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Cost Analysis Of Current Distribution And Redesigned Distribution Systems For Vaccines In Rwanda

Thesis submitted to the University of Rwanda, in partial fulfilment of the requirements for the degree of Masters in Health Supply Chain Management (MSc HSCM)

By

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DECLARATION

This is my original work and has not been presented to any other University. No part of this research should be reproduced without the authors' consent or that of University of Rwanda.

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DEDICATION

This study is dedicated to my Husband Aimable NKUBITO and to my children NKUBITO Lyn Andy and ISIMBI Liza Cindy for thoughtful and caring assistance and support during my studies.

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ABSTRACT

Background:

Immunization program is one of the recognized and successful public health cost effective investment. Immunization supply chain management is among components of immunization program and is a program's drive making vaccines delivery possible to reach every child even in hard to reach areas, though found to be static as the program is experiencing rapid changes with introduction of new vaccines. Rwanda immunization programme has been rating successful and the coverage reached 94.3% attributed to HR and capital investment from both Ministry of Health and its development partners. However, the way the current system is designed, requires the programme to avail a budget on annual basis dedicated to support vaccines delivery to lower levels. Current distribution system design does not contribute to self-financing of the programme in the long-run considering the mode and frequency applied. Assessing how much the programme would save if the system is re-designed by changing distribution mode and frequency is the purpose of the study.

Methods:

Financial documents were reviewed to determine the cost of the current vaccine distribution system and compare it with an estimated cost of a new distribution system with reduced frequencies between CVS and DVS.

Results:

The key drivers of the current distribution system are fuel, and per-diems for drivers and nurses during travels from their working places to CVS while the new distribution model are vehicle maintenance with reduced expenses on fuel and per-diems to optimization of route planning. The current vaccines distribution system is costly expensive as it requires DHS to always avail two staff, vehicles and time for vaccines pick-up while the new distribution model would only require efficient use of existing resources by changing the distribution model and frequencies. From the costs comparison, applying the new distribution model with reduced frequencies the current distribution costs would decrease at 37%.

Conclusion:

The study findings have confirmed a huge opportunity of getting the current distribution costs reduced when the distribution is redesigned from pull to push and frequency from twelve to four per year. It was discovered that the programme would save 37% of the current distribution costs once the system is redesigned.

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ABBREVIATIONS AND ACRONYMS

CCE: Cold Chain Equipment

CCEOP: Cold Chain Equipment Optimization Platform

CMHS: College of Medicine and Health Sciences

CVS: Central Vaccine Store

DH: District Hospital

DVS: District Vaccine Store

EPI: Expended Immunization Program

EVM: Effective Vaccine Management

EVMA: Effective Vaccine Management Assessment

FRW: Francs Rwandais

Gavi: Global alliance for vaccines and immunization

HCs: Health Centres

HSS: Health System Strengthening

IRB: Institutional Review Board

iSCM: immunization supply chain management

LMICs: Low and Middle-income Countries

QALY: Quality Adjusted Life Years

RBC: Rwanda Biomedical Centre

SPIU: Single Project Implementation Unit

UNICEF: United Nations Children’s Funds

US: United States

USA:	United States of America
USD:	US dollars
VPDP:	Vaccine Preventable Diseases Program
WHO:	World Health Organization

CHAPT I. INTRODUCTION

1.1. Background to the study

Immunization program is one of the recognized and successful public health cost effective investment (1). Studies conducted in USA and Canada showed that estimated cost effectiveness of vaccination in those aged over 65 years was 980USD per QALY saved in 2000 dollars. While in Canada a strategy of universal coverage reduced influenza cases at 61% and related death at 28% (2). With proven strategies making it accessible to all even in the hard to reach areas the immunization program is very attractive intervention in health to invest in (3).

The immunization supply chain management is a drive of immunization program making vaccines delivery possible to reach every child even in those areas that are hard to reach (4). Initiated in the years of 1970s, the immunization supply chain management has been very effective in immunization program but became outdated with years as a lot of change are being made with new technologies(5) and introduction of new vaccines in last two decades. Among challenges of immunization supply chain management includes the vaccination logistics and distribution system.

The immunization supply chain management is a critical area that should operate with success to satisfy customers need. The supply chain management of vaccines involves different components that require critical devotion to make it successful and those include: human resources, systems and all operations involved from their production point to the beneficiaries. The introduction of new vaccine comes as solution to save lives in low & middle income countries and the supply chain system at this point is constrained for various reasons and the distribution system may be impinged among others.(6)

Using WHO effective vaccine management (EVM) tool, an assessment was performed to evaluate country's performance in regard to the immunization supply chain management. Among the nine criterion of effective vaccine management, distribution is among other and in 2015, was found with low performance (17%), although increased to meet the target with 2018 assessment it is obvious that an improvement is required for efficiency. This is also linked to other components like vaccine management and information system also found to under the target score of 80%.(7)

The program of immunization program in Rwanda was created in 1978 with six antigens to combat six vaccine preventable diseases and at that moment with only one component of supply system, then the program became operational in 1980. The program has been operating effectively until 1994, during genocide where all activities related to vaccination ceased from April to August 1994(8).

Since then the supply chain have been working with difficulties since human resource was an issue during that moment and later the system performed as the fact the coverage increased dramatically and continued to be improved and maintained(9). There is no way that the coverage would improve or increase without supplies, this shows that supply chain was performing. Performance was taking place with difficulties where distribution system was not scheduled. Immunization supply system is a three level system;Central Vaccine Store (CVS), District Vaccine Stores (DVS) and Health Centres. Using a pull system with a month of stock level, DVS personnel would come to collect vaccines at any moment; this would depend on his/ her convenient time.

There was no plan of distribution and at that moment only two personnel were working as logisticians and could also go on field for other supply chain activities including Cold Chain Equipment (CCE) repairs. Later the program decided to redesign the system and elaborated a plan of distribution where distribution can be done in a period of two weeks in a month. Later in 2015, it was found that distribution can be done within one week, on monthly basis to all 42 district store till today

In Rwanda the Effective Vaccine Management (EVM) assessment has been conducted three times in nine years consecutive and areas of improvement were highlighted and those include vaccine arrivals and management information system(10). The evidence that supplies are being supplied timely is real as being shown by the increased and maintained vaccination coverage (11), the quality is also required and optimization of supply chain management should be thought of as studies showed the gap in human resources in Middle Income Countries(MICs)(6) which was a case in Rwanda. Considering available opportunities there is always a room for improvement to optimize the supply system. Gavi is supporting Rwanda immunization program up to 84%; This includes all the support provided to the country including vaccines introduction co-financing, cold chain equipment and operational cost(12). Gavi co-financing policy indicates in its objectives that, their purpose is to increase countries' budget for Gavi supported vaccines to sustain themselves ensuring vaccines are accessible to all. Countries are required to increase their contributions of co-financing level as they transition from one level to the other (that is from low income countries to the middle income countries) until they sustain themselves (13).

