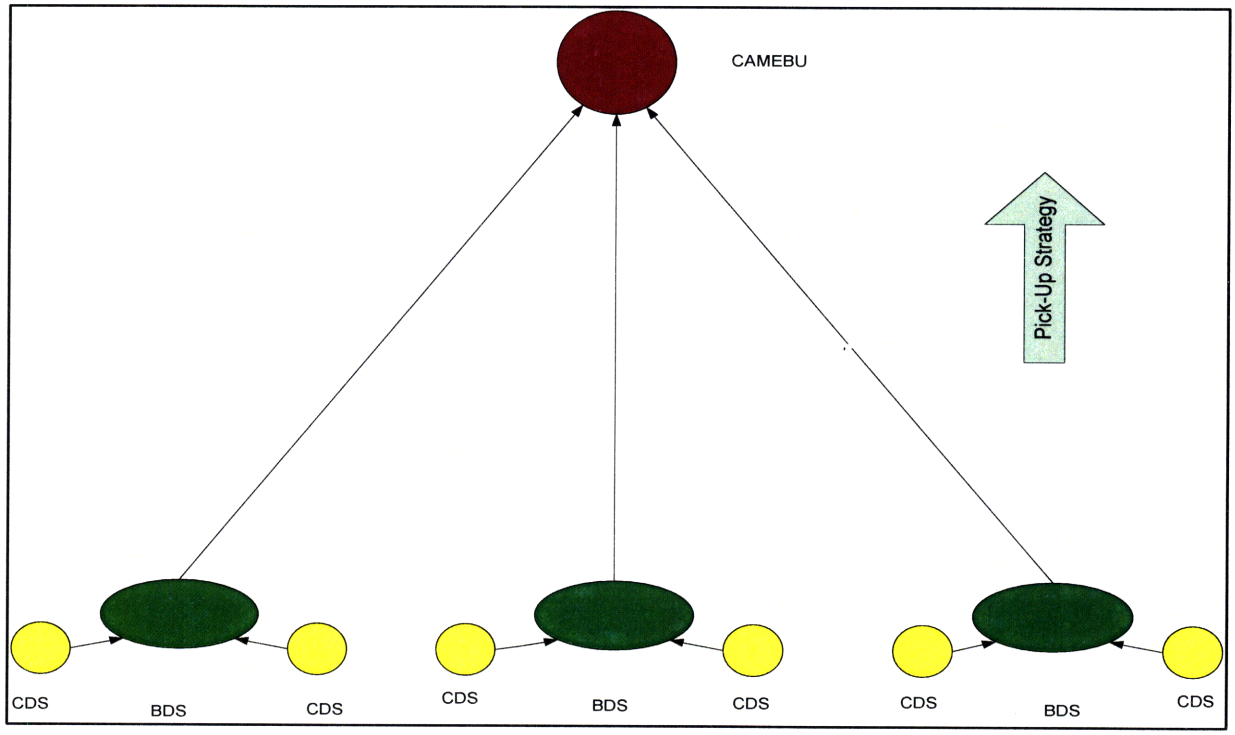

Figure 18. District Based System with Pick-Up Strategy

To analyze the transportation costs of pick-up from the 44 BDS locations we used the pick-up cost model. To estimate the distance to each of the BDSs, we assumed that the average distance between the BDS locations in a province and CAMEBU was equal to the distance between the BPS in that province and CAMEBU. The transportation costs for pick-up from the 44 BDS locations are summarized in Table 9 below.

Table 9. Annual transport costs of pick-up in the reformed system.

Province	No of Districts	Distance (km)	Duration (days)	Vehicle Costs (F Bu)	Perdiem Cost (F Bu)	Frequency (Trips/year)	Annual Transport Costs (F Bu)
Buja Mairie	3	4	1	4,083	0	4	48,994
Buja Rural	3	40	1	40,828	0	4	489,936
Bubanza	2	86	1	87,780	35,000	4	982,242
Muramvya	2	96	1	97,987	35,000	4	1,063,898
Cibitoke	2	122	1	124,525	35,000	4	1,276,203
Mwaro	2	132	1	134,732	35,000	4	1,357,859
Kayanza	2	188	2	191,892	70,000	4	2,095,133
Gitega	4	200	2	204,140	70,000	4	4,386,240
Bururi	3	212	2	216,388	70,000	4	3,436,661
Ngozi	3	252	2	257,216	70,000	4	3,926,597
Rutana	2	276	2	281,713	70,000	4	2,813,706
Karuzi	2	316	2	322,541	70,000	4	3,140,330
Makamba	2	334	2	340,914	70,000	4	3,287,310
Ruyigi	3	340	2	347,038	70,000	4	5,004,456
Kirundo	4	394	3	402,156	105,000	4	8,114,493
Muyinga	3	398	3	406,239	105,000	4	6,134,863
Cankuzo	2	432	3	440,942	105,000	4	4,367,539
Total	**44**	**3,822**	**31**	**3,901,115**	**1,015,000**		**51,926,458**

3.5.2. Scenario 4: Delivery Mode –

The fourth scenario assesses the reformed district-based system operating in a delivery mode. This alternative makes better use of the potential of the distributed structure to decrease stock out occurrences, because the centralized management, and visibility provided from the BPSs serving as management and support centers would theoretically allow better forecasting, and replenishment procedures. However, managerially, it would be much more complicated to manage centrally than the current system operating in a delivery mode due to the greater number of intermediate stocking points. Managers would have to create forecasts and replenishment schedules for 44 facilities instead of 17. In this scenario, CAMEBU would deliver drugs and supplies to each of the 44 BDSs one per quarter.

