Assessment of the distribution lead time of essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division

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DECLARATION

I, Martin de Tours NYIRUMUGISHA, hereby declare that the practicum capstone thesis has been written by me without any external unauthorized help, that it has been neither presented to any institution for evaluation nor previously published in its entirety or in parts. Any parts, words, or ideas in the thesis, however limited, that are quoted from or based on other sources, have been acknowledged as such without exception.

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DEDICATION

To the five pillars of my life: God, my wife, my children, my siblings and parents, I dedicate this thesis.

God, walking with You, through this journey has given me confidence and strength.

Gyslaine, my beloved wife, you are everything for me, without your love and understanding, I would not be able to make it. I am truly thankful for having you in my life.

My kids, Orlane, Odran and Concorde, you have been like my guardian angels and without the relaxing moments spent with you, I would not be able to make it.

My Sister Justine, thanks for your love and encouragement;

My parents and siblings who are no longer of this world, your memories continue to regulate my life. You meant and continue to mean so much to me.

We made it…

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The accomplishment of this work was the fruit of our effort combined with the one of several people to whom we owe our sincere thanks.

Thanks to God who granted to us life, intelligence and firm spirit. We thank the University of Global Health Equity for the golden opportunity to learn this program.

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I owe so much to my whole family for their undying support: my beloved wife Gyslaine, my kids Orlane, Odran and Concorde, our regretted parents, our brother Janvier and sister Justine.

May our classmates, to this day, feel thanked for good memories and shared exploits.

«May each one of you and unlisted find through this practicum thesis, the fruit of the unforgettable service rendered»

ABSTRACT

Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD) has the mission to avail to all Rwandan people the right medicines, in the right quantity, at the right place, at the right moment, in the right condition and at the right cost. To fulfill this mission, RBC/MPPD executes the active distribution to District Pharmacies who are the main customers serving all the public Health Facilities.

The lead time (the time between when new stock of essential medicines is ordered and when it is received and available for use) is among the main factors to consider in this active distribution. The literature states that the lead time has a major effect on quantities required for stock levels and when lead times are underestimated, the likely results are shortages, expensive emergency purchases and poor customer satisfaction.

This project assessed the distribution lead time of essential medicines at RBC/MPPD, and found that the average lead time is 20 days. Our goal was to find the root causes of the significant length and implement an intervention in order to shorten it from 20 days to 14 days in order to make the essential medicines regularly available to the population through improved work.

We employed a mixed method explanatory sequential design composed of quantitative and qualitative data. For the quantitative part, we sampled 120 orders of active distribution, for the period December 2016-November 2017, and we measured the central tendency and the spread of each step of the process using the file audit.

The following four steps were found as too long:

- Time in days between when order is received by Order Processing (OP) staff and when order is processed by RBC/MPPD, taking 5 days
- Time from starting picking products, checking and production of delivery note invoice, taking 5 days,
- Time in days between picking creation, transmission and starting picking the products by RBC/MPPD, taking 4 days,
- Time in days between Order submission by DP and order transmission to Order Processing staff by Customer care staff, taking 3 days.

Thus, the delay is likely to be imputed only to RBC/MPPD side and not on customers' side regardless the order submission step by DP.

The qualitative study used a semi structured interview process with 11 RBC/MPPD participants. The thematic analysis results suggested that the main causes of the long lead time were related to the RBC/MPPD human resources, RBC/MPPD workload, RBC/MPPD stock level, RBC/MPPD warehouse facilities, active distribution calendar observance, RBC/MPPD distribution design and RBC/MPPD system. Those causes have been found interconnected,

one impacting on another and their coincidence worsens the delay and this is the origin of the long maximum times observed in our results.

We found the root causes of the long distribution lead time at RBC/MPPD and these findings should guide in future to disseminate the results and to implement the intervention in order to execute the recommendations delivered. This will contribute to the regular availability of essential medicines and to the customer satisfaction through an improved distribution system.

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LIST OF ABBREVIATIONS

DH	District Hospital
DP	District Pharmacy
EDM	Essential Drugs and Other Medicines department
e-LMIS	Electronic Logistics Management and Information System
HC	Health Centre
HIV/AIDS	Human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS)
MPPD	Medical Procurement and Production Division
OP	Order Processing
RBC	Rwanda Biomedical Centre
RBC/MPPD	Rwanda Biomedical Centre/Medical Procurement and Production Division
RH	Referral Hospital
WHO	World Health organization

CHAPTER ONE: INTRODUCTION

1.1. BACKGROUND

The main mission of the Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD) is to avail essential medicines to all Rwandan people (Rwanda Prime Minister, 2011a). This mission is implemented through the distribution of products procured from different international suppliers (SCMS & Rwanda Ministry of Health, 2013).

The distribution of essential medicines is done predominantly via a pull system by which RBC/MPPD delivers essential medicines to customers upon their requests (Yadav, Tata, & Babaley, 2011). The routine distribution of health commodities at RBC/MPPD is managed through a monthly active distribution calendar by which RBC/MPPD transports ordered essential medicines to the District Pharmacies (DP) (SCMS & Rwanda Ministry of Health, 2013). The ordering process is done through the electronic Logistics Management and Information System (e-LMIS) linked to SAGE system - the warehouse management system of the central Medical store MPPD (Rwanda Ministry of Health, 2015a).

As the Sales Officer of RBC/MPPD, we always encounter claims from our customers and from RBC/MPPD staff about delays and stock outs. These claims pushed us to search for the source of these issues. After the analysis of distribution files for 2016 and 2017 and different publications on supply chain management, we found that the long distribution lead time (the time between when new stock is ordered and when it is received and available for use) could be one of the main reasons pertaining to these issues (USAID Deliver, 2011).

We learned from distribution files that in RBC/MPPD supply chain, the distribution lead time takes usually between 15 and 26 days calendar with average of 20 days and the lead time for emergency ordering is 3 days. Referring to the Rwanda standard lead time of 14 days obtained from number of calculations, the distribution lead time at RBC/MPPD is too long, given that the distribution is done monthly (USAID Deliver, 2011).

Through this distribution cycle period, there are number of different operations made on both the customer's side and the MPPD's side. These operations include, but are not limited to, the order creation in e-LMIS, alternative product suggestions, order cloning, order revision, order quotation, order picking, order checking and dispatch, order transportation, order delivery, and products reception by the customer. The complexity of the ordering process makes it extremely protracted and undermines the customers' satisfaction. The lead time has a major effect on quantities required for safety stocks and when lead times are underestimated, the likely results are shortages and more expensive emergency purchases (USAID Deliver, 2011; Yadav et al., 2011).

The aim of this project is to reduce the lead time at RBC/MPPD from 20 days to 14 days. This will make the essential medicines regularly available to the population. The workload will be reduced, as the unnecessary steps of the distribution cycle will be removed, and others improved. The satisfaction will then improve on both the customer and RBC/MPPD sides.

Specifically, this study focuses on ten tracer drugs selected from the list of 250 tracer drugs of Rwanda National Essential Medicines List (Rwanda Ministry of Health, 2015b). This study focuses on supply chain, in general, and discusses the distribution as the step concerning the problem that we intend to solve. Other parts of supply chain such as quantification, procurement and storing are not herewith discussed. This project includes our discussions on public supply chain system, and the private sector is not herewith analyzed.

1.2. PROBLEM STATEMENT

The distribution lead time of essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division is too long.

1.3. OBJECTIVES

1.3.1. GENERAL OBJECTIVE

To provide strategies to reduce the distribution lead time of essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD) from an average of 20 days to 14 days by April 2018.

1.3.2. SPECIFIC OBJECTIVES

- Measure the distribution lead time steps at RBC/MPPD by February 2018
- Identify the root causes of the long average lead time of 20 days by March 2018;
- Provide recommendations by April 2018.

1.4. JUSTIFICATION OF THE PROJECT, SETTING AND BENEFICIARIES

This study is being conducted in Medical Procurement and Production Division (MPPD), former CAMERWA (Centrale d'Achat des Médicaments Essentiels et Génériques au Rwanda). MPPD is one of different divisions of Rwanda Biomedical Centre (RBC) in charge of procurement, production and distribution of essential medicines in the country (Rwanda Prime Minister, 2011b). It is a Central Medical Store and avails health commodities to all the public health facilities through District Pharmacies (Yadav et al., 2011). The distribution is done on a monthly basis via a regular Active Distribution and the theoretical average lead time is 20 days considered as long comparatively to the standard one of 14 days (SCMS & Rwanda Ministry of Health, 2013; USAID Deliver, 2011).

