AN ASSESSMENT OF DRONE TECHNOLOGY UTILISATION TO IMPROVE THE AVAILABILITY OF LIFESAVING PRODUCTS. CASE STUDY 30 RURAL DISTRICT HOSPITALS IN RWANDA

A dissertation submitted in partial fulfilment of the requirements for the degree of Master of health supply chain management

In the College of Medicine and Health sciences

By

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Master of Health Supply Chain Management 2022

DECLARATION

I, MUMUSHIMIRE James, hereby declare that this research project proposal is my original work and has not been previously presented anywhere. It contains my work and any parts, words, or ideas that are cited from other scientific sources; they have been correctly acknowledged without exception; it has been tested and passed through the anti-plagiarism system and it is compliant, and this is the approved final version of the research project proposal.

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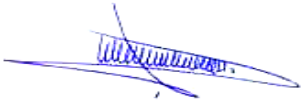

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Date __1 April, 2022_____

SUPERVISOR'S DECLARATION

This dissertation has been submitted for review with our approvals as University supervisors:

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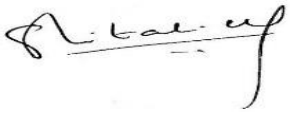
Signature: 

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ABSTRACT

Background: In this digital age, drone technology is used to improve health care delivery by fast distribution of lifesaving products. To ensure the availability of lifesaving products, in 2015 Rwanda government in partnership with Zipline Company began the distribution of lifesaving products in a rural areas using drone technology. The aim of this research was to evaluate the use of drone technology to improve the availability of lifesaving products in rural district hospitals in Rwanda.

Methods: The cross-sectional Survey assessed the utilization of drone technology to improve the availability of lifesaving products in 30 rural district hospital in Rwanda. The participants were 90 health professionals as target population. A questionnaire was used to collect relevant data. Quantitative and demographic data were analyzed using SPSS 21.0 and excel. Pearson correlation was analyzed to describe the relationships between variables.

Results: In this study 92.2% of participants provided feedback. Drone technology reduced time to receive lifesaving products from four to five hours up to 30 minutes. The availability of blood products was at 100 % in the hospitals and drone technology distributed all blood products needed while the availability of lifesaving medicines was at 86% and drone technology distributed 34% of lifesaving medicines available in the hospitals. The stock out and expires of lifesaving products were reduced respectively from 24% to 12% and from 31% to 9 % after drone technology.

Conclusion: The use of drone technology improved the availability of lifesaving products in Rwanda. The blood products distributed by drone technology at 100% were available at 100% while the lifesaving medicines distributed by drone technology at 34% were available at 86% in rural district hospitals. The distribution of lifesaving medicines could be done only by drone technology to improve the availability, to minimize stock out and expires of lifesaving medicines in Rwanda.

Keywords: Blood products, lifesaving medicines, availability, stock out, expires, drone technology

DEDICATION

This work is dedicated to my beloved wife, Niyigena Kamaliza Lucie, as well as my beloved children, Sezerano Shema Aldo and Mumushimire Hirwa Japhet.

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I shall not leave without thanking my classmates for their excellent collaboration throughout this adventure. Your participation was quite valuable. I wish to express my heartfelt appreciation to my cherished family for their love, patience, and encouragement throughout this academic adventure.

LIST OF ABBREVIATIONS AND ACRONYMS

ARVs: Anti Retro Virus

ATC: Air Traffic Control

CBHI: Community-based health insurance

FFP: Fresh Frozen Plasma

GCS: Ground Control Station

ICT: Information, Communication, Technology

MOH: Ministry of Health

MPDD: Medical procurement and Distribution Division

NCBT: National Centre for Blood Transfusion

NCD: Non-Communicable Diseases

RBC: Red blood cells

RBC: Rwanda Biomedical Center

RMS: Rwanda Medical Supplies Ltd

RTDA: Rwanda Transport Development Agency

UAS: Unmanned Aircraft System

UAV: Unmanned Aerial Vehicle

WHO: World Health Organization

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CHAPTER ONE: INTRODUCTION

1.1 Context

The Rwandan Government, through the Ministry of Information, Communication, Technology, and Innovation have a mission to address national priorities for economic growth and poverty reduction based on the development of ICT (1).

To accelerate the use of ICTs in the health sector the government of Rwanda is set to become a first digital primary healthcare service globally, for that reason, the government collaborates with Babylon a British company to provide telemedicine to Rwandan people, Rwanda has spent on a broadband internet infrastructure that now covers 90 percent of the country and mobile phone penetration has surpassed 75percent of the people, the Government also develop different ICT system to improve health information management systems include Electronic Medical Record (EMR), Health Information Management System (HIMS) and electronic Logistics management information system (eLMIS).

To strengthen health supply chain management, in 2015 Rwanda was the first country globally introduced the use of drone technology by fast delivery of blood products and lifesaving medicines to save the life of patients. Nowadays Rwanda is expanding the use of drone technology in other industries to position Rwanda as a leading technology center (1).

1.1 Background of the study

Drone technology has been used first in military history. In World War One, the United States Navy and researcher's team of British at the Ordnance College of Woolwich experimented with aerial torpedoes to battle German U-boats. These efforts powered research into pilotless aircraft where the Navy tested radio control systems on the N-9 Aircraft from 1922 to 1925, the first successful radio-controlled aircraft from takeoff to landing occurred in 1924 (2). In this digital age, drone technology has emerged as a common solution to humanitarian and development challenges (2). Drone technology helps to improve health services delivery by rapid distribution

of vaccines, lifesaving medicines, blood products, and other health supplies to areas where they were needed as emergencies to save the life of patients (3).

According to the World Health Organization, an estimated 7.6 million children under five years died every year, and an estimated 1000 women died every day because of complications connected to pregnancy or childbirth and the main of deaths occurred in developing countries. The numerous causes of these deaths could be avoided or cured if life-saving products were available. However, the availability of lifesaving products in public health facilities was still a challenge in many countries (4). According to the UN Secretary-General report, there were inequitable lifesaving products worldwide and many millions of people died each year due to stock out of life-saving medicines and health commodities. However, the availability and proper use of lifesaving products in hospitals could contribute to the reduction of the mortality rate (5).

According to a world economic forum report, drone technology use to improve the availability of lifesaving products worldwide; it is used to reduce also the stock-outs and expiries of lifesaving products because drone technology resupply rapidly on-a demand basis the right quantity needed by health facilities; drone technology is used also to reduce times of transport lifesaving products from central medical store to the last mile, the drone technology assured the quality of all lifesaving products delivered as well as cold-chain products and drone technology also reduce wastage due to expiry, mismanagement, and inappropriate storage conditions (6).

Regardless of the poverty and poor infrastructure, sub-Saharan countries led the way of utilization of drone technologies in the distribution of lifesaving products in rural areas to improve their availability (7). The Six African countries including Malawi, Ghana, Rwanda, South Africa, Tanzania, and Madagascar have been recognized as practicable for commercial drone technology operations in the health system especially in the distribution of lifesaving products in the rural areas (8).

Even though Rwanda is a small country, the combination of good roads and poor road conditions especially in rural areas, hills, and a rainy season that causes regular floods on roads and bridges

and make transportation by vehicle difficult and time-consuming in rural areas (9).

In the mountain landscape country like Rwanda, poor road infrastructure and a lack of road maintenance make cold-chain delivery of medical supplies unreliable. Before the introduction of drone technology, the rural health facilities had frequency stock out of blood products, medicines, and other supplies. On the other hand, the blood products and lifesaving medicines were expired due to overstocking. In such cases, the lifesaving products were distributed to health facilities but were never used (9).

To address these challenges and ensure the availability of lifesaving products, in 2015 the Rwandan government, in collaboration with Zipline Company began the rapid distribution of lifesaving products used drone technology in rural district hospitals (9). However, since the drone technology was used in the distribution of lifesaving products in Rwanda. There are limited studies on use of drone technology to improve availability of lifesaving products in Rwanda. This study aimed to assess the utilization of drone technology to improve the availability of lifesaving products in Rwanda.

1.2 Problem Statement

Rwanda is country with mountains and rainy season that causes regular floods that damage roads and bridges and it affect availability of lifesaving products. According to the Ministry of Health, before the introduction of drone technology unreliable wastes of lifesaving products especially cold chain sent from the Centre store to rural areas was between 25% -40%. The rural health facilities had frequency stock out and expires of lifesaving products. In such cases, the lifesaving products were distributed to health facilities but were never used (9). The lifesaving products are subject to be the stocked out and expired in health facilities. Some lifesaving products have low consumption rates with a high risk of expiration and stock out but save the life of patients in case needed in health facilities. The management of lifesaving products is not easy due to their low consumption rate which leads to overstock and then expired in health facilities while are stocked out in other district hospitals. To overcome those challenges Rwanda government, introduce

drone technology in the distribution of life-saving medicines and blood products in different health facilities.