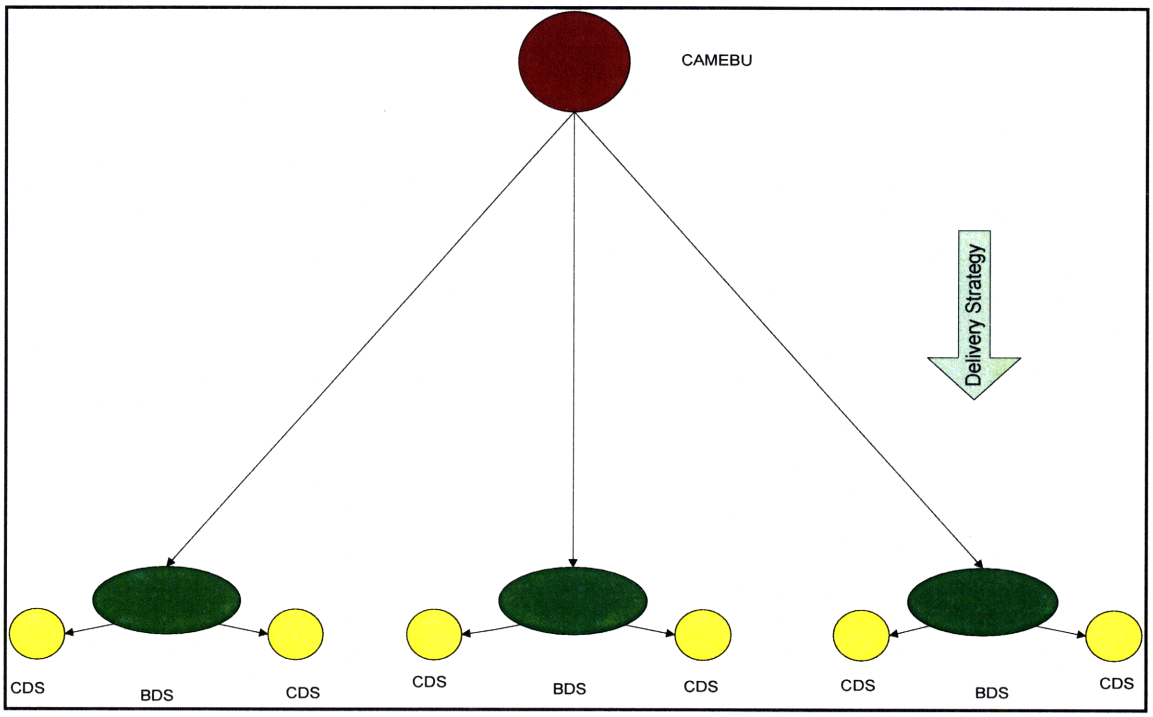

Figure 19. District Based System with Delivery Strategy

In this scenario, the drugs would be delivered from CAMEBU to the 44 district level centers (BDS). To analyze the transportation costs of delivery to the 44 BDS locations we used the delivery cost model. We maintained the same six clusters as in the case of delivery to the BPSs (Scenario 2). However, in this case, each tour would include a stop at all the BDS locations within the provinces of each cluster. In order to estimate the total distance for each tour, we assumed an additional distance of 25 kilometers within each province of a cluster. Based on the transport rate determined for delivery to the BPSs we calculated the quarterly vehicle costs of delivery as summarized in Table 10 below.

Table 10. Quarterly vehicle costs for delivery in the reformed district-based system.

Cluster	BPS Tour Distance (km)	No of Provinces	BDS Tour Distance (km)	Vehicle Cost (FBU)
1	271	3	346	353,162
2	460	2	510	520,557
3	435	3	510	520,557
4	332	3	407	415,425
5	142	3	217	221,492
6	370	3	445	454,212
Total	**2,010**	**17**	**2,435**	**2,485,405**

In order to calculate the per diem costs, we needed to determine the duration of each tour. We assumed each stop at a BDS to add one hour to duration of the trip. With the current set up of the clusters with 6 to 9 BDSs each, we added a total of 6 to 9 hours to the duration of each tour. Based on the average speed of 21.3 kilometers per hour determined from the regression analysis for delivery to the BPSs, we calculated the equivalent distance added to each tour. This equivalent distance served as the basis for per diem to estimate the number of days needed for the tours based on the range of trip distances and corresponding duration listed in Table 4. We assumed that 2 people from CAMEBU travelled for each delivery tour, which is consistent with the assumption for delivery to the BPS locations. Using the established per diem rate of 17,500 FBU per person-day and estimated number of days for each tour, we calculated the total per diem costs for the 2 people from CAMEBU travelling to deliver the drugs to the BDS locations. With quarterly delivery trips to the BDSs, we calculated the total costs of delivery in the reformed system as the sum of the transport costs and per diem costs multiplied by the annual frequency of 4 trips as summarized in Table 11 below.

Table 11. Total annual costs of delivery in the reformed district-based system

Cluster	Distance (km)	Duration (days)	Vehicle Cost (FBU)	Per Diem Cost (FBU)	Total (FBU)	Frequency (trips/year)	Annual Cost (FBU)
1	346	3	353,162	105,000	458,162	4	1,832,649
2	510	4	520,557	140,000	660,557	4	2,642,228
3	510	4	520,557	140,000	660,557	4	2,642,228
4	407	4	415,425	140,000	555,425	4	2,221,700
5	217	3	221,492	105,000	326,492	4	1,305,968
6	445	4	454,212	140,000	594,212	4	2,376,846
Total	**2,435**	**22**	**2,485,405**	**770,000**			**13,021,618**

While the analysis for total annual costs of delivery to BDSs in the reformed system was completed using the same six clusters for delivery to the BPSs in the current system, it is important to note one major difference. Assuming that demand at the health center level stays the same in the case of the current province-based system and the reformed district-based system, the average amount of inventory would increase significantly as described in the inventory section which follows. Consequently, more trips would be required to deliver the drugs and supplies from CAMEBU to all the BDSs. This would increase the vehicle and per diem costs accordingly.

3.6 Transportation Summary:

Based on the analysis of transportation costs, we found that total annual costs in the current system (with BPSs as the intermediate stocking point) were lower than in the reformed system (with BDSs as the intermediate stocking point) for a given mode of operation. Further, the total annual costs in the delivery mode were lower than the costs in the pick-up mode for a given system structure. A summary of the costs for the 4 different scenarios considered is presented in Table 12 below. It is

evident that a delivery mode of operation with the current system structure is the most cost efficient option in terms of total annual transportation costs. The table also shows the percentage change in total annual costs from the base case, which is the current system operating in pick-up mode.

Table 12. Total annual transportation costs for the current and reformed system operating in pick-up and delivery modes.

System	*Current*		*Reformed*	
Mode	*Pickup*	*Delivery*	*Pickup*	*Delivery*
Distance (km)	15,288	8,040	40,312	9,740
Total Duration (days)	124	56	332	88
Transport Costs (F Bu)	15,604,462	8,206,428	41,146,458	9,941,618
Perdiem Cost (F Bu)	4,060,000	1,960,000	10,780,000	3,080,000
Total Annual Costs (F Bu)	**19,664,462**	**10,166,428**	**51,926,458**	**13,021,618**
% Change	**0%**	**-48%**	**164%**	**-34%**

A comparison of the total annual transportation costs is graphically illustrated in Figure 20 below.