Vaccine distribution system modeling was thought of, as there is a plan to expand storage capacity with Gavi support through cold chain equipment optimization platform (CCEOP). Being eligible to the support(14), Rwanda applied for this support (15)and was approved. This brought an idea of redesigning the system considered as strategic approach to sustain the program once linked to the assessment on how the CVS could save money through immunization supply chain system redesign.

Redesigning distribution system is among other strategies to sustain the program considering financial constrains where the big part of the program is sustained by outside supports (Gavi is the one that provides a big support) considering that this support will not last for long; it will get to an end one time(16).

Once the country graduate from Gavi support, it's better to have an alternative plan or a contingency plan to avoid the catastrophic situation which may take lives of many. Rwanda plans to sustain the program although it is not easy considering scarcity of resources, different approaches are being thought about to find strategies that are cost-effective to ensure sustainability. The distribution system is among other strategies predicted to be cost beneficial once redesigned by reducing supply frequencies from twelve to four times per year. The supply plan is twice a year and distribution is currently monthly, where district hospitals holds a 1 months stock with a buffer of one month and service point are also supplied on monthly basis with a buffer of two weeks.

An increase of the storage capacity at district hospital is an opportunity for the program save some money as it is the plan to use all opportunities that may arise while keep watching over the sustainable solution for this program.

1.2. Problem Statement

The immunization supply chain management in Rwanda is experiencing challenges related to the performance. This is revealed by the EVM assessment of 2018 and audit reports for the past three years. Among the issues alleviated include monitoring of vaccination activities, data quality, supportive supervision, monitoring of vaccine utilization and wastage management which may become an issue. This is happening while Gavi is still supporting the program, and most of personnel at least at CVS are salaried by Gavi funds, distribution cost from central to end point is also a Gavi fund support. Strategies of sustainability of these activities after support is stopped are under way; among them the distribution system redesign is considered. The distribution is currently being done once in months. Immunization system redesign is expected to optimize the system where other activities with low performance will be getting performed. These include supportive supervision, monitoring of vaccine utilization and wastage management found with gap by EVMA and auditor general 'audits. With scarce resources being financial and or HR, it is a possible to optimize the supply chain system by re-designing the distribution system. To our knowledge there are no other studies related to the immunization supply chain in Rwanda, this study therefore analyzed the cost of the current distribution system and predict for the potential cost benefits (monetary value) due or as a result of the distribution system re-designed and implemented.

1.3. Purpose of the study

. As vaccine supply system is done on monthly basis, using Gavi-HSS, this study intends to identify cost implications of vaccine distribution system currently and what will be the cost of the redesigned system. With cost for both distribution systems, a comparison was done to weight program's cost saving considering that the program is not going to make a new investment, only available opportunities were considered. The findings of the study will inform the program/policy maker on whether the planned system redesign is the right decision and on how much it would cost.

1.4. Objectives

1.4.1. General objective

- To understand how the current vaccines distribution model in Rwanda works and what it cost, and what could be the cost savings once redesigned

1.4.2. Specific Objectives

- Describe the current vaccines distribution system and determine its costs,

- Identify the cost for the new distribution system and determine what could be the costs saving once the distribution model is redesigned.

1.5. Research Questions

- How the current vaccines distribution system works and how much does it cost?
- To what extent will the new design be beneficial to program compared to the current system?

1.6. Delimitations

Content and Concept: This research was done to determine the cost saving of immunization supply chain system design and precisely, vaccine distribution system redesign at DVS. The cost of the current distribution model and the estimated cost of the new/redesigned distribution model were analyzed and compared to show if the new model is likely to allow the program save cost..

Geographical scope: The study was carried out in Rwanda at the CVS where relevant documents related to funding transfers to DVS were reviewed to determine the costs incurred to distribution system then cost estimates for the new or redesigned distribution model was calculated and later the comparison between the two were determined.

Time: This study was performed within eight months, that is from February to September 2019.

CHAPT II. LITERATURE REVIEW

2.1. Introduction

This chapter focused on the review of the existing literatures, including textbook and document related to the immunization supply chain system design within the health system.

This chapter comprises the critical review, conceptual framework of the study and summary.

2.2. Overview of the topic

The immunization supply chain management has always been behind the success to the program, knowing that the immunization coverage can't be achieved without logistics services that perform well. It should therefore be updated and improved to avoid some issues that may impinge the success of the program(19). The supply plan in Rwanda is twice a year and distribution is currently monthly, the pull system is applied. The immunization supply chain is a three level system and made of:

- One Central Vaccine Store,
- Forty Two (42) District Vaccine Stores and,
- Five hundred and four (504) Service delivery points (health centers)

All district vaccine stores get supplies from central vaccine stores and service delivery point gets vaccines from district hospital every month. The funding of vaccine distribution is from RBC on the Gavi-HSS support where the transfer of funds is done on quarterly basis, from RBC to all 42 district hospitals holding vaccine store and then from there to health centers in their respective catchment areas.

This is among crucial activities of the immunization program that takes a lot of funds and it is externally funded. Knowing Gavi supporting policy, the support will get to an end once country has graduated from low income to middle income countries level, if this was not planned before some systems may be paralyzed which could be reason of losing lives of many. The immunization program is trying to identify each area of its components that can be redesigned to optimize services using little that invested in rather than spending a lot that comes from donors.

It is in this context that the program has started the process of redesigning its supply chain management system redesign with a focus on distribution model. Different scenarios presented below are costed and compared to guide the decision making process. Two alternatives are compared and choose appropriate distribution model and its frequency that is more attractive than the other.

2.3. Distribution Model

The mode of vaccine delivery being used currently in Rwanda is pull system with three levels of vaccine supply system chain. This means that health centers collects vaccines from district hospital and this from central vaccine store. A study done in seven countries in sub-saharan Africa (South Africa, Botswana, Malawi, Mozambique, Namibia, Zambia and Zimbabwe) with purpose of assessing the reduction of supplying cost; this study revealed that the regional distribution centers establishment has no significant impact in terms of cost reduction but also showed to be not attractive investment for small countries with low quantities of distribution. This is applied to both models of delivery, being pull of push systems of vaccines delivery.(20)

In Rwandan context, an ideal of investing in regional infrastructure would not be attractive considering the area of the country and requirements of establishing a new level within the existing system. The farthest distance district hospitals (9.5%) take maximum of 8 hours. There is no such long distance that would require establishment of a new level.