Since drone technology started distribution of life-saving products in Rwanda to solve such problems through on-demand deliveries by drone technology, there are limited studies on the contribution of drone technology in improving lifesaving products availability in Rwanda; considering this gap and the purpose of the integration of drone technology in the health supply chain, this study aims to assess the utilization of drone technology to improve the availability of lifesaving products in Rwanda.

1.3 Research purpose

The purpose of the study was to assess the utilization of drone technology to improve the availability of lifesaving products in 30 rural district hospitals using drone technology in Rwanda.

1.4 Research objectives

1.4.1 General objective

The overall objectives of this research was to evaluate the use of drone technology to improve the availability of lifesaving products in rural district hospitals

1.4.2 Specific objectives

The specific objectives of this study were:

1. To explore the experience of the health care providers on the use of drone technology to improve the availability of lifesaving products
2. To analyze the relationship between utilization of drone technology and the availability of lifesaving products in Rural District Hospitals
3. To evaluate the stock out status of lifesaving products in rural district hospitals before and after drone introduction

4. To assess the expiration rate of lifesaving products in rural district hospitals before and after drone introduction

1.6 Research Questions

2. What is the experience of the health care providers on the use of drone technology to improve the availability of lifesaving products?
3. What is the relationship between drone technology and the availability of lifesaving products in Rural District Hospital?
4. What is the stock out the status of lifesaving products in rural district hospitals before and after drone introduction
5. How is the expiration rate of lifesaving products in rural district hospitals before and after drone introduction?

1.5 The Study significance

This research project was significant in the following ways: it assisted the researcher in understanding how the use of drone technology improved the availability of lifesaving products in rural district hospitals in Rwanda, and it provided information on stock outs and expiries of lifesaving products in rural districts hospitals. The findings from this research effort added new literature linked to the application of innovation and technologies in health supply chain management, which helped other academics and scholars interested in the topic.

1.6 Scope of the Study

The scope of this research focused on the utilization of drone technology to improve the availability of lifesaving products in rural district hospitals in Rwanda. It covered the time, geographic and conceptual scope.

1.8.1 Time scope

This study project considered the period between 2016-2021. This research was completed over five months, from October 2021 to February 2022.

1.8.2 Geographical scope

The research project was carried out in 30 rural district hospitals located in Rwanda and working with Zipline drone technology.

1.8.3 The conceptual scope

This study project covered the assessment of utilizing drone technology to improve the availability of lifesaving products in 30 rural district hospitals working with Zipline drone technology in Rwanda.

1.7 Limitation

The scope of our work is to focus on the assessment of utilizing drone technology to improve the availability of lifesaving products in rural district hospitals. The study was limited to 30 rural district hospitals working with Zipline drone technology in Rwanda

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter emphasis on the review of the existing literature, including textbooks and documents related to drone technologies, blood products, and lifesaving products availability in hospitals. This chapter comprises an overview of the topic, an empirical literature review, and a conceptual framework.

2.1 Overview of the topic

This section emphasis on the review of the literature related to drone technologies and lifesaving products availability in the hospitals. It covers the definition of some main concepts that were used in this research project. It also provides deep understanding of the topic and facilitated the discussion of the results.

2.1.1 Drone technology

The drone is an aircraft means of transportation that does not carry by a human hand. It is an element of an unmanned aircraft system (UAS), which is made up of three systems: the drone (UAV), the ground-based controller, and the communication system. The drone relies on aerodynamic forces to deliver vehicle lift. It flies alone, controlled remotely on ground using the computers system by a pilot (11).

2.1.1.1 Unmanned Aerial Vehicle Systems

A UAV is the most visible component of a larger system required to fly the aircraft autonomously controlled remotely on ground using the computers system by a pilot. The UAV is controlled via the Ground Control Station (GCS) from the ground, therefore strong communication lines are necessary needed. The GCS serves as a workspace for a pilot,

instrument operator, navigator, and in most cases, an operation commander. The GCS processes the information received from the instruments on ground or sends it to a processing center using ordinary telecommunications methods (12).

2.1.1.2 Drone technology in medical services

Drones are most commonly used in military applications; the demand for unmanned drones increased during Second World War because of the high rate of loss of airplane and their pilots in reconnaissance operations. However, the drone technology was successfully used in military missions during the Vietnam war. In addition to military missions, the drone technology is now used in a variety of activities, including aerial photography, fast delivery of goods, management of disaster, operations of rescue and searching victims. The effective use of drone technology in those various activities has resulted in the application of drone technology in the fast distribution of lifesaving products such as blood products and lifesaving medicines (13). Currently, land transportation via vehicles or motorcycles and air transportation via helicopters and airplanes are the most prevalent modes of transportation for medical products. With rapid advancements in information technology, drone technology has been introduced in medical transportation everywhere to increase mobility across difficult geographic barriers, reduce carbon emissions, and improve the cost-effectiveness of health service delivery (14).

Drone technology has improved availability of lifesaving products globally by decreasing the time to transport laboratory tests, blood products, and life-saving medicines over vast distances or too difficult to reach rural places. Drone technology has been deployed in disasters in Haiti and the United States of America, Canada, the Caribbean, and Nepal in the distribution of health products. It was also used in the Netherlands to distribute Automated External Defibrillator (AED) to heart-attack patients; it was used in distribution of HIV testing kits in Malawi, and distribution of blood products in Rwanda and Ghana. The examples above demonstrate the growing use of drone technology as a future model of medical product transportation around the world (14).

2.1.2 Lifesaving Products

2.1.2.1 Blood products

2.1.*2*.1.1 Red Blood Cells

Red blood cell is a blood product component that plays the job of oxygen delivery in the body. RBC is the most often transfused blood product in hospitals. Patients who get RBC include those with chronic anemia due to kidney failure or gastrointestinal bleeding, as well as those with acute blood loss due to an accident or trauma. They are also useful in the treatment of blood abnormalities such as sickle cell disease. (15) The Red Blood Cells are allowed to be stored at temperatures ranging from +2°C to +6°C in a standardized blood bank or refrigerator equipped with a fridge temperature monitor and alarm before being administered to the patient who requires them (16).

2.1.*2*.1.*2* Platelet

Platelets are transfused to individuals with thrombocytopenia or platelet function deficits to prevent or treat bleeding. The bulk (50–80 percent) of platelet units transfused in affluent nations are transfused as prophylaxis for patients with bone marrow loss due to leukemic illness or its treatment with chemotherapy or radiotherapy. As bone marrow failure becomes more common later in life, demand for platelet transfusions has increased in affluent countries with aging populations. Platelets are also transfused to treat hemostatic dysfunction in cardiovascular surgery (about 17% of transfusions), as well as to manage major hemorrhage and gastrointestinal bleeding. The platelet has a short shelf life of 3 to 5 days and should be maintained at +20°C to +24°C with constant agitation on a platelet shaker and in an incubator, that maintains the required storage temperature (17).

2.1.2.1.3 Fresh Frozen Plasma (FFP)

Frozen Fresh Plasma FFP is plasma made from whole blood, either by first centrifugation of whole blood into red cells and plasma or by secondary centrifugation of platelet-rich plasma. Fresh Frozen Plasma (FFP) requires a particular storage temperature of - 30°C to maintain its quality throughout storage. FFP was first used in 1941 as a volume replacement; however, it is now mostly utilized in cases of severe bleeding or to avoid bleeding in patients with abnormal coagulation tests who are undergoing invasive surgery. Its application has been expanded to include patients who have coagulopathy but are not bleeding (18).

2.1.2.1.4 Cryoprecipitate

Before being replaced by specific preparations, cryoprecipitate was developed and used to treat hemophilia A and von Willebrand disease. Cryoprecipitate contains a high concentration of fibrinogen, von Willebrand factor/ VIII complex, and fibrin stabilizing factor/XIII and has been used in all transfusion protocols since the dawn of the whole blood era. The primary indication for cryoprecipitate was the repair of plasma labile factor-VIII deficiency, which was thought to be one of the vital defects caused by massive whole blood transfusion. Both the need for fibrinogen supplementation and the utility of cryoprecipitate as a source of this factor were recognized as advanced. Cryoprecipitate needs a special storage condition of -30°C to maintain its quality during storage before administration to the patients (19).

2.1.2.2 Lifesaving medicines

Lifesaving medicines are medicines that are used to save lives in an emergency. These medicines can keep a person alive or prevent further harm and difficulties, and they are used in emergency services, intensive care units, and maternity. These medications should be kept on hand at all times at the hospital to save patients' lives (20).

2.2 Rwanda health Supply chain system

Rwanda Medical Supplies LTD (RMS Ltd) is Rwanda's national medical store, in charge of the national purchase, forecasting, and distribution of medicines and medical consumables. As a central warehouse, RMS Ltd distributes medical items to 30 RMS branches and Referral Hospitals. In turn, the RMS branch provides medicines and health consumables to health posts, health centers, and district hospitals. Depending on the amount of treatment required, patients can receive medical services from community health workers, health posts, health centers, district hospitals, private hospitals, or referral hospitals. Blood products are provided to hospitals from blood transfusion centers. The Logistics Management Office (LMO) coordinates supply chain tasks in collaboration with RMS Ltd. All activities are overseen and supervised by the Ministry of Health. Zipline is situated between the RMS Ltd and health facilities including district hospitals and health centers acting as a link between those parties (9).