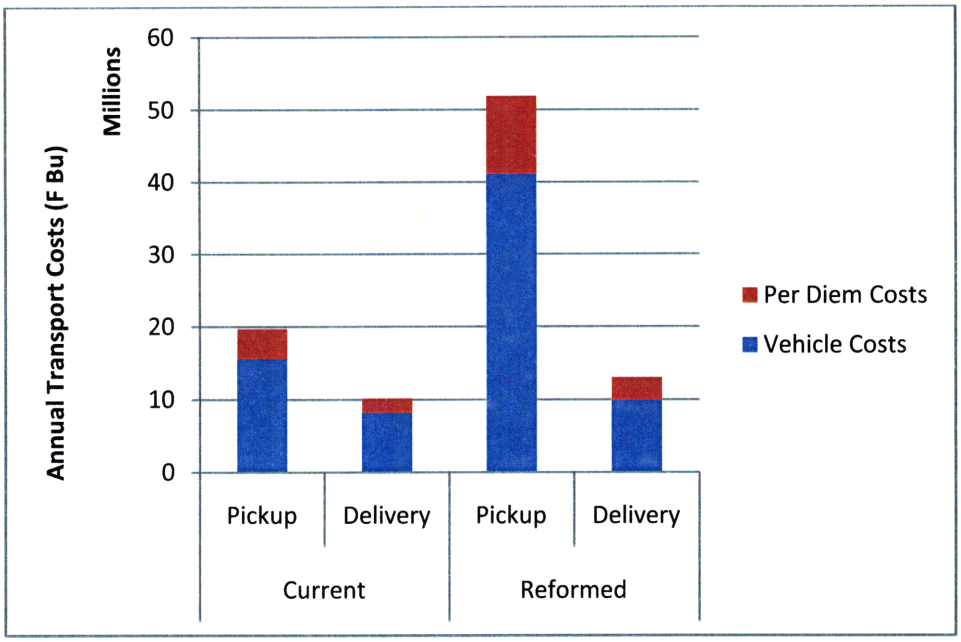

Figure 20. Comparison of total annual transportation costs for the current and reformed system operating in pick-up and delivery modes.

3.7 Extending the transportation analysis to the Health Centers:

The transportation analysis presented to estimate costs between the central level and the provincial or district level (intermediate stocking point) in the current and reformed systems respectively can be extended to estimate transportation costs to the health centers. In the current system, each BPS serves an average of 23 public health centers and 6 mission-based health centers. The number of public health centers in each province range from 9 to 35 as illustrated in Figure 21.

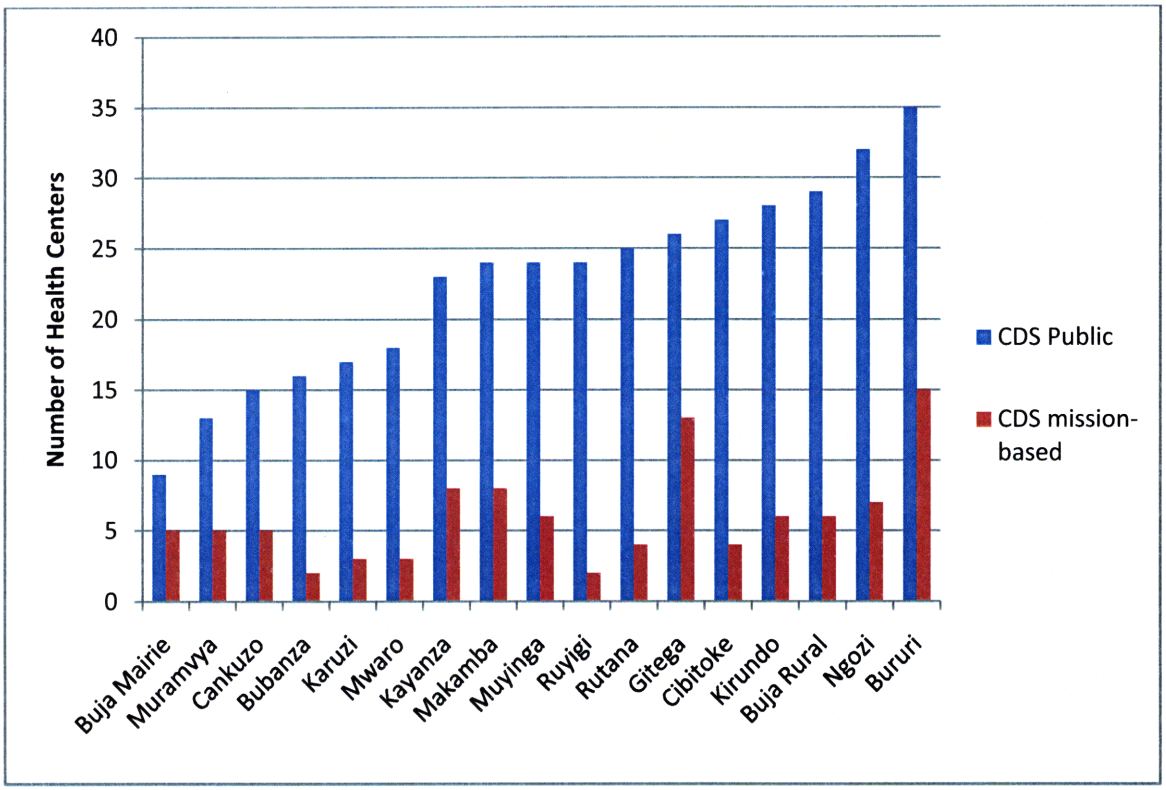

Figure 21. Number of health centers by province.

When operating in the pick-up mode, each health center within a province makes a round trip to the BPS and back. These costs can be calculated with a cost model developed based on the vehicle and per diem costs incurred by the health centers. An estimate of the distances between the health centers and their respective BPSs would also be needed to compute these costs. If operating in a delivery mode, all the health centers within a province would be grouped into clusters and the BPS would arrange multi-stop routes to deliver drugs and supplies to the health centers. Additionally, delivering drugs to the health centers would free up valuable human resources to spend more time on providing health services than performing administrative functions.

In the case of the district-based system, each BDS would serve an average of 9 public health centers ranging from as few as 2 to as many as 17. The extension of the transportation analysis in the reformed system would be similar to that in the current system with the exception that the distance from the health centers to the BDS would be shorter on average than the distance to the respective BPSs.

3.8 Inventory Discussion:

3.8.1. Scenario 1 – Province-Based System in Pick-Up Mode:

As designed, inventory levels at the BPSs and CDSs are managed under a periodic review ordering policy. The review period is 3 months or once per quarter at the BPS level and monthly at the CDS level. However, as Figure 6 indicates, in reality pick-ups occur more frequently due to BPSs and CDSs requesting emergency replenishments when they are stocked out. This erratic replenishment practice makes it difficult for CAMEBU and the BPSs to forecast and stock appropriate levels of inventory.

This scenario provides low visibility to demand, because upstream stocking points are not aware of demand until an order is received when a representative arrives for a pick up. The order form (in Appendix 3) is filled out with requested quantities and brought to CAMEBU when the BPS representative is there to pickup materials. There is no separation in the timing of information flows and material flows. To increase service in this scenario without changing the supply chain structure or pick-up mode, higher levels of safety stock would have to be carried to compensate for the high variability in demand. At the time of this study, quantities

ordered by the CDSs and BPSs as well as inventory information at the CDS, BPS, and CAMEBU levels were unknown. As a result of these two issues, it is very difficult for CAMEBU and the BPSs to forecast and maintain inventories to fulfill demand.