2.4. Current vaccines distribution frequency

The frequency of vaccine distribution in Rwanda is currently monthly. The distance form districts to central store is not far considering the area of the country of 26,338 km^2 the ideal investment for vaccine delivery would be reduction of frequency and increasing monitoring system. This was found to be effective with small countries but a challenge to countries with large areas.(20) With opportunities of Gavi supporting in cold chain equipment optimization platform project, district stores capacity will be increased. This could reduce the monthly distribution costs between CVS-and DVS and most importantly save money and time for both levels.

2.5. Determinants or summary of factors associated with vaccine distribution system design

2.5.1. Immunization supply chain management

Supply chain management refers to all events related to it directly or not in order to satisfy customer requirements. It includes manufacturer, supplier transporter, warehouses retailers and clienteles themselves. It comprises also, functions involved in receipts and satisfying customer requests including productions, marketing and distributions, operations and customer services.(21)

Immunization supply chain management is similar to other but it requires complex logistics as vaccines should be kept at conditioned temperatures following manufacturers' instructions. Its role is to ensure that effective vaccine storage, handling and stock management and temperature control within the chain. The immunization supply chain management also ensures uninterrupted availability of quality vaccines from manufacturer to the end user and this requires a system to maintain the supply chain rights. Additionally it ensures the maintenance of adequate logistics management information system.(22)

Having supply chain in place for several decades is not a fact that its performance is maximized. A study done in 57 countries eligible for Gavi support revealed that countries do not need only support for vaccines but also functional systems. With this study it was found that redesigning immunization supply chain system would be an investment to opt for supply chain system optimization.(23)

More challenges of the immunization supply chain management were identified and risks were predicted due to higher volume and doses of vaccines, considering the introduction of new vaccines. With this trend of introducing new vaccines in the LMIC, and taking in to consideration the low performance of the immunization supply chain system in those countries, a number of strategies to respond on the risks and challenges in this area were proposed and among them the system design was included. This was thought of, it can be easy to implement as there is a baseline and from that an improvement is possible using innovations, available opportunities and new technologies would bring changes and increase performance(24). Bearing in mind the rapid change of immunization programs with existing supply chain systems was found to be difficult referring to the WHO report on case studies conducted in five countries(Ethiopia, Benin, Mozambique, Nigeria and Canada and one private industry, it was mentioned that a system design is the best strategy to respond to the supply chain challenges once well designed and supported (25)

Among the components of the immunization supply chain management, vaccine distribution (transportation) and storage are included. As suggested by Gharote et.al, the distribution system need to be structured in optimal ways to avoid wastage and unnecessary additional costs.(26)

2.5.2. Immunization supply chain system design

The immunization supply chain system design consists of processes that can take different forms of vaccine logistics for better improvement management tactic including changing roles and responsibilities of supply chain managers to the completion of the system renovation by changing transport cycles, number of levels within the system and frequency of distributions in iSCM system. It has a role of identifying the gap related to performance within the system and find support both financial and political to address identified gaps. (27)

Vaccines costs have increased tremendously through introduction of new vaccines in three decade, but supply chain system remained the same and the focus was mostly given to cold chain equipment while other components of supply chain struggling that even those being strengthened performance can't be achieved as there should be integration and interaction of activities to perform. With introduction of new vaccines, storage capacity is increasing management of those vaccines should require more strategies to avoid wastage.(28). It was found that some area are getting improved while others stay static which also constrains the performance as all should work synergistically.

2.5.3. Benefits of redesigning the supply chain system

It has been proven that the system design can play a big role in increasing performance once smoothly implemented and decrease capital expenditure and operating costs(29). The supply chain system redesign has also been proven to be among approaches that contribute to the increase of performance. The study conducted in Benin Comé health zone, revealed that vaccine supply chain system redesign does not only decrease funding in activities but also increases in motivation and professional awareness due to training, supportive supervision, and improved work conditions(30). Similarly in Mozambique after redesigning the vaccine supply chain system, logistics tasks were being performed by few staff compared to that time before redesigning, time spent on logistics activities decreased from 348 to 138 days in a year, stock outs decreased at 34% , the cost per dose delivered became less expensive at an average of 21% and the immunization coverage increased from 70% to 95.4%(31).

There are no written documents in Rwanda about system design but it was discussed many times in different meetings but not documented or published as report or in the form of research publications. With experience from people working in immunization program, the distribution system model used to be push, then after it was changed to a pull system. The frequency was dynamic, especially after changing the system to pull system. DHs used to collect vaccines when they want, there were no schedule, so vaccines were being distributed every day during a month. After experiencing this with difficulties, the immunization programme in Rwanda decided to schedule the distribution in two weeks during a month (second and third weeks of the months). This was also found to be tiresome, as the staff couldn't get enough time to do other work related to the vaccines supply chain management including monitoring of supply chain activities at lower levels.