2.3 Empirical literature review

The study conducted by Demuyakor (2020), related to the impact of the distribution of emergency medicines using drone technology in Ghana, showed that using drone technology in health services in Ghana has a positive impact, reduced times to receive emergency medicines, ordering medicines using the technology of drone make users efficient, emergency medicines are requested mostly using telephone via WhatsApp, order lead-time is about 45 to 60 minutes, drone technology delivers emergency medicines on time, ensuring availability and accessibility of emergency medicines to save the life of patients, a drone is cost-effective to transport emergency medicines, drone technology in improved management of emergency cases in Ghana and improve customer satisfaction (21).

Demuyakor (2020), also in his research on the impact of distribution of emergency medicines using drone technology in Ghana, shown that there is appreciation of drone in Ghana where there a significant difference in the average scores of concerns on the positive impacts for using drone technology in providing health care services in Ghana, which include "The use of drone medical technology to deliver healthcare has had a significant impact and has saved many lives."

(M=4.59, SD=.63), "The drone technology in delivering medical supplies to our hospital/clinic has saved us a lot of time and made us efficient" (M=4.38, SD=.74); "The drone technology in delivering health care in our hospital/clinic is cost-effective in terms of transportation for medical supplies" (M=4.43, SD=.75); By using drone technology to deliver medical supplies to our hospital/clinic, we were able to save the lives of many emergency cases and patients who visit this health facility" (M=4.43, SD=.74); and "I ordered medical supplies using drone technology, and it was delivered to our hospital on time" (M=4.41, SD=.73) (21).

Konert et al (2019), in his research related to the distribution of emergency medicines using drone technology, practical and legal aspects in Poland showed that the use of drone technology in health services have advantages like helping quickly in an emergency, reducing time to reach the patients, distribution of emergency medicines to inaccessible places during floods or blocked roads (22).

The study related to the distribution of blood products using the drones in Rwanda conducted by Mhlanga et al (2021) showed that Zipline drone technology increased blood availability to the Rwandan population, Zipline delivering 75% of all blood products in rural areas, Zipline improved accessibility of medicines to some hospitals in the eastern province of Rwanda and distribution of blood products using drone technology contribute to saving the lives of mothers and newborn during in maternity wards (9).

The report conducted by USAID global health supply chain program procurement and supply management (2017) showed that the drone technology distributes blood products and emergency medicines faster and safely considering to Rwandan mountains and road conditions, the drone technology takes around 30 minutes to distribute blood products and emergency medicines to the last mile health facilities, the drone carried out 1.5 kg of blood and emergency medicines and 150 shipments were done daily from distribution center to the health facilities (23).

The study conducted by Abrha et al (2018) related to availability and accessibility of priority life-saving medicines for the children under 5 years in Ethiopia, showed that the availability for life-saving medicines used to treat children under five years was 34.1% (24).

The study conducted by Michael et al (2019) related to the optimization of vaccine supply chain using drone technology showed that drone technology should be integrated into the distribution of vaccines in Nigeria because the drone is faster than vehicles to distribute vaccines, drone technology is cost-effective because do not require fuel it is used battery charge system, insecurity and issues of cold chain maintenance where the acceptability of drone by health professionals were 85% by and feasibility of drone technology in Nigeria Vaccine Supply Chain were 75% (25)**.**

The study conducted by Thiels et al (2021) related to the transportation of medicines using Unmanned Aerial Vehicles showed that the transportation of blood products and emergency medicines using drone technology in remote locations is more suitable than using vehicle, drone technology speed, the capabilities of the drone to travel over closed roads and terrain without risk to a flight crew are valuable and drone technology promotes customer satisfaction by reducing patient transfers to other level and it is cost-saving and minimize hazards to human life (26).

2.4. Conceptual framework

The conceptual framework serves as the foundation for the study. It classifies the network of relationships between variables thought to be important in the study of a assumed problem. In this study, the drone technology is the independent variable, with the following indicators: trained staff, staff qualification, telephone, computer, drones, and internet can all affect the dependent variable, which is the availability of lifesaving products, with the following indicators: availability of lifesaving products, reduction of expiries and stock out of lifesaving medicines, saving patients' lives and improving healthcare service delivery, and fast communication with concerned rural district hospitals. Rwanda’s government policy, political will, regulation, SoPs and guidelines for drone technology, and Zipline support are the variables that form a causal link between other variables and are referred to as mediating variables or intervening variables in this study.

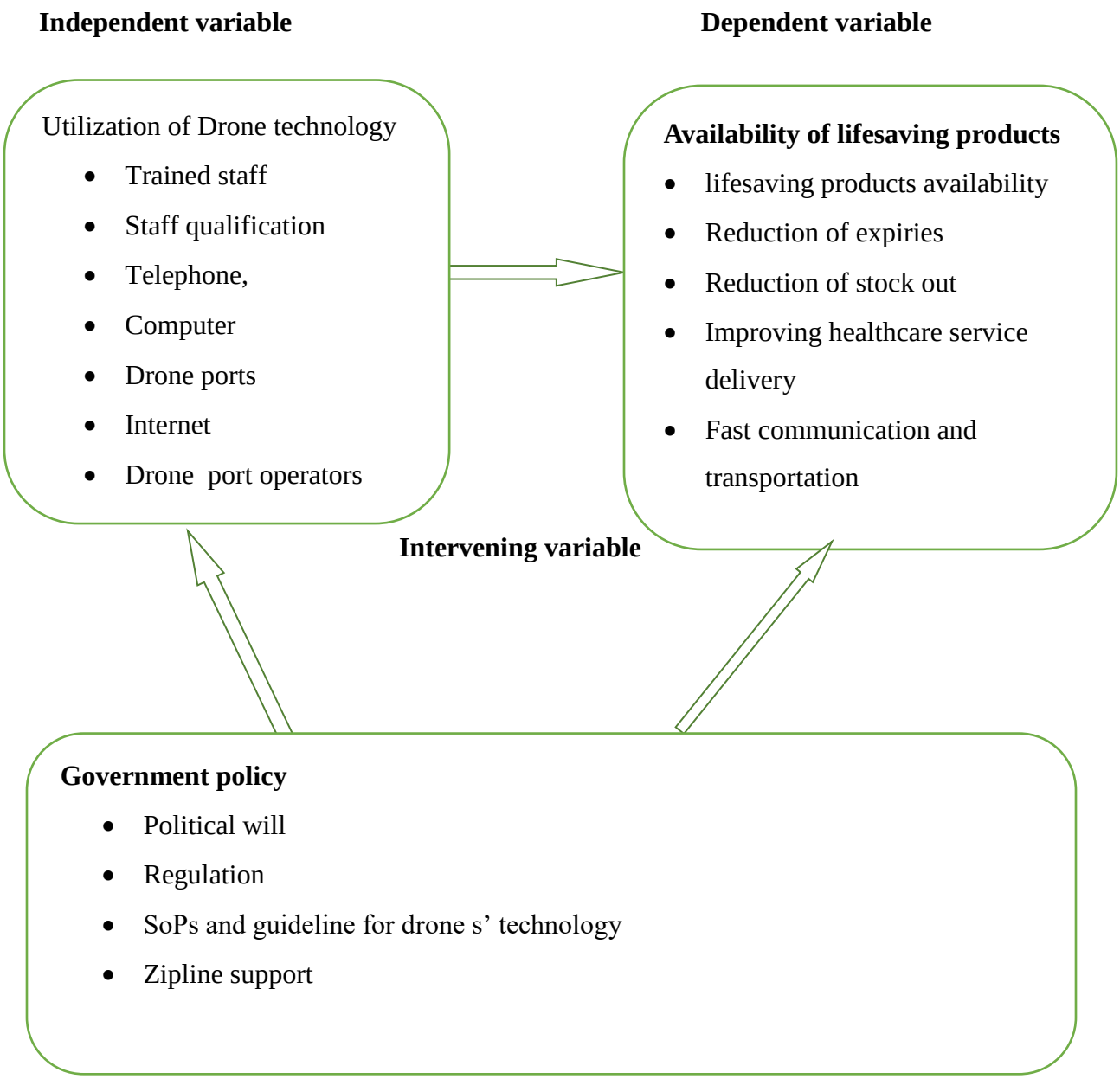

Figure 2. 1: Conceptual Framework *Source: Primary data, 2022*

Figure 2.1 indicates the relationship between independent variables under the study: drone technology supply chain has the attributes of trained staff, staff qualification, telephone, computer, drone s, internet, and drone port operators. The study also conceptualized on the dependent variables: lifesaving products availability, reduction of expiries and stock out of lifesaving medicines, communication, and improving healthcare service delivery

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

The section presents the research methodology that has been used to conduct the research project. The chapter covered the study design, the population, sampling techniques, data collection, and data analysis procedure.