3.8.2. Scenario 2 - Province-Based System in Delivery Mode:

Though this alternative would share the periodic review policy of scenario 1, it is assumed that there would be some differences in the ability to supply demand due to the centralization of distribution. To determine replenishment quantities at the provincial and district levels, CAMEBU and BPSs would have to receive demand information before sending a shipment. This decoupling of the information and material flows would help CAMEBU to forecast demand and stock adequate inventory levels throughout the primary distribution system.

In scenario 1, numerous BPSs could unexpectedly arrive at CAMEBU simultaneously requesting emergency replenishments, of which CAMEBU would not be prepared to fulfill from inventory. Assuming that supply is not constrained at the CAMEBU level, CAMEBU would have the opportunity to stagger deliveries to BPSs, which would have the effect of smoothing demand at the BPS level, which would then allow CAMEBU to provide higher service levels to BPSs. Staggering shipments would also reduce personnel needs, as staffing could also be balanced. Any increase in management requirements (route planning, delivery coordination etc), would most likely be offset by the reduction in daily variability of staffing needs precipitated by emergency replenishment requests. Additionally, per diem

payments would be reduced because there would be no waiting time for BPS personnel at CAMEBU for replenishments.

3.8.3. Scenario 3 – District-Based System in Pick-Up Mode:

The increase in intermediate warehouses from 17 BPS warehouses, to 44 BDS warehouses in the district-based system would have positive and negative effects. Service to CDSs would be increased because the BDSs would be closer to the CDSs. This would decrease travelling distances on average and consequently shorten lead times, thereby making the system more responsive. A decrease in lead time could also lead to a decrease in inventory levels at CDSs. The impact of these inventory reductions would most likely be marginal as the distance between most CDSs and the BDS would not be much shorter than the distance from the CDSs to the BPS due to the relatively small provinces. Our interviews revealed that a few existing BPS locations would be converted into BDSs. In these cases, there would be no increase in responsiveness, or decrease in inventory levels at the CDSs.

Slightly more inventory would need to be held at the BDS level due to marginally longer lead times. This is because the distance between CAMEBU and the BDSs would be slightly longer on average than the distance between CAMEBU and the BPSs in each province. This would not be the case for those existing BPS locations that are converted to BDSs. Additionally, given the larger number of BDSs than BPSs higher levels of inventory would need to be maintained at the intermediate level due

to lesser risk pooling or increased variability in demand because of aggregation of fewer CDSs per BDS.

As a rule of thumb, according to the square root law, the amount of system inventory would be increased by the square root of the number of new facilities (Eppen, 1979). In this case the difference in inventory levels could be described by the following ratio to compare current inventory levels to inventory levels in a district-based system with BDSs.

$$\text{Factor of increase} = \frac{\sqrt{44}}{\sqrt{17}} = 1.6$$

Accordingly, if 44 BDS replaced 17 BPS, system inventory levels would have to increase by a factor of 1.6 or by about 60% to provide the same level of service.

3.8.4. Scenario 4 – District-Based System in Delivery Mode:

Managing a larger number of facilities centrally is the main challenge of a district-based system operating in a delivery mode. Obtaining and coordinating demand data, designing replenishment routes, and forecasting for 44 BDSs would be a significant undertaking compared to doing so for 17 BPSs. The BPS, performing a management function in the district-based system, would help in this regard, but the initial transition to this program could be challenging. The responsiveness to CDS demand in scenario 3 was due to the ability of the CDSs to make an emergency

replenishment pick-up from a nearby BDS, due to short lead times. However, in a delivery mode, the replenishments would dictated by the BDS delivery schedule.

3.8.5. Inventory Summary:

Based on an analysis of inventory considerations of each alternative, and an assessment of other inventory-related managerial opportunities, we found that the greatest advantages to inventory dynamics are independent of the structure of the system, but rather dependent on management policies. The service increases, and inventory reductions that can be achieved by increasing replenishment frequencies and risk pooling would most likely be greater than those achieved by keeping existing policies whether the Province-Based or District-Based alternative is chosen. We also noted that significant increases in management complexity, system inventory requirements, and capital costs reduce the incentive to transition to a District Based System.

3.9 Other Supply Chain Considerations:

Burundi's public health distribution system operates in an environment with multiplicity; there are multiple sources of drug supply at each level of the supply chain operating independently. Though this increases the complexity of the system, it also offers opportunities. Specific opportunities have been identified that could benefit Burundi's Public Health Supply Chain. Increasing replenishment frequencies

could decrease inventory levels. Risk pooling could decrease the occurrence of stock outs thereby improving service levels. Improving cash flow through the supply chain would enhance CAMEBU's ability to procure drugs. Sharing transport would reduce transportation costs, and strengthening the transport infrastructure would reduce lead times, ultimately reducing inventory.

3.9.1. Increasing Replenishment Frequencies:

In the current ordering policy common to the four considered scenarios, BPSs replenish from CAMEBU quarterly, and CDSs replenish from BPSs monthly. Interviews revealed that in reality, BPSs usually replenish more frequently than once per quarter due to emergency shipments. Formally instituting an inventory policy that increases the frequency of replenishments at the BPS would theoretically cause the cost of transportation to increase, would decrease inventory, and would provide risk-pooling benefits at the CAMEBU level.

Increasing the replenishment frequency would reduce the amount of demand that BPSs would have to keep in inventory at a specific time, because only the amount of inventory necessary to last until the next replenishment would be necessary. This would decrease the level of inventory at the BPS level, but would not decrease total system inventory levels. Rather, more inventory would be held at the CAMEBU level, which could have positive risk pooling effects and thus reduce system inventory.

3.9.2. Inventory Risk Pooling:

Risk pooling is decreasing demand variability by aggregating multiple sources of inventory at a level of a supply chain (Simchi-Levi, 2001). Since transshipment, shipments between facilities at the same level, is not currently used, holding more inventory that has not been committed to a BPS at the CAMEBU level would be risk pooling. This would have the effect of decreasing stock outs of drugs at the BPS level. It would also have the effect of reducing stock outs due to drug expiration, as CAMEBU would have the opportunity to supply drugs from multiple stocks using a First to Expire First Out mechanism (Owens, 2003).

Risk pooling could also be applied at the CDS level. CDSs sometimes hold two distinct stocks of drugs: Drugs procured through the Primary Distribution Channel, which are sold for cost recovery, and drugs that are provided by vertical programs or donors to be given free to patients. A patient may not be able to receive a drug because it is either not available or expired. If the CDS had the flexibility to provide drugs from the cost recovery stock to patients who qualify for free drugs, and vice versa, CDSs would be able to decrease the amount of stock outs at the CDS level. Of course there would need to be a way to account for transfers, and replenishments of both types of stocks. If CDSs were able to check both stocks and always provide the drugs closest to expiration, stock outs due to expiration could be decreased. At the CAMEBU level, risk could be pooled in the same way between CAMEBU's internal stocks and those of vertical programs. The event of a stock outs due to lack of the drug on hand, and due to expiration would be decreased if CAMEBU could tap other stocks to fulfill demand.