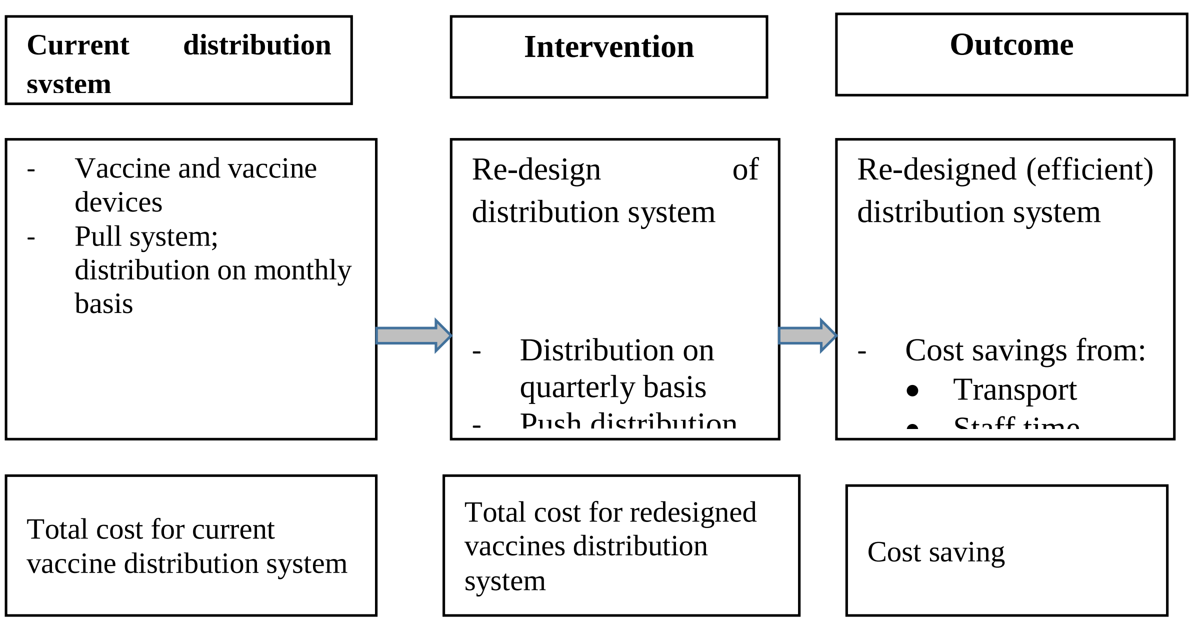
With the facts from other countries that performed system redesign, it is an attractive approach for improvement and sustainability of the programme.

2.5.4. Cost benefits analysis of immunization system re-designs

Benefits for the vaccine supply chain management system redesign are numerous; studies revealed that there is important reduction of cost related to distribution or supply of vaccines. Although, a change is made for distribution process, there is no additional cost; rather, financial benefit from cost reduction due to changes made to supply system.(29) Redesigning the supply system has not only contributed to the program by reducing supply cost but also, is time saving for the operators. This is applied to both sides, central and middle level where the reduced time for supply can be used for other milestones like supportive supervision and monitoring to optimize the system.(32) Simplifying the supply system and tailoring the design by changing layers, supply frequencies, distribution model (push or pull) was found to be cost effective.(33)

2.6. **Conceptual framework**

Figure 1 Conceptual framework



The cost comparison between the two distribution models (current and new design) and the redesigned frequency of distribution for the year were done to determine possible financial benefits of redesigning the distribution system. The financial benefits may be influenced by the number of distribution frequencies, number of personnel involved in one round of vaccines distribution from CVS to DHs and ideal routing or itinerary. The simulation analysis showed the relationship between cost and benefits of redesigning the system of vaccine distribution informing Rwanda Immunization programme for decision-making purposes.

CHAPT III. METHODOLOGY

3.1. Research Design

This study is a costing study that involved analysis and comparison of the cost of the current and planned vaccines distribution systems. Target Population& Sample Design

This study presents the cost of the two vaccine supply system from central vaccines store to District vaccines stores. All were included in the cost analysis. Therefore for this study no sample size was required.

Data Collection Methods

Financial records related to vaccine distribution were reviewed to determine the cost of current vaccine distribution and cost estimates for the distribution for the planned system re-design. We collected resource-use data for the vaccine, distribution system, including per diems and fuel for vehicles used in delivering or collecting vaccines and dry goods between any of the two tiers of the immunization supply chain system.

Calculations for per diems were based on the ministerial law/order related to the mission allowances for the workers on mission; this helped the researcher to determine how much each category of staff involved in vaccine distribution should be paid depending on the number of days spent on one mission. The second item was costed is vehicle maintenance fees and this was calculated based on the available maintenance plan per year for the two recently acquired tracks. The third is fuel costs which was calculated based on the DHs locations determined by distance between those DHs and CVS, cost of current fuel per litter multiplied by distance/Km considering vehicle consumption equaling 7km/l and an annual inflation rate was considered while projecting the cost of the two distribution system in a period of time.

For transportation of dry goods, we considered outsourcing of the tracks, which can be done twice a year as DHs can store dry goods for six months considering that the available tracks are refrigerated and using them for transportation of dry goods will be a miss use, transportation of the cold storage should be maximized to reduce frequencies. Data was collected and entered in a developed excel tool designed purposely for the data analysis of this study.

3.2. Validity and Reliability

The reliability is determined by the use of a particular instrument and the regularity of the measures obtained and indicates the extent of random error in the measurement method. Whereas, validity of an instrument measures is the concept in question and that concept is accurately measured. This study is valid and reliable as the costing estimates was done using a pre-designed data collection tool(34).

3.3. Data Analysis

The analysis and comparison of costs for the current vaccine distribution system and the planned distribution redesign, was done to determine whether there are cost-saving associated with the redesigned distribution system. The data collection tool was designed by the researcher purposely for this study and included all items related to the distribution vaccines that could take money; these incudes: mission allowance for the driver and EPI focal person as well as fuel for the current system. For the redesigned system, the researcher included maintenance of the vehicle on top of the fuel and mission allowances costs. The estimated costs of the two distribution models were compared to determine which model could help the programme to save money (monetary benefits) in addition to non-monetary benefits.

3.4. Ethical Consideration

This study did not involve human subjects, therefore, no samples from human subjects, this study used information and data on current vaccines distribution system (cost and system design) from Central Warehouse to District Hospital, data was collected and analysed with an overall objective of assessing the cost benefit of a system redesigned. The information on vaccines distribution related cost was collected for all District hospitals and Central Warehouse.

There were no private personal data or medical data to be collected and data on vaccines distribution related costs was used for academic purpose only, and thesis report was submitted to the University of Rwanda as a degree awarding institution and findings will also be published and shared to the Vaccination Program leadership in Rwanda.

To be able to carry out this study with respect to ethical consideration for any scientific work, the researcher has secured an ethical clearance/authorization issued by UR CMHS Institution Review Board (IRB) with approval notice: No 384/CMHS IRB/2019 which authorization was then presented to RBC, Immunisation programme for accessing data.

3.6. Limitation

The scope of this study was limited to the analysis of financial cost of the current vaccines supply system and planned redesigned supply system in the perspective of the Immunisation program. Therefore, it does not include the items for which the cost is not incurred by the program, including the cost related to infrastructure and or any other investment as the existing resources are the ones to be used for the system redesign. Furthermore, the cost related to staff time was not included, due to complexity of estimation, despite its potential to contribute to the cost savings.

The time for this study was too short to cover all benefits other than the cost saving a program could make once the system is redesigned. The source of the cost information for some items was collected from the program, based on annual standard cost. Although the cost of some items such as fuel have fluctuation during the year, that were not adjusted for in this study, other items such as mission allowances remain constant during a year.