3.1. Research design and research approach

A descriptive cross-sectional study design was conducted to describe the utilization of drone technology in improving the availability of lifesaving products in 30 rural district hospitals working with Zipline drone technology in Rwanda. Before and after drone technology utilization was used as the research approach. According to Inaam (2016), the descriptive research study design is used to describe phenomena as they exist and to study the current situation and it should be used to study the conditions of work in the health system (27).

3.2. Description of the study area

This study was conducted in 30 rural District Hospitals in Rwanda working with Zipline drone technology in the distribution of life-saving medicines. The table below is the list of 30 rural District hospitals working with Zipline drone technology in Rwanda.

Table 3. 1: List of 30 Rural District Hospitals

No	District Hospital Name	District	No	District Hospital Name	District
1	Butaro DH	Burera	16	Kinihira DH	Rulindo
2	Byumba DH	Gicumbi	17	Kirehe DH	Kirehe
3	Gahini DH	Kayonza	18	Kiziguro DH	Gatsibo
4	Gakoma DH	Gisagara	19	Mugonero DH	Karongi
5	Gatunda DH	Nyagatare	20	Muhororo DH	Ngororero
6	Gitwe DH	Ruhango	21	Munini DH	Nyaruguru
7	Kabaya DH	Nyabihu	22	Murunda DH	Rutsiro
8	Kabgayi DH	Muhanga	23	Nemba DH	Gakenke
9	Kaduha DH	Nyamagabe	24	Ngarama DH	Gatsibo
10	Kibilizi DH	Gisagara	25	Nyagatare DH	Nyagatare
11	Kibogora DH	Nyamasheke	26	Nyanza DH	Nyanza
12	Kibungo DH	Ngoma	27	Ruhango DH	Ruhango
13	Kibuye DH	Karongi	28	Ruli DH	Gakenke
14	Kigeme DH	Nyamagabe	29	Rwinkwavu DH	Kayonza
15	Kilinda DH	Karongi	30	Shyira DH	Nyabihu

Source: Primary data, 2022

The researcher carried out the study in the elaborated hospitals to achieve the objective of the research project.

3.3 Target Population

This research project had a purpose to assess the utilization of drone technology in improving the availability of life-saving products in 30 rural district hospitals. The study population for this research project was health professionals working in 30 rural district hospitals who have expertise in health supply chain management and who work closely with Zipline drone technology. The 90 health professionals from rural district hospitals working with Zipline drone technology, involved in supply chain management of medicines was considered as the target population of this research project. This means that in each Rural District Hospital, the researcher selected three health professionals including Laboratory Manager, Clinical Director /Medical Doctor, and Pharmacist.

For the objective one to explore health providers' perceptions on the use of drone technology on the availability of lifesaving products all health professionals were used including Laboratory Managers, Clinical Directors/ Medical Doctors, and Pharmacists for each rural district hospital while only the Laboratory Managers and Pharmacists were used for the other objectives including to link drone technology to the availability of lifesaving products in Rural District Hospital, to assess the duration of stock out of lifesaving products in rural district hospitals before and after drone introduction and to assess the expiry rate of lifesaving products in rural district hospitals before and after drone introduction.

3.3.1. Inclusion criteria

3.3.1. 1. Selection of participants

This study was conducted in 30 rural district hospitals working with Zipline drone technology and it focused on Laboratory Managers, Clinical Directors/Medical Doctors, and Pharmacists. The participants were selected based on their willingness to participate in this study; participants must have experience of more than one year in the hospital and must be on duty during the period of data collection.

3.3.1. 2. Selection of lifesaving products

All the lifesaving products used in the survey in our study were selected from the National list of essential medicines 6th Edition, 2015. They were blood products or lifesaving medicines used to save lives in case of emergency and have the ability to hold life or prevent further damage and complications, and they must be used in emergency services, intensive care units, or in maternity to save the life of patients, the medicines were injectable dosage form.

3.3.2 Exclusion criteria

All lifesaving products did not include in the National list of essential medicines 6th Edition, 2015, the lifesaving products did not be managed at the district hospital level, not used to save lives in emergency cases and the medicines which are not injectable dosage form were excluded in this study.

3.3.3. Sample size

In this research project, the Researcher used all target populations because it was less than 100 population and it was not expensive to cover them and it helped to achieve the research objectives

Table 3. 2: Sample size

No	Category of Staff	Population	less than 100 (ratio)	Sample Size
1	Laboratory managers	30	1	30
2	Clinical/Medical Doctors	30	1	30
3	Pharmacists	30	1	30
	TOTAL	**90**	**1**	**90**

Source: Primary data, 2021

3.3.4. Sampling techniques

In this is a research project, the researcher used the purposive sampling technique based on the position of employees where at the first step, the technique helped to select 90 respondents to questionnaire while a second step, the technique has been applied to select respondents to each group of staffs involved in supply chain management of medicines in the hospital that were included in the sample study.

3.4 Data collection tools

In this study project, the questionnaire and checklist were used to get information and data on the utilization of drone technology in improving the availability of lifesaving products in 30 rural district hospitals. The questionnaire and checklist to assess the utilization of drone technology in improving the availability of lifesaving products in rural district hospitals were developed by the researcher, tested prior in five district hospitals, and revised. The questionnaire and checklist were used to gather the needed information on the utilization of drone technology in improving the availability of lifesaving products from 2016 up to December 2021.

The questionnaire and checklist were developed in English and Kinyarwanda based on available literature on health supply chain web-based tools. This questionnaire contained two sections; the first section contained the information about respondent's demographic section data that influenced staff's knowledge, skills, and experience in health supply chain management; in this section, the participants responded about their age, sex, educational level, training received in health supply chain management and working experiences and the second section presented a series of statement related to the exploration of health providers' experiences on the use of drone technology on the availability of lifesaving products and it provided space for respondents to express whether they strongly agreed, agree, disagree, strongly disagree or they were neutral about the statement. The checklist was used to link drone technology to the availability of lifesaving products in Rural District Hospital, to assess the duration of stock out of lifesaving products in rural district hospitals before and after drone introduction, and to assess the expiries rate of lifesaving products in rural district hospitals before and after drone introduction

3.5 Data Analysis

In this research project, the data were analyzed and presented in tables, figures, and graphics generated by using SPSS 21.0 version and MS Excel based on the variables of the research subject, and the data were checked before being analyzed. Demographic characteristics and the utilization of drone technology in improving the availability of lifesaving products were analyzed using descriptive statistics.

The Pearson correlation coefficient has been used to describe the relationships between two variables, such as the availability of lifesaving products at the hospital and lifesaving produc ts obtained from Zipline drone technology center.

The Pearson correlation coefficient with a significant relationship is between -1 and +1 which means a correlation between 1to 0.5 indicate strong correlation, between 0.5 to 0 indicating a weak positive correlations and zero indicates that there is no correlation while zero to -0.5 outlines a collation between 1 to 0.5 indicate strong positive correlation, between 0.5 to 0 indicating a weak positive correlation and a correlation equal to zero indicates that there is no correlation, a correlation coefficient between 0 and -0.5 outlines a low negative correlation while a correlation coefficient between -0.5 and -1 outlines a high negative correlation. (28).

3.6 Validity and Reliability of the tools

The validity is the range to which a concept is accurately measured in a quantitative study. The reliability of a research instrument is defined as the extent to which it consistently produces the same results when used in the same situation on multiple occasions (29). Before starting the data collection, the researcher checked and pre-tested the questionnaire for validity and reliability to the health professionals working in 30 rural district hospitals who have expertise in health supply chain management and who work closely with Zipline drone technology.

3.7 Pre-testing

According to Bowden et Al (2002), pre-testing is defined as the chance for a researcher to measure the meaning attributed to the questionnaire before using it in the data collection. The purpose of a pre-test study is to test the instrument for inaccuracy, identify potential bias in data collection for modifying them before the main study and gain experience with the methodology and instrument (30).

For this research project, a pilot study was conducted to determine the reliability and validity of the questionnaire as far as possible whether the tool was worked and did not contain bias. It gave an idea of the time to spend completing the questionnaire. The pre-test study was conducted in 5 rural district hospitals two weeks before the major study. Participants were explained about the study to get voluntary consent then, unclear questions were modified.

3.8 Ethical Considerations

The researcher gained ethical clearance to collect data after submitting the study to the Institutional Review Board (IRB) of the College of Medicines and Health Sciences and the National Health Research Committee for approval. The respondents were informed about the overall nature of the study; they were informed about the study's goal, and they had the right to withdraw without penalties during data collecting. The respondents were advised that their confidentiality and personal privacy would be respected and that the data from this study would not be utilized for any other reason. The questionnaire did not include the identities of research participants; instead, all surveys were coded, and participants were then asked to sign a consent form for the study.