The beneficiaries of our project are first of all the patients who will get regular products, as stockouts will decrease. The health facilities will benefit from the product availability, increase patient's satisfaction and credibility from the patients as well, the District Pharmacies will gain credibility from health facilities and the stress of medicines stockouts will decrease. The MPPD will also gain credibility from the customers and workload will decrease because unnecessary activities will be removed from the process. Globally, the Rwanda health care system will benefit as the reduction of the lead time increase the drug availability, which is the mirror of a well-designed supply chain system and a well functioning health care system.

There is no prior study which focused specifically on the RBC/MPPD lead time, and this project will offer the opportunity to find out the causes of distribution delays and will contribute in reducing the lead time from 20 days to 14 days.

1.5. ORGANIZATION OF THE DISSERTATION

Our project has 6 chapters. The introduction states the background describing the setting and the rationale of the problem; it highlights clearly the problem as well as its magnitude; it states also the general and the main objectives and it also describes the setting and the beneficiaries.

The following chapter, the literature review, defines key words of the topic, provide the importance of improved access to essential medicines; it states the situation of supply chain management of essential medicines in the World; it describes factors pertaining to the Lead time in Supply chain management system as well as the Situation of distribution Lead time across the region by citing some important lead time studies across regional countries. It clarifies finally the Rwanda Supply chain system context and the issue of lead time within RBC/MPPD.

The Chapter 3 concerns the method of research describing RBC/MPPD as the project setting, it states also the design which is the explanatory sequential design collecting and analyzing quantitative distribution data which are explored more in qualitative study to find out the root causes of the long lead time. Within this chapter, we explain how we chose the sample of 120 orders and talk about the saturation in qualitative part as well as what type of data has the

project measured. This part describes also the data collection tools used, the selection rationale of the intervention as well as the data analysis methods and ethical considerations.

The chapter 4 presents the results using tables, charts and figures to highlight the findings while the chapter 5 discuss them by interpretation of their meaning, showing what contributed to the findings and describes the limitations encountered in the study.

Finally, in the conclusive chapter, we summarize our project and furnish recommendations based on our findings.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION AND DEFINITIONS

Essential medicines, as defined by the World Health Organization (WHO), are "those that satisfy the priority health care needs of the population" (World Health Organization, 2004). It is crucial that such products are available to all of the population in a timely manner given their value in the health system and their contribution to the welfare of the people (Chalira et al., 2004). In fact, essential medicines protect people when they are available, affordable, of assured quality and properly used (Pilon, 2016; World Health Organization, 2004).

These essential medicines are managed through a logistics management system that takes care of planning, execution and control of the movements, storage of the supplies and related data from the supplier to the consumers (USAID Deliver, 2011). The supply chain management of the health commodities contains all the logistics management system activities, the management of the personnel and different systems governing the flow of health commodities from the manufacturers to consumption point through suppliers (USAID Deliver, 2011). However, the terms logistics and supply chain are often used interchangeably (USAID Deliver, 2011).

The distribution of health commodities from the upper level point to a lower level store may follow the push or pull system or a combination of both (Minnich & Maier, 2007). For the pull system, which is predominantly used, orders are submitted by the low level and then processed and delivered by the upper level (Minnich & Maier, 2007). However, in a push

system, the upper level store determines the real quantities of medicines to issue to each lower level store based on centrally estimated allocation quantities (Minnich & Maier, 2007). The two methods may be mixed depending on circumstances and type of products supplied (Yadav et al., 2011).

The supply chain contains multiple features, but the distribution lead time is one of the important factors that impact the availability of essential medicines to the population (Chalira et al., 2004). The distribution lead time in this context is defined as "the time between when a new stock of essential medicines is ordered and when it is received and available for use" (USAID Deliver, 2011).

2.2. IMPORTANCE OF ACCESS TO ESSENTIAL MEDICINES

Given the importance of the essential medicines, their availability and accessibility to the population are deemed to be among the priorities of the WHO and health officials throughout the world (Lu, Hernandez, Abegunde, & Edejer, 2011). Still, lack of access to essential medicines remains a serious global health problem (World Health Organization, 2004). In 2004, in its publication named "Policy perspectives on medicines" WHO states that "through a combination of public and private health systems, nearly two-thirds of the world's population are estimated to have access to full and effective treatments with the medicines they need, leaving one-third without regular access" (World Health Organization, 2004).

In order to strengthen this access to essential medicines, in 1998, WHO set up the department of Essential Drugs and Other Medicines (EDM), with responsibilities to support quality,

safety, efficacy, and accurate information for all medicines (Pilon, 2016). EDM department works hand in hand with nations, different organizations to ensure that all people have access to the right essential drugs, in the right quantity, at the right place, at the right moment, in the right condition, at the right cost and that they are prescribed and used rationally (Pilon, 2016).

2.3. SITUATION OF THE SUPPLY CHAIN MANAGEMENT OF ESSENTIAL MEDICINES IN THE WORLD

In countries that have state funded medical programs, governments are providing more autonomy to distribution organizations, such as the central medical stores which transports medicines to storage depots and health facilities (Yadav et al., 2011). This central medical store is heading the supply chains system activities of those countries, but it is not working alone. A smart supply chain system ensures that all logistics activities are well linked allowing the smooth availability of the right essential medicines in timely manner, in right conditions, in right quantity, on the right time and affordable cost (Yadav et al., 2011). Thus, it is necessary to have a well-designed distribution system with suitable storage and distribution at multiple levels because the lonely central warehouse cannot ensure proficiently the delivery of medical commodities to all the health facilities (Yadav et al., 2011).

In order to build a well-expanded health commodities management system, some countries in Sub-Saharan Africa include three main sectors: public sector, non-governmental organizations support and private sector (Yadav et al., 2011). For example, in Kenya, the public or governmental sector is headed by KEMSA (Kenya Medical Supply Agency), the NGOs are

headed by MEDS (Mission for Essential Drugs and Supplies) and the public sector is supplied by Private wholesalers (Kariuki, Njeru, Wamae, & Mackintosh, 2015). Thus, in public sector the distribution involves a Central medical Store (CMS) distributing the medicines to regional or district stores which ensure the distribution to all the health facilities (Yadav et al., 2011).

In Francophone Africa the Central medical Store (CMS) is called the "Centrale d'Achat de Médicaments Essentiels" because it plays the role of procuring health commodities on behalf of the Ministry of Health (Yadav et al., 2011). The good example here is the former CAMERWA namely Centrale d'Achat de Médicaments Essentiels et Génériques au Rwanda replaced by RBC/MPPD (Rwanda Prime Minister, 2011a). Under such a system, orders are placed by the health facilities or lower level stores at regular intervals to the upper levels of supply chain system using the forced ordering method or the minimum-maximum stock ordering method (USAID Deliver, 2011; Yadav et al., 2011).

In order to fulfill this supply chain system, the logistic management and information system (LMIS) used previously a paper based model and this caused long distribution cycles due to long lead times and was the one of the main causes of stockouts in many countries. In Rwanda, the study on supply chain assessed the Essential Medicines Stock outs at Health Centers in Burera District in Northern Province (Nditunze et al., 2015). This study placed the use of paper based logistics management and information system among the core causes of long lead times and stockouts observed in the region and suggested that the introduction of e-LMIS should harmonize the existing tools (Nditunze et al., 2015). Nowadays, the ordering

process is becoming more and more computerized and web based, and thus decreasing the ordering cycle time. For example, the implementation of a computerized stock supply chain management in hospital pharmacy in Haiti and the rolling out of the electronic Logistics Management Information System (e-LMIS) in Rwanda public supply chain decreased the lead times improving consequently the drugs availability and decreased remarkably the stockouts (Holm, Rudis, & Wilson, 2015; Rwanda Ministry of Health, 2015a).

2.4. FACTORS PERTAINING TO THE LEAD TIME IN SUPPLY CHAIN MANAGEMENT

Generally, the factors contributing to the lead time include but are not limited to order handling, planning, procurement, delivery, inspection, manufacturing, handling, picking, packing, and delivery (Zhang, 2008). However, the study by Gabriel T. Tarty states 10 main factors affecting the lead time in public healthcare in Nairobi, Kenya, such as "equipment failures, poor warehouse management, poor flow of information, incorrect shipping of orders, poor order listing, poor sorting, ordering costs, high level bureaucracy, order packing challenges and poor warehouse planning" (Tarty, 2012).