3.9.3. Cash flow:

Cash flow through the public health supply chain in Burundi is major challenge and significant contributor to the costs of multiplicity in the system. CAMEBU is primarily funded by sales of drugs for which it receives payments from the BPSs or reimbursements from the Ministry of Finance. According to anecdotal estimates, CAMEBU gets paid directly by the BPSs for only 60% of the drugs it sells. The Ministry of Finance provides a guarantee to pay CAMEBU on behalf of the BPS for the remainder at the time of sale. However, due to a complicated reimbursement process, CAMEBU does not receive payments for drugs sold on credit for approximately 6 months and in some cases as long as 2 years after the transaction occurred. This long delay in reimbursements poses a severe strain on CAMEBUs cash position.

Operating with low cash on hand severely limits CAMEBUs capability to procure and stock the appropriate quantities of drugs and supplies that it needs. This in turn results in poor availability and frequent stock outs at CAMEBU. Additionally, this causes BPSs to typically receive only a fraction of the quantities of drugs and supplies they request. Consequently, the BPSs need to make several more trips to CAMEBU to pick-up smaller quantities. These frequent trips add a significant amount of unnecessary transportation costs. Additionally, poor availability at CAMEBU causes the BPSs to increasingly procure drugs and supplies from the private sector. The need to make multiple stops to get all the drugs and supplies needed lengthens the duration of their trips, which adds to transportation costs per trip. Further, the BPS also pays a premium over CAMEBU prices for all products,

which are procured through the private sector. This allocation or rationing of quantities due to inadequate supply permeates down to the health centers as well. The health centers then need to source materials from the private sector which adds direct costs and more importantly causes their personnel to spend more time away from the CDS. Furthermore, the resulting poor availability of drugs at the health centers not only limits effective health care delivery but also weakens the confidence in public health system

3.9.4. Asset utilization:

Despite the resource constrained environment in the public health system, there exists a significant opportunity for improving asset utilization. The sharing of assets among different groups within the MOH can not only decrease costs but also improve the impact derived from these resources. For example, transportation assets like trucks could be shared as a pooled resource between CAMEBU and the different vertical programs. Through our interviews in Burundi, we learned that CAMEBU has one or two trucks at its disposal. Certain vertical programs like PNSR own four trucks for their own distribution and they make only 16 delivery trips per year. Managing these dedicated assets as a shared resource would decrease transportation costs as fewer vehicles would need to hired or purchased for transporting the same amount of materials. Further, this would also reduce maintenance expenses, and spread depreciation costs. Additionally, fewer shared trucks would be needed compared to dedicated fleets for all the individual groups,

which would reduce the amount of capital expenses the MOH would need to incur for investing in additional dedicated assets.

While the different vertical programs provide significant value to the public health system, there is potential for realizing significant cost savings by stronger integration of distribution flows through CAMEBU. One potential challenge might be integrating the distribution of vaccines through this channel flow due the temperature-controlled environment required. However, this could be made feasible by installing refrigerated units on shared transport vehicles, which may be used for distributing vaccines.

The pooling of assets could also be extended into shared use of warehouses. While this is happening to a certain extent with a few vertical programs stocking supplies at CAMEBU there is an opportunity for further integration. This could be achieved even with independently managed stocks that were co-located so the vertical programs would still be able to monitor, evaluate and control their inventories. In sum, the sharing of transportation and warehousing assets would decrease costs, facilitate a more integrated distribution channel and improve the utilization of the pooled resources.

3.9.5. Transport Infrastructure:

Burundi currently suffers from a under-developed transportation infrastructure. In 2004, Burundi had a total of 12,322 km of roads, of which 5,012 km were national

highways and 282 km secondary roads (OTRACO, 2006). Feasible driving speeds are lower than in other parts of the world resulting in appreciably longer lead times. Additionally, poor road quality considerably increases vehicle maintenance costs. Improved transportation infrastructure will not only accelerate economic development in Burundi but will also significantly benefit the public health system. Better transportation infrastructure will decrease transport costs, reduce lead times and consequently the amount of safety stock, which needs to be held in inventory. Additionally, the lower transportation costs per trip make it more economically viable to increase the replenishment frequency thereby making the public health supply chain more responsive as well. Therefore, improved transportation infrastructure will allow the ministry of health to find the right balance between reducing costs and improving responsiveness and consequently service levels in the public health system in Burundi.

4 Conclusions

Through the interviews we conducted in Burundi, secondary research and our analysis we developed a few insights that have helped us create specific recommendations that would be beneficial for the public health system in Burundi. Additionally, we also recognized certain areas which were beyond the scope of our analysis which merit further investigation and have been highlighted as opportunities for further research.

4.1 Recommendations for Burundi

The goal of our research has been to understand and analyze distribution in the public health supply chain in Burundi with the intent of assessing the costs of multiplicity and generating insights to help mitigate these costs. The structure of the current system is the result of evolution of the supply chain through some challenging and chaotic times. There is now, a compelling opportunity, to redesign the flow of materials, information and finances in public health system to significantly improve health care delivery for the people of Burundi. We discuss a few specific changes that will improve the availability and affordability of care through the public health system in Burundi. Based on the analysis and conclusions from our research, we propose the following recommendations for consideration:

1. **Transition to delivery mode of distribution**

   Based on our analysis of transportation costs (summarized in Table 12), it is evident that distributing drugs and supplies in a delivery mode is far more cost-effective than the current pick-up mode in both the current province-based system as well as in the proposed district-based system. Additionally, with CAMEBU delivering the intermediate level (BPS or BDS), which in turn delivers to the CDSs frees up resources at health center to focus their efforts on patient care.

2. **Share assets between CAMEBU and vertical programs**

   The Ministry of Health in Burundi should consider facilitating the sharing of assets including vehicles and warehouses amongst CAMEBU and the vertical programs to reduce costs and improve utilization of the pooled assets. This would also reduce the amount of capital expenses for investment in additional assets that may be required.

3. **Improve cash flow**

   It is vital that the Ministry of Health and all the other stakeholders guiding policy dialogue for the health sector to prioritize the improvement of cash flow in the public health system. This would require increased transparency in the flow of finances and much shorter cycle times for reimbursements. A stronger cash balance is essential for CAMEBU to maintain adequate quantities of drugs and supplies required for the needed improvement in the availability of drugs in

Burundi's public health system. This would have the reinforcing effect of reducing costs by requiring fewer emergency replenishments, incenting higher percentages of procurement through CAMEBU, which would drive economies of scale and reduce costs further. This would result in improved affordability and higher levels of service, strengthening the public health system overall.

4. **Justify transition to district-based system**

Transitioning to a district-based system has several advantages from a management and monitoring standpoint however, there are significant costs involved in this restructuring of the PDC. Inventory costs at the intermediate level would go up and transportation costs would be higher as well (even in delivery mode). If the district-based system continues to operate in pickup mode, the transport costs would increase by 164% from approximately 20 million FBU to 52 million FBU. Additionally, setting up 44 BDS facilities and the necessary operating infrastructure requires a level of capital expenditure, which could potentially be allocated for improving the current system. We suggest a thorough due diligence evaluation to ensure the benefits of the district-based system outweigh the cost involved.