CHAPTER FOUR: RESEARCH FINDINGS

4.0 Introduction

Chapter 4 presents and interprets findings from data collected concerning the objectives of the study settled.

4.1 Response rating

All 90 questionnaires were distributed to Laboratory managers, Clinical/Medical Doctors, and Pharmacists in 30 district Hospitals. According to the findings of the study, among 90 questionnaires distributed 83 were responded, completed, and returned translating to a 92.2% (83/90) average return rate.

Table 4. 1: Questionnaires distributed and response rate

Respondent department	Questionnaires		Response rate (%)
	Distributed	Returned	
Clinical/Medical Doctors	30	27	30
Pharmacists	30	28	31
Laboratory managers	30	28	31
Total	**90**	**83**	**92**

Source: Primary data, 2022

4.2 Demographic characteristics of respondents

The main demographic characteristics of respondents that were considered important in the study were gender, age, academic qualification, current occupation in Rural District Hospitals, and respondent experiences. The results showed that 66% of respondents were male. The age group analyzed and the findings showed that most respondent were between 30-39 years old represented by 52%. The respondents' education level was analyzed and the findings showed that Pharmacists A0 represented by 34%, Bachelor in general medicines represented by 33%, Labo A0 represented by 25% and Labo A1 represented by 8%. From the findings, most of the respondents had worked between 1-5 years 53%.

Table 4. 2: Demographic characteristics of respondents

Variables	**Category**	**Frequency**	**%**
Gender	Male	55	66
	Female	28	34
Age	20-29	23	28
	30- 39	43	52
	40- 49	12	14
	Above 50	5	6
Academic qualification	Lab technician A_1	7	8
	Lab technician A_0	21	25
	Pharmacy A_0	28	34
	General medicines A0	27	33
Occupation	Clinical/Medical Doctors	27	32
	Pharmacists	28	34
	Laboratory Managers	28	34
Working Experience	1-5 years	44	53
	5-10 years	30	36
	Above10 years	9	11

Source: Primary data, 2022

4.3 Presentation of findings

4.3.1 Experience of the health care providers on the utilization of drone technology

The researcher wanted to explore the experience of the health care providers on the utilization of drone technology to improve the availability of lifesaving products. The results of the study are summarized in the table below

Table 4. 3: Experience of the health care providers on the utilization of drone technology

Variables	Category	Frequency	%
Trained staff on drone technology	Yes	59	71
	No	24	29
District Hospital request lifesaving products using drone technology	Yes	83	100
	No	0	0
Ordering Channels	WhatsApp	44	53
	Telephone	30	36
	Message by telephone	3	4
	Sending an email	6	7
Drone technology reduces time to receive lifesaving products requested	Yes	83	100
	No	0	0

Source: Primary data, 2022

According to the study's findings, 71 percent of respondents have received training on drone technology, all respondents confirm that 30 Rural District Hospitals request lifesaving products using drone technology, the most common ordering channel is sending WhatsApp messages represented by 53% all orders, and all respondents confirmed that drone technology reduces time to receive lifesaving products.

4.3.1.1 Time required to receive life-saving products before and after drone intervention

The result show that before the intervention of drone technology, the most time to receive lifesaving products was between four hours to five hours as represented by 52% while after the intervention of drone technology, the time required to receive lifesaving products was reduced where the most time the lifesaving products are received in 30 minutes represented by 55%. Table 4.5 below shows the number of the surveyed based on the reduction the time required before and after the intervention of drone technology in Rural District Hospitals.

Table 4. 4: Time to receiving life-saving products before and after drone intervention

Variables	Category	Frequency	(%)
Time required to receive products before drone technology	between 3 hours to 4 hours	32	39
	between 4 hours to 5 hours	43	52
	above 5 hours	8	9
Time required to receive lifesaving products after drone technology	30 minutes	46	55
	between 30 to 45 minutes	37	45

Source: Primary data, 2022

4.3.1.2 Appreciation of drone technology in the distribution of lifesaving products

The overall results of the study showed that all respondents appreciated the drone technology intervention in the distribution of lifesaving products in Rural District Hospitals as represented by 94% with a mean of 4.7 and a Standard Deviation of 0.450. The Table below shows the appreciation of drone technology by health care providers.

Table 4. 5: Appreciation of the role of drone technology

Variables	Success rating (1 lowest & 5 highest)					Mean of score	S.D	%
	1	2	3	4	5			
Appreciation of drone technology in the distribution of lifesaving products in rural hospitals.	0	0	0	23	60	4.7	0.45	94%
Contribution of drone technology in reduction of stock out of lifesaving products in the hospitals.	0	0	4	19	60	4.7	0.565	93%
Contribution of drone technology in reduction of expires of lifesaving products in the hospitals.	0	0	0	22	61	4.7	0.444	95%
Role of drone technology in the availability of lifesaving products in hospitals.	0	0	0	23	60	4.7	0.45	94%
Drone technology is recommended as a great supporter of the management and distribution of life-saving products in the hospitals	0	0	0	12	71	4.9	0.354	97%
						4.7	**0.453**	**94%**

Note: 1= (strongly disagree), 2= (disagree), 3= (Neutral), 4= (agree), 5= (Strongly agree)

Source: Primary data, 2022

4.3.2 The relationship between utilization of drone technology and the availability of lifesaving products in Rural District Hospital

The results showed that the blood products were available and distributed by drone technology at 100% in rural District Hospitals while current stock of lifesaving medicines were available at 86% in rural district hospitals, and 34% of lifesaving medicines were distributed by drone technology. The table 4.6 shown the availability of lifesaving products in rural district hospital and the contribution of drone technology.

Table 4.6: Status of lifesaving products availability in Rural District Hospital

No	Lifesaving products	Products managed at the hospital	Product available at the hospital	Products received from Zipline
	Blood products			
1	Cryoprecipitate	100%	100%	100%
2	Fresh Frozen Plasma (FFP)	100%	100%	100%
3	Platelet	100%	100%	100%
4	Red Blood Cells	100%	100%	100%
	S/Total	100%	100%	100%
	Lifesaving medicines			
5	Adrenaline Injection 1 mg/1ml	100%	96%	82%
6	Atropine Injection 0.5mg; 1 mg	100%	89%	79%
7	Calcium gluconate Injection 100 mg/ml	100%	79%	0%
8	Digoxin Injection 250µg /ml	100%	86%	0%
9	Dopamine Injection 40mg/ml	100%	93%	0%
10	Enoxaparin Injection 40mg/ml	100%	75%	0%
11	Ephedrine Injection 30 mg/ ml	100%	96%	82%
12	Gamma immunoglobulin	100%	100%	100%
13	Hydralazine injection 20mg/ml	100%	79%	0%
14	Ketamine Injection 50 mg /1ml	100%	89%	0%
15	Magnesium Sulfate injection 50% 10 mL Vial	100%	100%	89%
16	Morphine Injection 10 mg/1ml	100%	93%	86%
17	Naloxone Injection 0.4mg/ml	100%	61%	0%
18	Neostigmine Injection 500 µg/ml	100%	79%	32%
19	Phenobarbital Injection 100mg/ml	100%	82%	0%
20	Phenytoin Injection 250mg/5ml	100%	82%	0%
21	Potassium Chloride injection 1g/10ml	100%	86%	0%
22	Suxamethonium Injection 50 mg/ml	100%	75%	11%
23	Vecuronium Powder for injection 10 mg	100%	93%	86%
	Total average	**100%**	**86%**	**34%**

Source: Primary data, 2022

In this study, the Pearson correlation coefficients were used to explore relationship between lifesaving products availability at the hospital and lifesaving products received from Zipline using drone technology. The study shown that there is significant correlation between lifesaving products availability and utilization of drone technology where r (Pearson correlation) is = 0.799 and P = 0.000

Table 4.7: Variables correlation analysis

Correlations			
		Products are available at the hospital	**Products are received from Zipline**
Products are available at the hospital	Pearson Correlation	1	.799**
	Sig. (2-tailed)		.000
	N	23	23
Products are received from Zipline	Pearson Correlation	.799**	1
	Sig. (2-tailed)	.000	
	N	23	23
**. Correlation is significant at the 0.01 level (2-tailed).			

Source: Primary data, 2022

4.3.3 Stock out status of lifesaving products before and after drone technology intervention

The results demonstrated that there is a decrease of stock out of lifesaving products after drone technology intervention in Rural District Hospitals.