Other factors influencing the high lead time are "poor road conditions particularly in the rainy season, poor condition of delivery vehicles, increased work load at the issuing store, no availability of adequate resources at the central store and the consumption rate of drugs" (Chalira et al., 2004). Any change on one or many of these factors can produce the lead time reduction or growth. In an effort to decrease lead time, institutions noticed that 90% of

operations are non-essential and should be removed from the supply chain steps and get improved outcomes (Bharath & Prakash, 2014).

2.5. SITUATION OF DISTRIBUTION LEAD TIME ACROSS THE REGION AND STRATEGIES TO REDUCE IT BY GOVERNMENTS

The lead time is among determinants of availability of health commodities in many countries (USAID Deliver, 2011). The study of the order records done in Uganda in 2010 found that when the lead time was reduced from 8 weeks to 2 weeks, the stock out of Quinine injection (first drug stocked out in Uganda in 2010) changed from 52.7 % to 3.3% (Tumwine, Kutyabami, Odoi, & Kalyango, 2010). This shows that when the lead time is shortened, the order fill rate goes up and the stock out is remarkably reduced.

In Zimbabwe, the study conducted by WHO in 2000 compared the lead times of the provinces for the period from1993 to 1995 and the longest lead times of 150 days to 120 days were found in Mashonaland Central and East (Trap, Hogerzeil, Nathoo, Chidarikire, & Moore, 2004). The overall average lead time in Zimbabwe (Tab.1) was 71 days in 1989, 46 days in 1991, 48 days in 1993, 62 days in 1995, 44 days in 1995 and 49 days in 1998 (Trap et al., 2004).

Table 1. Lead times vs. Average drug availability in the public sector in Zimbabwe

Activity indicator	1989	1991	1993	1995	1996	1998
Lead-time (days total):	71	46	48	62	44	49

Availability of non-drug items %	56	87	73	75	75	74

The Government is aware of these long lead times over years and set measures to ensure total lead times of not more than 30 days; it must not take over 2 weeks to complete an order, leaving 2 weeks for approval and delivery (Trap et al., 2004).

In Tanzania, the minimum lead time to health Facilities is 8 weeks consecutively from Medical Store Department through zonal warehouses and district warehouses (Printz et al., 2013). This lead time is still long and the government set measures to reduce it by developing and adhering to a fixed delivery schedule and disseminate this to facilities well ahead of deliveries to ensure that all facilities know by when to submit their orders and exactly when the delivery will be done (Printz et al., 2013).

In Kenya, the study revealed that lead time had large influence on the effective delivery of essential drugs to health facilities by the Central warehouse with direct effect on stock levels (Kirui & Makau, 2016). The recommendation was to reduce the lead time up to a maximum of 15 days (Kirui & Makau, 2016).

In Rwanda, the partnership of Zipline company and the Government of Rwanda has seen the introduction of drones to transport the health commodities to the most remote areas (Rosen,

2017). Rwanda has been the first country in October 2016 to start using this technology delivering blood components to different remote site from Muhanga distribution Centre and plans to expand the delivered products to other essential medicines (Rosen, 2017). Actually, the drones carry blood supplies to those in need, 20 times faster than land-based supply methods and nowadays the maximum lead time with Zipline drones in Rwanda is 1 hour (Woollaston, 2016).

2.6. RWANDA SUPPLY CHAIN AND THE ISSUE OF LEAD TIME WITHIN RBC/MPPD

The Rwanda health system has realized great improvements after the aftermath of the Genocide of Tutsis of 1994, and the supply chain of essential medicines is being strengthened accordingly (Nsanzimana, McDermott, & Rhatigan, 2015). It is in this regard that Rwanda Biomedical Center (RBC) was created by the law No 54/2010 of 25th January 2011 with mission "To promote quality affordable and sustainable health care services to the population through innovative and evidence based interventions and practices guided by ethics and professionalism" (Rwanda Prime Minister, 2011b).

Among RBC divisions, there is Medical Procurement and Production Division (MPPD) ensuring that quality and cost effective drugs and medical equipment are available for the population (Rwanda Ministry of Health, 2015a). It improves storage and distribution of medical commodities through a computerized management system such as e-LMIS (electronic Logistics Management Information System) and SAGE 500 the warehouse management system (Rwanda Ministry of Health, 2015a). The Rwanda public supply chain system states

that all public Health Facilities must get essential medicines from District Pharmacies, which are supplied by RBC/MPPD; Referral Hospitals get health commodities from RBC/MPPD as well (Republic of Rwanda, 2015).

The Ministry of Health is implementing the electronic Logistic Management and Information System (e-LMIS) to support the supply chain processes and improve the visibility. The e-LMIS aims to facilitate the integration of the supply chain processes with other business functions; align logistics business process to other information systems; resulting in delivery of the highest quality products and services at reduced cost, with increased responsiveness to customer needs. The e-LMIS also aims to provide quick data access, optimize business process, increase cycle time and improve service delivery, ensuring that patients get their medication on time.

We learned from distribution files that in RBC/MPPD supply chain, the distribution lead time takes usually up to 15-26 days calendar with average of 20 days and the lead time for emergency ordering is 3 days. Referring to the Rwanda standard lead time of 14 days obtained from number of calculations, the distribution lead time at RBC/MPPD is too long, given that the distribution is done monthly (USAID Deliver, 2011).

Through this distribution cycle period, there are number of different operations made on both the customer's side and the MPPD's side. These operations include, but are not limited to, the order creation, order confirmation, alternative products suggestions, order cloning, order revision, order quotation, order picking, order checking and dispatch, order transportation,

order delivery, and products reception by the customer. All those operations are supported by the use of the e-LMIS and SAGE, 500 the warehouse management software used by MPPD. The complexity of the ordering process makes it extremely protracted and undermines the customers' satisfaction. The lead time has a major effect on quantities required for safety stocks and when lead times are underestimated, the likely results are shortages and more expensive emergency purchases (USAID Deliver, 2011; Yadav et al., 2011). Although being an interesting and challenging area, there is no study done specifically on Rwanda lead time before.

In fact, the aim of this project is to reduce the long lead time to make the essential medicines regularly available to the population. The workload will be reduced, as the unnecessary steps of the distribution cycle will be removed and others improved. The satisfaction will then improve on both the customer and RBC/MPPD sides. This project will be implemented in the RBC/MPPD and will evaluate deeply the distribution process, step by step, sort out all challenges, clarify the root causes of its complexity and take profit of all opportunities in order to come up with the improvement. Hence, we will identify the main weaknesses, problems, difficulties of the ordering process and their root causes and come up with the intervention plan. The results as well as the intervention plan will be communicated to stakeholders for improvement.

CHAPTER THREE: METHODS

3.1. SETTING

Our study has been conducted at RBC/MPPD, the National Rwanda Central Medical Store. The Medical Procurement and Production Division (MPPD) is one of different divisions, which constitute the Rwanda Biomedical Center (RBC) (Rwanda Prime Minister, 2011b). RBC/MPPD has 6 units such as:

1. Warehouse and Distribution Unit in charge of storage of medical commodities and their delivery to customers (inventory management);
2. Quantification and Stock Monitoring Unit in charge of estimating the quantities and costs of the health commodities and determine when they should be delivered by suppliers;
3. Sales and Marketing Unit in charge of ordering process management and customer management;
4. Health commodities Procurement Unit in charge of the process of finding and agreeing terms of acquiring health commodities from suppliers via a tendering and competitive bidding process;
5. Quality Assurance and Control in charge of measuring and assuring the quality of health commodities as well as ensuring that they meet customer expectations.
6. Medical Production Unit in charge of manufacturing health commodities.

