The Republic of Rwanda

Final Report
For
Data Collection Survey on
Medical Diagnostic Equipment
in
the Republic of Rwanda

April 2022

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Binko International Ltd.

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Summary

1. Request Background, History, and Overview

The disease structure of the Republic of Rwanda (Rwanda) is dominated by Non-Communicable Diseases (NCDs), which account for 44% of deaths[1]. The proportion of NCDs in Disability-Adjusted Life Years (DALYs)[2] has increased from 16% in 1990 to 35% in 2016, making it the leading cause of health loss[3]. Among NCDs, cancer deaths are reported to be second only to cardiovascular disease at 13% of all deaths (about 6,000 per year)[4]. However, in regard to the provision of required radiological diagnostic equipment for early cancer detection, currently, only three hospitals in the country are able to do CT scans, and the King Faisal Hospital (KFH) has an MRI machine.

In response to these circumstances, the Rwandan government formulated a five-year National Cancer Control Plan (NCCP), a National Cancer Registry, and National Cancer Management Guidelines in 2020. The government aims to establish a system for the early detection of cancer.

In April 2021, KFH, the country's top referral hospital, submitted a letter to the Embassy of Japan regarding its request to improve the quality of cancer care services and the diagnostic equipment shown in Table 1 below. The survey in this report was conducted to clarify the current status of NCD controls in Rwanda, and the challenges that this country faces, especially in terms of the current level of cancer diagnostic functionality and the medical situation for cancer care. This survey also aims to understand the contents of the letter from KFH, examine the possibility of JICA cooperation, and propose the direction and introduction scenario for any support that is given.

Table 1: Planned Equipment for Improving Nuclear Medical Services at KFH

Equipment name
PET-CT
Gallium Generator
Medical Cyclotron
Gamma Camera
Molybdenum Generator
Dose Monitoring and Calibration Instruments
Complete Set of Nuclear Medicine Facilities, including Hot Laboratory

Source: Prepared by the Survey Team

[1] WHO – Non-communicable Diseases (NCD) Country Profiles, 2018

[2] The comprehensive burden of disease in terms of years lost due to morbidity, disability, and premature death

[3] National Strategy and costed action plan for the prevention and control of NCDs in Rwanda, page 17.

[4] WHO - The Global Cancer Observatory, 2021

2. Overview of Cancer Care Services and the Health Insurance System in Rwanda

Table 2 below shows the cancer care services provided at major medical facilities in Rwanda. All facilities offer medical services such as pathology/hematology analysis, tumor markers, diagnostic imaging (ultrasound, and general radiography), and surgery.

Table 2: Cancer Care Service Delivery in Rwanda

Hospital Name	Cancer Care Service Details
KFH (King Faisal Hospital)	Diagnosis: Immunological tests, diagnostic imaging (CT, MRI, mammography)
	Treatment: Chemotherapy
CHUK (Centre Hospitalier Universitaire de Kigali)	Diagnosis: Immunological tests, diagnostic imaging (CT, mammography)
	Treatment: Palliative care
CHUB (Centre Hospitalier Universitaire de Butare)	Diagnosis: Immunological tests, diagnostic imaging (mammography)
	Treatment: Palliative care
BCCOE (Butaro Cancer Center of Excellence)	Diagnosis: Immunological tests, diagnostic imaging (mammography)
	Treatment: Chemotherapy, palliative care
RMH (Rwanda Military Hospital)	Diagnosis: Imaging (CT, MRI)
	Treatment: Radiotherapy with Elekta linear accelerator, chemotherapy, palliative care

Source: Prepared by the Survey Team, based on responses from KFH to questions from the Survey Team.

According to the NCCP's implementation plan, in the future a digital mammography unit will be installed at KFH, an MRI machine will be installed at CHUK, and a CT scanner will be installed at BCCOE. CHUK and CHUB are preparing to offer chemotherapy. The government has already sent people abroad so that they can be trained as highly specialized personnel in line with these plans. Once the above are in place, and the quality of cancer medical services has been improved, KFH plans to promote itself as a core hospital for medical tourism, including cardiac catheterization, renal transplantation, and brain surgery, to neighboring countries.

There are four types of public health insurance in Rwanda. Community-Based Health Insurance (CBHI) covers 87% of the total population, and subscribers receive medical care at lower-level health facilities with a co-payment of 10%. Those who belong to the public service or business sector, which accounts for 10% of the population, can receive medical care from lower-level hospitals at a co-payment of 15%. There is a system in place to cover high medical expenses. Patients who need to receive the advanced medical services provided by KFH (cardiac catheterization, kidney transplant, brain surgery, etc.) and those who need to receive treatment abroad are covered by a fund established within the Ministry of Health if approved by the government.

3. Overview of King Faisal Hospital (KFH) and Cancer Care Services in KFH

The hospital is named after King Faisal of Saudi Arabia as it was built with the cooperation of Saudi Arabia. It provides the highest level of medical care in Rwanda, including specialized departments such as neurosurgery, cardiovascular surgery, orthopedics, cardiology, urology, pediatrics, oncology, and supporting departments such as diagnostic imaging and clinical laboratories. Eighty-five specialists are on staff, and annually there are about 72,000 outpatients and 8,000 inpatients. Table 3 below shows an overview of the diagnostic imaging equipment for cancer diagnosis currently available at KFH.

Table 3: Major Cancer-Related Diagnostic Equipment in KFH

Type/Equipment	Summary
MRI (1 unit)	About half of all MRI scans are for cancer diagnosis. Reservations can be booked up to one month in advance. Approximately 8,900 cases (2021)
CT (1 unit)	Approximately 3,800 cases (2021)
General Radiography X-ray Systems (2 units)	In addition to general examinations, they are used for cancer diagnosis, and one unit is a digital type. Approximately 11,000 cases (2021)
Fluoroscopic Imaging System (1 unit)	Used for examination of the upper and lower gastrointestinal tract. Used for screening tests in combination with endoscopes. Approximately 6,400 cases (2021)
Mammography Unit (1 unit)	Used for breast cancer diagnosis. Biopsies are performed using an ultrasonic scanner. Approximately 880 cases (2021)
Ultrasound Scanner (1 unit)	Approximately 5,500 cases (2020) As of 2021, this reduced to approximately 800 cases because ultrasound examination is widely available in Rwanda.

Source: Prepared by the Survey Team, based on responses from KFH to questions from the Survey Team.

KFH performs surgery and chemotherapy as cancer treatments. Oncology-related medical personnel includes one oncology physician with a master degree from abroad, two oncology nurses with master degrees from within Rwanda, and 29 general physicians and paramedical staff. One physician in the diagnostic imaging department also studied reading nuclear medicine imaging abroad.

4. Plan to Install Nuclear Medicine Facility at KFH

Rwanda currently has no nuclear medicine facilities, and there are very few medical personnel with overseas experience in the operation of nuclear medicine diagnostic equipment. Nuclear medicine diagnostic equipment such as PET-CT and cyclotrons can be operated following 3-6 months of training provided by manufacturers. Therefore, when the nuclear medicine facility is installed, it is possible to simultaneously promote human resource development using the healthcare professionals currently working for KFH.

The estimated project cost is approximately 1.78 billion yen, including construction and maintenance of a nuclear medicine facility and the installation of diagnostic equipment, consumables for three years, and human resource development.

A two-stage development plan is proposed to secure human resources and expenses for facility operation. During the first phase, in addition to the construction of the nuclear medicine facility, a PET-CT that will contribute to the early detection of a wide range of cancers and a cyclotron that will significantly contribute to treatment will be installed.

Then, in the second phase, the interior construction work and installation of SPECT-CT, which contributes to a more detailed diagnosis, will be carried out.

The process of establishing a new nuclear medicine facility and the proposed project flow are shown in the following table. It shows the minimum timeframe required until the start of the project.

Table 4: Expected Process and Project Flow for Establishing a New Nuclear Medicine Facility

Business Process／Required Period （months）	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Establishment a founding comittee/examining specific directions, including fundraising	3 to 6 months																
Selection of funding sources/loan application							3 months										
Acceptance of expert survery team										2 to 2.5months							
Loan review													1 to 1.5 months				
Loan execution/project implementation starts														3 to 4 months			

Source: Prepared by the Survey Team

5. Scenario for Installing Nuclear Medicine Equipment at KFH

The estimated project cost is approximately 1.78 billion yen, including installation and maintenance of a nuclear medicine facility and diagnostic equipment, consumables, and human resource development. Regarding the balance of revenues based on the manufacturer's guaranteed 10-year expiration date for the installed equipment, it is estimated that the loan would be repaid in the ninth year after the introduction of the nuclear medicine facility for the first phase if all revenue from the facility was used for repayment only.

6. Recommendations

It is already widely known that early detection and initiation of early cancer treatment increases the subsequent 5- and 10-year survival rates. Chemotherapy is not a realistic option due to the financial burden on patients in Rwanda. BCCOE provides chemotherapy free of charge with the support of an NGO. However, despite increasing numbers of cancer patients only a limited number can be treated. In addition, patients and their families face the financial burden of traveling to and from treatment facilities.

A desirable outcome would be for KFH, RMH, and university hospitals, such as CHUK and CHUB, to strengthen their facilities, equipment, and human resources, provide chemotherapy under public health insurance, and expand the range of surgical cases, so as to reduce the strain on chemotherapy facilities.

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Location Map

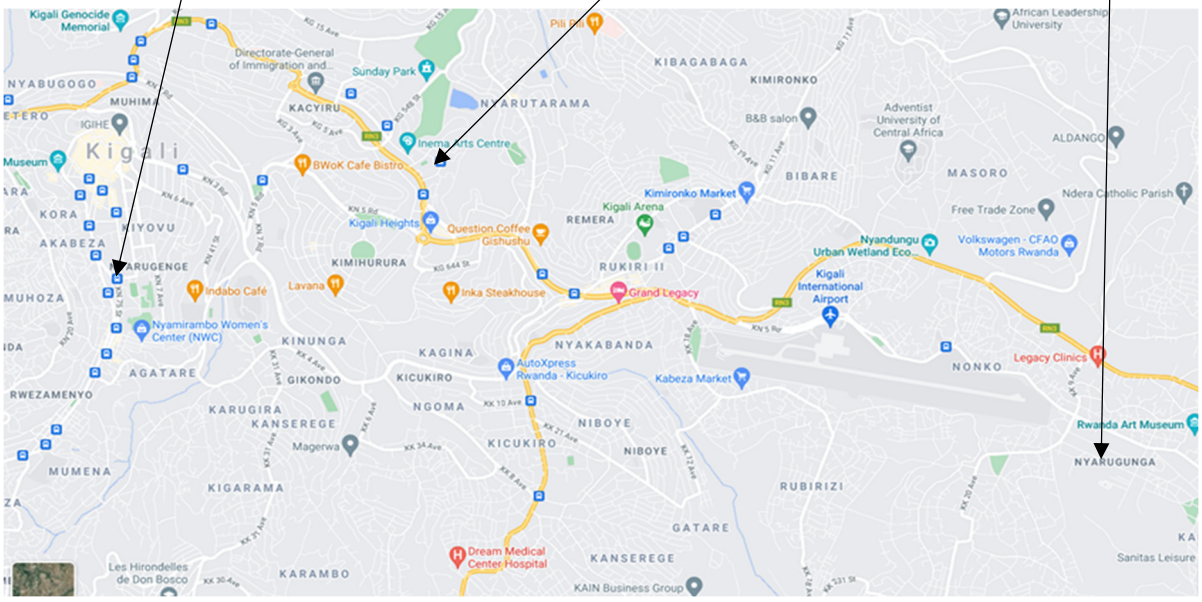
Butaro Cancer Center of Excellence (BCCOE)

Centre Hospitalier Universitaire de Butare(CHUB)

Centre Hospitalier Universitaire de Kigali (CHUK)

King Faisal Hospital (KFH)

Rwanda Military Hospital (RMH)



Source: Prepared by the Survey team（based on Google map）

Photo

KFH Diagnostic Imaging Department and Pathology Department Taken in December 2021

	
Good operation of MRI1.5T introduced in 2020	MRI interpretation room (average 800 cases/month)
	
Ventilator in the MRI room	General X-ray equipment (There are two in the hospital, one is digital)
	
German mammography unit procured in 2007 (without biopsy function)	Stainer procured in 2006 not in operation, no prospect of repair

	
Cryostat (for rapid intraoperative pathological diagnosis)	Embedding station (used for heating and cold treatment of embedded paraffin)
	
Manual staining set	Electric microtome, good operation
	
Teaching microscope	Deep freezer for organ storage

LIST OF FIGURES & TABLES

ABBREVIATIONS

Abbreviation	Official Name
AFCRN	African Cancer Registry Network
BCCOE	Butaro Cancer Center of Excellence
BMT	Biomedical Technician
CBHI	Community-Based Health Insurance
CEO	Chief Executive Officer
CHUB	Centre Hospitalier Universitaire de Butare (French)
CHUK	Centre Hospitalier Universitaire de Kigali (French)
COVID-19	Corona Virus Infectious Disease, emerged in 2019
DALY	Disability Adjusted Life-Years
DHIS2	District Health Information System 2
ENCO	European Nuclear Commission
FARG	Fund for Support to Genocide Survivors
FDG	Fluorodeoxyglucose
GLOBOCAN	Global Cancer Observatory
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
JICA	Japan International Cooperation Agency
JBIC	Japan Bank for International Cooperation
KFH	King Faisal Hospital
MMI	Military Medical Insurance
MOH	Ministry of Health
MRB	Medical Referral Board
NCCP	National Cancer Control Plan
NCDs	Non-Communicable Diseases
NCTWG	National Cancer Technical Working Group
NRC	U.S. Nuclear Regulatory Commission
PIH	Partners In Health
RAEB	Rwanda Atomic Energy Board
RAMA	Rwandaise d'Asssurance Maladie (French)
RBC	Rwanda Biomedical Center
RDB	Rwanda Development Board
RFDA	Rwanda Food and Drug Administration
RMH	Rwanda Military Hospital

Abbreviation	Official Name
RMS	Rwanda Medical Supply Ltd.
RSSB	Rwanda Social Security Board
RURA	Rwanda Utilities Regulatory Authority
UHC	Universal Health Coverage
WHO	World Health Organization

Chapter 1: Data collection survey summary

1.1 Survey Background

In the Republic of Rwanda (Rwanda), non-communicable diseases (NCDs) account for as high as 44% of deaths (approximately 30,000 deaths per year) which is higher than traumatic deaths caused by accidents and infectious diseases.[5]The proportion of NCDs in Disability-Adjusted Life Years (DALYs)[6] has increased from 16% in 1990 to 35% in 2016, making it the leading cause of health loss.[7] In addition, the novel coronavirus (COVID-19) which was declared a pandemic in 2020 has a high risk of causing severe illness in people with NCDs and other underlying diseases. The control of NCDs is crucial to reducing the number of deaths caused by COVID-19[8].

Among NCDs, cancer deaths, which account for 13% of all deaths (about 6,000 deaths per year)[9], are second only to cardiovascular disease. However, in terms of the provision of needed radiological diagnostic equipment for the early detection of cancer, only three hospitals in the country have CT scanners, and only the King Faisal Hospital (KFH) has an MRI machine. Due to a delay in the development of radiology equipment in Rwanda, patients who require more advanced nuclear medicine diagnostic equipment are forced to travel to other countries. Rwanda's Fourth Health Sector Strategic Plan 2018-2024, formulated under the Rwanda Vision 2050, aims to realize universal health care (UHC). Cancer care is one of the key issues in the national health policy, with the stated goal of providing prevention/treatment and supportive care to all citizens.

In response to these circumstances, the Rwandan government formulated a five-year National Cancer Control Plan (NCCP), a National Cancer Registry, and National Cancer Management Guidelines in 2020 and identified ten priority areas for promoting them.

There is an urgent need to formulate and implement a concrete plan for the introduction of more advanced nuclear medicine diagnostic equipment, such as PET-CT, in order to establish an early detection system for cancer in Rwanda. Establishing an early detection system also requires the development of a comprehensive medical system, including training physicians and technicians who can use advanced medical diagnostic equipment, developing medical technology and a setup that quickly links diagnostic results to treatment, and equipment maintenance.

As of 2021, the healthcare sector is not a priority area in Japan's Country Development Cooperation Policy for Rwanda, but JICA is currently implementing a data collection survey on health care facilities and equipment related to the spread of COVID-19 in the African region for 22 African countries, including Rwanda (completed at the end of February 2022). The purpose of

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[5] WHO - Non-communicable Diseases (NCDs) Country Profiles, 2018.

[6] The comprehensive burden of disease in terms of years lost due to morbidity, disability, and premature death.

[7] National Strategy and costed action plan for the prevention and control of NCDs in Rwanda, page 17.

[8] National Strategy and costed action plan for the prevention and control of NCDs in Rwanda, page 12.

[9] WHO-The Global Cancer Observatory, 2021.

this survey is to examine a future cooperation package that envisions supporting the development of medical facilities and equipment in developing countries.

The Egyptian government provides support as cooperation in medical equipment, for example introducing hemodialysis equipment and constructing wards at Rwandan military hospitals. In terms of NCDs control, especially in cancer care, only the WHO supports NCCP in Rwanda.

Since there are many challenges in regards to cancer medical diagnostic functionality, there is a need to consider cooperation in the cancer care field while at the same time taking into account future cooperation programs in the health sector in Rwanda.

1.2 Survey Purpose

The purpose of this survey is to understand the Rwandan government's health policy on cancer care, the medical situation in major hospitals in Rwanda, especially the current status and future improvement plans for cancer diagnostic functionality, and to examine the possibility of JICA cooperation for the improvement of cancer diagnostic functionality in Rwanda.

1.3 Survey Team Members

Name	Title	Position/ Belonging to
Prof. Hiroshi TOYAMA	Nuclear Medicine	JICA: Fujita Health University Professor /Radiologist
Ms. Yasuko ASANUMA	Chief Consultant/ Medical facilities	Consultant: Binko International Ltd.
Mr. Akio KANEKO	Medical Equipment	Consultant: Binko International Ltd.
Ms. Tomomi TEZUKA	Hospital management	Consultant: Binko International Ltd.