5. **Develop data collection plan**

In order to improve transparency, monitoring, performance evaluation, and to facilitate better planning we strongly recommend that the Ministry of Health

develop a data collection plan to capture the following information at the different levels of the system –

A) CAMEBU: CAMEBU should record the number of stock outs and the quantities of drugs short. For each transaction, they should also record in the IT system the quantities requested for each item against the actual quantities sold. They should record whether drugs were sold on credit on the ministry of health account. Additionally, CAMEBU should maintain a record of all donated drugs.

B) BPS: The BPSs should provide CAMEBU with their inventory on hand for each item with every quarterly order. This could be accomplished by simply adding an inventory column to their order form. BPSs should also record the number of stock outs and the quantities of drugs short. For each transaction, they should also record the quantities requested by the health centers for each item against the actual quantities sold.

C) Health Centers: The health centers should record their inventory on hand before they place their monthly order. This could be information passed on to the BPSs by simply adding an inventory column to their order form. They should also record the number of stock outs and the quantities of drugs short.

4.2 Areas for further research

Through the process of our research we identified a few opportunities for further investigation to drive additional improvements in the public health supply chain in Burundi. A quantitative study of the current costs of inventory and the benefits of risk pooling between vertical programs would complement this study providing total supply chain costs. A study determining which method of forecasting is optimal for pick-up versus delivery mode supply chains would inform management practices in Burundi's and other similar public health supply chains. A study of the supply chain effects of a nationalized insurance policy in Burundi would further the effort to determine the optimal supply chain structure for Burundi's public health care supply chain. Finally, an economic analysis on the supply chain implications of increased cash flow velocity at the CDS and BPS levels would be instrumental in shaping financial policies for the public health system.

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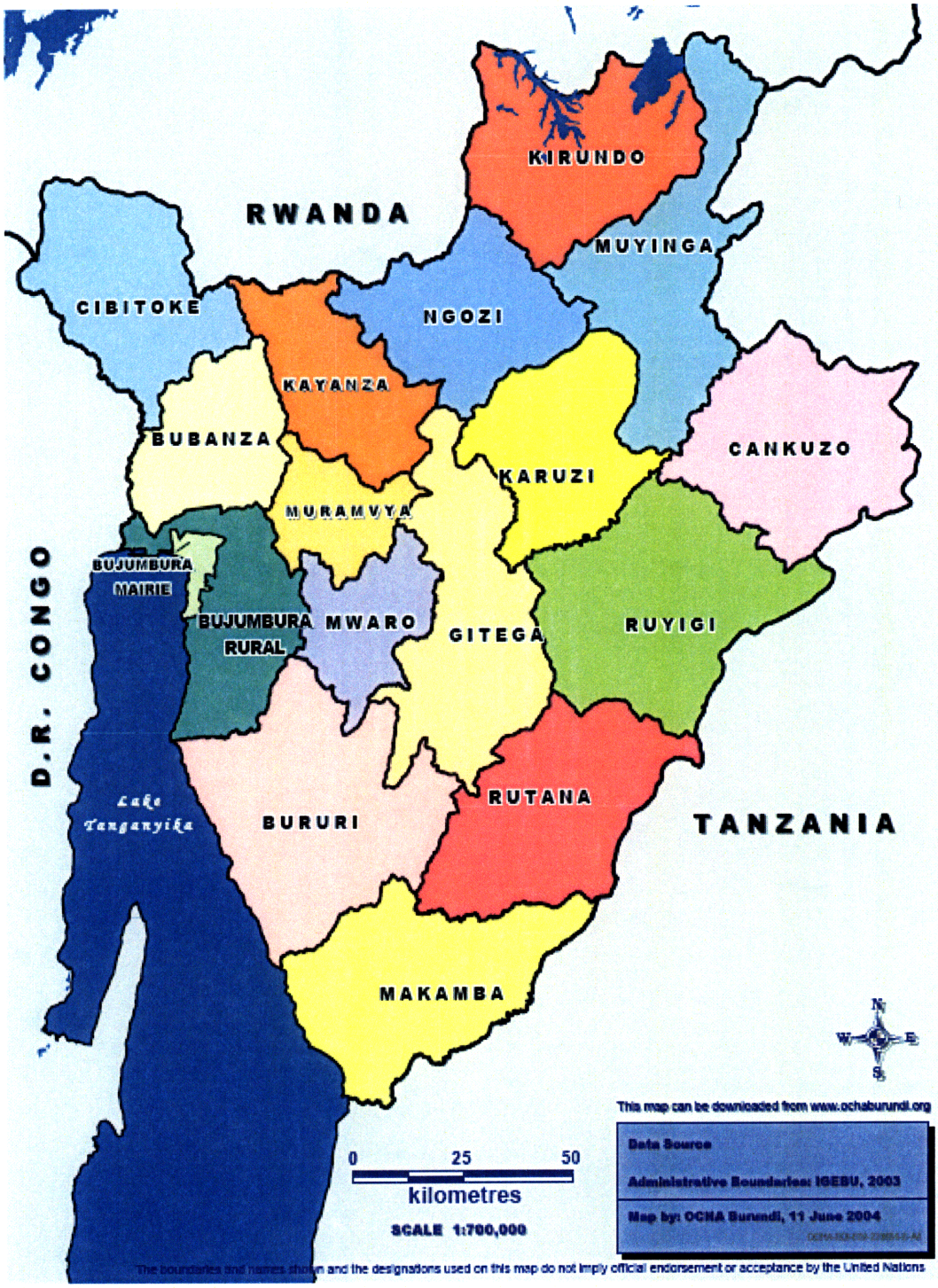
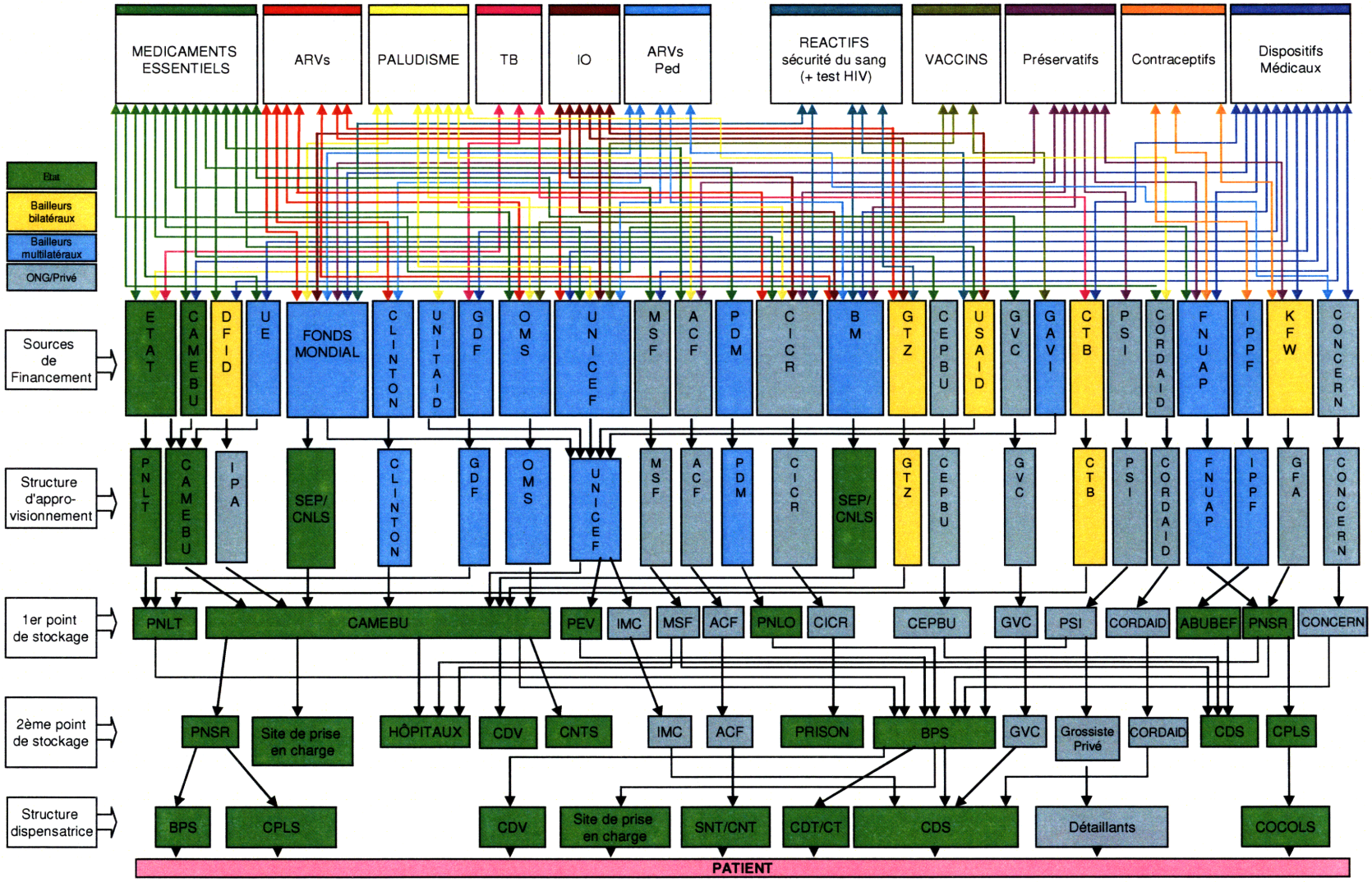
6 Appendices