Each unit is composed by different sections, which are the smallest working teams. The population concerned by this study is composed on RBC/MPPD side by Warehouse and distribution Unit and Sales and Marketing Unit. The concerned sections are:

For Sales and Marketing unit:

- Order Processing section (in charge of sales order management in eLMIS and SAGE 500 and produce the picking list) and
- Customer care section (in charge of follow up of the distribution schedule and facilitation of the relations of customers with RBC/MPPD in terms of distribution);

For the Warehouse unit:

- Order Picking section in charge of order preparation: taking and collecting health commodities from specified locations as per customer order and picking list;
- Order Dispatch section in charge of countercheck the picked health commodities and deliver them to customers with shipping documents);

On the customers' side, there are 30 District Pharmacies, which are the main customers of RBC/MPPD (Republic of Rwanda, 2015).

The normal supply chain of Medical commodities is designed as follow: RBC/MPPD as Central Medical Store (CMS) distributes health commodities to District Pharmacies and to the Referral Hospitals; District Pharmacies supply to District Hospitals and Health Centers which dispense drugs to patients like Referral Hospitals (Fig.1). The products managed by RBC/MPPD are of 2 categories such as essential medicines sold to customers and Program

products (Malaria products, Tuberculosis products, HIV products, Maternal Child and Community Health), which are distributed as donations to customers (Rwanda Ministry of Health, 2015b).

The distribution is done via Active Distribution (AD) upon a monthly calendar which sets the distribution timelines while the ordering process is managed through e-LMIS (electronic Logistics Management and Information System) (Rwanda Ministry of Health, 2015a). The distribution at MPPD is executed in many steps, which involve the RBC/MPPD staff and customers operations. Through these steps lay many realities, which make the lead time too long (Fig 2).

Figure 1. Distribution cycle of health commodities in public sector

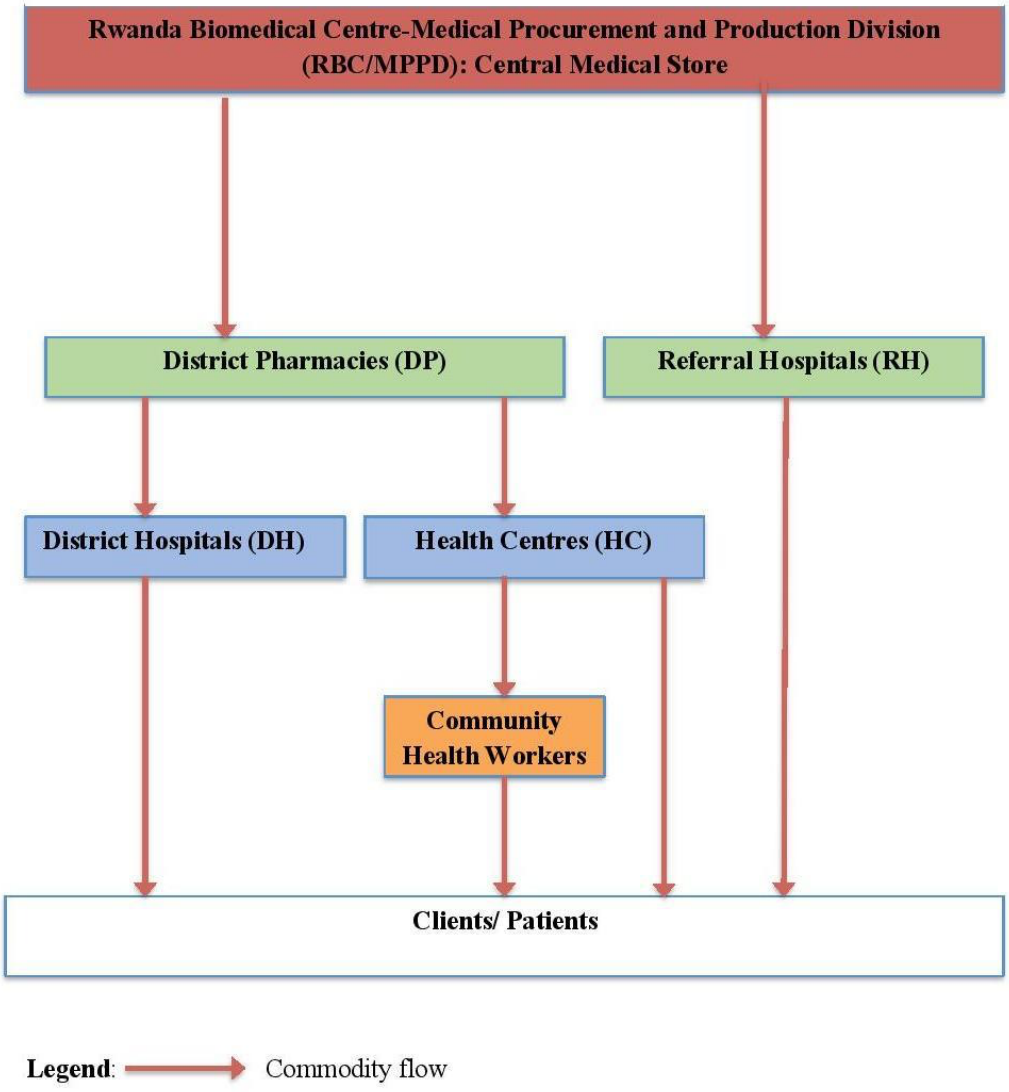
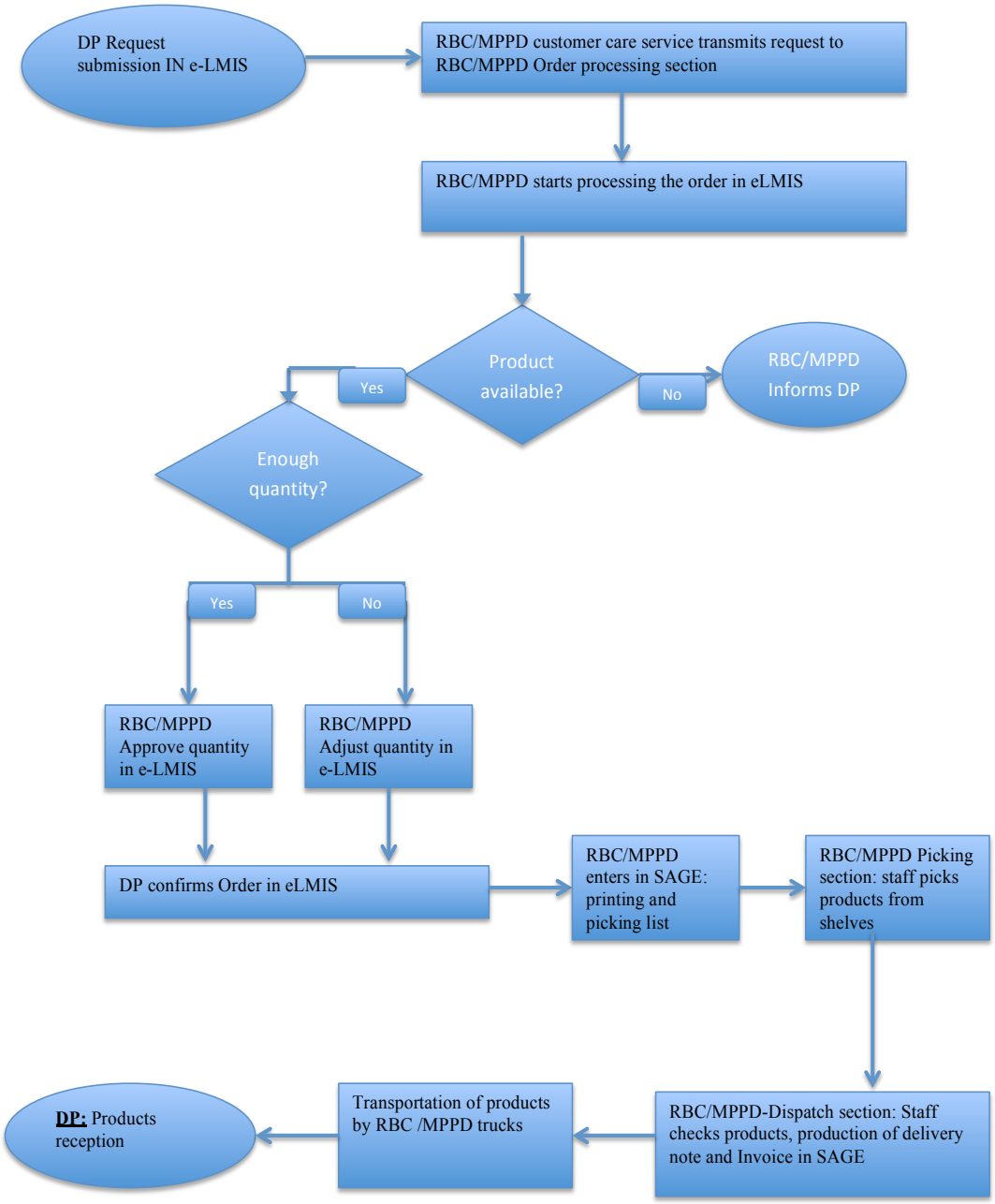