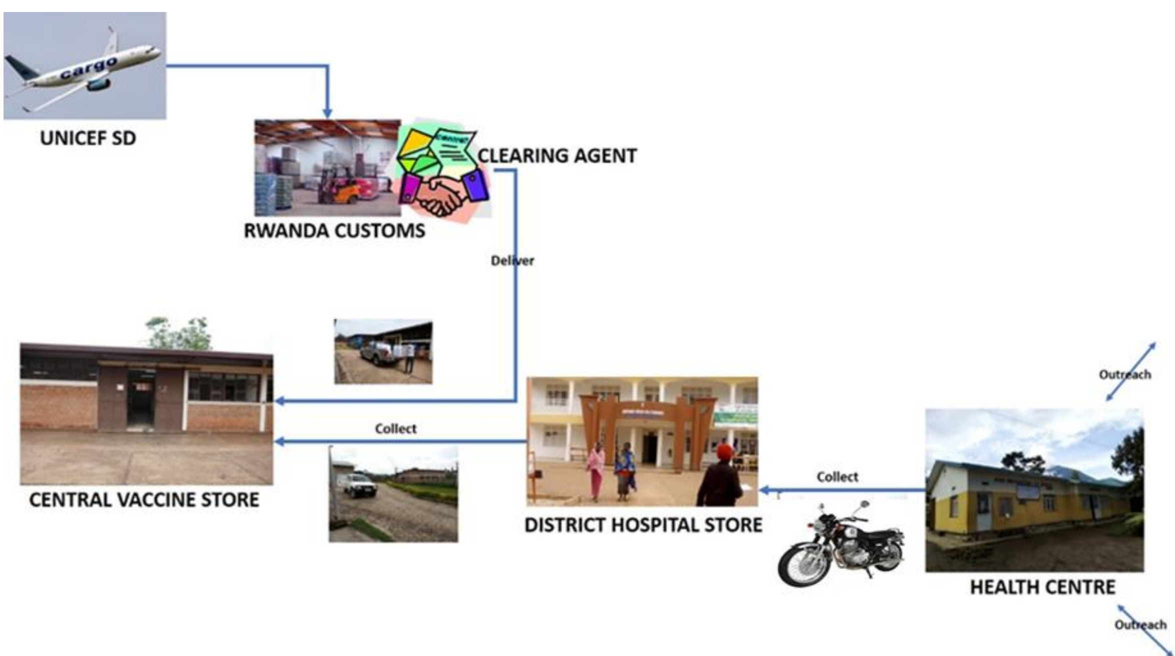
CHAPT IV. RESULTS

4.1. Description of the current vaccine distribution system in Rwanda

The plan for vaccine procurement is done every year and procurement services are performed by third party logistics (UNICEF supply Division). Supply plan is twice a year, shipment plan is done concomitantly with the forecasting of vaccines also done once a year prior end of the current year for following year.

Vaccine supply system in Rwanda is made of three layers, those include: 1. Central Vaccine Store CVS also known as primary level (PL), 2. District Vaccine Store (DVS) located at District Hospital (DH) and Health Centre (HCs) which is the service delivery point. Currently DVS collect vaccines from CVS every month, and form DH; HCs are responsible to collect vaccines every month. The EPI focal person who is coordinating all activities related to the immunization activities at DH prepares an order every month and come to collect vaccines at CVS with DH's vehicle 4X4 pick up. Also, HCs pick vaccines up from DHs every month using motorbikes.

Figure 2: The current vaccine distribution system in Rwanda.



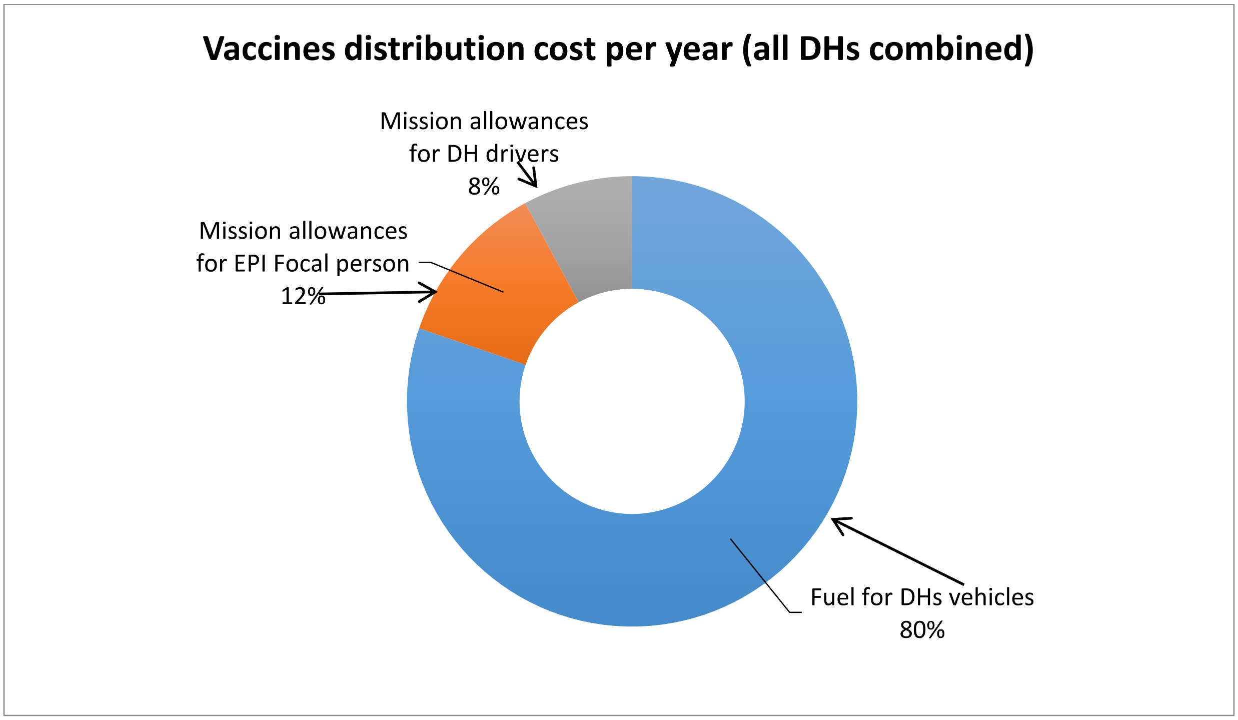
Source: EVM 2018

4.1.1. Current Distribution cost

Vaccine distribution cost is shared between two parties where CVS provides with lower levels fuel and per diems for the DH EPI focal person and the driver while DH avails the vehicle to collect vaccines. . This is transferred from Rwanda Biomedical Centre (RBC) through DHs and HCs as package for covering all related immunization activities with different budget lines detailing each milestone at each level. But for this study we focused on the supply budget up to DH level. The cost of vehicle is covered by the DH as per agreement; both parties should contribute to this milestone. Funds transfer is done on quarterly basis following quarterly cash flows DVS do not receive same amount, rather, amount they receive depends on their features including geographical location, targeted population and distance to be covered between DVS and its affiliated HCs. All these factors determine how much one DH will receive as budget support for vaccines distribution. This study provides details of operations happening between two layers, e;i CVS and DH following the scope of the study