Table 4. 6: Stock out of lifesaving products before and after drone intervention

No	Lifesaving Products	Stock out of lifesaving products before drone intervention	Stock out of lifesaving products after drone intervention
1	Cryoprecipitate	25%	0%
2	Fresh Frozen Plasma (FFP)	24%	0%
3	Platelet	21%	0%
4	Red Blood Cells	30%	0%
5	Adrenaline Injection 1 mg/1ml	11%	4%
6	Atropine Injection 0.5mg; 1 mg	36%	11%
7	Calcium gluconate Injection 100 mg/ml	32%	21%
8	Digoxin Injection 250µg /ml	39%	14%
9	Dopamine Injection 40mg/ml	18%	7%
10	Enoxaparin Injection 40mg/ml	21%	25%
11	Ephedrine Injection 30 mg/ ml	29%	4%
12	Gamma immunoglobulin	18%	0%
13	Hydralazine injection 20mg/ml	25%	21%
14	Ketamine Injection 50 mg /1ml	18%	11%
15	Magnesium Sulfate injection 50% 10 mL Vial	11%	0%
16	Morphine Injection 10 mg/1ml	18%	7%
17	Naloxone Injection 0.4mg/ml	36%	39%
18	Neostigmine Injection 500 µg/ml	32%	21%
19	Phenobarbital Injection 100mg/ml	14%	18%
20	Phenytoin Injection 250mg/5ml	18%	18%
21	Potassium Chloride injection 1g/10ml	14%	14%
22	Suxamethonium Injection 50 mg/ml	32%	25%
23	Vecuronium Powder for injection 10 mg	36%	7%
Total		**24%**	**12%**

Source: Primary data, 2022

Before the intervention of drone technology, there were lifesaving medicines, blood products stock out of 24%, and this decreased to 12% after the intervention of drone technology.

The Pearson correlation coefficient was used to determine the relationships between the Stock

out of lifesaving products before and after drone intervention correlation. There is correlation between stock out before drone intervention and stock out after drone intervention where r = 0.346, P = .105

Table 4. 7: Correlation of stock out of lifesaving products before and after drone intervention

Correlations			
		Stock out of lifesaving products before drone intervention	Stock out of lifesaving products after drone intervention
Stock out of lifesaving products before drone intervention	Pearson Correlation	1	.346
	Sig. (2-tailed)		.105
	N	23	23
Stock out of lifesaving products after drone intervention	Pearson Correlation	.346	1
	Sig. (2-tailed)	.105	
	N	23	23
*. Correlation is significant at the 0.01 level (2-tailed).			

Source: Primary data, 2022

4.3.4 The lifesaving products expiration rate before and after drone intervention

According to the research, findings presented in the table below the results of the study showed that there is a significant decrease of expiries of lifesaving products from 31% before the intervention of drone technology to 9% after the intervention of drone technology.

Table 4. 8: Expires of lifesaving and blood products before and after drone intervention

No	Lifesaving products	Expires of lifesaving products before drone intervention	Expires of lifesaving products after drone intervention
1	Cryoprecipitate	10%	0%
2	Fresh Frozen Plasma (FFP)	29%	0%
3	Platelet	27%	0%
4	Red Blood Cells	34%	0%
5	Adrenaline Injection 1 mg/1ml	11%	4%
7	Atropine Injection 0.5mg; 1 mg	39%	11%
8	Calcium gluconate Injection 100 mg/ml	46%	14%
9	Digoxin Injection 250µg /ml	54%	18%
10	Dopamine Injection 40mg/ml	39%	11%
11	Enoxaparin Injection 40mg/ml	14%	4%
12	Ephedrine Injection 30 mg/ ml	4%	0%
13	Gamma immunoglobulin	32%	0%
14	Hydralazine injection 20mg/ml	29%	14%
15	Ketamine Injection 50 mg /1ml	25%	11%
16	Magnesium Sulfate injection 50%	21%	4%
18	Morphine Injection 10 mg/1ml	0%	11%
19	Naloxone Injection 0.4mg/ml	50%	21%
20	Neostigmine Injection 500 µg/ml	36%	11%
21	Phenobarbital Injection 100mg/ml	29%	14%
22	Phenytoin Injection 250mg/5ml	32%	11%
23	Potassium Chloride injection 1g/10ml	71%	21%
24	Suxamethonium Injection 50 mg/ml	50%	14%
25	Vecuronium Powder for injection 10 mg	32%	11%
	Total	**31%**	**9%**

Source: Primary data, 2022

The Pearson correlation coefficient was used to determine the relationships between the expires of lifesaving products before and after drone intervention. The correlation between expires before and after drone intervention was significant, $r = 0.671$, $P = 0.000$.

Table 4. 9: correlation of expires of lifesaving products before and after drone intervention

Correlations

		Expires of lifesaving and blood products before drone intervention	**Expires of lifesaving and blood product after drone intervention**
Expires of lifesaving medicines before drone intervention	Pearson Correlation	1	.671**
	Sig. (2-tailed)		.000
	N	23	23
Expires of lifesaving medicines after drone intervention	Pearson Correlation	.671**	1
	Sig. (2-tailed)	.000	
	N	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Primary data, 2022

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1. Discussion

Drone technology improved the availability of lifesaving products, reduced stock out and expires of lifesaving products in rural district hospital in Rwanda. This study showed that the use of drone technology in the rural Rwanda is improving the availability of lifesaving products, reducing stock out and expires of lifesaving products. WhatsApp is the primary social media platform used by health workers while ordering lifesaving products from the Zipline drone technology center, allowing them to receive lifesaving products more quickly and easily. The time to receive lifesaving products has been reduced to 30 minutes compared to four or five hours before drone technology intervention.

The views of pharmacists, Labo managers and Clinical directors in rural District hospital which used drone technology confirmed that drone technology is contributing more in availability of lifesaving products which presented by 94% with a mean of 4.7 and Standard Deviation of 0.450. The findings of this study are similar to the study in Ghana by Demuyakor (2020), who found that using drone technology in health services reduced times to receive emergency medicines, improved availability of emergency medicines, enhanced customer satisfaction and health care providers appreciated the contribution of drones in Ghana (21).

The availability of blood products was at 100 % and all blood products were distributed by drone technology in rural district hospitals while the availability of lifesaving medicines in rural district hospitals was at 86% and the lifesaving medicines received using drone technology were 34% of all lifesaving medicines available in rural District hospitals. The use of drone technology in Rwanda is reducing stock out of lifesaving products in Rwanda, the finding from this study

shows that the stock out of lifesaving products was reduced from 24% before drone technology intervention to 12% after the intervention of drone technology. The use of drone technology in Rwanda also is contributing to the reduction of lifesaving products expired in rural district hospitals, the findings of this study revealed a significant decrease from 31% of lifesaving products expired prior to the intervention of drone technology to 9 % of lifesaving products expired after the intervention of drone technology.

Apart from drone technology contribution to the availability , reduction of stock out and expires of lifesaving products, the Rwandan government has undertaken other initiatives, such as the restructuring of the Rwanda supply chain where a new institution, Rwanda Medical Supply (RMS Ltd), was established in 2020 and improved the availability of lifesaving medicines in rural district hospital using redistribution approach from on branch where medicines are available to another branch where medicines are stocked out. The transfer of Medical Insurance Scheme (CBHI) from the Ministry of Health to Rwanda Social Security Board (RSSB) in 2015 contributed also to the availability , and reduction of stock out of lifesaving medicines in rural district hospitals where RSSB improved the payment of health facilities for services and medicines provided to CBHI members, which increased the availability of lifesaving medicines in health facilities (31).

5.3 Conclusion

The purpose of this research was to evaluate the use of drone technology to improve the availability of lifesaving products in rural district hospitals in Rwanda. It was found that the utilization of drone technology in Rural District Hospitals improved the availability of lifesaving products in Rwanda. All blood products were distributed by drone technology and were available at 100% in rural district hospitals while drone technology distributed 34% of all lifesaving medicines available in rural District hospitals and the availability of lifesaving medicines in rural district hospitals was at 86%. The drone technology contribute also in reduction of stock out and expires of lifesaving products in rural district Hospitals.

5.4. Recommendations

Considering the results of the study, the following recommendations were formulated to improve and strengthen the role of Zipline drone technology in Rural District Hospitals:

- The Ministry of Health as the supreme organ should continue to strengthen Rwanda's health supply chain management to improve the availability of lifesaving products in rural District Hospitals, as there are some lifesaving medicines that are not available in Rural District Hospital and at Zipline drone technology Center.
- The Ministry of Health should continue to use drone technology to improve the availability of lifesaving products in Rwanda
- The management and distribution of lifesaving medicines should be done only by Zipline drone technology to avoid stock out and expires of lifesaving products in Rural District Hospitals and to avoid parallel supply chain system.
- Zipline drone technology should extend support provide to Rwanda health supply chain management by distributing other critical products like vaccines.

5.5. Limitations and implications for future research

If the objectives designated for this study have been achieved, we cannot say that the study has exhausted all utilization of drone technology and its role in improving the availability of lifesaving products in Rwanda.

- Unavailability of staff in hospitals, it was difficult to find them as some of them were in training, in days offs, subjects and were busy with work, especially in the morning's hours, then requested to be waited for them in the afternoon's hours, when they finished their respective tasks.
- The researcher did not assess the appreciation of Zipline Drone technology by the clients
- The study did not consider costs effectiveness of distribution of lifesaving products using drones technology versus distribution of lifesaving products using vehicle

Future research:

This study is breakthrough research for the future in this area due to its findings, particularly in rural areas. The findings highlighted only the utilization of drone technology to improve the availability of lifesaving products in Rwanda and did not achieve all Zipline Drone technology parameters.