1.4 Survey schedule

Table 1: Consultant Member Survey Schedule (2021)

No	Date		Chief Consultant／Medical Facilities	Medical Equipment
1	3.Dec	Fri	Movement ; Narita⇒Doha	
2	4.Dec	Sat	Doha	
3	5.Dec	Sun	⇒Kigari、Waiting for PCR test result	
4	6.Dec	Mon	Explanation of Inception Report to MOH and discussion about field survey Meeting with JICA Rwanda Office Meeting with CEO and Radiologists of KFH	
5	7.Dec	Tue	Individual Meetings with Radiation treaty, Maintenance, Finance, HR department of KFH Agency of PHILIPS survey	
6	8.Dec	Wed	Hearing survey to Oncology doctors、Manager of procedure for the hospital, Infection control officer of KFH RSSB (Rwanda Social Security Board) survey KFH survey (Maintenance Disivion) Agency of SIMENS survey	
7	9.Dec	Thu	Major Hospital Survey (CHUK) Hearing Survey to RURA (about regulation on radiation and nuclear medicine) Online Meeting with Agency of GE (in Kenia)	
8	10.Dec	Fri	Courtesy Call of Embassy of Japan in Rwanda, Interim Reporting RBC Survey (Cancer Register Section)	
9	11.Dec	Sat	Hearing Survey to Medical Technology Division of RBC	
10	12.Dec	Sun	Internal Metting and Reporting	
11	13.Dec	Mon	Hearing Survey to Radiation Devision of KFH Hearing Survey to CMO of KFH	
12	14.Dec	Tue	Hearing Survey to PIH (about operation of diagnose and treatment service for cancer in Butare cancer center)	
13	15.Dec	Wed	Hearing Survey to RDB (about National human resource development plan、Foreign direct investment tax incentive policy etc.) Hearing Survey to Biopsy and Histopathology division of KFH(about operational status of equipment, equipment condition) Hearing Survey to Finance division of KFH (about medical tariff TARIFF, breakdown of revenue) Hearing Survey to RBC (about progres of NCCP organised by Cancer Unit in terms of its current situation and difficulties)	
14	16.Dec	Thu	Hearing Survey to Medical Technology Division of RDB (about problems associated with maintenance of equipment, investment plan for equipment of cancer treatment)	
15	17.Dec	Fri	KFH survey、PCR test result、Kigali ➡ Doha	
16	18.Dec	Sat	Doha➡	
17	19.Dec	Sun	Narita	

Table 2: JICA Member Survey Schedule (2022)

No.	Date	Day	Activities
1	10-Mar	Thu	Departure from Addis Ababa (ET0811) Arrival at Kigali
2	11-Mar	Fri	Presentation session at MoH (With all target institutions: MoH,RBC,KFH, CHUK, RMH and PIH)
3	12-Mar	Sat	Documentation
4	13-Mar	Sun	Documentation
5	14-Mar	Mon	Meeting with KFH's CEO
			Meeting with JICA Rwanda Office
			Meeting with some suppliers of equipments Meeting with WHO at hotel
6	15-Mar	Tue	Survey at CHUK
			University of Rwanda Meeting with Deputy Dean of College of Medicine (University of Rwanda)
			Meeting at Embassy of Japan
9	16-Mar	Wed	Survey at KFH
			Meeting with CEO of RAEB
10	17-Mar	Thu	Suvery at Butaro Hospital (BCCOE)
11	18-Mar	Fri	Survey at RMH
12	19-Mar	Sat	Departure from Addis Ababa (ET0644) Arrival at Bangkok
13	20-Mar	Sun	Departure from Bangkok (TG0644) Arrival at Chubu centrairport

1.5 Key Interviewees

Table 3: Key Interviewees

Organization	Title	Name
MOH : Ministry of Health	Head of Department of Clinical and Public Health Services Department	Dr.Corneille Killy NTIHABOSE
RBC: Rwanda Biomedical Center	Chief of Cancer Unit under NCD Dept.	Mr. Marc HAGENIMANA
RSSB: Rwanda Social Security Board	Head of Medical Services Dept.	Dr. Umutesi LYSETTE
RDB: Rwanda Development Board	Sector Capacity Building Analyst, Strategic Capacity Development Dept.	Amos MFITUNDINDA
KFH: King Faisal Hospital	Chief Executive Officer	Pr.Miliard DERBEW
	Chief Medical Officer	Dr. Sendegeya AUGUSTIN
	Radiologist	Dr. Jean Paul RUBONEKA
CHUK: Centre Hospitalier Universitaire de Kigali	Chief Consultant/Urologist, Director General Radiologist	Dr. Prof. Hategekimana THEOBALD Dr. Sabine NYIRANEZA
PIH: Partners In Health	Chief Medical Officer Coordinator	Dr. Kateera FREDRICK Ms,Joanna GALARIS
WHO :World Health Organization	National Program Offier Malaria/HIV AIDS/ NTD Officer	Dr. Jules MUGABO SEMAHORE Ms. Karin MIYAMOTO
UR: University of Rwanda	Deputy Dean, school of medicine and pharmacy	Dr. Innocent HAHIRWA, PhD. (Pharm)
RAEB(Rwanda Atomic Energy Board)	C.E.O	Dr. Fidel NDAHAYO
MININFRA: Ministry of Infrastructre	Technical Advisor/ NLO(National Liaison Officer) IAEA (International Atomic Energy Agency)	Mr. Jean Bosco MUGIRANEZA
RMH(Rwanda Military Hospital)	Radiotherapy and Oncology specialist at Rwanda Cancer Centre	Capt Dr. FELIX SINZABAKIRA
Butaro District Hospital	General Director	Lt. Col. Emmanuel KAITARE
BCCOE(Butaro Canter Center of Excellence)	Deputy Chief Medical Officer	Dr. Cyprien SHYIIRAMBEHI Mr. Frederic KATEERA
IAEA (International Atomic Energy Agency)	Technical Advisor/ National Liaison Officer	Mr. Jean Bosco MUGIRANEZA

Source: Prepared by the Survey Team (based on meeting records) (Details: Refer to Appendix 1)

1.6 Organizations Discussed and Summary of Discussion Results

Table 4: Major Organizations Discussed and Summary of Discussion Results

Organization	Summary of discussion results
MOH	・While the role of MOH is policy formulation, the role of RBC is to promote health services in collaboration with medical facilities. ・Two years ago, the Ministry of Health established a human resources department to strengthen Human Resources for Health and train specialized physicians and allied health professionals.
RBC	・Confirmation of NCCP progress and challenges ・Confirmation of the national cancer registry system ・Confirmation of cancer diagnosis and treatment provided by five major hospitals ・Confirmation of the medical equipment procurement plan for future cancer diagnosis and treatment
RSSB	・Confirmation of types and rates of health insurance provided by RSSB ・Confirmation of current health insurance issues and future policies, such as the fact that Chemotherapy is not covered by Community Based Health Insurance (CBHI[10])
KFH	・Confirmation of operational and administrative matters such as organization, revenue (including its breakdown), etc. ・Operating conditions of major equipment, allocation of cancer-related medical personnel ・Confirmation of the current status of the oncology-related in-service training course ・Confirmation of cancer diagnosis and treatment ・ Confirmation of needs of PET-CT and the contents of the request plan to introduce PET-CT. Explanation and discussions about concept paper proposed by the consultant Team
RDB	・Confirmation of HRH Development Plan based on the current gap analysis of the National Skill's Development & Employment Promotion Strategy 2019-2024 ・Confirmation of foreign direct investment incentives

Source： Prepared by the Survey Team based on meeting records

Chapter 2: Review of the Future Cancer Care Plan of the Government of Rwanda

2.1 Organizational Structure and Implementation System of Relevant Organizations

Figure 1 shows the organizational chart of the Ministry of Health. The Rwanda Biomedical Center (RBC) and the Rwanda Food and Drug Administration (RFDA) are among the institutions that are directly under the Secretary-General. The RFDA is also the approval body for medical devices.

[10] Mutuelle de Santé in French. Annual premiums vary depending on income. Subscribers pay 200 Rwandan francs or 10% of medical expenses. Coverage includes (1) medicines and medical services provided by health posts and health centers, (2) medicines and medical services provided at provincial or district hospitals, (3) medicines and medical services provided at other public hospitals and referral hospitals.

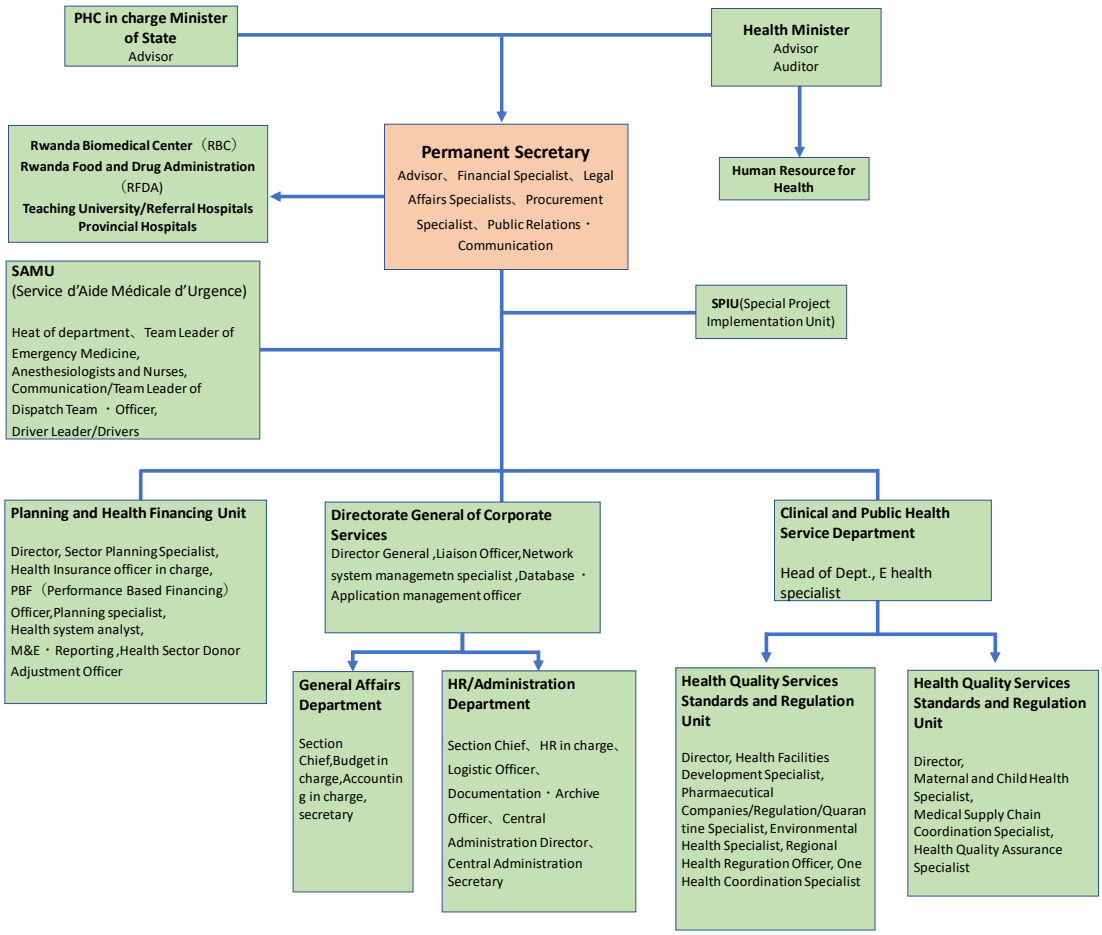


Figure 1: MOH Organization Chart

Source: Prepared by the Survey Team (based on Government of Rwanda 2020 Official Gazette n41 of 21/12/2020)

Rwanda's health system consists of the public sector that manages public health facilities and the private sector that manages private health facilities. MOH is in charge of formulating policies and budgets, while RBC coordinates the implementation of public sector health programs at the central level and works with health facilities to deliver health services to the population.

The budget application process goes from the RBC to the MOH and finally to the Ministry of Finance and Economic Planning for approval. Even if a budget is secured, it takes time until actual payment. The budget year runs from July through June of the following year, and mid-term reviews are held in December.

The national-level coordination of NCCP is led by the Cancer Disease Unit of the NCDs Division within RBC. The Cancer Disease Unit provides evidence-based information on the relationship between relevant infectious diseases and cancer and works closely with the National Cancer Technical Working Group (TWG). The organizational chart of RBC is shown in Figure 2.

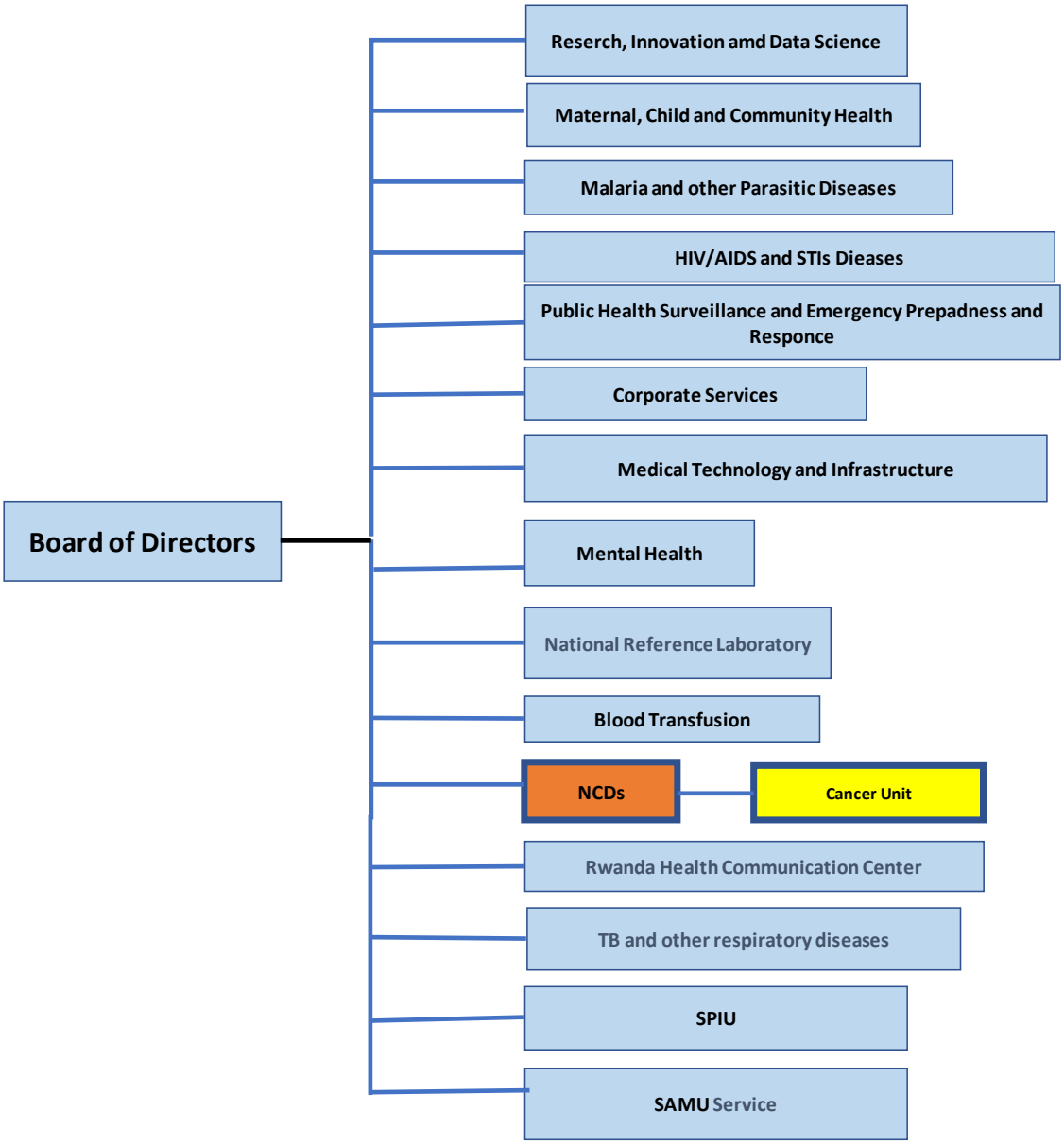


Figure 2: RBC Organization Chart

Source: Prepared by the Survey Team (based on RBC website and NCCP)

There are 52 public hospitals and 123 health centers in the country. The maintenance of medical equipment is under the jurisdiction of RBC's Medical Technology and Infrastructure Department, which has 14 technicians as of December 2021. RBC has set a target of assigning two technicians at District-level medical facilities and four Biomedical Technicians (BMTs) at referral and teaching hospitals. Currently, technicians are allocated only to referral and teaching hospitals.

2.2 Outline of NCCP 2020-2024

The outline of the policies, goals, and strategies of the NCCP (2020-2024) is shown in Table 5 below.

Table 5: Outline of NCCP

Items	Outline
Policy	A three-way approach for prevention, diagnosis, treatment/care, and decentralization to lead to a multi-layered of community campaigns, early detection, and effective diagnosis and treatment at medical facilities.
Goal	To reduce cancer mortality and morbidity and strengthen cancer control in all aspects, including risk factor prevention, early detection, quality diagnosis, treatment & care, including palliative care, and development and use of comprehensive systems of monitoring/evaluation (M&E) based on quality statistical data.
Specific objectives and strategies:	① **Reduce the Incidence of Preventable Cancers** 1) Tobacco control. 2) Prevention of excessive alcohol consumption. 3) Physical inactivity, dietary factors, obesity 4) Vaccination against Human papillomavirus (HPV) infections. 5) Proper management of infectious diseases that lead to cancer and reduction of exposure to carcinogenic substances
	② **Increase in Early Detection of Cancer and Screening Rates** 1) Improving cervical cancer screening by HPV/DNA tests. If thermal ablation devices and automatic visual evaluation are approved, it will be possible to treat precancerous lesions at health centers as part of decentralization. Mammography equipment will be introduced on a basis of population in the later stages. 2) The early detection and screening of breast cancer through clinical breast examinations at the primary health care (PHC) level, breast ultrasounds at district hospitals, and mammography equipment will be introduced on a basis of population in the later stages of NCCP. 3) Initiation of colorectal cancer screening at the PHC level, and improved access to diagnostic sigmoidoscopy and colonoscopy at referral hospitals. 4) Implementation of training for PHC-level healthcare professionals that enables early detection and timely referral of pediatric and other cancers through sensitization on signs and symptoms of cancers in the community.
	③ **Improve Access to Quality Cancer Diagnosis and Treatment Services** 1) Introducing new molecular tests and flow cytometry for specific cancer treatments to improve pathological capacity. 2) Capacity building of pathologists and technicians. 3) Implementation of an effective sample transportation system from district hospitals to pathology laboratories through the Information System of the Institute of Anatomical Pathology 4) Improving access to the latest medical imaging systems, including the upcoming nuclear medicine unit. 5) Capacity building for adequate number of radiologists and radiology technicians.
	④ **Provide Quality Pain Management and Palliative Care Services** 1) Integrating palliative care services into the existing health system. 2) Improving the local production of oral morphine solution. 3) Including palliative care in social security. 4) Strengthening palliative care at home.
	⑤ **Strengthen Cancer Information System and Research** 1) Strengthening the cancer registry. 2) Utilizing information technology systems to establish a National Cancer Registry.