The current distribution of vaccines is done using pull system where HCs collects vaccines from DVS and this from CVS. This study shows the cost of vaccine supply form CVS to DVS per delivery. The table below describes costed items for vaccine distribution per year.

Figure 3: Cost of vaccines distribution from CVS to VDS per year as per current system



The graph above shows the total cost of vaccine distribution for each item that requires funding. There are three items costed on the table including: a) fuel, b) mission allowance for the EPI supervisor and c) mission allowance for the driver. This study revealed that the vaccines reach to the VDS at a cost of 3,826,450 FRW which make 45,917,400FRW. Of the three above mentioned items, the fuel takes 80% of the total cost, while mission allowances for both EPI supervisor and driver takes 20% of the total cost.

The comprehensive multi-year plan (five years) of the programme has projected an increase in vaccines demand which in turn will increase the cost of vaccines distribution from all levels in the supply chain system. The projection of the vaccines distribution costs over a period of five years will significantly increase and the following factors will contribute to it:

- Increased birth cohort in five years to come,
- Increased volume or vaccines demand;
- Increased frequency distribution or vaccines pick-up,
- Storage capacity that will need to be increased to meet the vaccines availability and

- Inflation rate, which will affect the overall distribution, costs of vaccines delivery every single year.

Table1. Projected cost of vaccine delivery within five years

No	Vaccines distribution drivers/costed items	Total monthly distribution cost(all DHs)	Total distribution cost(Per year)	Distribution cost Year 2 (inflation rate 5.5%)	Distribution cost Year 3 (inflation rate 5.5%)	Distribution cost Year 4 (inflation rate 5.5%)	Distribution cost Year 5 (inflation rate 5.5%)
1	Fuel for DHs vehicles	3,071,000	36,852,000	38,878,860	41,017,197	43,273,143	45,653,166
2	Mission allowances for EPI Focal person	454,000	5,448,000	5,747,640	6,063,760	6,397,267	6,749,117
3	Mission allowances for DH drivers	301,450	3,617,400	3,816,357	4,026,257	4,247,701	4,481,324
	Total cost		45,917,400	48,442,857	51,107,214	53,918,111	56,883,607

This study revealed on the above diagram that the cost of vaccines delivery will keep increasing considering the inflation rate and the baseline cost of 2019 cost per deliver; within five years it will be increased at a rate of 17.4%

This study shows that, every year the program has to secure more than 45,917,400 FRW for vaccine delivery only. This shows how expensive the current distribution system is. With five years projection, the current cost will increase up to 22% by 2023. The annual budget support indicated above is externally funded (GAVI HSS Support) and an increase on annual basis would affect the financial sustainability of the supply system.

The assessment of the current program capacity (resources, HR, infrastructure or capital investment, etc) revealed a huge opportunity and availability of existing facilities which could help to reduce the trends in distribution costs if efficiently utilized. The programme has recently received two refrigerated vehicles for transportation of vaccines from airport to the CVS as this has been being transported by the clearing agents as per contract. This was seen as a risk because from airport to the CVS vaccines were not insured, in addition to temperature condition during transportation.. These vehicles can also be used to supply vaccines in DVS which can increase efficiency at reduced cost.

Using these trucks in distribution of vaccines to deliver monthly storage can decrease cost at high percentage mostly if looping distribution is applied,(36) but still the vehicle capacity will not be utilized optimally.

The storage capacity is sufficient at all levels in reference to the findings of EVMA of 2018 and those form 2017 cold chain inventory report. At CVS available storage capacity is utilized at an average of 50% with a six months stock as per the plan and at DVS and HCs the storage capacity of one month.

There is an opportunity of increasing storage capacity at lower level while replacing the obsolete equipment with Gavi funds through cold chain equipment optimization platform (CCEOP) project. With this project, all DVS will be equipped with CCE and their storage capacity will increase up to three months stock. This opportunity brought an idea of increasing stock at DVS from one month to three months stock and consequently the frequency of delivering vaccines at DVS could change to a quarterly basis (four times a year instead of twelve).

If the program decides modify model of supply and frequency where looping push model will be applied, distribution of vaccines will be being done once in quarter. This will only be applicable at DVS and HCs will continue to use existing model of pulling from DVS. If this is applied, the cost can decrease more, but the proposal for redesigning the system was inspired by the available facilities or opportunities. If there is another opportunity maybe for transportation facilities in DVS, the same can be applied but only model can be redesigned not the frequency, the push model was found to be cost effective. (36)

4.2. Determine what the programme will benefit financially once the system is redesigned

This part is showing the financial benefits of redesigning vaccine distribution system one of the main component immunization supply chain management system. Calculations were done based on the existing vaccine distribution system cost and that of redesigned vaccine distribution where when two components within the system have been modified e;i distribution model and distribution frequency. The new design is about changing model from pull to push system where CVS will be pushing to DVS and HCs pull fromDVS.

To be able to define the number of distribution frequencies that could happen once the system changed from pull to push system between primary and secondary levels, it is necessary to assess the suitable route planning (routing optimization) to ensure an uninterrupted supply and maximum cost savings per round of trip, the researcher proposed an efficient route plan. The grouping of DHs was done based on geographic information/data with which data were used to estimate how much the new distribution model (new frequencies) will be costing compared to the current model. The table below indicates the total cost for key drivers (Fuel and Mission Allowances) per year.