It is for this reason that we encourage other researchers to deepen this study, to address other aspects of paramount importance:

1. The appreciation of the beneficiaries on the role of Zipline drone technology in lifesaving, especially in rural areas.
2. Costs effectiveness of distribution of lifesaving products using drones technology versus distribution of lifesaving products using vehicle.

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APPENDICES

ANNEX 1: ETHICAL CLEARENCE

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 3rd/11/2021
Ref: CMHS/IRB/324/2021

MUMUSHIMIRE James
Master's in Health Supply Chain Management
CMHS, University of Rwanda

Dear MUMUSHIMIRE James

RE: ETHICAL CLEARANCE

Reference is made to your application for ethical clearance for the study entitled ***"An Assessment of Utilizing Drone Technology to Improve Availability of Lifesaving Products in Rwanda. Case Study 30 Rural District Hospitals"***

Having reviewed your application and been satisfied with your protocol, your study is hereby granted ethical clearance. The ethical clearance is valid for one year starting from the date it is issued and shall be renewed on request. You will be required to submit the progress report and any major changes made in the proposal during the implementation stage. In addition, at the end, the IRB shall need to be given the final report of your study.

We wish you success in this important study.

Dr Stefan JANSEN
Ag Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal, College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate studies, UR

Email: researchcenter@ur.ac.rw P.O Box 3286 Kigali, Rwanda www.ur.ac.rw

ANNEX 2: PROJECTED BUDGET

No	DESCRPTION	UNIT	QTY	UP (FRW)	TP (FRW)
1	Binding	1	4	3000	12,000
2	Communication	1	1	20000	20,000
4	Flash disk	1	1	8000	8000
6	Stationaries(Pencils ,Pens)	1	1	3000	3,000
8	Photocopying	1	200	50	10000
10	Printing	1	200	50	10000
12	Ream of papers	1	1	5000	5000
13	Transport for Data collection	1	30	20000	600,000
	TOTAL AMOUNT (FRWs)				**668,000**

ANNEX 3: RESEARCH PROJECT TIMELINE

MONTH/WEEK ACTIVITIES	JULY /2021				AUGUST/ 2021				**SEMPTB - ER/2021**				**OCTOBER /2021**				**NOVEM-BER/2021**				**DECEMB ER /2021**			
	w 1	**w 2**	**w 3**	**w 4**	**w 1**	**w 2**	**w 3**	**w 4**	**w 1**	**w 2**	**w 3**	**w 4**	**w 1**	**w 2**	**w 3**	**w 4**	**w 1**	**w 2**	**w 3**	**w 4**	**w 1**	**w 2**	**w 3**	**w4**
Research Proposal writing																								
Research Proposal Presentation																								
Final proposal ready for submission																								
Ethical committee approval																								
Data Collection																								
Data processing and data analysis																								
Writing dissertation																								
Working on the remarks of supervisors																								
Thesis defence																								
Dissemination of study findings																								

ANNEX 4: CONSERT FORM

CONSENT FORM (STATEMENT OF CONSENT)

I have read this consent form. I have had the chance to discuss this research study with a study researcher. I have had my questions answered to my satisfaction in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw at any time. I freely agree to participate in this research study. I understand that all efforts will be made to keep information regarding my personal identity confidential.

Name of participant: ……..

Signature of participant :……

Date :……..

RESEARCHER'S STATEMENT

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has been given an opportunity to ask questions about the activity, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been forced to giving consent, and the consent has been given freely and voluntarily.

Researcher's Name: ……...

Signature: ……

Date: …….....

ANNEX 4: DATA COLLECTION TOOL

QUESTIONNAIRE

INSTRUCTIONS/ AMABWIRIZA

1. This is questionnaire is used to collect data on the utilization of drone technology to improve availability of lifesaving medicines in rural district hospitals; it is composed by two parts / iyi fishe y'ibibazo yifashishwa mu gukusanya amakuru ajyanye no gukoresha ikoranabuhanga rya drone kugirango hongerwe iboneka ry'imiti irokora ubuzima bw'abarwayi mu bitaro by'akarere ko mu cyaro; igizwe n'ibice bibiri.
2. Respondent is requested to answer all questions/ Ubazwa asabwa gusubiza ibibazo byose
3. Answers have to be provided in appropriate, mentioned space/ Ibisubizo bigomba gutangwa muburyo bukwiye bikajya ahabugenewe.
4. You are not allowed to mention your name on this questionnaire/ Ntiwemerewe kwandika izina ryawe kuri iyi fishi y'ibibazo.

Section A : Demographic data / ibiranga usubiza

Please answer the following questions and give mark (X) On the parenthesis and fill in the blank area/ Subiza ibibazo bikurikira ushyira ikimenyetso (X) imbere y'igisubizo kiricyo cyangwa wuzuze igisubizo cyawe ahabugenewe

1. Please indicate your age/*Hitamo imyaka yawe*:

a) Between20-29 years/ Hagati y'imyaka 20-29 ☐
b) Between 30- 39 years/Hagati y'imyaka 30- 39 ☐
c) Between 40- 49 years/ Hagati y'imyaka 40- 49 ☐
d) Above 50 years/ hejuru y'imyaka 50 ☐

2. Please indicate your Sex / Hitamo igitsina cyawe

Male/ Gabo: ☐ ☐ Female/ Gore:

3. Select your level of education /Hitamo amashuri wize

Laboratory technician A2 / Umuraborante A2 ☐

Laboratory technician A1/ Umuraborante warangije ikiciro cyambere cya Kaminuza: ☐

Laboratory technician A0/ Umuraborante warangije ikiciro cyakabiri cya kaminuza: ☐

Pharmacy A0/ umuhanga muby'imiti warangije ikiciro kabiri cya Kaminuza ☐

Pharmacist with Masters / umuhanga muby'imiti warangije ikiciro cya gatatu cya Kaminuza ☐

Bachelor in general medicines/ Umuganga warangije ikiciro cya Kabiri cya kaminuza ☐

Masters in Specialized medicines/ umuganga warangije ikiciro cya gatatu cya Kaminuza ☐

4. Working experience/ uburambe mukazi

0-1years/ munsi y'Umwaka ☐

1-5 years/ Hagati y'umwaka umwe n'itanu ☐

5-10 years/ Hagati y'imyaka itanu n'icumi ☐

10-15 years/ Hagati y'imyaka icumi na cumi n'itanu ☐

Above 15 years/ hejuru ya cumi n'itanu ☐

5. What is your occupation at work place? Mukora iki aho mukorera ?

Clinical Director/ Umuganga uhagarariye abandi ☐

Medical Doctor / Umuganga ☐

Pharmacist/ umuhanga muby'imiti ☐

Laboratory Manager / Umuyobozi wa Labo ☐

Other / ikindi …….Specify/ Kivuge …….

6. Have you ever taken any training regarding drone technology in health supply chain? Wigeze ubona amahugurwa ajyanye n'ikoranabuhanga rya drone mugukwirakwiza imiti n'ibikoresho byo kwa muganga ?

No/ Hoya ☐

Yes/ Yego ☐

- **SECTION B: To assess the experience of the health care providers on the use of drone technology to improve the availability of lifesaving products**

. Please read the following sentences and Circle preferred answer among which are provided / Gucukumbura imyumvire yabakora kwa muganga kubijyanye no gukoresha tekinoroji ya drone kuboneka kubicuruzwa bikiza ubuzima. Soma interuro zikurikira ushyire uruziga kugisubiza nyacyo.