Figure 2. The steps of distribution process at RBC/MPPD



3.2. DESIGN

In order to find strategies to reduce the distribution lead time at Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD) of 10 tracer drugs from an average of 20 days to 14 days by April 2018, we used a mixed methods study. To do so, we used the explanatory sequential design: start by collecting quantitative data, analyze them, and then develop guides based on areas from our quantitative data that we utilized to explore more, then we used them to inform the follow-up qualitative phase composed by the collection of qualitative data and their analysis (Ranjit Kumar, 2011). The integration of data has been done using connecting method. As we conducted a file audit and qualitative interviews, the interviewees were selected from the population who was concerned by the quantitative sample, thus, the connecting occurred during sampling (Fetters, Curry, & Creswell, 2013).

Using relevant tools, we measured the duration of the different phases of distribution, we assessed the root causes of the long phases and their impact, and we set the strategies to reduce the lead time. The intervention will be implemented after and is not part of this study due to short time.

3.3. SAMPLE

For the quantitative part, our target population concerns orders done for the period of December 2016-November 2017. As we cannot work on the entire number of orders executed in that period, a sample of 120 orders has been studied using a file audit tool. This sample was taken from e-LMIS after a number of steps. First of all, we have extracted all orders delivered in the period of December 1st, 2016 to November 30th, 2017, then, from these orders, we have selected those containing at least 1 of the 10 tracer drugs listed below and from them we selected randomly 120 routine DPs orders, namely 10 orders per month. Thus, all the orders of essential medicines containing 1 of the 10 tracer drugs for the stated period are concerned with this study.

The exclusion criteria are that essential medicines orders without at least 1 of the 10 tracer drugs are excluded from this study. Emergency orders are also excluded. We estimate that a sample size of 120 orders is sufficient enough to procure the needed information, which means that we selected an average of 10 orders per month of the selected period of study.

For the qualitative part, data have been collected using the semi-structured interview in order to find the root causes of the results found in quantitative part. We used purposive sampling, which is a common sampling method in qualitative research. Thus, we have chosen particular individuals with characteristics relevant to our study and who are thought to be most informative. For example, in Order Processing section we chose those who are in charge of

processing the sold essential medicines and we excluded those processing the programs products. We added also the Supervisors in order to get diverse answers from both technical team and administrative staff.

In fact, our sample size was 16 individuals taken from different RBC/MPPD sections contributing to the execution of the active distribution. However, with the principle of data saturation, we interviewed only 11 people. In fact, data saturation is reached when there is enough information to replicate the study and when the ability to obtain additional new information has been attained, and when further coding is no longer feasible (Fusch & Ness, 2015).

3.4. MEASURE (S)

Our quantitative data are continuous, and we measured them as duration (time) of steps. We measured the time elapsed between one step and the next one. They are primary data as we collected them ourselves for a specific purpose: the distribution lead time length.

With these quantitative data, we are able to compute their mean, minimum, maximum, median, mode, standard deviation to the mean and interquartile Q1 and Q3. Our qualitative data are not numbers, they consist rather of words and they are not rendered into numerical measures.

3.5. DATA COLLECTION TOOLS AND METHOD

In order to get the real distribution lead time of RBC/MPPD, and build the baseline, we used a file audit and collected the real lead time for our 120 orders in the given period. This survey

collected the primary data from e-LMIS archives, from SAGE 500 and from distribution files. Hence, we found the time spent at each step of distribution of drugs and determined the total real lead time.

Quantitative data have been collected by myself (PI), and an assistant, an MPPD archive staff who got skills in MPPD archives filing. Data from the system (e-LMIS and SAGE 500) were collected by myself, and data from distribution archives (delivery notes) were collected by my assistant. I explained to my assistant the components of my data collection tool and I also gave to her a short refresher training in excel data sheet handling before starting data collection. Data have been aggregated in excel sheet. At each step of distribution, we have captured the data found in our excel sheet previously created. Then, with excel formula, the average of the time for each step of distribution has been calculated and the overall average lead time was obtained.

After the quantitative data collection and analysis, we conducted qualitative data collection and analysis. Qualitative data were collected by semi-structured interviews by which, a set of the same open-ended questions were prepared before and answered by all interviewees with flexibility to add probes during interviews in order to discover the root causes of the long lead time. The interview participants and questions asked were selected depending on which step of distribution was found long after completion of quantitative study.

Before starting the data collection for the full study, we proceeded with pilot data test with the tools designed for data collection. Thus, we have administered the tools to pilot subjects in exactly the same way as it would be administered in the main study. Thus, we have tested our file audit tool on 12 orders selected from our target population, selecting randomly 1 order per month of the period of study. The same pilot data collection process was applied also for qualitative study.

Our qualitative interview questions are only in English because all the interviewees had a good command of the English language, and the technical terms of supply chain management used at RBC/MPPD are in English.

3.6. INTERVENTION

As we had limited time, we could not execute the intervention and solve the problems found. We are planning to do it after data dissemination when we shall submit the recommendations to RBC/MPPD. Finding the root cause and emit recommendations is important but not enough; thus, we will need to prepare a plan of intervention and execute it in order to solve the problem stated from the beginning of this project and explained in our results.

The intervention will be accompanied by monitoring and evaluation process to make sure that the lead time is reduced as objectivized. Then, data will be gathered after the intervention period using the same tool as the one used before intervention (file audit) to test the success of the intervention.

3.7. DATA ANALYSIS PROCEDURE

For the quantitative part, data collected in excel sheet were used to calculate the time spent on each step for each order. We did sum of the time elapsed for each step which gave us the lead time for all the steps. Then, we calculated the average time for each step that has summed up to constitute the average lead time.

The total lead time is being compared to the standard lead time of 14 days and it is classified in terms of length. We analyze the time spent on each step in order to sort out which step takes long time causing the long lead time.

For our quantitative data analysis, we will present in this report descriptive statistics of our data at each step. We will report a measure of central tendency (mean, median or mode) and measure of spread (standard deviation, interquartile range, and range). The findings are presented in tables and graphs under the following chapter 4: "Results"**.** To perform the quantitative analysis, we have first cleaned and recoded our data.

For qualitative data analysis, we have used the thematic analysis (Maguire & Delahunt, 2017). We have first generated initial codes by open coding (inductive coding), and then collated all codes into themes, always checking if themes work in relation to the coded extracts and the entire data set. We have then generated thematic map of the analysis and defined and named

all the themes. All this allowed to produce the qualitative report relating the analysis back to the research problem, objectives and to the literature reviewed.

3.8. ETHICAL CONSIDERATION

3.8.1. VULNERABLE POPULATIONS

This is a process improvement project. Our study intends to improve the pharmaceuticals supply chain management and concerns the measuring and reduction of the lead time. The project does not involve vulnerable populations and there is no confidential or personal record collected.

3.8.2. ASSESSMENT OF RISKS TO PARTICIPANTS

This paragraph is applicable only for our qualitative interviews part. Even if we do not anticipate any risk or discomfort, our participants could feel some discomfort and hesitation to answer to the questions in fear of negative consequences to their careers. They could worry about the purpose of the study and the final impact of their answers to their job. They may be worried to lose their positions or any inconvenience to their careers.

To minimize this discomfort, we ensured to participants the confidentiality during and after the study. We informed our participants that the study concerns only the lead time. We ensured the participants that we shall protect the data and avoid any unauthorized release of

data, as the failure to do so would have a negative impact to the subjects. Note that this concerns the data collected during the qualitative interview. For the quantitative study, we only collected data from files and from the system (e-LMIS and SAGE 500).

3.8.3. MEDICAL OR PSYCHOSOCIAL SUPPORT

There is no medical or psychological support needed by participants after being involved in this study.