Appendix 1 – Map of Burundi[2]



[2] Source – Office for the Coordination of Humanitarian Affairs, United Nations.

Appendix 2 – Mapping of the Public Health System in Burundi[3]



[3] Source – WHO and Ministry of Health, Burundi

Appendix 3 – Sample BPS order form[4]

REPUBLIQUE DU BURUNDI
MINISTERE DE LA SANTE PUBLIQUE

BPS order form

PROVINCE SANITAIRE : .....
SECTEUR DE SANTE : .....
CENTRE DE SANTE : .....
T R I M E S T R E : .....
D A T E : .....

FICHE DE REQUISITION DES MEDICAMENTS ESSENTIELS
POUR LES CENTRES DE SANTE

NOM ET PRENOM
....

GRADE ET FONCTION
....

Qty Requested → Price/Unit → Qty in stock @ HC → Qty Issued

N°	DESIGNATION DU PRODUIT	QUANTITE COMMANDEE	P.U.	P.T.	QUANTITE FOURNIE	P.T.
	I ANESTHESIQUES LOCAUX					
1	Lidocaïne inj.2% sans adrenaline					
2	Lidocaïne inj.2% avec adrenaline					
	II ANALBESIQUES,ANTIPYRETIQUES					
3	Acide acetyl-salicylique cés 100 mg					
4	Acide acetyl-salicylique cés 500 mg					
5	Paracétamol cés 100 mg					
6	Paracétamol cés 500 mg					
7	Paracétamol suppo 100 mg					
	III ANTI - ALLERGIQUES, MEDICAMENTS POUR TRAITEMENT DE L'ANAPHYLAXIE					
8	Promethazine cés 25 mg					
9	Promethazine inj. 50 mg / 2 ml					
10	Hydrocortisone inj. 100 mg					

[4] Source –BPS Bujumbura, Ministry of Health, Burundi

Appendix 4 – List of Questions for Interviews conducted in Burundi[5]

General Questions :

1. How many tiers ar there between CAMEBU and hospitals/Health Centers? Describe them? Can you explain the difference between distribution to the Regional and distribution to the District level?
2. How are orders within the system determined and executed?
3. Who manages distribution?
4. Who funds distribution costs? How are they accounted for?
5. How are products transported within the system?
6. Are there parallel distribution systems? Who are the players? Would integration be advantageous?
7. How are products stored, handled, etc?
8. What are the target service levels? What value added services are provided?
9. Who has decision making authority? What are the relationships between different units?
10. Are special provisions required to ensure product remains effective (i.e. cold chain)?
11. What are some of the key challenges you face today?
12. What are some of the potential improvements you would like to see implemented?
13. What are the obstacles delaying our preventing these changes?

Inventory Management :

1. What are your current inventory levels? How do you determine what your inventory levels will be? Do you have different ordering/re-stocking policies for different products? (Asked for pertaining to BPS, and pertaining to CAMEBU.)
2. How are these levels determined? Safety stock calculation, etc.
3. How often do SDPs stock out? How long does the stock out last? Does it vary by product type? What are the main causes? If you have stock out at BPS, what do you do?
4. What is the order frequency for products? Do they vary by product?
5. How long are lead times? Do lead times vary by product?
6. Procurement- who does it? Local, International, etc?
7. Where are cold chain products held?

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[5] Note - Only questions relevant to interviewer's job functions/locations were asked.

8. If there is a stock-out do you procure products from the private sector? What types of products are available & affordable locally? What is the difference in drug cost between the public sector and private sector?
9. What are the most challenging aspects about maintaining proper inventory levels? i.e. variable demand, variable lead time, inadequate space, lack of information, etc?
10. If you could change one or two things about the way the system operates, what would they be?
11. When you are stocked out what do customers do for the different products? (i.e. go to private sector to buy, substitute, go without, etc)
12. What products do you consider to be the most important to have in stock? How frequently are they available? What do you do to try to maximize availability?