Items	Outline
	3) Promotion of cancer research.
	⑥ **Strengthen Coordination, Partnership, and Financing for Cancer Control** 1) The Cancer Diseases Unit under the NCDs Division in RBC manages and coordinates the NCTWG. 2) Strengthening partnerships with different national and international organizations that are active in cancer control. 3) Promoting public-private partnerships for cancer control, as well as increasing domestic funds to cancer control.
Treatment	1) Creating a comprehensive National Referral Cancer Centre (i.e., "Rwanda Cancer Centre"). 2) Establishing systemic therapy capacity at university teaching hospitals (e.g., CHUK, CHUB). 3) Strengthening the capacity of surgical oncology. 4) Capacity building of an adequate number of human resources for cancer management. 5) Improving access to new therapies such as immunotherapies and biologics, and reducing the financial burden on patients.

Source: Prepared by the Survey Team (based on NCCP)

Table 6 below summarizes the current status of Rwanda's cancer care services, and the challenges and strengths at each stage.

Table 6: Current Status, Challenges, and Strengths of Rwanda's Cancer Control

Stage	Current status	Challenges	Strengths
Prevention	Implementing cancer prevention campaign (e.g., hepatitis B vaccinations for liver cancer, HPV vaccinations to prevent cervical cancer, "Car Free Days" to promote exercise, etc.).	The general public awareness of cancer is low because public institutions are not active in prevention and early detection activities that lead to diagnosis and treatment.	Advocacy groups support cancer patients and their families by raising cancer awareness, early detection, and providing psychosocial support: Rwanda Children's Cancer Relief, Breast Cancer Initiative East Africa, and Conquer Breast Cancer.
Early Detection	Cervical and breast cancer screening is conducted in 52% of health centers and district hospitals.	Delays in diagnosis and treatment can be attributed to both patients and health services. Patients may delay seeking care for several logistical and psychosocial reasons, while health services may delay making a diagnosis and initiating treatment.	Trained community health workers conduct breast examinations in the community.
Diagnosis, Treatment, and Care (including Palliative Care)	The majority of cancers are not diagnosed or treated (estimated to be only about 20% of all new cancers).		Women's cancer clinics are set up in 50% of health facilities to lead early detection, diagnosis, and treatment of cervical and breast cancers and all facilities are scheduled to be expanded.
	BCCOE study reveals that 20% of breast cancer patients had stage I or II diseases at diagnosis, 46% had locally advanced (stage III) disease, and 31% had metastatic disease.	**Lack of advanced diagnostic equipment** Most public and private hospitals use conventional or digital radiography. Ultrasound scanners are available at all district hospitals.	Increases in medical imaging equipment at private hospitals and clinics in Kigali has reduced patient waiting times.
	Cancer care services, including diagnosis, surgery, and chemotherapy, are provided by CHUK, CHUB, RMH, KFH, and BCCOE. The National	Mammography and CT scanners are available only at five major hospitals. KFH is the only public health care facility with an MRI	Two linear accelerators for radiation therapy were installed at the Rwanda Cancer Center (inside RMH), and the number of treatments

Stage	Current status	Challenges	Strengths
	Radiation Therapy Center opened at RMH in April 2020 as the final referral site for comprehensive cancer treatment.	machine. There are private hospitals with MRI machines. PET/CT and PET/MRI are not available in Rwanda. Ultrasound-guided fine-needle aspiration biopsy, drainage, and CT-guided biopsy are available only in private hospitals.	overseas has decreased significantly.
	Standard laboratory techniques such as biochemistry and hematology are available across the country. Immunohistochemistry is available at CHUK, RMH, KFH, and BCCOE. Tumor markers are performed at tertiary hospitals, teaching hospitals, and BCCOE. Pathology services are provided at the above five hospitals.	There are currently no advanced pathology services such as diagnostic molecular pathology.	The first phase national cancer registry is currently planned to collect and manage data from all teaching hospitals (RMH, CHUB, CHUK, and KFH), BCCOE, all district hospitals in Kigali, several private hospitals, clinics and laboratories, Rwinkwavu Hospital and Kabgayi Hospital.
		Rwanda cannot become a center for medical care, and thusly medical tourism is not feasible, without advanced cancer care services.	Palliative care is provided at all medical level facilities and has been rolled out in the community.
Others	Public health insurance members have to co-pay 10% of the cost of lifelong and expensive treatments such as cancer and heart surgery, making it difficult for low-income people to receive these treatments.	Public health insurance coverage limits need to be reviewed. Even with increased enrollment, the pooled premiums cannot keep up due to increased health care costs.	Most of the population is covered by public health insurance. Government spending on the health sector is higher than in other countries.
	Chemotherapy is not covered by public health insurance.		

Source: Ministry of Health, Rwanda (2020) National Cancer Control Plan 2020-2024, National Strategy and Costed Action Plan for the Prevention and Control of Non-Communicable Diseases in Rwanda 2020-2025, Rubagumya et al. (2020) State of Cancer Created by a consultant from Control in Rwanda: Past, Present, and Future Opportunities

2.3 Implementation Status of Cancer Care Policy based on NCCP

NCCP (2020-2024) will conduct a midterm review in 2022. Current progress, and discovered issues, is shown in Table 7 below.

Table 7: Progress and Issues of NCCP per Category

Category	Progress and Issues
Screening	・Implementation with RBC budget A program is conducted for cervical and breast cancers in women. Cervical cancer screening is carried out in 12 out of 30 districts, and cervical cytology (Pap smear), HPV tests (recommended by WHO), etc., are conducted for 20% of the total target population. Coverage is limited to 20% due to financial limitations. Screening has not been implemented for breast cancer, and physicians and nurses are trained to refer patients suspected of having breast cancer by palpation for ultrasound and mammography. Mammography examination is available at CHUK, KFH, and RMH. Screening for prostate and other cancers in men is not available. About 5% of HPV tests are positive, of which about only 0.5% is confirmed as cervical cancer.

Category	Progress and Issues
Diagnosis	・Performed in the pathology and diagnostic imaging departments of hospitals. It is carried out at the expense of hospitals and in cooperation with RBC's National Reference Lab. The procurement of diagnostic equipment (CT, MRI, etc.) is decided by the Medical Technology Division of the RBC, which leads to procurement. The procurement of MRI for CHUK has not yet been officially decided. ・PIH has decided to procure CT for BCCOE using its own budget.
Treatment	・Implementation protocol has been developed with experts.
Advocacy and Awareness	・Awareness-raising activities through radio, community health workers, nurses and medical students by NCDs Alliance (NGO). ・Paper materials were also used prior to the COVID-19 pandemic.
Palliative care	・People are given guidance on access to palliative care.
Supply of medicine	・Chemotherapy is currently provided at KFH and RMH. These two hospitals collaborate to jointly procure medicine, but bulk procurement through the Rwanda Medical Supply (RMS) has not been implemented. It is necessary to establish a bulk procurement route and system through RMS to start chemotherapy at CHUK and CHUB in the future.
Cancer registry	・Submission of data such as cancer incidence rates to the Global Cancer Observatory (GLOBOCAN). ・Oncology nurses and statisticians at hospitals are trained as focal persons, and data is collected from hospitals through DHIS2 (District Health Information System 2) and added to the Cancer Registry. ・Numerical values are also used to evaluate NCCP implementation. Previously, detection of cervical cancer at stage 4 was 35% of all cases, but by 2020, the percentage had decreased to 20%, which shows a gradual improvement. ・Cancer registration forms are distributed to each hospital, and cancer patients are registered and updated using the forms of A. Hospital B. Lab Report and C. Death Registration. Deaths are registered using the Rwanda death registration form (no cancer-specific form).

Source: Prepared by the Survey Team based on hearing results from the Cancer Unit, including Cancer Registry Division

2.4 Plans for the Allocation of Cancer Care Facilities and Equipment

In regard to the installation of cancer-related equipment at the five major hospitals, the installation of a CT scanner at Butaro Hospital as described in the NCCP is expected to be realized. As for other plans, in each case the Medical Technology Infrastructure Department of the RBC examines the appropriateness of the applied for equipment, and the Ministry of Finance and Economic Planning makes the final decision on budget execution. An application has been made for a plan to install an MRI machine at CHUK , but a decision won't be made until June 2022, and if it is approved then it will be procured next year.

Other plans mentioned in the NCCP 2020-2024 include establishing the National Referral Cancer Center with two radiotherapy machines in February 2020 to start radiotherapy in the country. Preparations are underway within the MOH/RBC to start chemotherapy treatment at the two university hospitals, CHUK and CHUB, but the start date has not yet been determined.

As of December 2021, there is a development plan for installing a digital mammography unit at KFH which will be funded by the Rwandan government in the 2022/2023 financial year.

2.5 Outline of the Medical Tourism Promotion Plan and the Positioning of Cancer Care in the Plan

2.5.1 Medical Tourism

As of December 2021, Rwanda has not announced a national medical tourism policy, as recommended in a final report compiled by a private consultant in 2014[11]. Rwanda is motivated to take advantage of its intrinsic resources, such as the country being very safe, linguistic support in English and French being available, and to provide attentive medical services that can accept patients from DR Congo, Tanzania, Uganda, French-speaking countries in Central Africa, as well as other countries. As an example, KFH has received a loan from the Bank of Kigali, has procured a cardiac angiography system, and started providing catheter treatment to Rwandan and foreign patients with cardiovascular diseases, dialysis services for patients with kidney failure and kidney transplantation surgeries.

The status of cancer control in Rwanda and neighboring countries, which are potential markets for medical tourism, is summarized in Appendix 5 as comparative data based on WHO Cancer Country Profiles (2020).

2.5.2 Human Resource for Health

The Rwanda Development Board (RDB) has developed the National Skills Development and Employment Promotion Strategy 2019-2024, which describes human resource development strategies based on a gap analysis of specific sectors. The Health Sector Skills Council is included in the strategy for the health sector. The council members include the Rwanda Medical & Dental Council, the Council of Pharmacists, the Allied Health Professions Council, and others. In the health sector, many patients who require treatment using specialized medical skills, such as neurosurgery, cardiovascular surgery, and cancer treatment, must receive medical services from outside of Rwanda, such as in India. Therefore, it was mentioned that there is a need to establish expertise[12] in Rwanda. In nuclear medicine human resources development, the Rwandan government sends people overseas to acquire knowledge about nuclear medicine. The government aims to improve cancer care by developing human resources that can diagnose and treat all cancer cases in Rwanda.

Currently, medical education in Rwanda covers all aspects of medicine during six years of medical school, with no specialized courses in diagnostic imaging. Lectures on radiation therapy are usually offered in the same program as oncology departments and are taught in separate programs from diagnostic imaging departments. There are no training institutes for medical

[11] Entrepreneurial Solutions Partners (2014) Final Report: Consultancy Service for Development of a Health Care Services Strategy for Medical Tourism in Rwanda: Paving the Way for Medical Tourism in Rwanda, February 2014.

[12] There is one person each at KFH and CHUK who has studied nuclear medicine abroad.

physicists in Rwanda, so medical physicists must be educated abroad. Due to a lack of nuclear medicine facilities there are also no opportunities to learn about nuclear medicine through classroom lectures or practical learning using actual equipment. Therefore, all students need training overseas. Once nuclear medicine facilities, including a PET-CT facility, are established at KFH, this will enable training to start in Rwanda.

2.5.3 Latest Status of Cancer Control in Rwanda[13]

KFH carried out repair work in its cancer diagnosis and treatment facility in 2021, installed a new MRI machine, and established a catheterization laboratory. CHUK plans to install additional CT scanners by the end of 2022. In addition, there are plans to build new medical facilities within the next 3 years in Masaka district (Kichukiro District of Kigali), a densely populated area of Kigali. In addition, RMH intends to create a new ward.

RBC has developed guidelines for screening for breast cancer and is planning and coordinating the implementation of a large-scale screening campaign to prevent and detect cervical and breast cancer in collaboration with healthcare facilities. RBC also performs supervision and monitoring of endoscopic mucosal resection (EMR).

Regarding the cancer registry, data on cancer diagnosis, treatment, laboratory results, and deaths have been collected from all healthcare facilities and input into a database since 2019. Challenges include a lack of personnel, a small budget and incomplete data collected from hospitals.

This incomplete data is due in turn to a shortage of human resources. In addition to dealing with cancer patients, medical staff must perform various administrative tasks within limited work hours. As they have busy schedules they often put off entering data or they make mistakes during data entry.

In regard to the strengthening of diagnostic capacity, RBC is working to ensure that the necessary imaging equipment for cancer diagnosis is available and well maintained at teaching hospitals. RBC has maintenance contracts with manufacturers for all major imaging equipment installed at teaching hospitals. Training of end-user technicians is conducted after new equipment is installed, and refresher training is provided when requested by hospitals. Needs assessments for imaging equipment is undertaken annually to identify the needs at all hospitals, and new equipment is procured according to the budget. Appendix 4 summarizes the cancer registry statistics for the past three years.

[13] This section is described based on the responses from RBC to the questions of the Survey Team at the end of January 2022.

2.6 Cancer Care-Related Support from Other Donors

Partners In Health (PIH), an international health NGO, provides 90% of cancer-related support in Rwanda. The table below shows donor assistance related to cancer care services in Rwanda.

Table 8: Donor Assistance Related to Cancer Care in Rwanda

Organizations	Summary of Support
Partners In Health	PIH opened a cancer center in 2012 at Butaro Hospital in Burera District, northern Rwanda, and as of December 2021 it has treated 3,800 patients. The center also accepts patients from Uganda and the Democratic Republic of Congo which share a border with Rwanda. Construction is underway to increase the number of beds and install cancer diagnostic equipment such as CT scanners, a mammography unit, and a digital X-ray unit. The Butaro cancer center is the only medical facility where CBHI patients can receive free chemotherapy. In 2019, the Butaro Cancer Center of Excellence was established to provide free lodging for patients undergoing treatment, as well as their families, on the hospital grounds. The University of Global Health Equity was founded near the hospital with support from the Bill & Melinda Gates Foundation and others, with bachelor's/master's programs for students to become physicians, surgeons, or to study international health (Currently, 3rd year students are studying).
Clinton Health Access Initiative	Support for cervical cancer screening through HPV/DNA testing (e.g., lower prices for equipment and consumables required for cervical cancer screening and treatment)
World Health Organization	Support for the development of the NCCP 2020-2024 Technical support for early detection of cervical cancer
American Cancer Society ＆Hospice Without Boarders	Support for the Rwanda Palliative Care and Hospice Organization. Support for pain management using opioids (oral morphine) at medical facilities.
NGOs (Rwanda Children's Cancer Relief, Breast Cancer Initiative East Africa, Conquer Breast Cancer)	Various types of support for cancer patients and survivors; advocacy groups raise awareness about cancer, promote early detection, and provide psychosocial support.
International Agency for Research on Cancer (IARC), African Cancer Registry Network (AFCRN)	Support for the national cancer registry: training of staff involved in the cancer registry and technical and scientific support for the national cancer registry.
International Atomic Energy Agency： IAEA	Support for capacity building in radiation therapy, technical support for the NCCP, budget planning for the first Rwanda radiation therapy center within RMH. Currently, two physicians and four radiation therapists are receiving long-term IAEA fellowships.
IAEA AFRA（African Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology） Projects in Rwanda	Project Title: Capacity Building for Radiotherapy Provide training in radiotherapy by dispatching experts to Rwanda Military Hospital/Rwanda Cancer Center and support the design and construction of the Rwanda Cancer Center (annexed to RMH) Project title: Legal Support Support for RURA (Rwanda Utilities Regulatory Authority) in developing various laws, introduction procedures, and standard specifications for peaceful usage of

Organizations	Summary of Support
	nuclear energy through personnel exchange, dispatch of experts, and remote guidance. Project Title: Organizational Strengthening A new project that the IAEA Board just approved in 2021, with this support, the Rwanda Atomic Energy Board (RAEB) was established in 2022, independent from the Office of the President.
IAEA AFRA Regional project	Human Resource Development 1. As of March 2022, one medical student has been approved by IAEA to study abroad to obtain a degree in nuclear medicine and is applying for admission to a university in Algeria. Once they complete this program, they will be the first student from Rwanda to obtain a PhD in nuclear medicine. 2. Preparations are underway to establish a new specialized department within the College of Medicine and Health Sciences at the University of Rwanda with the aim of training radiologists. The department is expected to be established within a year or two.

Source: Prepared by the Survey Team based on information from RBC (NCDs division) and the websites of government agencies and the results of the interview survey

Chapter 3: Overview of Cancer Care in Rwanda

3.1 Overview of Medical Services

3.1.1 Cancer Care System

The Butaro Cancer Center of Excellence (BCCOE), which receives and treats many cancer patients in Rwanda, is a specialized cancer diagnosis and treatment center located adjacent to the Butaro District Hospital and which is operated by an NGO called Partners In Health (PIH). Approximately 50-60% of BCCOE's medical personnel costs, and the purchases of medical equipment and drugs, are funded by PIH. According to a press report dated December 10, 2021, there are plans to increase the number of beds at Butaro District Hospital from 150 to 240-250.