3.8.4. INFORMATION AND CONSENT PROCESS

For the qualitative interviews, the informed consent forms were sent via email to the participants in order to give them time to read it and ask questions about it. In addition, it was explained, presented to participants and signed by them at time of the study. Participants were informed about the purpose of the project and the type of data collected.

For participants who will need to withdraw from the study, this will be done without conditions. For the sake of sample size, the participants withdrawn could be replaced by others of same characteristics, but no withdraw happened.

This part is not applicable to the quantitative data collection, which only collected data from e-LMIS, SAGE 500 and distribution files.

3.8.5. PROTECTION OF PRIVACY AND CONFIDENTIALITY

There is no privacy involved in this project. There is no personal and private information involved in this project. The assurance of confidentiality in the qualitative part is stated in the data collection tool used. Subjects were allowed to decide what measure of control over their personal information they are willing to relinquish to us. Data collected from files and e-LMIS/SAGE will be kept confidential and will be only communicated to the RBC/MPPD management for improvement.

3.8.6. DE-IDENTIFICATION OF DATA

For the de-identification of data, we masked personal identifiers from data records by "Pseudonymization" which is a procedure by which the most identifying fields within a data record are replaced by one or more artificial identifiers, or pseudonyms (Garfinkel, 2015; Hintze & Emam, 2017).

3.8.7. SAFEKEEPING OF DATA

The collected data are masked as described above. The data aggregation tool contain no personal information. All data are kept in a safe and well-locked cupboard and the soft data will be kept in a protected file in our computer in the PI's office with limited access and should be discarded after 10 years long. The free access to data is only for PI.

CHAPTER FOUR: RESULTS

4.1. QUANTITATIVE DATA COLLECTION SUMMARY

Using the validated file audit, we collected the primary data from e-LMIS, SAGE 500 and from distribution archives (delivery notes). In e-LMIS, for each order, we had looked for the time when each of the following steps was performed: order creation by DP, order approval by MPPD, order revision/confirmation by DP and acceptance by MPPD. In SAGE 500, we looked for the time of picking list creation and time of order invoicing. In distribution files, we looked for the date the products were received.

After data collection in the excel tool, we processed to a data cleaning steps where outliers were eliminated, and irrelevant data replaced or removed. After the data cleaning we did data analysis described in the following section. We collected step times for 120 orders.

4.2. QUANTITATIVE RESULTS ANALYSIS

After quantitative data collection, the results are presented and analyzed in the following tables and figures.

Table 2. Time in days spent on each step and comparison to the average time

No	Description of step	Mean (SD)	Range
1	Time in days between Order submission by DP and order transmission to Order Processing staff by Customer care staff	3 (+/- 3.24)	0-13
2	Time in days between when order is received by Order Processing staff and when order is processed by RBC/MPPD	5 (+/-3.09)	0-14
3	Time in days between when order is processed by MPPD and when order is confirmed by DP	1 (+/-1.49)	0 -6
4	Time in days between picking creation/transmission and starting picking the products by RBC/MPPD	4 (+/-5.28)	0-18
5	Time from when to start picking products & checking and production of delivery note invoice	5(+/-2.89)	1-13
6	Time in days from when order ready to deliver until products delivered by RBC/MPPD and received by DP	2 (+/-1.93)	0-7
Lead time (Sum of all steps): Time between order submission and products reception		20 (+/- 4.68)	15 -35

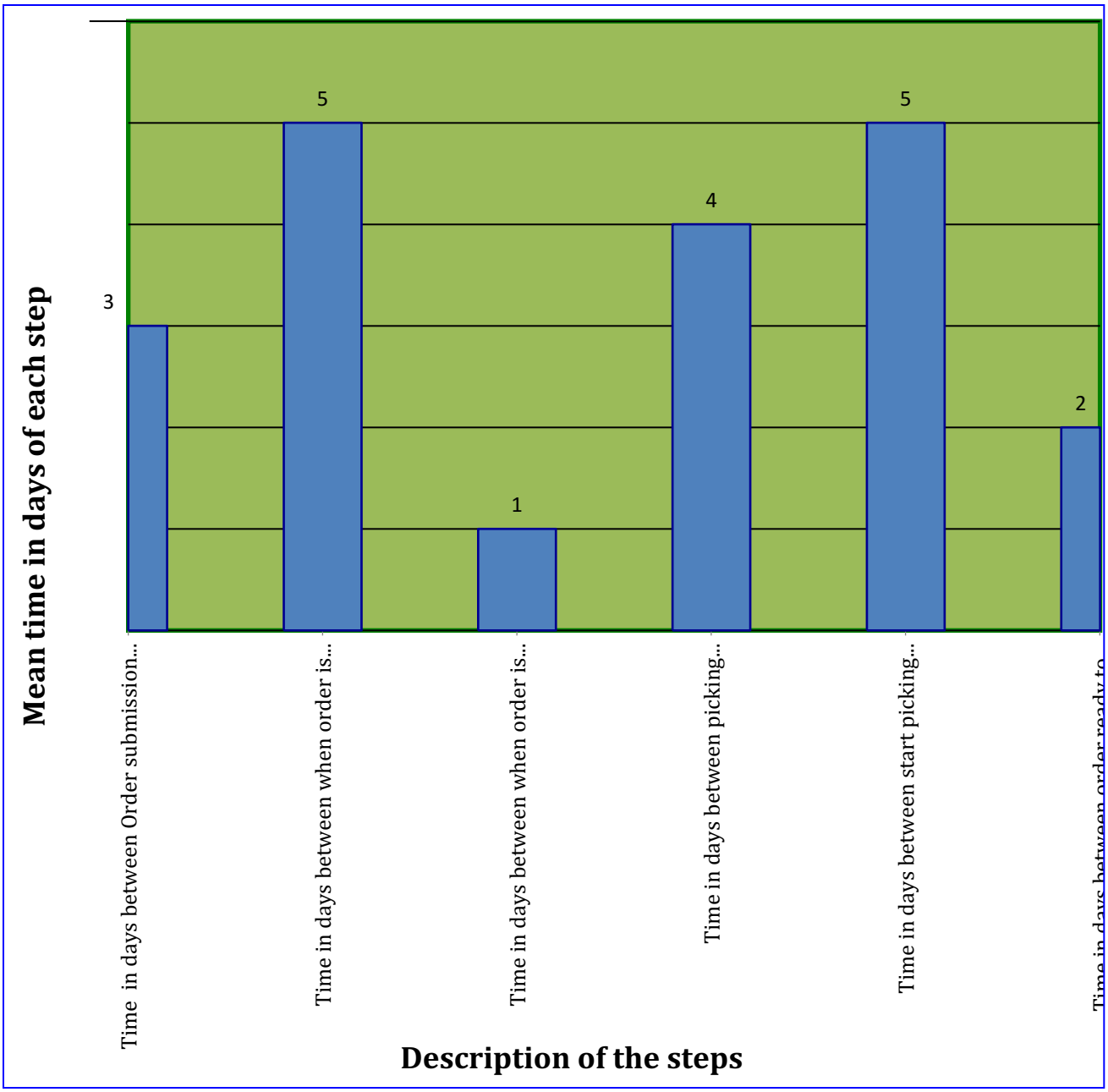
As per the table 2, the lead-time is the total sum of all the 6 steps; the minimum lead time is 15 days, the maximum lead time is 35 days and the average lead time is 20. The time in days between Order submission by DP and order transmission to Order Processing staff by Customer care staff varies from 0 day (same day) to 13 days with average of 3 days (Step 1); the time in days between when order is received by Order Processing staff and when order is processed by RBC/MPPD varies from 0 days (same day) to 14 days with average of 5 days (Step 2); the time in days between when order is processed by MPPD and when order is

confirmed by DP varies from 0 days (same day) to 6 days with average of 1 day (step 3); the time in days between picking creation transmission and starting picking the products by RBC/MPPD varies from 0 days (same day) to 18 days with average of 4 days (step 4); the time from when start picking products & checking and production of delivery note and invoice varies from 1 day to 13 days with average of 5 days (step 5), and the time in days from order ready to deliver until products delivered by RBC/MPPD and received by DP varies from 0 day to 7 days with average time of 2 days. Note that the time "0 day" means that the consecutive steps were processed the same day.