Table 2: Total cost of vaccine delivery per year when route optimization is applied

DHS	Fuel cost for CVS Per Delivery to all DH		Transport cost of devices per year	Total mission allowance per year
All DH	Fuel cost	2,232,144	6,364,800	2,525,600
	Inflation rate: 5.5%	122,767.92	350,064.0	138,908.0
	Total delivery cost + inflation rate	2,354,911.92	6,714,864.0	2,664,508.0
Redesigned system cost per year				11,734,283.92

The analysis of the total estimated cost for vaccines distribution in Rwanda using the proposed frequency of distribution or delivery schedule is extremely low compared to the current distribution costs. The total estimated cost with an inflation rate of 5.5% is FRW 11,734,283.92 compared to FRW 45,917,400. If the programme is to consider redesigning the frequency of vaccines distribution under push model between the two levels (primary and secondary), the EPI could make a net saving of 74.7% of the current distribution costs.

However, changing the distribution frequency and model push-pull system requires the primary level (CVS) to get ready and prepared for meeting vaccines demand at the last mile taking into consideration potential distribution challenges between the secondary and third level (DHs and HCs). Keeping the vaccines availability ratio at high level would require the CVS to take care of the current available resources i.e. trucks which will be used to distribute vaccines as per the proposed grouping model. The most challenging and very sensitive activity or driver that would negatively affect and reduce the potential net savings is the "Preventive and Regular Maintenance" of the two existing trucks.

Trying to understand how much this driver is likely to affect the vaccines availability and projected costs benefit, the researcher did estimate how much the preventive and regular maintenance of the trucks will cost and the table below:

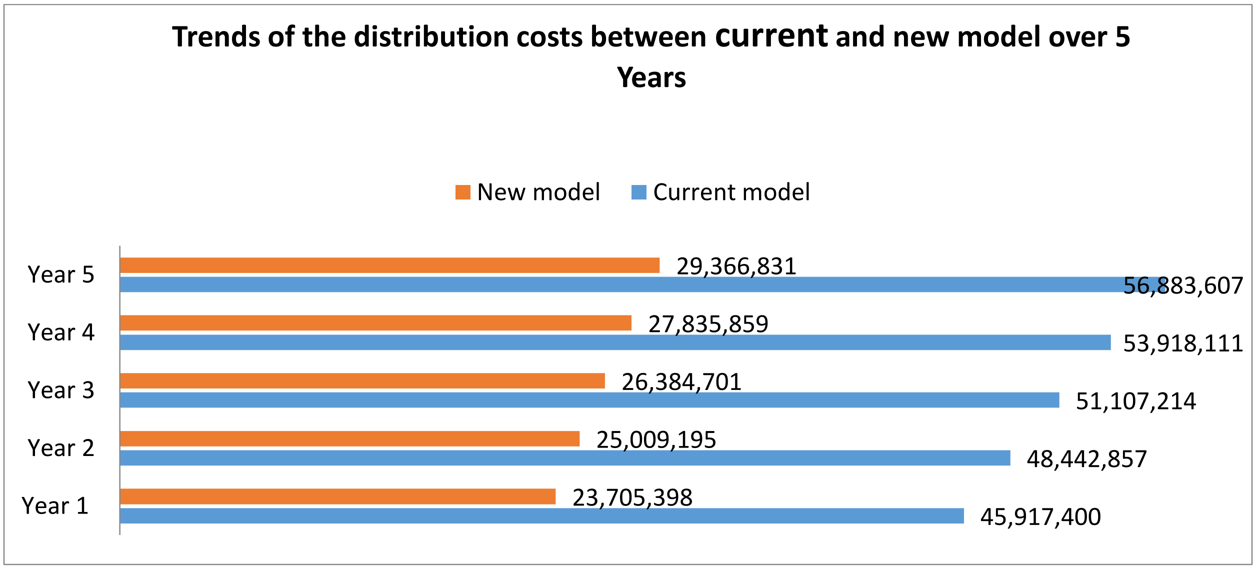
Table 3: Maintenance cost for the two tracks per year

No	Preventive Maintenance	Estimated cost per one truck (quarterly basis)	Frequency(quarter/yearly)	Quantity	Estimated costs for two trucks per year
1	Vehicle Service Maintenance(5,000 Km)	536,683	4	2	4,293,463
2	Maintenance Repairs (annual basis)	1,238,825	1	2	2,477,651
3	Annual Maintenance of Mobile Cold room	5,200,000	1	2	10,400,000
	TOTAL (estimated) COST FOR MAINTENANCE				17,171,114

The table above shows the total cost (17,171,114) of maintenance for the two refrigerated tracks that will be added to the total cost of the vaccine distribution per year. This makes the total cost of the new distribution model increased up to 28,905,398 per year making 37% decrease of the distribution cost compared to the current distribution system.

The graph below indicates the trends in vaccines distribution over five years when comparing the two systems. Results of this study revealed that current system is more expensive compared to the new designed system.

Figure 4: Trends of distribution cost between current and new model over 5yrs



This indicates that the cost of vaccine delivery form CVS to DVS will decrease to 37% once the system is modified by changing frequency and model of vaccine distribution.

CHAPT V. DISCUSSION OF RESULTS

The discussion of this study focuses on the results related to the objectives. The current distribution system of vaccine in Rwanda is performing well with an average of 89% at all levels as a result, no stock outs occurred in past three years, there is no expiries as well that would determine a gap(37). Although the system is highly performing, it is expensive considering available resources that are basically external that leads to sustainability issues of the program. A lot of money and time are spent for vaccine delivery considering model and frequency of vaccine distribution system. Pull system and frequency of 12 times a year is evident that it has a high cost. This is similar to the study done in Benin and Mozambique, where the fact that redesigning the system reduced the cost while increasing time for human resource in their systems(38).

Being expensive, with cost projections it was revealed that the cost will keep increasing year by year which found to be difficult for the program on itself-sustainability as the program is externally funded. Redesigning Immunization supply chain management system requires an investment cost that may constrain the program to decide on the intervention known to be efficient. It is evident that when changing the model from pull to push system, cost will be reduced but investment cost will always be high but operational cost is low (36).

The same case in Rwanda, the cost of vaccine distribution will highly reduce at 37% but the investment cost is high when we consider storage capacity at DH levels and refrigerated vehicles for transportation of vaccines. Available opportunities that can be used no cost will be allocated to infrastructure and this will ease the transition from pull model to push model. The program recently procured refrigerated track with $40m^3$ intended to transport vaccines from airport to CVS. Same vehicles can transport vaccines from CVS to DVS and this is more efficient especially where route optimization is applied. In addition to the route optimization the, frequency of distribution was found to decrease the cost where, instead of twelve, distribution is done four times a year.