This plan would position the current district hospital as a specialized hospital. The NCCP also plans to install medical equipment at BCCOE, including a CT scanner unit, a mammography unit, an ultrasound scanner, a digital X-ray unit, and other cancer-related diagnostic equipment, and also two cancer-specific operating rooms.

Cancer patients are currently transferred to Kigali for CT imaging, and depending on their symptoms, they may be sent to Nairobi for further examination. Although PIH bears all the transport costs, many people prefer to have CT imaging done locally. If the above improvements are implemented, it is expected to save on the cost of transporting referred patients, and thereby reduce the financial and physical burden on patients.

Figure 3 below shows the Rwanda health system. A referral system of referral hospital/provincial hospitals, district hospitals, and health centers has been established with the National Referral Hospital at the top.

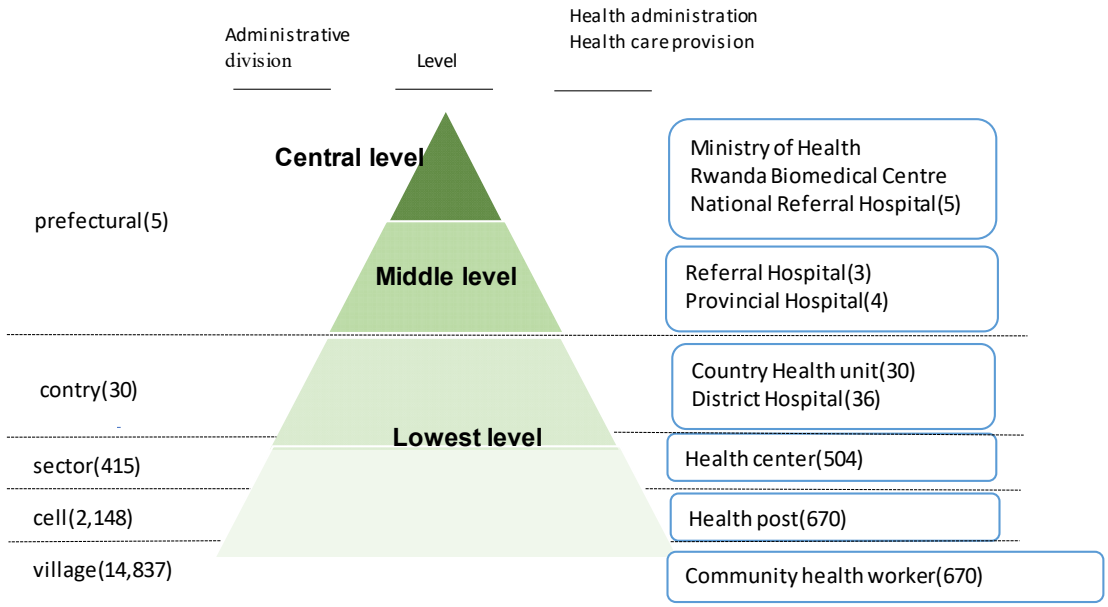


Figure 3: Rwanda Health System

3.1.2 Major Related Facilities for Cancer Care

Table 9 below summarizes cancer diagnosis and treatment services at Rwanda's leading cancer care facilities.

Table 9: Facilities Offering Cancer Care Services and Main Services

Hospital/Location	Interview Results	Cancer Related Service
KFH (King Faisal Hospital), Kigari	Radiotherapy patients are transported to RMH.	(Diagnosis) Pathology/hematology analysis, tumor markers, immunological tests, diagnostic imaging (ultrasound, general X-ray, CT, MRI、mammography) (Treatment) Surgery, chemotherapy (few cases)
CHUK (Centre Hospitalier Universitaire de Kigali), Kigari	Pediatric cancer beds are always full, and patients requiring chemotherapy must be referred.	(Diagnostics) Pathology/hematology analysis, tumor markers, immunological tests, diagnostic imaging (ultrasound, general X-ray, CT, mammography) (Treatment) Surgery, palliative care
CHUB (Centre Hospitalier Universitaire de Butare), Southern Province, Huye District Butar Sector	Cervical and breast cancer patients are referred to BCCOE, while other cancer patients are transported to KFH or RMH.	(Diagnosis) Pathology/hematology analysis, tumor markers, immunological tests, diagnostic imaging (ultrasound, general X-ray, CT, MRI, mammography) (Treatment) Surgery, palliative care
BCCOE (Butaro Cancer Center of Excellence), Northern Province,	3,500 cancer patients are being treated under the PIH program, and the hospital can	(Diagnosis) Pathology/hematology analysis, tumor markers, immunological tests, diagnostic Imaging (ultrasound, general X-ray, CT, MRI,

Hospital/Location	Interview Results	Cancer Related Service
Burera District Buraro Sector	accommodate 20 children and 40 adults. Hospital beds are always full.	mammography) (Treatment) Surgery, chemotherapy, palliative care
RMH (Rwanda Military Hospital), Kigari	Radiation therapy treatment cases 2019: 246 cases 2020: 519 cases 2021: 280 cases	(Diagnosis) Pathology/hematology analysis, tumor markers, diagnostic imaging (ultrasound, general X-ray, CT, MRI) (Treatment) Surgery, radiation therapy using ELECTA linear accelerator, chemotherapy, palliative care

Source: Prepared by the Survey Team (responses from RBC to the questions of the Survey Team, Website of each hospital, telephone interview survey, quoted from NCCP 2020-2024)

As of March 2022, BCCOE's diagnostic imaging department is equipped with a general X-ray unit and mobile X-ray unit, which is operated by one radiology technician. A CT scanner and mammography unit, etc., are scheduled to be additionally installed by the end of 2022, and a radiologist will be assigned.

The Rwanda Cancer Center (RCC) is located on the premises of the Rwanda Military Hospital (RMH). RCC is equipped with two linear accelerators capable of intensity-modulated radiation therapy (IMRT)[14] and is staffed by six radiation oncologists and three medical physicists. One CT scanner and one MRI machine are installed at RMH, and one diagnostic imaging physician has been assigned to use them. No diagnostic imaging physicians are allocated to RCC. CT images at RMH are used to locate the irradiation position of the linear accelerator. The radiation oncologists create an irradiation field for treatment using the linear accelerator and determine treatment plans in consultation with medical physicists.

3.1.3 Status of Health Insurance

Rwanda has two main types of health insurance: public health insurance operated by RSSB (including the Fund for Support to Genocide Survivors) as mentioned in the below table and health insurance managed by private companies such as UAP Old Mutual Holdings and SANLAM Insurance, Investment and Financial Planning. Since KFH is the top referral hospital in the country, it is also used by financially well-off private insurance subscribers.

Table 10: Public Health Insurance Operated by RSSB

Name	Eligible persons	Enrollment rate	Contributions (Premiums)	Cost-sharing of medical care, benefits, etc.
RAMA: (Rwanda Medical Insurance Scheme)	Public servants and people working at companies	About 10% of all citizens	Employer: 7.5%、Employee: 7.5 % of monthly salary	If patients pay a specific contribution they can visit the best medical facilities like KFH. Patients pay 15% of medical expenses.

[14] An innovative irradiation technology that can concentrate radiation only on a tumor using a computer.

Name	Eligible persons	Enrollment rate	Contributions (Premiums)	Cost-sharing of medical care, benefits, etc.
				100% of diagnosis and treatment costs must be paid by the patient if they directly visit KFH or other top medical facilities.
CBHI: (Community Based Health Insurance)	People who do not work at companies	About 87% of the nation's population	3,000RF annually per person （subsidized by the government）	Bypass visits outside the referral system are not allowed, and even cancer patients must come to KFH after being diagnosed at a tertiary care facility such as CHUK, or a district hospital or health center. Co-payment is 10% of medical expenses. 100% of diagnosis and treatment costs must be paid by the patient if they directly visit KFH or other top medical facilities.
MMI: (Military Medical Insurance)	Military and their families	About 2 % of the total population	Employer: 7.5%、Employee: 8.5 % of monthly salary	Same as RAMA.
FARG: (Fund for Support to Genocide Survivors)	Genocide victims	About 1 % of all people	None	Similar to RAMA, but with no co-payment (100% free treatment and diagnosis)

Source: Prepared by the Survey Team based on the interview survey

When a CBHI subscriber cannot receive medical services that are exclusively provided by KFH (cardiovascular catheterization, brain surgery, kidney transplant surgery, etc.), the patient is referred to the Medical Referral Board (MRB) within the MOH, which administers a fund to provide advanced medical services for the poor.

If a CBHI subscriber requires advanced medical care, RMH is the final referral medical facility. The MRB will also cover medical expenses for patients who cannot be treated by RMH or who cannot be treated by KFH and must be transferred overseas for treatment.

3.1.4 Current Status of Cancer Diagnosis and Treatment

In Rwanda, cancer diagnosis and treatment are provided at the five medical facilities listed in Table 10. CBHI subscribers, who account for almost 90% of the population, undergo testing (HPV, mammography, ultrasound, biopsy, etc.) at higher-level medical facilities if cancer is suspected during cervical cancer tests and breast cancer palpation tests conducted at health centers and other facilities. Treatment is provided if they are identified as having cancer. Treatment that is currently available in Rwanda includes surgery, radiation therapy, chemotherapy, and palliative care.

For any of these procedures, patients must pay 10% of the total cost or 200 Rwf, which is a significant cost considering the transportation costs and consultation time required to access medical care.

Chemotherapy represents an even more significant financial burden because it is not covered by public health insurance, and this makes it difficult for CBHI patients who do not have sufficient income to receive treatment. At present, MOH and RSSB are discussing ways to create an environment whereby CBHI patients can receive chemotherapy. The BOOCE, with the cooperation of NGOs, provides free treatment and accepts many patients in need of chemotherapy, but the center has its limitations. There is also the issue of the geography within Rwanda. Butaro Sector is located in the northern part of Rwanda, and due to road conditions it takes more than 3 hours to travel there from Kigali, which places a significant financial and physical burden on patients.

An oncologist at BOOCE, commented, "In Rwanda, often cancer is diagnosed at a much advanced stage. If PET-CT is introduced at KFH, and PET diagnosis becomes available for CBHI members with a low income[15], it will lead to earlier detection and more efficient treatment planning. It will also lead to improved 5-year survival rates, and resource allocation for chemotherapy."

Rwanda is characterized by a low incidence of lung cancer and a high incidence of breast and cervical cancer. The low incidence of lung cancer is due to the low smoking rate but also a lack of diagnostic equipment and systems. On the other hand, breast and cervical cancer can be detected by physical examination without diagnostic equipment. As pointed out in Table 6, "Current Status, Challenges, and Strengths of Rwanda's Cancer Control," a lack of advanced diagnostic equipment delays the diagnosis and treatment of cancer, regardless of the site.

3.2 Overview of Cancer Medical Equipment Market in Rwanda/Status of Law and Regulations Related to Nuclear Waste Disposal

3.2.1 Nuclear Medicine Equipment Manufacturers

Medical devices related to cancer are diverse, including equipment for clinical testing, diagnostic imaging, surgery and rehabilitation. In this survey, only the medical device market for diagnostic imaging, with a focus on PET-CT/SPECT-CT, was investigated. The five leading manufacturers of PET-CT equipment that supply African markets are listed in Table 11 below. These manufacturers have not yet supplied equipment to Rwanda.

There is a Chinese manufacturer (United Imaging Healthcare) that manufactures PET-CT, has delivered to South Africa and other countries, and has expressed a desire to expand into Rwanda. However, it has no plans to enter the Rwandan market at this time.

[15] MOH and RSSB are currently in discussions to establish additional insurance service to cover advanced medical diagnosis/treatment for CBHI people as of April 2022.

Table 11: PET-CT/SPECT-CT Manufacturers and their Response to the Rwandan Market

Manufacturers	Primary country of origin of product	Response to Rwanda
GE Healthcare Systems	USA, the EU, Japan, India, and others	Supplies and services can be provided through local distributors.
SIEMENS Healthineers	Germany and others	
United Imaging Healthcare	China	Maintenance and inspection staff can be stationed on-site once product is installed.
Philips Healthcare	Netherlands and others	Future expansion plans are unknown.
Canon Medical Systems Corporation	Japan	Exports are not possible because there are no local distributors that can handle maintenance.
Shimadzu Corporation	Japan	Only manufacturers PET-CT for breast scans. Exports are not possible because there are no local distributors that can handle maintenance.

Source: Prepared by the Survey Team through the interview

Three leading cyclotron manufacturers can supply the Rwandan market, and their activities are shown in Table 12 below. None of these manufacturers has a track record in regard to supplying Rwanda.

Table 12: Cyclotron Manufacturers and their Response to the Rwandan Market

Manufacturers	Product country of origin	Response to Rwanda
Ion Beam Applications (IBA)	Belgium, France	Supply and service available through SIEMENS distributors.
Sumitomo Heavy Industries, Ltd.	Japan	No local distributor
GE Healthcare Systems	USA	Can be supplied together with PET-CT.

Source: Prepared by the Survey Team through interviews

3.2.2 Operation and Management System for Nuclear Medicine Equipment

The effective use of nuclear medicine equipment such as PET-CT requires training as well as the education of equipment users. Know-how is needed to manage patients before and after imaging, to read and diagnose images, respond to test reports, handle radioactive chemicals, import raw materials for reagents (fluorodeoxyglucose (FDG))[16], manufacture test drugs, conduct accuracy tests, and dispose of radioactive waste.

The administrative tasks for safely running a nuclear medicine facility are critical. While it is technically possible to introduce this operational know-how separately and integrate a

[16] It is a drug similar to glucose and was initially used to see the glucose metabolism of organs, mainly the glucose metabolism function of the brain. It is still used to observe brain and heart functions. Still, it is very effective for identifying primary cancer sites and diagnosing infiltration, metastasis, recurrence, etc., by FDG-PET examination.

management system, this requires a high level of operational capability from project managers. In regard to these issues, GE Healthcare Systems and Siemens Healthineers have a lot of experience providing integrated services for PET-CT operation systems. A system can be easily set up to begin operation immediately after equipment procurement by utilizing one of their comprehensive packages.

Siemens Healthineers, through its sole distributor International General Equipment (IGE), accounts for 90% of the nuclear medicine market share in Tunisia and has supplied 3 PET-CT units and 12 gamma cameras to Tunisia. IGE has already confirmed that when a new nuclear medicine facility is established in Rwanda, it can provide comprehensive training in cyclotrons, ancillary equipment, FDG dispensers, and other equipment by dispatching Tunisian physicians to Rwanda. The company will also offer additional opportunities for personnel exchanges, such as sending Rwandan physicians to Tunisia.

3.2.3 Status of Laws and Regulations Related to Nuclear Waste Disposal

The Nuclear & Radiation Protection Division of the Rwanda Utilities Regulatory Authority (RURA) is developing nuclear medicine laws and regulations, and inspection compliance. Currently, the Rwanda Standard Board is in charge of radiation-related regulations and inspections, but once legislation is prepared assessments may be transferred to RURA.

Nuclear medicine-related laws and regulations are currently being drafted by several officers trained in nuclear medicine-related laws and regulations at the IAEA and also by jurists. They have received training in medicine-related atomic laws and rules in France.

The final drafts of documents A. to D. below will be formulated by June 2022, this will be followed by scrutiny by the IAEA and consultation with the Rwanda Atomic Energy Board (RAEB). Upon approval by the RURA Board of Directors, they are expected to be officially put into effect by the end of December 2022.

A. Laws and regulations, guidelines, and standards related to the construction of nuclear medicine facilities and equipment installation that must be complied with.
B. Administrative procedures related to the installation of advanced diagnostic equipment (PET-CT) that contains a cyclotron for isotope manufacturing (including imports).
C. Technical procedures regarding installing advanced diagnostic equipment (PET-CT) that contains a cyclotron for isotope manufacturing (Design standards, etc.).
D. Handling of radioactive waste related to nuclear medicine, availability of waste storage facilities, etc., and related laws and regulations.

On the other hand, regulations and standards to be complied with for each project have been prepared according to the IAEA, and it is possible to construct facilities, import and install advanced equipment, etc., without having to wait for the above documents to come officially into force.

The Nuclear & Radiation Protection Division of RURA is a new division that was established in 2019, and it is vigorously working on nuclear-related laws and regulations as a part of government policy. It is also responsible for the code of planned nuclear power plants.

Even before the promulgation of these new laws, there are no problems with proceeding with the design and construction of nuclear medicine-related facilities with reference for IAEA guidelines. After the new laws have been promulgated, it is believed that adjustments can be made as necessary to other Rwandan laws and regulations. In general, as IAEA guidelines have stricter requirements there should be no problems as long as their guidelines are met.

The Rwanda Atomic Energy Board (RAEB) has already been established to promote a nuclear energy policy. Specifically, RAEB promotes the establishment of facilities in various research fields (agriculture, environment, and nuclear medicine, etc.).

3.2.4 Procedures for the Construction of Nuclear Medicine Facilities and Equipment Installation

Both facility construction and equipment installation will proceed under the supervision of RURA at the request of the end-user (KFH in this case), as noted in Table 13 below. The following procedures shall be observed even for business plans that include a cyclotron (inside the hospital or on the premises).

Table 13: Steps from planning and application to operation of nuclear medicine facilities

Step	End-User (KFH)	RURA （Approval Body : Board）	
1	Explanation of business plan	Site survey and inspection of construction (installation) sites	Approval
2	Preparation of technical specifications and bid documents such as planning drawings (Prepared by RURA standard specifications and regulations)	Inspection of contents of technical specifications and bid documents Consultation with RAEB as needed	Approval
3	Bidding, contract negotiation, and contracting	Not Applicable	
4	Commencement of procurement, installation, and construction work	Not Applicable	
5	Completion of delivery, installation, and construction Delivery and Commission Inspection	Inspection results are submitted to the RURA Board in the presence of the three parties (client, contractor, and RURA)	Approval
6	Commission completed （signed by the client, contractor, and RURA as Witness. ）		Approval
7	Handover of facilities and equipment → Operation		

Source： Prepared by the Survey Team (based on the interview with RURA)

Therefore, it is essential to closely exchange information with Nuclear and Radiation Protection Department of RURA from the early planning stages and seek technical assistance from time to time.