Besides, there is a large deviation from the average time for data of the steps 1, 2, 4 and 5 (+/-3.24, +/-3.09, +/-5.28 and (+/-2.89) while the standard deviation for steps 3 and 6 is smaller (+/-1.49 and (+/-1.93). Compared to steps 3 and 6, steps 1, 2, 4 and 5 also have a larger range. There are two longest steps such as step 2 and step 5, which last each the average of 5 days. The following step is step 4 that lasts the average of 4 days. The step 1 lasts the average of 3 days and the step 6 lasts the average of 2 days while the smallest step is step 3, which lasts the average of 1 day.

Note that our mean and the median are very similar for every step; this is why we chose to report the mean and standard deviation in the table 2. Furthermore, all these data are averages calculated from all the 120 orders.

Figure 3. Comparison of mean time spent on each step



The results presented in figure 3 are also shown in table 2 presented and analyzed above.

4.3. QUALITATIVE DATA COLLECTION SUMMARY

After quantitative data collection and analysis we sought to understand why steps 1,2,4, and 5 take longer than step 3 and 6 by conducting a qualitative study. Normally the steps 1 and 2 are for RBC/MPPD order processing team while the steps 4 and 5 are for RBC/MPPD warehouse operations (picking and checking).

Thus, the qualitative research concerned only those steps. Qualitative data were collected by semi-structured interviews. The interview participants and questions asked were selected depending on which step of distribution was found long after completion of quantitative study.

4.4. QUALITATIVE RESULTS ANALYSIS

The thematic analysis of the qualitative data collected on RBC/MPPD steps identified 7 themes and 7 subthemes characterizing the dimensions of significant causes for the long lead time at RBC/MPPD. Those themes are named as follow: RBC/MPPD human resources, RBC/MPPD workload, RBC/MPPD stock levels, RBC/MPPD warehouse facilities, Active distribution calendar observance, RBC/MPPD distribution design and RBC/MPPD system.

Our data are not herewith reduced to numbers; we will use a narrative logic method. Our research problem was that the distribution lead time of essential medicines at RBC/MPPD is too long and we intend to find the root causes. The main root causes found are described below through the abovementioned themes.

The human resources was found as one of the major causes of delay given that the number of staff contributing in active distribution is stated by all the interviewees to be low. This is revealed by the way that the concerned sections are frequently asking for support when they are overloaded. Besides, there is a high turnover without new recruitment. This theme is connected with that of the workload. In fact, there are unplanned additional tasks, which impede the execution of the active distribution calendar such as distribution plans from RBC divisions, emergency orders and audit reports. Even if the staff is qualified, the interviewees stated that they receive neither relevant nor formal on job trainings and this makes them to be disoriented in the system, which is repeatedly changing settings and this delay processing. One interviewee said: “I have been working in RBC/MPPD for more than 5 years and I received no training” (Participant PIC-E-9).

The stock level is another root cause given that when the product is not available, the staff takes time to search for alternative. For products with near expiry date, the staff takes time to contact first the customer for their acceptance. Sometimes, the products on the picking list differ from what is seen physically in bin location and there is time spent for repetitive correction of these inconsistencies. This theme is linked to the insufficient warehouse facilities. All these activities take time and elongate the lead time.

The compliance to the active distribution calendar on the side of RBC/MPPD is also a contributing factor. In fact, the delay of one step impacts on the others. The same, the delay of

one section or one staff impacts on others. One interviewee said: “Order processing team staff say that they have Internet issues, they give too many picking list in delay and we are overloaded at the end and we delay also” (Participant PIC-AR-8). Note also that the customer’s delay makes that orders are submitted on the undue time and staff are overloaded on the last minute. A staff member stated that “Some customers delay submitting their orders and put them on the last minute and we are overloaded, we process in delay their orders and this causes also the delay in processing the following Customer orders” (Participant OP-JUS-7). This impacts also on the duration of the lead time.

The distribution design through active distribution calendar has also its key role in the lead time. The steps are not well allocated in the way that some are given little time and others more time with some steps that are not really necessary, and with time elasticity in execution. This may foster to wait the last minute to start process. There is easy room to large waiting time while processing time is short. An interviewee responded to the question of how much time does it take to process the order: “It depends on the order size, but 2 hours maximum are enough to process a big order” (Participant OP-AN-5).

The RBC/MPPD distribution system is composed by 2 systems, e-LMIS and SAGE 500, which are interconnected. The 2 systems have been reported to be complex and require high attention. One interviewee avowed: “Each system is too protracted and it would be better to use 1 system instead of 2” (Participant CC_V-1). Another narrated that: “e-LMIS require more internet network and sometimes goes very slowly, sometimes it knows breakdown, like

nowadays and we, and our customers are not working normally, and Active Distribution is stuck" (Participant SUP-3). Many interviewees declared that the systems use complex codification so that even one product may have multiple codes and some staffs are lost in diversified codes. Another issue stated by most of the interviewees is that the system has not a way of communication between RBC/MPPD and Customer: "we are wasting most of our time calling customers at each step and for any change to do" (Participant OP-AN-5).

CHAPTER FIVE: DISCUSSION

As per the results above, the lead time of 20 days observed in our data is longer than the standard lead time of 14 days (SCMS & Rwanda Ministry of Health, 2013; USAID Deliver, 2011). Thus, we confirm our literature data that the RBC/MPPD distribution lead time of essential medicines is too long.

The reason we find a longer lead time than recommended is due to the distribution steps done on the side of RBC/MPPD (steps 1,2,4 and 5). These 4 steps can be condensed into 2 steps: step 1 and step 2 making the step of time from when DP submits order until the order is processed by RBC/MPPD; step 4 and 5 merging into the step of warehouse operations: picking and checking. In fact, step 1 is a waiting time step due to the elasticity of distribution design. Even the step 2 considered as a processing step contains in it the waiting time because the time to process the order is very short (3 hours maximum and it is why it is not herewith presented because our unit time is "day"). The step 1 and 2 may delay due to the system breakdown and to the delay encountered on previous DPs mainly in late order submission condensing massive ordering on the last minute. Furthermore, step 4 also includes waiting time step due to the fact that the picking process may not be started at due time because of the workload and human resources issues which also may impact on the following step.

Thus, the delay is encountered on the side of RBC/MPPD while the customers' side is quite good. The minimum and the maximum for those long steps are highly more distant which

means that there is lots of spread for these steps, as they tend to be far to the mean. For those steps, many orders take so much time to be processed while few take slight time. This means that those steps are not sufficiently controlled and the allocated time is not respected.

However, the literature didn't indicate a standard time for each step in the best practices, but the qualitative part research found the processing time to be short. The reasons for the processing time to take long time have been the interconnection of the themes abovementioned. The poor training on system, making a staff to take long time processing or correcting mistakes done in process or due to variances in warehouse. Furthermore, an overloaded staff cannot respect the calendar and the delay encountered impact on the following steps, other orders and the following DPs on the calendar. The origin of this overload is the unplanned activities such as distribution plans from divisions, lot of emergency orders, unplanned reports and few staff with few picking materials.

Actually, we did not expect to find that the delaying steps are totally on the RBC/MPPD side and not on the District Pharmacies' side, we expected to find delay on both sides and this result surprised us. However, we noted that the delay on side of DPs to submit orders (step that is not studied here as we consider orders already submitted) might condense massive orders in the same undue time and impacting on the RBC/MPPD time.

We could not conduct the intervention due to the limited time. However, we are planning to

execute it after results dissemination to RBC/MPPD administration for improvement. We will emit the intervention plan based on the implementation of the recommendations below mentioned.

Our study encountered some challenges and we are describing here the majority of them. The orders of the sample are not equal in terms of the number of items ordered. Some are long and others too short and this could limit our study in the way that the time to process them would differ too much. Thus we should have taken orders with same number of items to overcome this challenge. However, we have taken 1 day as unit time and normally the time to process one order cannot go beyond that time, and then, this solved the challenge we had.

We have not been able to separate the warehouse operations: picking from checking as there is no tool to record the transmission of picked orders to checking section in order to know separately the duration of picking process and checking process. Thus, we could not identify the waiting time, which may be on the side of checking step. However, we were informed that checking should not take too much time and depends on compliance of the picking step. Another limitation is that DP submits many orders from diverse programs making that the data collected on one order might be influenced by other orders; the delay of an order impacting on the process of others. Fortunately, the processing time is very short, in terms of minutes/hours so that 1 staff can process many orders in 1 day.