7. Does your hospital request lifesaving products including blood products and medicines at Zipline Drone technology? / Ibitaro byanyu bijya bisaba amaraso n'imiti muri Zipline hifashishijwe ikoranabuhanga rya drone ?

a. No /Hoya
b. Yes/Yego

8. Is it easy to request lifesaving products including blood products and medicines at Zipline Drone technology? **/** Biroroshye Gusaba amaraso n'imiti muri Zipline hifashishijwe ikoranabuhanga rya drone

a. No /Hoya
b. Yes/Yego

9. How do you make an order of lifesaving medicines or blood products at Zipline Drone technology / Nigute usaba amaraso cyangwa imiti muri Zipline ?

a. Call using Telephone/ Guhamagara nkoreshesheje Telephone ☐
b. Sending message by Telephone/ kohereza ubutumwa bugufi kuri telephone ☐
c. Sending message using WhatsApp/ kohereza ubutumwa kuri watsapu ☐
d. Sending email using computer / Kohereza ubutumwa nkoresheje mudasobwa ☐
e. Other /Ubundi buryo ☐

10. Did drone technology reduce time to receive lifesaving medicines and blood products requested as emergency?/ Drone yaba yagabanyije igihe byatwaraga ngo umuntu yakire imiti n'amaraso byo gutabara muburyo bwihuse ?

a. No /Hoya

b. Yes/Yego

11. How much times required to receive lifesaving medicines and blood products requested as emergency before Drone technology?/ Byasaba igihe kingana iki kugirango mubone imiti n'amaraso byo gutabara muburyo bwihuse mbere y'ikoreshwa ry' ikoranabuhanga rya Drone ?

a. Less than one hour / Munsi y'isaha imwe ☐

b. Between one hour to two hours / hagati y'isaha imwe n'amasaha abiri ☐

c. Between two hours to three hours / hagati y'amasaha abiri n'amasaha atatu ☐

d. Between three hours to four hours / hagati y'amasaha atatu n'amasaha ane ☐

e. Between four hours to five hours / hagati y'amasaha ane n'amasaha atanu ☐

f. Above 5 hours /hejulu y'amasaha 5 ☐

12. How much times to receive lifesaving medicines and blood products requested from Zipline drone technology?/ Bisaba igihe kinganiki kugirango ubone imiti n'amaraso wasabye muri Zipline ukoresheje ikoranabuhanga rya Drone ?

a. Less than 30 minutes/ Munsi y'iminota 30 ☐

b. Between 30 minutes to 45 minutes/ hagati y'iminota 30 na 45 ☐

c. Between 45 hour to 60 minutes / hagati y'iminota 45 na 60 ☐

d. Above1 hours /Munsi y'isaha ☐

13. Do you appreciate the role of Zipline drone technology in Distribution of lifesaving medicines and blood products in the hospitals? Wishimiye uruhare rw'ikoranabuhanga rya Drone za Zipline mugukwirakwiza imiti n'amaraso mubitaro?

a. Strongly agree/ Ndabyemera cyane ☐

b. Agree/ Ndabyemera ☐

c. Disagree/Simbyemera ☐

d. Strongly disagree/ Simbyemera habe nagato ☐

e. Neutral / Ndifashe ☐

14. Using drone technology in distribution of lifesaving medicines and blood products can contribute to reduction of stock out of lifesaving products in the hospitals. / Gukoresha ikoranabuhanga rya drone mugukwirakwiza imiti n'amaraso bishobora kugira uruhare

mukugabanya ibura ry'imiti n'amaraso mubitaro?

a. Strongly agree/ Ndabyemera cyane ☐

b. Agree/ Ndabyemera ☐

c. Disagree/Simbyemera ☐

d. Strongly disagree/ Simbyemera habe nagato ☐

e. Neutral / Ndifashe ☐

15. Using drone technology in distribution of lifesaving medicines and blood products can contribute to reduction of expiries of lifesaving products in the hospitals. / Gukoresha ikoranabuhanga rya drone mugukwirakwiza imiti n'amaraso bishobora kugira uruhare mukugabanya imiti n'amaraso irangiriza igihe mubitaro?

a. Strongly agree/ Ndabyemera cyane ☐

b. Agree/ Ndabyemera ☐

c. Disagree/Simbyemera ☐

d. Strongly disagree/ Simbyemera habe nagato ☐

e. Neutral / Ndifashe ☐

16. Using drone technology in distribution of lifesaving medicines and blood products can contribute to availability of lifesaving medicines in the hospitals. / Gukoresha ikoranabuhanga rya drone mugukwirakwiza imiti irokora ubuzima bw'abarwayi bishobora kugira uruhare mukuboneka kw'imiti irokora ubuzima bw'umurwayi kwa muganga ?

a. Strongly agree/ Ndabyemera cyane ☐

b. Agree/ Ndabyemera ☐

c. Disagree/Simbyemera ☐

d. Strongly disagree/ Simbyemera habe nagato ☐

e. Neutral / Ndifashe ☐

17. Could you recommend that Zipline have to contribute to management and distribution of lifesaving medicines in the hospitals?/ Urashobora gusaba ko Zipline igomba gutanga umusanzu mugucunga no gukwirakwiza imiti irokora ubuzima bw'abarwayi mubitaro?

a. Strongly agree/ Ndabyemera cyane ☐

b. Agree/ Ndabyemera ☐

c. Disagree/Simbyemera ☐

d. Strongly disagree/ Simbyemera habe nagato ☐

e. Neutral / Ndifashe ☐

- **SECTION C. 1. To assess the link between utilization drone technology to the availability of lifesaving products in Rural District Hospital**

No	Item description	The product is managed at hospital. Yes/No	The product is available at hospital. Yes/No	Did the products be received from Zipline ? Yes/No	Comments
Blood products					
1	Cryoprecipitate				
2	Fresh Frozen Plasma (FFP)				
3	Platelet				
4	Red Blood Cells				
Lifesaving medicines					
5	Adrenaline Injection 1 mg/1ml				
6	Amphotericin B Powder for injection 50 mg				
7	Atropine Injection 0.5mg; 1 mg				
8	Calcium gluconate Injection 100 mg/ml				

9	Digoxin Injection 250µg /ml				
10	Dopamine Injection 40mg/ml				
11	Enoxaparin Injection 40mg/ml				
12	Ephedrine Injection 30 mg/ ml				
13	gamma immunoglobulin				
14	Hydralazine injection 20mg/ml				
15	Ketamine Injection 50 mg /1ml				
16	Magnesium Sulfate injection 50% 10 mL Vial				
17	Mannitol Injectable Solution 20%				
18	Morphine Injection 10 mg/1ml				
19	Naloxone Injection 0.4mg/ml				
20	Neostigmine Injection 500 µg/ml				
21	Phenobarbital Injection 100mg/ml				
22	Phenytoin Injection 250mg/5ml				
23	Potassium Chloride injection 1g/10ml				
24	Suxamethonium Injection 50 mg/ml				
25	Vecuronium Powder for injection 10 mg				

3. **To assess stock out status of lifesaving products in rural district hospitals before and after drone introduction**

No	Item description	Before introduction of drone technology		After introduction of drone technology	
		Did the Product Stocked out in last 12 months? Yes or No	**Number of days of stock out**	**Did the Product Stocked out in last 12 months? Yes or No**	**Number of days of stock out**
Blood products					
1	Cryoprecipitate				
2	Fresh Frozen Plasma (FFP)				
3	Platelet				
4	Red Blood Cells				
Lifesaving medicines					
5	Adrenaline Injection 1 mg/1ml				
6	Amphotericin B Powder for injection 50 mg				
7	Atropine Injection				

	0.5mg; 1 mg				
8	Calcium gluconate Injection 100 mg/ml				
9	Digoxin Injection 250µg /ml				
10	Dopamine Injection 40mg/ml				
11	Enoxaparin Injection 40mg/ml				
12	Ephedrine Injection 30 mg/ ml				
13	gamma immunoglobulin				
14	Hydralazine injection 20mg/ml				
15	Ketamine Injection 50 mg /1ml				
16	Magnesium Sulfate injection 50% 10 mL Vial				
17	Mannitol Injectable Solution 20%				
18	Morphine Injection 10				

	mg/1ml				
19	Naloxone Injection 0.4mg/ml				
20	Neostigmine Injection 500 µg/ml				
21	Phenobarbital Injection 100mg/ml				
22	Phenytoin Injection 250mg/5ml				
23	Potassium Chloride injection 1g/10ml				
24	Suxamethonium Injection 50 mg/ml				
25	Vecuronium Powder for injection 10 mg				

3 To assess the expiry rate of lifesaving products in rural district hospitals before and after drone introduction

No	Item description	Before introduction of drone technology		After introduction of drone technology	
		Did the products expired in last 12 months	Quantity expired	Did the products expired in last 12 months	Quantity expired
Blood products					
1	Cryoprecipitate				
2	Fresh Frozen Plasma (FFP)				
3	Platelet				
4	Red Blood Cells				
Lifesaving medicines					
5	Adrenaline Injection 1 mg/1ml				
6	Amphotericin B Powder for injection 50 mg				
7	Atropine Injection 0.5mg; 1 mg				
8	Calcium gluconate Injection 100				

	mg/ml				
9	Digoxin Injection 250µg /ml				
10	Dopamine Injection 40mg/ml				
11	Enoxaparin Injection 40mg/ml				
12	Ephedrine Injection 30 mg/ ml				
13	gamma immunoglobulin				
14	Hydralazine injection 20mg/ml				
15	Ketamine Injection 50 mg /1ml				
16	Magnesium Sulfate injection 50% 10 mL Vial				
17	Mannitol Injectable Solution 20%				
18	Morphine Injection 10 mg/1ml				
19	Naloxone Injection 0.4mg/ml				
20	Neostigmine Injection 500 µg/ml				
21	Phenobarbital Injection 100mg/ml				
22	Phenytoin Injection 250mg/5ml				
23	Potassium Chloride injection 1g/10ml				
24	Suxamethonium Injection 50 mg/ml				
25	Vecuronium Powder for injection 10 mg				