3.2.5 Information on Radioactive Medical Waste

A small temporary storage facility for radioactive medical waste is currently being prepared. As of March 2022, land acquisition has been completed, site inspection of the proposed construction site has been completed, bidding has been conducted, and the shield structure inside the storage tank is currently being designed with the technical advice of IAEA experts. Installation completion is planned for by the end of December 2022.

Chapter 4: Overview of King Faisal Hospital

4.1 Organization and Management Structure

The Rwandan government funded the initial investment for the hospital, and the facility is a public medical facility that was constructed with the cooperation of Saudi Arabia. Since KFH was built with this cooperation, the hospital was named after King Faisal of Saudi Arabia. The hospital has been responsible since its opening for managing and operating the facility autonomously. All income (public and private insurance funds, etc.) is governed by the Board of Directors and is used for operational expenses. Any profits generated are used for investment in future hospital facilities and clinical activities.

As the top referral hospital in the country, it provides more advanced medical care than other medical facilities and more medical services than referral hospitals. For this reason, the medical fees are set higher than those of other public medical facilities. The hospital also accepts patients from abroad at 100% patient cost (kidney transplants, cardiovascular catheters, MRI scans, etc.). The Corporate and Administration Division has seven staff members, and the latest organization chart as of December 2021 can be seen below.

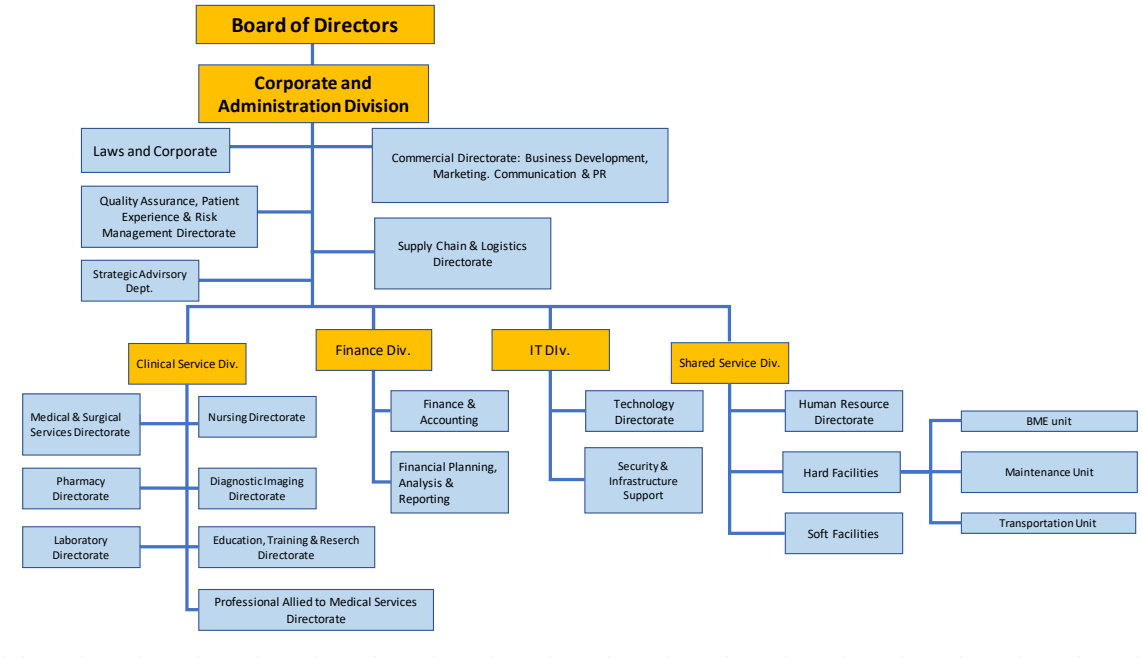


Figure 4: KFH Organization Chart

Source: Prepared by the Survey Team based on KFH information

4.2 Implementation Structure and Services

The implementation structure is shown in the organizational chart in Figure 4, with the Clinical Services Division being under the Corporate and Administration Division.

Large-scale capital investments, such as renovation work to obtain the Council for Health Service Accreditation of Southern Africa (HAS - a hospital accreditation body in South Africa) and the maintenance of medical equipment, are funded by the government through MOH. On the other hand, KFH has borrowed money from a bank to install a cardiovascular angiography system for catheterization to increase the hospital's income, and despite being a public medical facility it has independent management.

It is a facility that provides the highest level of medical care in Rwanda, and it has specialized clinical departments such as neurosurgery, cardiovascular surgery, orthopedics, cardiology, urology, pediatrics, and oncology, as well as their supporting diagnostic imaging and clinical laboratory departments. Eighty-five specialists are on staff, and the hospital has an average of about 72,000 outpatients and 8,000 inpatients per year (Source: KFH questionnaire responses and interviews). KFH management policies are shown in Table 14.

Table 14: KFH Management Policies (Vision, Mission, and Values)

Vision	To be a center of excellence in health care delivery, clinical education, and research
Mission	To provide quality special care, clinical training, and research
Values	Quality care, Compassion, Accountability, Integrity, Professionalism, Innovation, and Teamwork

Source: Prepared by Survey Team quoted from KFH website

A radiologist and the hospital director are involved in planning PET-CT installation. Creating a project team with more people is needed to implement this installation plan during the implementation phase.

KFH is in the process of focusing on equipment for non-cancer-related operating rooms, ICU equipment, etc., and renovating and expanding the hospital (construction of laundry facilities, outpatient clinics, etc.) in order to obtain international accreditation by HAS.

4.3 Financial Situation

Table 15 below shows KFH's revenue for the last four years.

Table 15: KFH's Revenue Trends

Unit: Amounts in Rwandan francs

Item/Year	FY 2018	FY 2019	FY 2020	FY 2021
Revenue Amount (USD in parentheses)	10,211,659,280 (9,803,192)	11,558,329,608 (11,095,996)	11,503,242,174 (11,943,112)	12,327,140,739 (11,834,055)

Source: Prepared by the Survey Team based on KFH question responses and interviews

COVID-19 made it impossible to travel between Kigali and rural areas during 2020 and for part of 2021, and fewer patients were admitted. On the other hand, revenues increased due to the extension of newly-launched catheterization and MRI imaging in the cardiology department and other departments.

As shown in Table 16, all revenues come from insurance including some cash self-pay, and as the hospital offers advanced medical services the most significant percentage of patients are privately insured, followed in turn by RAMA members (civil servants and company employees). Other patients are members of FARG, who have been identified as genocide survivors, and 15% of patients are under CBHI, which covers 87% of the population.

KFH provides services with certain user charges described in Table 17 that referral hospitals such as CHUK, CHUB, and university teaching hospitals cannot offer. Since CBHI patients who follow the referral system can receive diagnosis and treatment at 15% of cost, a certain number of CBHI patients are admitted to the hospital.

Table 16: KFH Revenue Breakdown for 2021

Amount (RWF)

Item	Amount	Percentage
RSSB・RAMA	3,121,831,349	25%
RSSB・CBHI	1,801,229,372	15%
FARG	2,380,194,033	19%
MMI	1,026,077,339	8%
Private Insurance	3,997,808,646	33%
Total revenue	12,327,140,739	

Source: Prepared by the Survey Team based on information from the KFH

(※ Note that the above private insurance includes cash self-pay)

Table 17: Major Diagnostic Unit Prices

Item	Unit price（RWF）
CT examination（without contrast）	60,000～80,000
Breast ultrasonography	10,000
Breast ultrasound-guided biopsy	30,000
X-ray examination	10,000～15,000
MRI imaging	Approx. 160,000
Flow cytometry examination	Approx. 30,000
Cryostat	6,000
Hospitalization fee Private room per day	55,000
ICU	150,000

Source: Prepared by the Survey Team based on information from the KFH financial division

Chapter 5: Overview of Cancer Care Services at King Faisal Hospital

5.1 Overview of Cancer Care Services (Overview of Cancer Care Facilities and Equipment, etc.)

In 2020, the number of inpatients decreased due to COVID-19, but the number of patients increased. About half of MRI patients are suspected cancer patients. Table 18 below shows the clinical activities of the oncology department at KFH, including outpatients, inpatients, and diagnostic imaging.

Biopsies are performed under ultrasound guidance, and about 25 breast biopsies are performed per month. Biopsies of the liver and muscles are also performed and diagnosed by the pathology department in the hospital. Two to three intraoperative pathology examinations using a cryostat (cold sectioning device) are performed per month. Most of the samples from public hospitals are received from CHUK. Pathology samples are also accepted from private hospitals.

Table 18: Clinical Activity Data of the KFH Oncology Department

Item	2018	2019	2020	2021
Cancer-related outpatients	1,087	1,753	2,328	NA
Cancer-related inpatients	312	325	265	NA
Diagnostic imaging tests (CT)	3,816	4,858	3,766	3,858
Diagnostic imaging tests (MRI)	6,290	6,667	3,676	8,901
Endoscopy	N.A	600	2,400	NA
Ultrasonography	5,675	5,713	5,536	818
General X-ray	11,570	10,555	9,876	11,931
Fluoroscopic examination	NA	NA	556	6,416
Mammography examination	NA	NA	704	889

Source: Prepared by the Survey Team based on KFH question responses (NA: Not Available))

The Tumor Board (an interdisciplinary organization) in the hospital decides on diagnose and treatment plans based on imaging such as MRI, CT, general radiography, and subjective symptoms such as bleeding, lumps, etc. KFH offers surgery and a certain level of chemotherapy (anticancer drugs, immunotherapy, hormonal therapy, etc.). CV port (subcutaneous port), in which anticancer drugs are continuously administered through a port in the chest, is also being tested.

5.2 Cancer Diagnoses (including Details of Services and the Level of Technology)

Although the hospital is equipped with a certain amount of radiological, diagnostic imaging, and pathology-related equipment necessary for cancer examinations, the diagnostic imaging equipment, except for the MRI machine and CT scanner, is about ten years old and is deteriorating as described in Table 19. This equipment should be replaced as soon as possible.

Doctors at KFH have studied in Europe, including Belgium, France and other European countries, and provide medical services that are close to the international level.

Table 19: Major Cancer-Related Diagnostic Equipment

（Radiology and Diagnostic Imaging）

Type/Equipment	Summary
MRI (1 unit)	About half of all MRI scans are for cancer diagnosis. Reservations are booked up to one month in advance. This was procured with the Rwandan government budget in 2020 and is under free warranty.
CT (1 unit)	Procured in 2017. This equipment is under a maintenance contract with a local distributor.
General X-ray Unit (2 units)	This equipment is more than ten years old, and there are concerns about the deterioration of its functionality. One of the two units is digital.
Fluoroscopy Imaging Unit (1 unit)	This is used for examination of the upper and lower gastrointestinal tract. This equipment is more than ten years old, and there are concerns about the deterioration of its functionality.

Type/Equipment	Summary
Mammography Unit (1 unit)	Biopsies are performed using an ultrasound scanner. It is used for breast cancer diagnosis. This equipment is more than ten years old, and there are concerns about the deterioration of its functionality.
Ultrasound Scanner (1 unit)	This equipment is more than ten years old, and there are concerns about the deterioration of its functionality.

（Pathological Diagnosis）

Type/Equipment	Summary
Pathology Diagnostic Equipment	All the equipment used for cytopathological diagnosis (pretreatment, embedding, sectioning, staining, and speculum) is available. It is also available for the training of students and resident staff. Immunostaining is not possible.

Source: Prepared by the Survey Team based on the field interview.

5.3 Cancer Treatment (including Details of Services and the Level of Technology)

Most cancer surgeries are performed in Rwanda, although patients with complicated cases at KFH are referred to India and other countries. After surgery, treatment is continued with chemotherapy and radiotherapy (provided by RMH), with the aim of complete cures and palliative care.

Major equipment for cancer treatment at KFH is described in Table 20.

Table 20: Major Equipment for Cancer Treatment

Type	Summary
Surgery	The operating room is equipped with and utilizes a full range of equipment, including contrast-free lights, operating tables, anesthesia machines, electrocautery, and suction device.
Chemotherapy	Procurement of drugs is not sufficient, and medical services are provided with a limited range of drugs. Equipment is limited and includes chairs, patient beds, treatment tables, infusion pumps, syringe pumps, etc.

Source: Prepared by the Survey Team based on field survey

5.4 Oncology-Related Healthcare Professionals (Staffing Allocation and System, In-Service Training, etc.)

5.4.1 Status of Cancer-Related Medical Staffing, etc.

Table 21 shows the educational level of human resources and their deployment in clinical departments in relation to cancer patients at KFH.

As of December 2021, the University of Rwanda (URW) and the University of Global Health Equity (UGHE) are the country's only two medical education institutions. URW offers master's degrees in anesthesiology, internal medicine, obstetrics and gynecology, pediatrics, surgery, anatomic pathology, otolaryngology, orthopedics, urology, and neurosurgery. There are also courses in pediatric nursing, medical-surgical nursing, nephrology nursing, neonatal nursing,

oncology nursing, and leadership and management in the nursing field.

Table 21: Medical Staff in Cancer-Related Clinical Department

Clinical department	No. of Physicians	No. of Paramedics	No. of Support staff	Level of education/training
Oncology	2 Physicians	Oncology Nurse (2) general nurse (2)	2 people	- Oncologists (Master's level) - Oncology Nurse (Masters level) - General Nurse (Bachelor's level)
General surgery	5 Physicians	General Surgery Nurse (4)	Shared with other clinical departments	- General surgeon (Masters level) - Nurse (Bachelor's level)
Diagnostic imaging department	3 Physicians	Radiology Technologist (11) Sonologist (2)	Health Care Assistant 1, Nurses 1	Of the three physicians, the department head studied nuclear medicine in Belgium and has 2 to 3 years of experience in the interpretation of radiograms in nuclear medicine Radiologist （Bachelor or Diploma level） Sonologist （Bachelor level ）
Pathology department	4 Physicians	Histopathology Technician (3） Laboratory Technologist (27)	N/A	1 Physician (Hemato Pathology) 3 Physicians (Anatomy Pathology)

Source: Prepared by the Survey Team based on KFH question responses

5.4.2 In-Service Training for Cancer-Related Healthcare Professionals

In-service training for oncology-related healthcare professionals is being planned and implemented. The twenty-one oncology-related in-service training courses currently being offered in December 2021 and scheduled to be offered in January 2022 are listed in Table 22 below. These courses are provided for KFH staff using KFH funds. In the future, KFH plans to develop in-service training for healthcare professionals in other public healthcare facilities with the cooperation of the RBC Cancer Unit and others.

Table 22: List of Cancer-Related In-Service Training Conducted or Scheduled at KFH

Course	Target	Duration	Goal
Course for identification and appropriate management of toxicity of chemotherapy, molecular targeted therapy, and immunotherapy (already started)	Oncologists and Oncology Nurses	1 week	Understand the significant adverse effects associated with systemic therapies and their management
Course for oncology emergencies (already started)	Oncology Nurses	1 week	Recognize and understand timely management of oncological emergencies
Course for the introduction of radiation therapy-related adverse effects (scheduled to start in January 2022)	Oncology Nurses	1 week	Recognize, manage and reference radiation therapy-related toxicities.
Course for psychosocial support for cancer patients (scheduled to start in January 2022)	Oncology Physicians, Oncology Nurses, and Social Workers	1 week	Understand, appropriately handle and refer to psychological issues related to the diagnosis and management of cancer.
Course for placement and maintenance of portable implants for chemotherapy (scheduled to start in January 2022)	Oncology Physicians, Oncology Nurses	1 week of training and later validation period	Understand the way to insert portable implants, their complications, and manage complications

Source: Prepared by the Survey Team based on KFH question responses

Chapter 6: Planning the Installation of Nuclear Medicine Equipment at KFH

6.1 Survey Process and Outline of Introduction Plan

This survey is being conducted based on the strong intention to improve medical services at KFH as a referral hospital for medical tourism policy in the future. Since Rwanda recognizes that Japan has a great deal of knowledge on nuclear medicine diagnosis, including nuclear waste disposal, a request letter was submitted to the Embassy of Japan in Rwanda in April 2021.

Based on the survey results of the actual conditions of cancer care in Rwanda, the team has compiled a concept paper on individual aspects of cancer care in Rwanda, including a priority introduction plan for equipment, human resource training, investment costs, and annual expenditures. The survey team also considered the planned equipment, human resources required for the operation of a nuclear medicine facility, and a payment plan for maintenance costs, as described in the request letter.

The Survey Team gave an explanation about this concept paper to the Chief Medical Officer (CMO) and the Head of the Radiology Department of KFH, who originally drafted the request letter. Based on the concept paper, it described the input costs and expected number of patients required to develop advanced medical equipment, especially PET-CT.

The Survey Team further explained that the concept paper needs to be further updated based on the results of a site visit by Professor Toyama, a nuclear medicine specialist and a radiologist

who was later dispatched as a member of the second survey team. The team explained that the concept paper needs to be further brushed up as a starting point for further discussions on establishing a framework for Japanese cooperation.

In particular, the development of human resources in nuclear medicine is of great interest to the Rwanda side. In his capacity as a medical specialist, Professor Toyama surveyed and evaluated the current level of the cancer-related medical skills of medical professionals in Rwanda, especially those at KFH, during the second survey. He provided specific suggestions on how it would be appropriate to work with Japan (specifically universities in Japan) to develop human resources, how nuclear medical care should be provided, and how to promote the development of nuclear medicine equipment. The figure below shows the survey process in chronological order.