CHAPTER SIX: CONCLUSION AND RECOMMENDATION

This project aims to assess the distribution lead-time of essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division. The main result is that this lead time was found too long with an average of 20 days comparatively to 14 days proposed by the literature for the case of the Rwandan Supply Chain System.

Four steps of the active distribution were found to be the cause of this delay such as "Time in days between when order is received by Order Processing staff and when order is processed by RBC/MPPD", "Time from start picking products & checking and production of delivery note invoice" taking 5 days each, and the steps "Time in days between picking creation & transmission and starting picking the products by RBC/MPPD" and "Time in days between Order submission by DP and order transmission to Order Processing staff by Customer care staff " taking respectively 4 and 3 days

Thus, the delay is likely to be imputed only to RBC/MPPD side and not on the customers' side regardless the order submission step by DP. The main root causes are stated to be RBC/MPPD human resources, RBC/MPPD workload, RBC/MPPD stock level, RBC/MPPD warehouse facilities, Active distribution calendar observance, RBC/MPPD distribution design and RBC/MPPD system. Those causes have been found interconnected, one impacting on another and when more than 1 cause coincide worsen the delay and this is the origin of the long maximum times observed in our results.

We found the root causes of the long distribution lead time at RBC/MPPD and these findings should guide in future to disseminate the results and to implement the intervention in order to execute the recommendations delivered below. This will contribute to the regular availability of essential medicines and to the customers' satisfaction through the improved distribution system.

Thus, we are recommending the following:

- To lessen the waiting time and improve the processing execution, and make it in practical and realistic time. To do so, the distribution design should be revised, improved and measures to optimize the observance of the distribution schedule should be set up;
- To create a tool between picking and checking steps in order to monitor each step separately;
- RBC/MPPD management to upgrade the system
- RBC/MPPD HR to improve staff capacity building
- We recommend also these next steps:
  - ✓ Disseminate results to the RBC/MPPD administration;
  - ✓ To conduct an intervention of type pre-post study design, focusing on the findings of the quantitative and qualitative researches in order to achieve the objective of reducing the lead time from 20 days to 14 days;
- Researchers in future should conduct a research and intervention on the side of Customers' order submission step in order to improve it because it has been reported to impact on the lead time. The lead time of programs products (HIV commodities,

Malaria commodities, tuberculosis commodities and other programs) should also be studied.

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APPENDICES

APPENDIX 1. TOOL FOR DATA COLLECTION: FILE AUDIT

I am Martin de Tours NYIRUMUGISHA, working as Sales Officer at Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD) and concomitantly doing a Master in Global Health Delivery (MGHD) at the University of Global Health Equity (UGHE). At present, I am doing my Master's practicum and the topic is "**Assessment of the distribution lead time of essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD)".** As part of my study, the data have to be collected by file audit, so I request you kindly allow me collect data from e-LMIS and distribution files for the period of December 2016-November 2017. The collected information will be kept as confidential and it will be used only for academic research and all the data will not be shared with anybody under any circumstances.

Instructions:

- **Objective:** To measure the time spent at each step of distribution
- **Different phases of distribution**: Order submission by District Pharmacy (DP), order confirmation by Medical Procurement and Production Division (MPPD), order confirmation by DP, interface e-LMIS-SAGE (quotation status), order processing, order picking, order checking, order dispatch, order loading in truck, order delivery (transportation in system and physically), order reception by Customer.
- **Main stakeholders of the distribution**: Medical Procurement and Production Division (MPPD) staff and District Pharmacies (DPs) personnel
- **Type of data**: Primary data (from files and e-LMIS)
- **Setting and source of data**: RBC/MPPD distribution files and e-LMIS and SAGE archives (in the system)
- The orders herewith concerned are normal routine distribution via monthly distribution calendar (Emergency orders are not concerned)
- Consider the District Pharmacies as the customers in this tool.
- All orders pass through e-LMIS
- 1 Day= working day and include exclusively all working hours each time must be converted in "day" as standard time measure for my study

e-LMIS order number	SAGE order number	AD cycle period	Order submission in e-LMIS (date and hour)	Time of 1st order processing by MPPD (date and hour)	Time of 1st order confirmation by DP (date and hour)	Final order confirmation by MPPD (date and hour)	Order processing and picking list creation in SAGE (date and hour)	Order picking time (date and hour)	Order dispatched time (date and hour)	Products transportation to DP	Products reception time (Date and hour)
		Source of data: Distribution files	Source of data: e-LMIS	Source of data: e-LMIS	Source of data: e-LMIS	Source of data: e-LMIS	Source of data: SAGE	Source of data: Distribution file	Source of data: SAGE	Source of data: Distribution file	Source of data: Distribution file

APPENDIX 2. LIST OF 10 TRACER DRUGS AT RBC/MPPD

1. Amoxicillin 250mg capsule B/1000
2. Paracetamol 500mg tablet B/1000
3. Iodine polyvidone 10% sln 200ml B/1
4. Metronidazole 250mg tablet B/1000
5. Prednisolone 5mg tablet B/1000
6. Sodium Chloride 0.9 500 ml B/1
7. Phenobarbital 100mg tablet B/1000
8. Penicillin V 250mg tablet B/1000
9. Methyldopa 250mg tablet B/1000
10. Furosemide 40mg tablet B/1000

APPENDIX 3. CONSENT FORM

CONSENT FORM

Title of Project: Assessment of the distribution lead time of the essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division (RBC/MPPD)

Name of Researcher: Martin de Tours NYIRUMUGISHA

Please initial all boxes

1. I confirm that I have read and understand the information sheet dated **13/01/2018** (version **NO 1)** for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. ☐

3. I understand that relevant sections of my information collected during the study, may be looked at by the researcher himself from **RBC/MPPD.** From regulatory authorities, where it is relevant to my taking part in this research, I give permission for these individuals to have access to my anonymous records. ☐

4. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Person taking consent.	Date	Signature

APPENDIX 4. QUESTIONNAIRE FOR IN-DEEP INTERVIEW (SEMI-STRUCTURED INTERVIEW)

I am Martin de Tours NYIRUMUGISHA, working as a Sales Officer at RBC/Medical Procurement and Production Division and concomitantly doing a Master in Global Health Delivery (MGHD) at University of Global Health Equity (UGHE). At present, I am doing my Master's practicum and the topic is "**Assessment of the lead-time of the distribution of essential medicines at Rwanda Biomedical Centre/Medical Procurement and Production Division".** We are conducting both quantitative and qualitative analyses to get a better understanding of lead-times.

We are currently conducting interviews to better understand what contributes to lead-times at the different phases. The results of this study will only be used for academic purposes and your information and answers will be kept completely confidential.

Thank you for sparing your valuable time to respond to my questions.

Objective the interview: To find out the root causes of the long lead time

Instructions:

- The orders herewith concerned are MEG orders for normal routine distribution via monthly distribution calendar (Emergency orders and programs orders are not concerned)
- The customers concerned are the District Pharmacies
- All orders pass through e-LMIS
- 1 Day= reference time
- This is an interview guide as the questions may change with the distribution phase.

Identification of the interviewee

Code:

I am going to ask you a series of questions. Please respond as openly as possible.

1. Walk me through the steps that you take to process an order (from when order is received until it is finished);
2. How much time does it take you to start processing the order submitted by a customer?
3. How much time does it take you to process the order?
4. What are the tools you use to process the order?
5. What are the tools you use to (work on) process the order?
6. How much time does it take you to start picking an order?
7. How much time does it take you to pick an order completely?
8. How much time does it take for an order already picked, to begin the checking in dispatching area?
9. How much time does it take for checking an order in dispatching area?
10. How much time does it take for dispatch to generate all dispatching documents (delivery note and Invoice)?
11. How much time elapses after the order is ready to deliver until the truck is available?
12. What do you think on the effectiveness of the systems used at MPPD: e-LMIS and SAGE?
13. How do you find the facilitation of distribution at MPPD in terms of:
    1. Materials?
    2. Staff number?
    3. Staff qualification?
    4. Staff on job training?
14. What can you say about the distribution design at MPPD?
15. Is there any challenge do you encounter at your process level?

Sampling: 16

I will ensure to involve people on each distribution phase at MPPD:

1. Supervisors: 2
2. Order processing: 4
3. Customer care: 2
4. Picking: 4
5. Dispatch: 4

Total Sample: upon data saturation