Reduction of distribution frequency, requires additional storage capacity, but the country is has applied for the cold chain equipment grant from Gavi, this application is approved and the equipment is planned to arrive in country shortly. With this the storage capacity at DVS will be sufficient for a three months stock. With this there will not be other additional cost for the storage that will be required to redesign the system by reducing the frequency.

Preventive and regular maintenance as estimated is another driver or contributing factor in addition to mission allowances and fuel for ensuring vaccines availability and its operating costs needs to be considered and catered for by the EPI in its annual budget.

If the preventive maintenance estimated costs on annual basis is added to basic or regular drivers in the new distribution system design, the consolidated costs for delivering vaccines per year will still be far low compared to the annual cost of delivering vaccines under the current distribution model. If the EPI is to use efficiently available resources (trucks) and deliver vaccines to secondary level, the programme would save up to 37% of the current distribution costs.

This is a very significant cost benefits that will result from redesigning the distribution frequencies and effective use of existing resources. If one is to compare the cost benefits (in monetary terms) of the two distribution systems, it is very clear that in a period of five years, if nothing is done to save on the distribution costs, the programme will be far to start the journey. for self-sustainability.

With the redesigned system, the cost may also keep decreasing if costed items are reduced like when the program decide to prepare packages properly for each DVS, rebel them and send the driver with products would cut the EPI staff's budget that will be another additional cost cost savings. Time spent by health workers (driver and EPI Focal person) during vaccines pick up will be another benefit since the time they spent for travels for vaccines pick up will be saved and can be dedicated to other activities like monitoring and evaluation of what is happening at last mile of vaccine delivery and supportive supervision to ensure quality of immunization supply chain and data visibility at the last mile.

CONCLUSION AND RECOMMENDATIONS

➢ Conclusion

The study findings have confirmed a huge opportunity of getting the current distribution costs reduced when the distribution is redesigned from pull to push and frequency from twelve to four per year. It was discovered that the programme would save 37% of the current distribution costs once the system is redesigned.

➢ Recommendations

With study results, the researcher recommends the immunization program to consider redesign the Vaccine distribution system by changing distribution frequencies from twelve to four times per year and mode of distribution from pull to push system from CVS through DVS. This would allow the programme to reduce the cost of the current distribution and use this opportunity to increase its self-financing,

- ❖ To consider how effectively and efficiently the new acquired vehicles fully owned by the programme could be used and contribute to programme sustainability,
- ❖ Plan to change the model and implement push system from DVS to HCs, by applying route optimization because this was proved to decrease cost significantly and,
- ❖ To consider carrying out a comprehensive study to assess how much the entire programme does costs and what could be done to continue decrease the distribution costs.

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APPENDICES

1. Data collection tool

1.1. Current cost of vaccine distribution

	Hospital name	VACCINES PICK UP (FROM CVS TO DHs) - CURRENT COLLECTION RELATED COSTS					
		FUEL FOR DHs VEHICLE	MISSION ALLOWANCES (EPI SUPERV/months)	MISSION ALLOWANCES (DRIVER /month)	NUMBER OF DAYS PER COLLECTION (PER DH)	TOTAL COST OF VACCINES' PICK UP (PER PER DH/MONTH)	TOTAL COST PER/YR SUPPLY UP TO DH
1	Bushenge						
2	Butaro						
3	Byumba						
4	Gahini						
5	Gakoma						
6	Gihundwe						
7	Gisenyi						
8	Gitwe						
9	Kabaya						
10	Kabgayi						
11	Kabutare						
12	Kaduha						
13	Kibagabaga						
14	Kibilizi						
15	Kibogora						

16	Kibungo						
17	Kibuye						
18	Kigeme						
19	Kilinda						
20	Kinihira						
21	Kirehe						
22	Kiziguro						
23	Masaka						
24	Mibilizi						
25	Mugonero						
26	Muhima						
27	Muhororo						
28	Munini						
29	Murunda						
30	Nemba						
31	Ngarama						
32	Nyagatare						
33	Nyamata						
34	Nyanza						
35	R Rukoma						
36	Ruhango						
37	Ruhengeri						
38	Ruli						
39	Rutongo						
40	Rwamagana						
41	Rwinkwavu						
42	Shyira						
	Total						

1.2. Cost of redesigned system

Costting of designed system

DHS		FUEL FOR CVS VEHICLE PER DELIVERY TO DH	TRANSPORT COST OF DEVICES PER DELIVERY DH (Lorry 2.5-5T) Ref: Ministerial Order)	TRANSPORT COST OF DEVICES PER DELIVERY DH (Lorry 2.5-5T) Ref: Ministerial Order)	TOTAL MISSION ALLOWANCE PER QTR	TOTAL MISSION ALLOWANCE PER YEAR	MAINTAINANCE COST PER YEAR/2TRACK	TOTAL COSTESTIMATED FOR THE REDESIGNED DISTR. SYST. (without inflation rate)	INFLATION RATE ADJUSTMENT /(Ref BNR Qrt inflat report, Third Qrtr 2018)	TOTAL W INFLATION RATE
GROUP1	TOTAL DISTR. COSTS PER QRTR	TOTAL COST per YR	HIRED VEHICLE PER QTR	HIRED VEHICLE PER YEAR					5.5%	
Bushenge										
Gihundwe										
Kibogora										
Mibilizi										
Kibuye										
Kabgayi										
Mugonero										
Murunda										
Kilinda										
Gisenyi										
Nemba										
Ruhengeri										
Kabaya										
Muhororo										
Shyira										

Nyanza										
Kabutare										
Kigeme										
Kaduha										
Munini										
Gakoma										
Gitwe										
Ruhango										
Kibilizi										
Nyagatare										
Gahini										
Kiziguro										
Ngarama										
Rwamagana										
Rwinkwavu										
Kibungo										
Kirehe										
Kibagabaga										
Muhima										
Masaka										
Nyamata										
Byumba										
Rutongo										
Ruli										
R Rukoma										
Butaro										
Kinihira										
Total										

1. Research Activities, Schedule And Estimated Budget

Activity	Schedule	Estimated budget (RWF)
Research proposal/protocol writing	April –May 2019	0
Ethical clearance submission fee	June- July 2019	300,000
Data collection and data entry	July 2019	100,000
Data analysis, interpretation discussion and report writing	1^{st}-15^{th} August 2019	70,000
Finalization of the dissertation	16^{th}-20^{th} August	0
Scientific paper write up and presentation of findings	September 2019	0
Paper submission		500,000
TOTAL		**970,000**