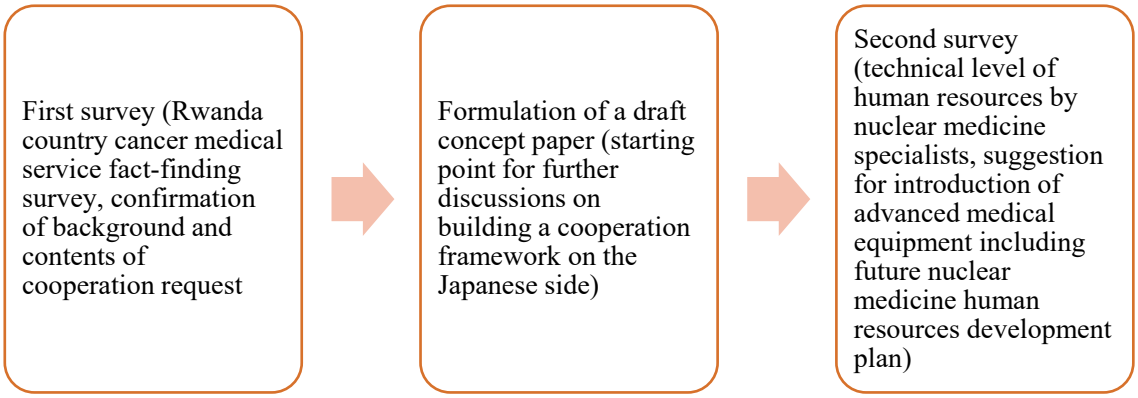


Figure 5: Survey Process in Chronological Order

Source: Prepared by the Survey Team

The second survey results showed that the introduction of PET-CT in Rwanda would be beneficial for the improvement of cancer diagnoses. The survey also reaffirmed that PET-CT would make it possible to perform systemic treatment and activity assessment of the foci of infections and inflammatory diseases typical in Africa, such as fevers of unknown origin, tuberculosis, amebic dysentery, brucellosis, and tumors.

In addition, Rwanda is likely to become a diagnostic center for cancer treatment for neighboring countries since the only other nuclear medicine facility is located in Kenya, in East Africa. In regard to human resource development, physicians who work at nuclear medicine facilities in Rwanda could possibly be accepted onto a Japanese government scholarship and trained in the Department of Diagnostic Imaging at Medical University in Japan for a master's degree (2 years) or PhD degree (4 years). Alternatively, the IAEA is planning to implement a nuclear medicine-related human resource development program which would provide financial support for the development of nuclear medicine personnel.

The cooperation concept is assumed to start with the introduction of a PET-CT and cyclotron specialized for oncology, which KFH considers to be its highest priority. The team has proposed to install two PET-CT units to avoid wasting the FDG that can be extracted from one cyclotron. Since the gamma camera effectively diagnoses cancer in the bone region and in the neurosurgery field, it would be arranged so that this can be introduced in the second phase of the project.

The equipment development, facility development (including the proposal of the location of the nuclear medicine facility on the premises), human resource allocation, annual maintenance costs, and the amount of investment required for each phase are shown below. Furthermore, the flow is shown in chronological order of the processes needed to establish a nuclear medicine facility.

Improvement Plan

Table 24 below shows the differences between PET-CT and gamma cameras. PET-CT can be widely applied for imaging cancer across a whole body, while gamma cameras can be applied mainly for imaging cancer in bone areas.

Considering the high incidence of cancer, and that most cancers are detected at an advanced stage, it is appropriate to prioritize cancer diagnosis and develop equipment and facilities accordingly under two phases described in Table 23.

Table 23: Improvement Plan
(Comparison of KFH Request and Survey Team Recommendations)

Request from KFH	Survey Team Recommendations
PET-CT System Gallium Generator Medical Cyclotron Gamma Camera Molybdenum Generator Dose monitoring & calibration devices	First Phase PET-CT System – Two units Medical Cyclotron – One unit Dose monitoring & calibration device – One set Construction work required for the installation of the above (including building structure work for second phase) Second Phase Gamma Camera（SPEC-CT) – One unit Molybdenum Generator – One unit Interior work required for the installation of the above

Source: Prepared by the Survey Team based on the request letter from KFH

Table 24: Differences between PET-CT and Gamma Cameras

Item	PET-CT	Gamma Camera (SPECT-CT)
Principle of imaging	Positron emission tomography	Single-photon emission tomography
Applicable diseases	Observation of biological function: Tumor, epilepsy, ischemic heart disease, etc.	Observation of biological function: Cerebrovascular disease, heart diseases, tumor, bone, etc.
Time of Imaging	Approx. 30 minutes	Several minutes to tens of minutes
Typical isotope for imaging	18F-FDG	99mTc
Radioactive half-life	109.771 minutes	6.015 hours
Isotope production method	On-site production by cyclotron. It can be purchased externally if there is a cyclotron nearby.	On-site production using a molybdenum generator. (The half-life of molybdenum used is 65.9 hours, it can be imported)
Features	▪Possible to take full-body range images. A tomographic image can be obtained. ▪A radioactive isotope must be produced immediately before administration by a cyclotron or other means ▪Two gamma-rays (photons) are emitted. ▪Measurement is made by many gamma-ray detectors arranged around the human body.	▪Possible to take full-body range images. A tomographic image can be obtained. ▪Uses inexpensive and easy-to-handle common radioactive isotopes ▪A single gamma-ray (photon) is emitted ▪Consists of two to three detectors. ▪Measurements are taken while moving around the patient.
Corresponding diseases	Mainly cancer. Others (epilepsy, Alzheimer's disease, ischemic heart disease, large vessel vasculitis), etc.	Cerebrovascular disease, Parkinson's disease, Lewy body dementia, cardiac sympathetic nerve function, bone scintigraphy (bone cancer), thyroid cancer, etc.

Source: Prepared by the Survey Team

6.2 Facility Plan

Prototype Nuclear Medicine Facility (Including future expansion area for gamma camera installation)

The facility development, as presented with a prototype layout in Figure 6, will be divided into two phases, which is shown in Table 23. In the first phase, two PET-CTs, a cyclotron, a hot laboratory, and other equipment will be installed, and only the building structure of the expanded part will be constructed. It is proposed that the interior construction for the gamma camera (SPECT-CT) and other ancillary equipment takes place in the second phase.

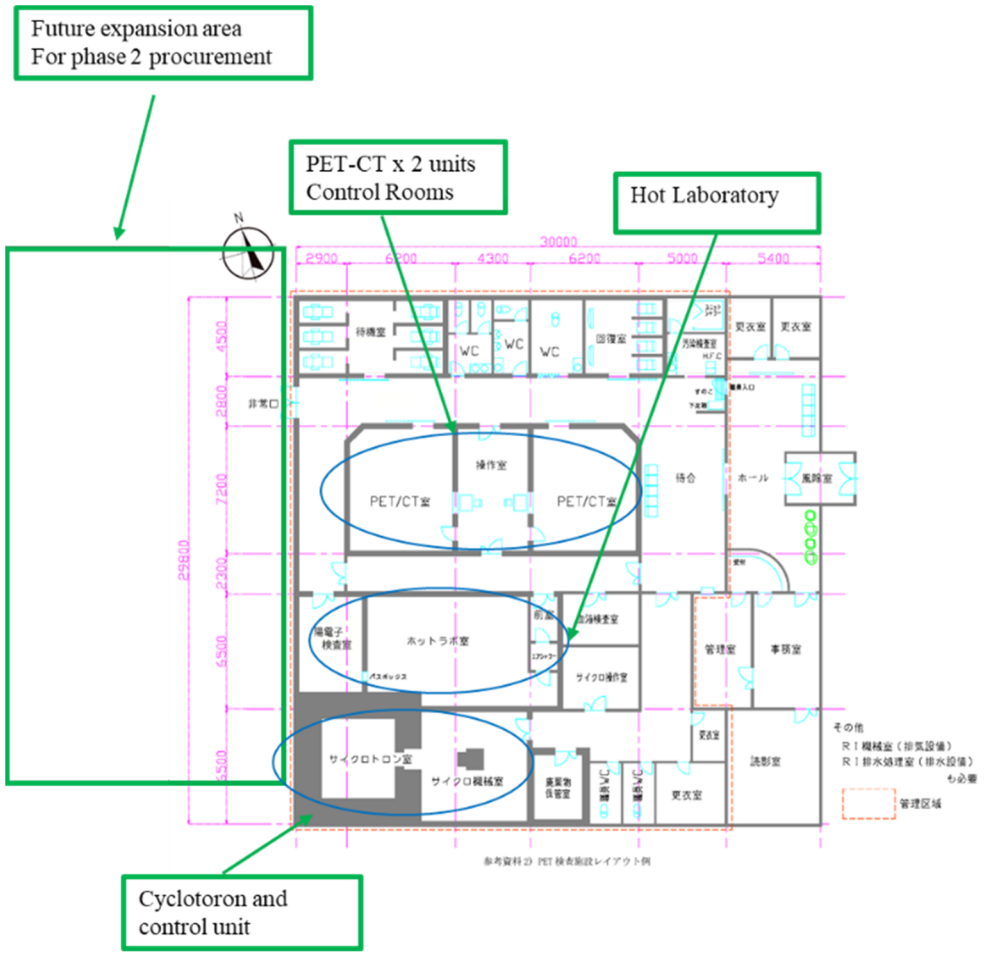
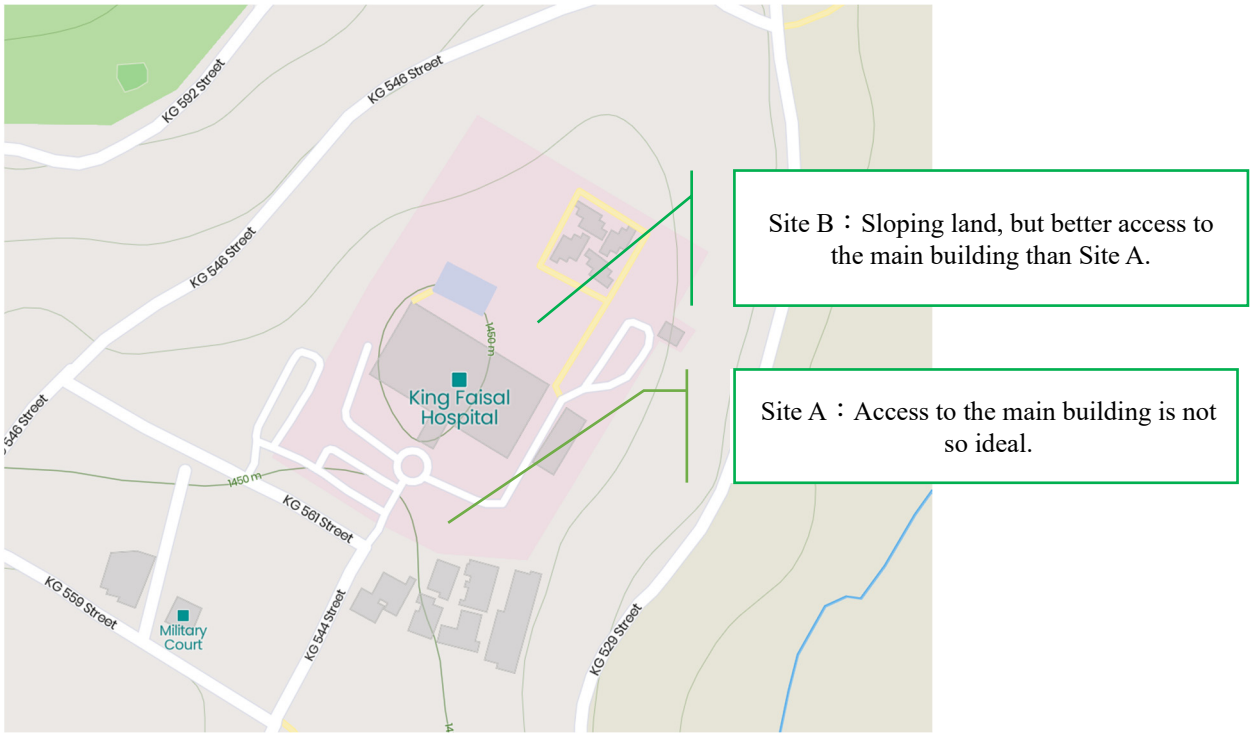


Figure 6: Nuclear Medicine Facility Layout (Prototype)

Source: Adopted from the Japan Medical Imaging and Radiological System Industries Association (established in December 2008, revised on October 31, 2018)

Candidate construction site and consultant's recommendation

KFH is currently working with RBC to develop a hospital development master plan, and a potential site for the nuclear medicine facility is to be included in the master plan. The CEO wanted to build on Site A (presented in Figure 7), but the survey team recommended Site B due to the distance from the existing diagnostic imaging department and medical facilities.



Source： Prepared by the Survey Team based on the information on https://mapcarta.com/33150286 （Access: 11th Dec.2021）

Site A | Site B

Source: Survey Team (photographed on Dec. 2021)

Figure 7: KFH Vicinity Map and Site Photo

The nuclear medicine facility requires power supply facilities (including power distribution panels and generators from electric power companies, solar power generation facilities, an uninterruptible power supply, etc.), general water supply facilities, medical and special gas supply facilities, general wastewater treatment facilities, temporary tanks for radioactive wastewater, and a radioactive waste temporary storage area.

6.3 Outline of Business Plan

6.3.1 Facility and Equipment Development Plan

Future medical services include a plan to develop a system to accept medical tourism patients from neighboring countries and cancer patients from foreign countries. The plan is to construct the first nuclear medicine service facility in Rwanda, one that also has diagnostic and testing equipment.

The project will be implemented in two phases (First Phase and Second Phase), taking into account the scale of the project, investment efficiency, and beneficial effects. The project aims to construct a dedicated facility and equip it with two PET-CT units, a gamma camera (SPECT-CT), a medical cyclotron, and related equipment.

6.3.2 Project Cost Estimate and Breakdown

The estimated project cost (investment) is approximately 2.117 billion yen. The estimated project cost per phase is shown in Table 25, and the breakdown is shown in Table 26.

Table 25: Estimated Project Costs for Each Phase

(1USD=115JPY)

Project Phase	U.S. dollar (USD)	Japanese Yen
First Phase	13,659,000	Approx.1.57 billion
Second Phase	1,802,052	Approx.207 million yen
Total	15,461,052	Approx.1.78 billion yen

Source: Estimated by the Survey Team

Table 26: Estimated Project Cost Details for Each Phase (USD)

(First Phase)

No.	Equipment Name	Quantity	Unit price (USD)	Amount (USD)
1	PET-CT	2	1,909,091	3,818,182
2	Medical cyclotron	1	3,072,727	3,072,727
3	Construction costs, including a building structure for the second phase	1	4,881,818	4,881,818
4	FDG syringes apparatus	1	272,727	272,727
5	Dispenser isolator	1	90,909	90,909
6	Automatic dispensing system	1	59,091	59,091
7	Quality control system	1	136,364	136,364
8	Laboratory equipment etc.	1	90,909	90,909
9	Training costs	1	209,091	209,091
10	Multi-year maintenance costs for PET and cyclotron	1	909,091	909,091

No.	Equipment Name	Quantity	Unit price (USD)	Amount (USD)
	(three years)			
11	Medical consumables (three years)	1	109,091	109,091
12	Facility maintenance costs (three years)	1	9,000	9,000
	Total			13,659,000

(Second Phase)

No.	Name of Equipment	Quantity	Unit price (USD)	Amount (USD)
1	Gamma camera (SPECT-CT)	1	1,131,880	1,131,880
2	Molybdenum generator	1	10,000	10,000
3	Maintenance cost of gamma camera (three years)	1	272,727	272,727
4	Medical consumables	1	100,000	100,000
5	Training costs	1	104,545	104,545
6	Facility maintenance cost (three years)	1	9,000	9,000
7	Facility interior construction costs	1	173,900	173,900
Total				1,802,052

Source: Estimated by the Survey Team based on its findings for medical equipment and supplies and maintenance costs.

6.3.3 Human Resource Allocation Plan

Human resources to be assigned to the nuclear medicine facility and the roles of each position

Rwanda has no nuclear medicine facilities. The number of human resources who have operational experience in equipment such as PET-CT is limited; personnel who do have such experience gained it overseas. Securing experienced medical personnel is needed if a nuclear medicine facility is to be developed under this project. There are three possible approaches to obtaining human resources: (1) educate and train personnel already employed by KFH and reassign them to nuclear medicine facilities, (2) recruit and train new personnel from outside the hospital, or (3) obtain support (dispatch staff) from manufacturers, etc.. This project promotes the placement of human resources by combining (1) and (2). Since physicians in the radiology and oncology departments can also serve concurrently, it is possible to allocate human resources across these departments. If new employment is unsuccessful, then it may be needed to include approach (3) while promoting on-site human resource development.

The most effective approach is to proceed with on-site educational training at the exact timing of equipment installation in collaboration with equipment manufacturers. Personnel with basic knowledge of science and technology can acquire a full range of operational skills for a PET-CT and cyclotron following three to six months of training by the manufacturer, and this includes being able to obtain a basic knowledge of nuclear medicine.

However, it is crucial to consider approach (3), and to receive support from the technicians of

manufacturers to improve the technical skills of relevant staff, with the basic aim of continuously improving medical services. The human resource plan required under the business plan is shown in Table 27 below.

Table 27: Human Resources to be Assigned to the Nuclear Medicine Facility

KFH Staffing plan (persons)	Project Staffing plan (persons)
Nuclear medicine physicians (2) Nuclear medicine technologists (4) Radiation pharmacists (4) Nurse dispensers (3) Biomedical engineers (2) Nuclear physicians (2)	(First Phase) Facility manager (1) Nuclear medicine physician (1) Nuclear medicine technologists (3) Radiation pharmacist (1) Nuclear medicine nurse (nurse and nursing assistant) (2) Nuclear physics technician t (1) Biomedical engineers (2) Cleaners (4) Security guards (9) (Second Phase) Nuclear medicine physician (1) Nuclear medicine technologist (1) Nuclear medicine nurse (1) Cleaner (1) Security guards (3) Biomedical engineer (1)

Source: Prepared by the Survey Team based on the request letter from KFH

The job title and roles and responsibilities of the medical personnel required to be deployed in this project are shown in Table 28 below.