Distribution/Product Flow:

1. Do any products flow direct from CAMEBU to CDSs? Which ones? Why?
2. Are any products not stocked at CAMEBU but at other tiers? How, why?
3. Are any orders bundled at CAMEBU for CDSs and sent to BPS for pick-up/delivery? (cross docking) Would it be feasible?
4. How often does CAMEBU transfer stock to BPS? Does this frequency vary by product?
5. How often do BPSs transfer stock to CDS? Does this vary by product?
6. Is there sufficient warehouse space? Is it expandable?
7. Can you explain the operational details such as eceiving, storage, picking, employee roles, etc?
8. How is product quality control handled?
9. Which products are the most troublesome to deal with? Why?
10. Is the medicine free? Or do you charge the medicine to your patient? If so, how to you charge patients at CDSs.

Transportation:

1. How are products delivered from the supplier base? How are products shipped out from CAMEBU? (rail, road, water, air, motor, bus, bicycle)?
2. How is product Integrity managed? Describe the cold chain? What is the weakest link?
3. Explain the delivery method and the frequency of delivery? Vary by product and shipment requirement? Please explain any difference between how this is managed on the CAMEBU level compared to the BPS level.
4. Do delivery method and frequencies very by CDSs? If so, how? Do any patient pick up from BPSs?
5. How many trucks, drivers, and trailers are available? How are fuel and repairs paid for? Is there enough equipment to meet patient demand?
6. Are there pre-defined delivery routes? How are they designed and managed?
7. Is transportation ever outsourced to private transportation providers? Are these services available?

8. Do you receive deliveries or do you pick up your orders from BPSs?
9. How reliable are the deliveries? What is your estimated service level at each level of the supply chain
10. When a BPS or CDS picks up how do they get there and back? How are costs allocated or reimbursed?
11. What are the biggest challenges with transportation? How would you change the system?

Information flow :

1. Do BPSs order products or does CAMEBU allocate quantities?
2. Is consumption data collected? If so, for what products?
3. Does each BPS have a budget? Approximately, what is this budget? How do budgets differ between provinces?
4. What kind of IT systems are being used?
5. What records are maintained of products received, distributed or sold?
6. What kind of reports are generated? What metrics are used?
7. What additional information would you like to capture?

Financial Flows –:

1. Who pays for all the drugs arriving at CAMEBU? How are thy procured?
2. Do patients pay for all drugs? Are any provided free?
3. What is the cost structure like for highest volume drugs at CAMEBU?
4. What is the price list for the highest volume drugs at SDPs?
5. Are prices consistent across SDPs in different provinces?
6. How are the drugs prices?
7. Is there significant variation in purchase price at CAMEBU?
8. How does money flow through the supply chain?

Appendix 5 – List of questions in the BPS Transportation Cost Survey

Transportation Survey for BPS –

Name of Bureau Provincial de Santé: **Province:**

Contact Person: **Phone No:**

1. **How often to you go to pick up drugs/supplies from CAMEBU or private pharmacies?**

Place	No of trips	Units
CAMEBU		Trips/year
Private Pharmacies		Trips/year

2. **Please list the approximate dates you picked up drugs last year (as best you can remember) –**

   CAMEBU –

   Private Pharmacies –

3. **How often do you use each of the specified types of transport?**

Mode	No of trips	Units
Own Car		Trips/year
Hire Truck		Trips/year
Hire Taxi		Trips/year
Hire Motorcycle		Trips/year
Other (specify)		Trips/year

4. **What is the average cost per trip for each type of transport used?**

Mode	Cost per trip	Units
Own Car		F Bu
Hire Truck		F Bu
Hire Taxi		F Bu
Hire Motorcycle		F Bu
Other (specify)		F Bu

5. **How long are the trips (on average)?**
   _____ days
6. **What are the per diem costs per trip (in F Bu)?**
7. **How much (percentage) of your budget is spent on transport?**
8. **Did Ministry of Health pay for fuel for the trips?**

Appendix 6 – Example of a Completed BPS Transportation Cost Survey[6]

Mini-Enquete sur les coûts de transports médicaments - BPS

Nom du Bureau Provincial de Santé: MUYINGA Province: MUYINGA

Personne contact: NDABAGUYE Irenée No de tel: 79842481 / 22506781

1. Avec quelle fréquence allez vous chercher des médicaments / consommables a la CAMEBU ou auprès de pharmacies privées?

Lieu	Nombre de trajets	Unités
CAMEBU	6	Trajets/an
Pharmacies privees	–	Trajets/an

2. Pouvez-vous lister les dates approximatives auxquelles vous etes allés chercher des médicaments l'année dernière (dans la mesure ou vous vous en souvenez) –

CAMEBU – Données non disponibles

Pharmacies privées –

3. Avec quelle fréquence utilisez-vous les différents moyens de transports ci-dessous?

Moyen	Nombre de trajets	Unités
Voiture personnelle	–	Trajets/an
Camion loué	6	Trajets/an
Taxi loué	–	Trajets/an
Moto louée	–	Trajets/an
Autre Véhicule (spécifier) BPS	12	Trajets/an

4. Quel est le coût moyen pour chaque type de transport utilisé?

Mode	Coût par trajet	Unités
Voiture personnelle	–	F Bu
Camion loué	500.000 Fbu	F Bu
Taxi loué	–	F Bu
Moto louée	–	F Bu
Véhicule BPS	150.000 Fbu	

[6] The survey was translated into French for distribution in Burundi. Responses to only first 4 of the 8 questions were received.

Appendix 7 – Table of distances between provinces[7]

PROVINCE NAME	BUBANZA	Buja Mairie	Buja Rural	BURURI	CANKUZO	CIBITOKE	GITEGA	KARUZI	KAYANZA	KIRUNDO	MAKAMBA	MURAMVYA	MUYINGA	MWARO	NGOZI	RUTANA	RUYIGI
BUBANZA	0																
Buja Mairie	43	0															
Buja Rural	-	-	0														
BURURI	167	106	-	0													
CANKUZO	256	216	-	187	0												
CIBITOKE	51	61	-	168	287	0											
GITEGA	140	100	-	90	116	161	0										
KARUZI	195	158	-	148	107	219	58	0									
KAYANZA	75	94	-	201	167	83	116	112	0								
KIRUNDO	178	197	-	245	126	197	155	94	103	0							
MAKAMBA	204	167	-	37	166	228	127	185	238	282	0						
MURAMVYA	67	48	-	119	168	109	52	110	55	150	156	0					
MUYINGA	180	199	-	183	60	188	93	48	185	64	220	143	0				
MWARO	109	66	-	84	148	127	46	104	101	171	12	46	139	0			
NGOZI	107	126	-	233	135	115	84	78	32	71	270	86	73	104	0		
RUTANA	181	138	-	60	137	200	69	130	185	207	51	121	162	98	153	0	
RUYIGI	210	170	-	138	49	232	77	99	174	176	138	119	109	93	142	88	0

[7] Source – Abbreviated from table of distances provided by the Ministry of Tourism, Burundi