Table 28: Roles of Medical Personnel Positions at a Nuclear Medicine Facility

Job Title	Role/Responsibility
Facility manager	Responsible for the overall management of the facility and equipment.
Nuclear medicine physician	Perform image analysis and diagnostic imaging.
Nuclear medicine technologist	Perform PET-CT operations.
Radiation pharmacist	Responsible for the preparation of FDG and its quality control.
Nurse/dispenser	Responsible for injecting FDG into patients, health observation, etc.
Assistant nurse/dispenser	Assists in all aspects of patient care services, from reception, guidance, and examination to going home.
Biomedical engineer	Maintains the medical equipment in the nuclear medicine facility in cooperation with the agency and others.
Nuclear physic technician	Responsible for cyclotron management, operation, and safety.
Cleaner	Receives specialized instruction in nuclear medicine facility cleaning and ensures safe cleaning.
Security guard	Provide professional guidance for the security of the nuclear medicine facility and perform security safely and appropriately.

Source: Prepared by the Survey Team based on the request letter from KFH

6.3.4 Operational and Maintenance Expense

Annual expenditures (personnel and other expenditures)

In order to reduce the initial operating costs, it is believed to be reasonable to include within the procurement budget the maintenance costs for the cyclotron and PET-CT, facility maintenance costs, and costs for consumables, for the first three years, and to also consider this as a method for establishing a foundation for financial self-sufficiency.

Table 29 below shows the breakdown of this project's estimated operation and maintenance costs. Annual expenditures are forecasted as shown in the table below.

Table 29: Estimated Annual Operation and Maintenance Costs

(1USD=115JPY)

Expenses	Estimated Cost (USD)	Estimated Cost (JPY)
Personal expenses	726,400	83,536,000
Maintenance (PET-CT and Cyclotron)	200,000	23,000,000
Consumables	738,636	84,943,140
Electricity	20,000	2,300,000
Medical gas	10,000	1,150,000
Facility maintenance	3,000	345,000
Total	1,698,036	195,274,140

Source: Estimated by the Survey Team (personnel costs are based on KFH cooperation request letter; all other expenses were estimated by the Team)

In addition, operating a Hot laboratory requires the procurement of consumables such as those listed in Table 30 below. If the variable cost is assumed to be 87 dollars per patient for 3,000 patients in a year, it is estimated that about 260,000 dollars (about 30 million yen) will be required.

Table 30: List of Consumables

For FDG[17] production	For FDG injection	For Waste Disposal
Materials for FDG production Medical gas FDG inspection material	Special syringes Tubes for extraction from the cyclotron to syringes (GE 650USD/set)	Waste bags Disposal boxes Drum cans Land for the temporary storage of nuclear materials

Source: Prepared by the Survey Team

[17] FDG consists of F (fluorine) and DG (deoxyglucose: a type of sugar that is very similar to glucose). F (fluorine) is made from a cyclotron, combined with DG in a synthesizer before being administered to patients, and used for testing.

6.4 Project Implementation Flow (Process for Establishing a New Nuclear Medicine Facility)

Assuming that the nuclear medicine facility development project will be carried out based on external finance sources, the project will proceed according to the following steps.

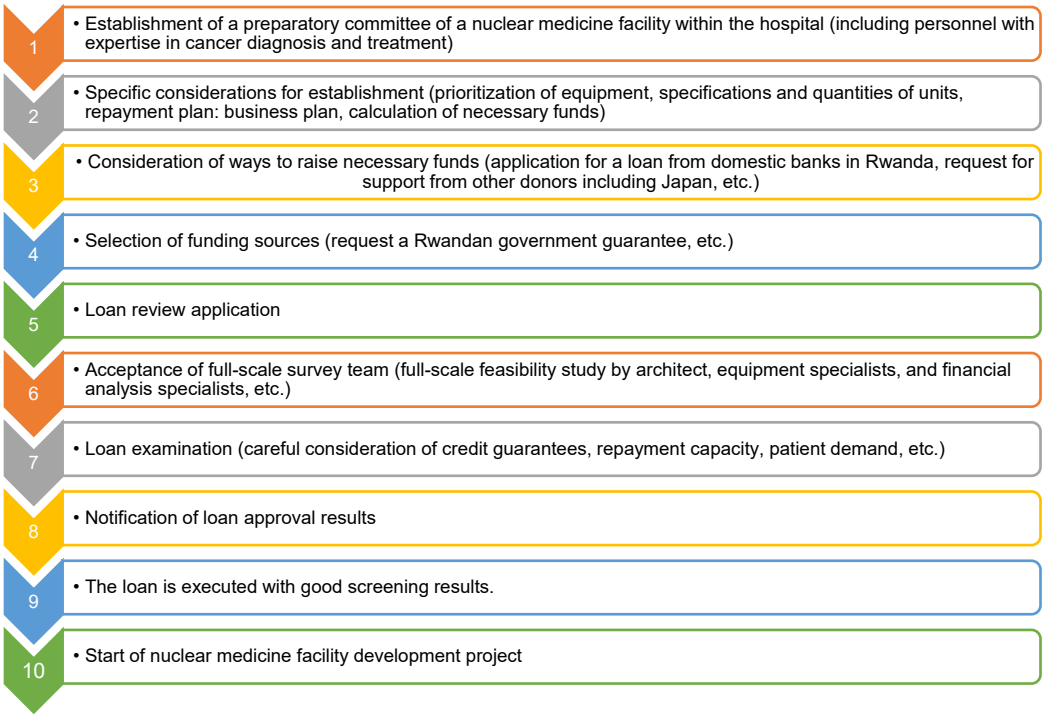


Figure 8: Ten Steps in the Process for Establishing a Nuclear Medicine Facility

Source: Prepared by the Survey Team

The time required for each process is shown in the table below.

Table 31: Expected Time Required for the Process of Establishing a New Nuclear Medicine Facility

Process Number correspondence number	Estimated time required	Points to be noted
Step 1 to 3	About 3 to 6 months	It's premised that the committee is set up promptly and specific studies are conducted promptly.
Step 4 and 5	About 3 months	If the Ministry of Finance and Economic Planning is also involved, more time may be required to finalize the national loan recipients across ministries.
Step 6	About 2 to 2.5 months	The period indicated on the left refers to the period between acceptance preparation and the actual survey.
Step 7	About 1 to 1.5 months	The period on the left refers to the analysis of the survey results, especially whether or not the project is financially viable to for a repayment plan.
Steps 8 to10	About 3 to 4 months	The period required for loan screening and notification of screening results varies depending on the loan applicants.
Total period	About 12 to 17 months	

Source: Prepared by the Survey Team

A period of about at least 1 to 1.5 years should be expected from the start of the business plan to the start of the project.

Chapter 7: Recommendations: Nuclear Medicine Diagnostic Equipment Installation Scenarios

7.1 Project Development and Profit Balance

7.1.1 Estimated Annual Patients

If a nuclear medical examination facility is opened under this project, the demand for PET-CT examination patients is expected to be about ten patients per day, including patients that are referred by major hospitals in Rwanda and patients from overseas, as shown in Table 32. The Rwanda side aims to build a PET-CT diagnostic system that promotes the acceptance of medical tourism patients. Once this diagnostic system is in place, the number of patients from neighboring countries is expected to increase. KFH currently accepts foreign and domestic cancer patients.

Table 32: PET-CT Demand Projections (per day)

Facilities from where patients may come	Number of patients (persons)
KFH (Estimation from number of MRI patients) including patients from CHUK	5
CHUB (Estimated 10% of KFH patients)	0.5
Military hospitals (Estimated 50% of KFH patients)	3
BCCOB (Estimated 10% of KFH patients)	0.5
Medical tourism patients	1
Total	10

Source: Prepared by Survey Team based on field survey

7.1.2. Repayment Plan

The manufacturers project the instrument life of a PET-CT to be ten years. Therefore, developing a business plan with a ten-year repayment plan is desirable. As indicated in chapter 6, the operation of PET-CT incurs operational expenses such as personnel costs, including nuclear medicine physicians, and various consumables, etc. The related expense expenditures would need to be subtracted from PET-CT revenues, and the remaining turnover would be used for repayment. However, with the current anticipated number of patients it is estimated that the loan would be repaid in the ninth year after the introduction of the nuclear medicine facility for the first phase if all revenue from the facility was used for repayment only. This is shown in further detail in the business plan presented in Table 33.

Table 33: Business Plan Following Construction of Nuclear Medicine Facility (First Phase)

Years since procurement	PET-CT shooting unit price	Estimated number of people / year *	A. Revenue from PET	B. Annual expenditure**	C: (A－B) Repayment	Sum up of repayment amount
1 year	$800.00	3,000	$2,400,000.00	$1,698,036.00	$701,964.00	$701,964.00
2 years	$800.00	3,300	$2,640,000.00	$1,698,036.00	$941,964.00	$1,643,928.00
3 years	$800.00	3,630	$2,904,000.00	$1,698,036.00	$1,205,964.00	$2,849,892.00
4 years	$800.00	3,630	$2,904,000.00	$1,867,839.60	$1,036,160.40	$3,886,052.40
5 years	$800.00	4,500	$3,600,000.00	$2,054,623.56	$1,545,376.44	$5,431,428.84
6 years	$800.00	5,400	$4,320,000.00	$2,260,085.92	$2,059,914.08	$7,491,342.92
7 years	$800.00	6,000	$4,800,000.00	$2,486,094.51	$2,313,905.49	$9,805,248.42
8 years	$800.00	6,000	$4,800,000.00	$2,734,703.96	$2,065,296.04	$11,870,544.46
9 years	$800.00	6,000	$4,800,000.00	$3,008,174.35	$1,791,825.65	$13,662,370.10
10 years	$800.00	6,000	$4,800,000.00	$3,308,991.79	$1,491,008.21	$15,153,378.31
					$15,153,378.31	

・Annual operating days are assumed to be 300 days

・Annual expenditure is assumed only for the first phase.

Source: Prepared by the Survey Team (Assumptions for estimation are shown below.)

Assumptions for estimation.

① Unit cost per PET-CT test:

Calculated at USD 800.00 based on PET-CT examinations in neighboring countries such as Kenya (PET-CT examination fee in Kenya is USD 700.00).

② Number of patients per year:

The number of examination days per year is 300 days, with ten patients per day in the first year and a 10% increase in the second and third years. Subsequent years include examinations for medical tourism patients and domestic follow-up patients. The number of patients could reach 12 to 20 per day.

③ Examination revenues:

The examination fee inflation rate is not considered due to the difficulty of predicting future price fluctuations and other factors. A fixed unit price was used in the calculation.

④ Annual expenditures (operational costs):

Since maintenance and management costs for the facility and its equipment are expected to increase by the fourth year due to age-related deterioration, operating costs are calculated to increase by 10% each year thereafter.

⑤ Repayment:

Repayment of the procurement cost (USD 13,659,000) is possible by the ninth year. This repayment plan has been calculated with consideration for the first phase only.

7.2 Considerations and Recommendations for Implementation

7.2.1 Adequate consideration for safe handling of radioisotopes

Education and training to properly handle isotopes and avoid exposure to personnel and the environment are essential for establishing and operating a new nuclear medicine facility. Technical support from abroad is necessary to properly develop both the environment and human resources, and ensure the that this nuclear medicine facility is used appropriately for patient and medical personnel safety.

7.2.2 Recommendations

When PET-CT is introduced at KFH, one treatment area that will need immediate improvement is chemotherapy. Chemotherapy that is currently performed at public health facilities, including KFH, is limited to chemotherapy treatment with a limited number of medicines. Discussions are underway to incorporate this treatment into public health insurance schemes. Public health insurance does not cover drugs for chemotherapy treatment; thus, patients have to pay the total cost.

Chemotherapy is not a realistic option for patients due to the financial burden. BCCOE provides chemotherapy to patients free of charge with the support of NGOs, but the number of patients that can treat is limited in the face of an increasing number of people that need treatment. In addition, patients and their families have to take on the financial burden of traveling to and from BCCOE.

It is strongly desired that university hospitals such as KFH, RMH, CHUK, CHUB, etc., strengthen their capacity in terms of facilities, equipment, and human resources to start chemotherapy treatment under public health insurance, and that the range of surgical cases are expanded to reduce the burden of chemotherapy.

APPENDICES

1. List of interviewees
2. List of collected materials
3. Concept paper
4. Statistical data on cancer registries in Rwanda for the past three years
5. Status of cancer medical care in Rwanda and neighboring countries

Appendix 1: List of interviewees

Organization	Title	Name
MOH	Head of Department of Clinical and Public health Services Department	Dr.Corneille Killy NTIHABOSE
RBC	Cancer unit manager	Dr. Marc HAGENIMANA
RBC	Cancer registry in charge	Ms. Businge Lydia
RBC	Medical Technology Division Manager	Eng.Francine UMUTESI
RSSB	Head of medical services department	Dr. Umutesi Lysette
King Faisal Hospital	Chief Executif officer	Pr.Miliard DERBEW
King Faisal Hospital	Chief medical officer	Dr. Sendegeya Augustin
King Faisal Hospital	Unit manager of biomedical unit, hard facility department	Mr. Diogene Nsabimana
King Faisal Hospital	Finance in charge	Mr. Jean de Dieu BARAHIRA
King Faisal Hospital	HRH in charge	Mrs. Umufide Patience
King Faisal Hospital	Oncologist	Dr. Achielle Manirakiza
King Faisal Hospital	ICP manager	Mrs. Gladys Kayonde
King Faisal Hospital	Unit manager, general aintenance	Mr. Philemon IYAMUREMYE
King Faisal Hospital	Radiologist (focal person of PET-CT project)	Dr. Jean Paul Ruboneka
RDB	Sector capacity building analyst, strategic capacity development department	Mr. Amos MFITUNDINDA
RDB	Sector marketing analyst	Mr. Chantal R. Atukunda
RURA	Senior manager /Nuclear & radiation protection	Mr. Jean de Dieu TUYISENGE
CHUK	Chief consultant/urologist , director general	Prof. Dr. HATEGEKIMANA
Partner's in health	CMO	Dr. Kateera Fredrick
Partner's in health	Strategy Implementation and resource mobilization advisor	Mrs. Joanna Galaris
Future Health & Technologies Ltd. (Philips)	Executive chairman	Mr. Ramba Afrique
Future Health & Technologies Ltd. (Philips)	General manager	Mr. Gideon Kemboi
IGE(Siemens)	General manager	Mr. Mehdi Cheikh
IGE(Siemens)	General manager	Mr. Essai Walid
MEDISYST LTD.	Managing director	Mr. Oscar Rurangwa
World Health Organization	Officer	Ms. Karin Miyamoto
University of Rwanda	Deputy Dean, school of medicine and pharmacy	Dr. Innocent Hahirwa, MPharm, PhD.
Rwanda Atomic Energy Board	C.E.O	Dr. Fidel
International Atomic Energy Agency	NLO (National Liaison Officer)	Mr. Jean Bosco Mugiraneza
Rwanda Military Hospital	Radiotherapy and Oncology specialist at Rwanda cancer centre	Capt Dr. FELIX SINZABAKIRA
BCCOE(Buraro Cancer Center of Excellence)	Oncologist	Dr. Cyprien

Appendix 2. List of collected materials

S/N	Name of materials	Author/Published organization	Issued year
1	Application of ionizing radiation for diagnostic purposes	RURA	2021
2	Common Application Nuclear Technology	RURA	2021
3	(Draft) REGULATION No…./…/RURA/2021 OF…./…./2021GOVERNING RADIOLOGICAL AND NUCLEAR EMERGENCY PREPAREDNESS AND RESPONSE	RURA	2021
4	LAW N°59/2017 OF 24/1/2018 GOVERNING RADIATION PROTECTION	RURA	2017/2018
5	REGULATION Nº 004/R/RS-RP/RURA/2021 OF 04/05/2021GOVERNING RADIATION PROTECTION IN DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY	RURA	2021
6	REGULATION N°003/R/RS-NRP/RURA/2021 OF 25/02/2021GOVERNING RADIATION PROTECTION IN RADIOTHERAPY IN RWANDA	RURA	2021

Appendix 3 Concept paper

Cooperation Framework proposed to Rwanda side
(Reference Only)

As of 16 Dec., 2021
Binko International ltd.
JICA Data Collection Survey Team

【Overall recommendation】

Under this cooperation framework, it is recommendable to improve cancer diagnosis with top priority, then move on to future extensions for flammability detection etc. This means that it is better to divide procurement into two phases for easier repayment.

1. Recommendation of medical equipment/other related facilities

(Medical equipment)

Even though KFH made a request to have 1 unit of Gamma camera along with molybdenum generator and 1 unit of PET-CT along with cyclotron, it is better to have 2 units of PET-CT along with cyclotron for improvement of cancer diagnostic in the country. It is because Gamma camera can be used only for cancer in bone area, and other cardiac/neurological diseases. Thus, the shortest and more economically improvement plan divided into two phases are shown in below table.

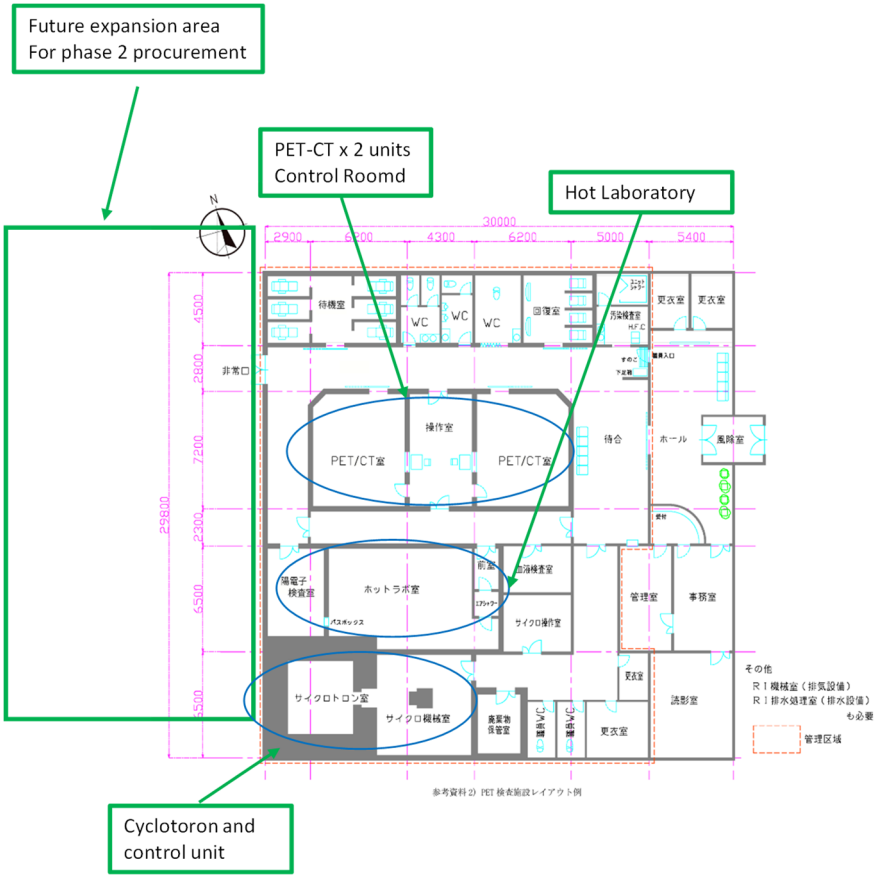
Table 1: Improvement Plan

Proposal from KFH	Recommendation from Consultant
PET-CT Gallium Generator Medical cyclotron Gamma camera Molybdenum Generator Dose monitoring & calibration device	(First investment phase) PET-CT 2 units Medical cyclotron 1 unit Dose monitoring & calibration device 1 set Future expansion space (Second investment phase) Gamma Camera （SPEC-CT) 1 unit Molybdenum Generator 1 unit

Source: request letter from KFH to embassy in April, and prepared by the consultant

(Facilities including 2 PET-CT rooms, Hot Lab, Cyclotron room) Approx. 900m2

-Following facility needs to be established separately as a nuclear medicine department.



Space for Future extension area for diagnosis as Gamma Camera and Molybdenum Generator etc. planned to be procured by phase 2 need to be added on above drawings.

★ Consultant recommends to have above facilities just closed to the main building in consideration with work flow of radiology department and other related medical staff.

Source：https://mapcarta.com/33150286　（Access: 11th Dec.2021）

Site A	Site B
	

※Master plan of hospital is under development. It is better to take into consideration where to construct nuclear medicine facilities.

(Human resource)

For proper operation of nuclear medicine facilities, not only medical staff but also other personnel are necessary to be assigned.

Table 2: Human Resource to be assigned for nuclear medicine facility

KFH staffing plan (persons)	Project staffing plan (persons)
Nuclear medicine physicians (2) Nuclear medicine technologists (4) Radiation pharmacists (4) Nurse dispensers (3) Biomedical engineers (2) Nuclear physicians (2)	(First Phase) Facility manager (1) Nuclear medicine physician (1) Nuclear medicine technologists (3) Radiation pharmacist (1) Nuclear medicine nurse (nurse and nursing assistant) (2) Nuclear physics technician t (1) Biomedical engineers (2) Cleaners (4) Security guards (9) (Second Phase) Nuclear medicine physician (1) Nuclear medicine technologist (1) Nuclear medicine nurse (1) Cleaner (1) Security guards (3) Biomedical engineer (1)

Source: request letter from KFH to embassy in April, and prepared by the consultant

* Role of each cadre is mentioned in the below table;

Table 3: Role of each cadre

Job Title	Role/Responsibility
Facility manager	Responsible for the overall management of the facility and equipment.
Nuclear medicine physician	Perform image analysis and diagnostic imaging.
Nuclear medicine technologist	Perform PET-CT operations.
Radiation pharmacist	Responsible for the preparation of FDG and its quality control.
Nurse/dispenser	Responsible for injecting FDG into patients, health observation, etc.
Assistant nurse/dispenser	Assists in all aspects of patient care services, from reception, guidance, and examination to going home.
Biomedical engineer	Maintains the medical equipment in the nuclear medicine facility in cooperation with the agency and others.
Nuclear physic technician	Responsible for cyclotron management, operation, and safety.
Cleaner	Receives specialized instruction in nuclear medicine facility cleaning and ensures safe cleaning.
Security guard	Provide professional guidance for the security of the nuclear medicine facility and perform security safely and appropriately.

※ It may possible to re-educate existing radiologist /oncology nurses to become nuclear medicine physicians or nurses/dispensers.

※ The important points are to assign specially trained facility manager, cleaner and security in terms of safety and security of patients and medical personnel.

Table 4: Annual personnel expenses (USD)

No.	Position	Salary	Number	Total
First Phase				
1	Facility manager	84,000	1	84,000
2	Nuclear Medicine Physician	84,000	1	84,000
3	Nuclear Medicine Technologist	50,400	3	151,200
4	Radio Pharmacist	50,400	1	50,400
5	Nuclear Nurse	42,000	2	84,000
6	Nuclear physicist	42,000	1	42,000
7	Cleaner	10,000	4	40,000
8	Security	10,000	9	90,000
9	Biomedical engineer	50,400	2	100,800
Total			24	726,400
Second Phase (additional personnel)				
1	Nuclear Medicine Physician	84,000	1	84,000
2	Nuclear Medicine Technologist	50,400	1	50,400
3	Nuclear Nurse	42,000	1	42,000
4	Cleaner	10,000	1	10,000
5	Security	10,000	3	30,000
9	Biomedical engineer	50,400	1	50,400
Total				266,800

(Training components)

Special training is needed to handle cyclotron, inject to patients, take PET-CT images, interpretation of images, proper nuclear waste management and safety operation for both patients and medical personnel by monitoring exposure doses. While training including danger of radio-isotope and management of exposure dose for medical personnel will be done by Japanese medical university or other sources, equipment and facility maintenance training will be done by supplier, which means manufacturer's local agents.

Human resource exchange is mandatory for proper management of nuclear medicine facility including provision of medical services with good quality.

2. Business plan (Scenario)

2-1 Needs of PET-CT Diagnosis and Current situation of Overseas diagnosis/treatment

Cancer deaths account for the second largest number of NCDs after cardiovascular disease, accounting for 13% of the total (about 6,000 people annually). Regarding availability of image diagnostic examination, at present, only 3 hospitals have CT scans and King Faisal Hospital (KFH) is the only hospital equipped with MRI, and introduction of advanced medical equipment such as image diagnostic equipment in Rwanda has been delayed. When those examinations are required, it is necessary to dispatch patients abroad including PET-CT scanning. According to

Medical Referral Board (MRB) which is funded to dispatch patients to abroad for diagnosis and treatment, followings are summary of MRB activities.

Medical Referral Board

・Annual budget is approx.. 500,000USD in total.
・25% for kidney transplant, 18% for cardiac diseases (open heart surgery, catheter intervention: this figure will drop after introduction of angiography at KFH), 10% Cancer
・As for 2019, 76 cases (consisting of 15 cancer cases including 4 PET-CT cases), all PET-CT examinations were performed in India.
・PET-CT cost is 700 USD in Kenya, while India offers it by USD 500 which is cheap with quality.

C.M.O of KFH who is also working as a chairman of medical referral board mentioned that once PET-CT technology is introduced in the country, there is a great demand to be diagnosed by PET-CT for detecting the cancer and following up patients. (As an example of MRI, before introduction, MRI examination referral to abroad was only 3 cases /year, but currently, MRI examination cases of KFH is approx. 800 cases in a month including patients coming from Republic of Congo or others.)

2-2 Annual Expected Number of PET-CT patients

Annual patient numbers can be expected based on the current situation and interviews with relevant counterparts were shown in below table.

Table 5: Expected number of patients for PET-CT

No.	Source of patient	Per day
1	KFH (Estimation from MRI patient) including CHUK	5
2	CHUB (10% of KFH number)	0.5
3	Military hospital (50% of KFH number)	3
4	BCCOB (10% of KFH number)	0.5
5	Foreigners	1
	Total	10

** At KFH, there is no proper data about patients who came from overseas. Because it is difficult to differentiate foreign nationals who live in Rwanda, and foreign nationals who came from abroad.

2-3 Capital Investment Cost

Following investment cost is needed to open nuclear medicine facility newly.

Table 6 : Capital Investment Cost for First phase procurement (PET-CT, cyclotron and equipment for hot laboratory) in USD

(First Phase)

No.	Description	Quantity	Unit price (USD)	Amount (USD)
1	PET-CT	2	1,909,091	3,818,182
2	Cyclotron	1	3,072,727	3,072,727
3	Construction cost including future expansion	1	4,881,818	4,881,818
4	FDG syringes apparatus	1	272,727	272,727
5	Dispenser isolator	1	90,909	90,909
6	Automatic dispensing system	1	59,091	59,091
7	Quality control system,	1	136,364	136,364
8	Laboratory equipment etc.	1	90,909	90,909
9	Training fees	1	209,091	209,091
10	Multiple year warranty for PET & Cyclotron (three years)	1	909,091	909,091
11	Medical consumables (syringes) for three years	1	109,091	109,091
12	Multiple year warranty for facility (three years)	1	9,000	9,000
	Total			13,659,000

Table 7: Capital Investment Cost for second phase procurement (Gamma Camera and affiliated equipment/facility) in USD

(Second Phase)

No.	Description	Quantity	Unit price (USD)	Amount (USD)
1	Gamma Camera (SPECT-CT)	1	1,131,880	1,131,880
2	Molybdenum Generator	1	10,000	10,000
3	Maintenance cost of Gamma camera (three years)	1	272,727	272,727
4	Medical consumables	1	100,000	100,000
5	Training fees	1	104,545	104,545
6	Maintenance cost of facility (three years)	1	9,000	9,000
7	Facility interior construction costs		173,900	173,900
	Total			1,802,052

Prepared by the consultant based on estimated cost by supplier

※It is ideal to procure equipment and medical consumables for three years along with main unit to minimize initial running costs to save the initial operation and maintenance cost.

Table 8: Summary table of capital investment

1. First phase cost	: USD 13,659,000
2. Second phase cost	: USD 1,802,052
Total :USD 15,461,052 (Approx.JPY 1.78 billion)	

2-4 Expenditure

As for the daily operation, the following medical consumables/ PPE materials are required in addition with cost of medical gas and electricity cost etc.

Table 9 : List of daily expenditure items

(for FDG production)	(for FDG injection)	(for Waste Management)
FDG production material Medical gas FDG inspection material	Special syringes Extracting tubes from cyclotron to syringes (GE 650USD/set)	Waste bags Waste boxes with protection Drum cans Land for isotope temporary storage

Source: Prepared by the consultant

(For Patient)

- Examination ware
- Slipper
- Drinking water after examination

Table 10: Annual Expenditure (USD) after three years for first phase

Category	Estimated cost(USD)
Personal expenses	726,400
Maintenance cost (PET CT and Cyclotron)	200,000
Consumables	738,636
Electricity cost	20,000
Medical gas cost	10,000
Facility maintenance cost	3,000
Total	1,698,036

Source: estimated by the consultant

END

Appendix 4 Statistical data on cancer registries in Rwanda for the past three years

Items	2018	2019	2020	2021 (Up to Oct.)
Number of cancer type (cases)	3,177	4,764	4,755	No data
Number of deaths by cancer type (persons)	703	1255	946	No data
Survival rate	No data	No data	No data	No data
Number of outpatients (persons)	1884	2153	1821	No data
Number of confirmed diagnoses (patients)	3203	4948	4547	No data
Number of surgical operations (cases)	606	673	595	No data
Number of radiation therapies (cases)	17	246	519	280
The number of cancer-related physicians (persons) (Oncologists, general practitioners, etc.,)	4	7	8	No data
Cancer-related nurse (person)	25	35	40	No data
Cancer-related technician (persons)				

Appendix 5 Status of cancer medical care in Rwanda and neighboring countries

	Kenya	Uganda	DRC	Tanzania	Burundi	CAR	Cameroon	Rwanda
Total population（2019）	52,573,967	44,269,587	86,790,568	58,005,451	11,530,577	4,745,179	25,876,387	12,626,938
Total # cancer cases（2018）	47,887	32,617	48,890	42,060	8,682	2,618	15,769	10,704
Total # cancer deaths（2018）	32,987	21,829	36,691	28,610	6,792	2,122	10,533	7,662
Top 5 new cancer incidence（2018）	Breast, Cervix, Prostate, Colorectum	Cervix, Kaposi sarcoma, Breast, Prostate, Non-Hodgkin lymphoma	Breast, Cervix, Prostate, Liver, Colorectum	Cervix, Prostate, Breast, Colorectum, Kaposi sarcoma	Cervix, Kaposi sarcoma, Prostate, Breast, Oesophagus	Breast, Prostate, Cervix, Colorectum, Liver	Breast, Cervix, Prostate, Liver, Colorectum	Cervix, Breast, Colorectum, Stomach, Liver
Top 5 cancer mortality (2018)	Oesophagus, Cervix, Breast, Stomach, Prostate	Cervix, Kaposi sarcoma, Oesophagus, Liver, Non-Hodgkin lymphoma	Cervix, Prostate, Liver, Breast, Colorectum	Cervix, Prostate, Oesophagus, Colorectum, Liver	Cervix, Kaposi sarcoma, Oesophagus Prostate, Breast, Liver	Breast, Cervix, Prostate, Colorectum, Liver	Breast, Cervix, Prostate, Liver, Colorectum	Cervix, Stomach, Liver Breast, Colorectum,
Availability of population-based cancer registry (PBCR)	High quality（2019）	High quality（2019）	No info.（2019）	PBCR（2019）	No info.（2019）	No info.（2019）	Registration Activity（2019）	PBCR（2019）
# of external beam radiotherapy (photon,	2.3（2019）	0.3（2019）	0.0(2019)	1.2（2019）	0.0(2019)	0.0(2019)	0.5(2019)	1.9 (2019)

	Kenya	Uganda	DRC	Tanzania	Burundi	CAR	Cameroon	Rwanda
electron) [a]								
# of mammographs [a]	15.0 (2020)	6.4 (2020)	1.2 (2020)	25.9 (2020)	2.3 (2020)	3.8 (2020)	23.5 (2020)	8.4 (2020)
# of CT scanners [a]	34.5 (2020)	7.1 (2020)	2.5 (2020)	5.9 (2020)	4.6 (2020)	3.8 (2020)	17.8 (2020)	10.3 (2020)
# of MRI scanners [a]	10.4 (2020)	0.9 (2020)	0.0 (2020)	1.2 (2020)	0.0 (2020)	0.0 (2020)	0.6 (2020)	0.9 (2020)
# of PET or PET/CT scanners [a]	0.2 (2020)	0.0 (2020)	0.0 (2020)	0.2 (2020)	0.0 (2020)	0.0 (2020)	0.0 (2020)	0.0 (2020)
Available staff in MOH who dedicates a significant proportion of their time to cancer	Yes (2019)	Yes (2019)	n/a (2019)	Yes (2019)	Yes (2019)	Yes (2019)	Yes (2019)	Yes (2019)
# of radiation oncologist [a]	n/a (2019)	n/a (2019)	n/a 2019)	n/a (2019)	0.0 (2019)	0.0 (2019)	n/a (2019)	n/a (2019)
# of medical physicist [a]	0.8 (2019)	0.0 (2019)	n/a (2019)	1.0 (2019)	n/a (2019)	n/a 2019)	n/a (2019)	n/a (2019)
# of surgeons [a]	66.0 (2014)	62.5 (2012)	11.0(2013)	23.8(2010)	n/a (n/a)	34.4 (2014)	52.6 (2013)	39.2 (2014)
# of radiologist [a]	62.6 (2019)	13.5 (2019)	19.4(2019)	14.3(2019)	6.9 (2019)	n/a (2019)	25.4 (2019)	n/a (2019)
# of nuclear medicine physician [a]	0.6 (2019)	0.9 (2019)	0.6(2019)	1.2(2019)	0.0 (2019)	0.0 (2019)	n/a (2019)	0.0 (2019)
# of medical & pathology lab scientists [a]	1,252.9 (2004)	n/a (2015)	n/a (2009)	22.1(2014)	18.4 (2010)	n/a (2009)	n/a (2004)	n/a (2015)

	Kenya	Uganda	DRC	Tanzania	Burundi	CAR	Cameroon	Rwanda
NCCP（ including cancer types）	Operational（2019）	Under development（2019）	n/a（2019）	Operational（2019）	Operational（2019）	n/a（2019）	Under development（2019）	n/a（2019）
Cancer management guidelines	Yes（2019）	Yes（2019）	Yes（2019）	Yes（2019）	Yes（2019）	No（2019）	No（2019）	Yes（2019）
# of treatment services (surgery, radiotherapy, chemotherapy)	2（2019）	2（2019）	0（2019）	3(2019)	0（2019）	0（2019）	3(2019)	0（2019）
Breast cancer screening program	Yes（2019）	No（2019）	n/a（2019）	No（2019）	No（2019）	No（2019）	No（2019）	No（2019）
Breast cancer screening program: starting age, target population	35	No（2019）	n/a（2019）	No（2019）	No（2019）	No（2019）	No（2019）	No（2019）
# of cancer centres per 10,000 cancer patients [a]	0.4（2019）	0.9（2019）	n/a（2019）	1.0(2019)	n/a（2019）	n/a（2019）	1.3 (2019)	2.8 (2019)
Pathology services	Generally available（2019）	Generally not available（2019）	Generally not available（2019）	Generally available（2019）	Generally not available（2019）	Generally available（2019）	Generally available（2019）	Generally not available（2019）
Bone marrow transplantation capacity	Generally not available（2019）	Generally not available（2019）	n/a（2019)）	Generally not available（2019）	Generally not available（2019）	Generally not available（2019）	Generally not available（2019）	Generally not available（2019）
HPV vaccination programme	n/a（2018）	71.5% (2018)	n/a（2018）	15.7% (2018)	n/a 2018）	n/a（2018）	n/a（2018）	84.1% (2018)

	Kenya	Uganda	DRC	Tanzania	Burundi	CAR	Cameroon	Rwanda
coverage								
Cervical cancer screening	Yes（2019）	No（2019）	n/a（2019）	No（2019）	No（2019）	No（2019）	No（2019）	No（2019）
Annual cancer cases (0-14 years old)	2,791（2020）	2,833（2020）	5,109（2020）	3,501(2020)	723 (2020)	261 (2020)	1,390 (2020)	687 020)

[a] shows the value per 10,000 cancer patients.

Source: WHO Cancer country profiles (2020)