

FINAL REPORT

RCA Research Project on Closing the Gap in Radiotherapy Access in RCA Government Parties (RCARP03)



RCA Regional Office

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Executive Summary

Cancer remains a significant public health challenge in many countries within the Regional Cooperative Agreement (RCA) region, particularly in low- and middle-income settings. Access to radiotherapy, a cornerstone of effective cancer treatment, is often limited by infrastructure, financial constraints, and workforce shortages. The RCA project was initiated to address these challenges by evaluating the current status of radiotherapy services, identifying needs and gaps, and fostering regional collaboration to improve cancer outcomes.

Scope and Methodology

The project undertook a comprehensive assessment of radiotherapy services across the participating countries. Data collection included cost-benefit analyses, country-level surveys, and the synthesis of existing literature. The project also facilitated high-level discussions with government stakeholders and international scientific communities to ensure that findings and recommendations were grounded in both scientific evidence and policy realities. Several scientific papers stemming from this work have already been published or are under review, further disseminating the project's findings and recommendations.

Key Findings

The project highlighted significant disparities in access to radiotherapy across the RCA region. These gaps are particularly pronounced in larger low- and middle-income countries such as Indonesia, the Philippines, and Malaysia, where barriers to radiotherapy remain substantial. In contrast, access to radiotherapy is comparatively better in Australia—a high-income country—and Mongolia, which, due to its smaller population, has a lower overall need for radiotherapy services.

The project revealed notable differences in the investment needed to enhance radiotherapy services across the RCA region. For example, the total investment required for Mongolia is less than 50 million USD, in contrast, Indonesia faces a significantly higher requirement, with total investment exceeding 2 billion USD. Other countries also require substantial investments: Australia needs an additional \$312 million USD, Malaysia \$67 million USD, the Philippines \$745 million USD to fully implement radiotherapy technology. These figures highlight the varying financial needs and underscore the importance of tailored strategies for expanding radiotherapy access in each country.

A critical finding from the project was the substantial potential of radiotherapy to reduce cancer mortality and morbidity. For instance, in Indonesia alone, radiotherapy was estimated to save up to 221,000 life years for lymphoma patients, 103,000 for nasopharyngeal cancer, and 8,000 for breast cancer. These figures underscore the life-saving potential of scaling up radiotherapy services. However, the data also revealed significant disparities in access to radiotherapy across the RCA region, with many countries facing shortages of equipment, trained personnel, and financial resources.

The project highlighted the urgent need for a coordinated approach to expand access to radiotherapy. This includes investing in new equipment, increasing the number of trained professionals, and integrating

radiotherapy services into national cancer control plans. The findings were discussed in several high-level government meetings and international scientific forums, emphasizing the importance of political commitment and regional collaboration.

Capacity Building and Regional Collaboration

An important component of the project was building awareness and enhancing the capacity of radiation oncology communities in the RCA countries. Through training workshops, expert exchanges, and the development of evaluation tools, the project empowered local professionals to conduct nationwide assessments and strategic planning for radiotherapy services. Regional collaboration was also strengthened, facilitating the sharing of best practices and resources among countries facing similar challenges.

Impact and Publications

The project's efforts have already contributed to a growing body of scientific literature on radiotherapy access in the RCA region. These publications provide valuable evidence for policymakers and practitioners, supporting the case for increased investment and reform. The dissemination of findings at international and government meetings has raised awareness, fostered dialogue, and catalyzed action towards improving cancer care infrastructure.

Recommendations

- **Scale Up Investment:** Governments should prioritize funding for radiotherapy equipment, facilities, and workforce development, recognizing the significant health and economic benefits of improved cancer care.
- **Integrate Radiotherapy into National Cancer Control Plans:** Strategic planning should ensure that radiotherapy is accessible, affordable, and integrated with other cancer treatment modalities.
- **Foster Regional Collaboration:** Continued cooperation among RCA countries will help address shared challenges, such as equipment procurement, training, and quality assurance.
- **Promote Research and Data Collection:** Ongoing research is necessary to monitor progress, identify emerging needs, and optimize resource allocation.
- **Engage Stakeholders:** Sustained dialogue with policymakers, healthcare professionals, and international organizations is essential for translating evidence into action.

Conclusion

The RCA project has made significant strides in documenting the status of radiotherapy services in the region, raising awareness, and building capacity for future improvements.

Despite substantial challenges, the evidence demonstrates that expanding access to radiotherapy can save countless lives and improve cancer outcomes. Continued commitment from governments, international partners, and the scientific community will be vital to realizing the full potential of radiotherapy in the fight against cancer.

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1. Introduction

This document presents the final report of the research project RCARPO3 - Closing the Gap in Radiotherapy Access in RCA Government Parties.

RCARPO3 is a research project (RP) managed by the RCARO. The regional project theme was proposed by Indonesia and selected as the main regional research project theme by the Research Review Committee. The objective of the project is “to measure the gap in radiotherapy services, specifically in the RCA region and to estimate the potential economic and life loss upon failure to close the gap”

The project was decided to follow a classical IAEA CRP where separate projects would be going on simultaneously, reporting at Research Coordination Meetings, joint publication might be pursued, when relevant. All participating GPs submitted proposals of their national projects in line with the “key points” of the regional theme, which was reviewed by the RRC, accepted then contracted.

The author of this report (Prof. Yavuz Anacak) from Izmir, Turkiye (Ege University, Department of Radiation Oncology) was contracted and designated as the Technical Officer (TO) to provide coordination of the project.

The project was decided by the RCA for a duration of 36 months, and officially started in January 2022.

2. Cancer and radiotherapy in Asia Pacific region

a. Epidemiology of Cancer in Asia Pacific

In 2022, there were an estimated 20 million new cancer cases and nearly 10 million cancer-related deaths reported globally, representing approximately 17% of all deaths. Of these, the RCA region accounted for 9.3 million new cases and 5.3 million cancer deaths, corresponding to 46% of all new cases and 53% of global cancer mortality. Projections indicate that the number of new cancer cases in the region will rise to 11.3 million by 2030, 13.9 million by 2040, and 16.1 million by 2050. The incidence of cancer is increasing across all countries in the region, regardless of socioeconomic status. Among the 22 RCA countries, China, India, and Japan recorded the highest number of cancer cases in 2022, each exceeding one million cases, whereas Palau, Fiji, and Mongolia had the lowest numbers. ^{1, 2}

b. Radiotherapy Services in Asia-Pacific Region

Radiotherapy is a fundamental and cost-effective approach in the management of cancer. Evidence from Australia and Canada demonstrated that approximately 50% of oncology patients require radiotherapy as an integral component of their treatment regimen. Radiotherapy is utilized at all stages of cancer care, with applications ranging from curative intent and survival extension to palliation of cancer-associated symptoms.

Multiple studies have shown that radiotherapy is a cost-effective treatment option compared to chemotherapy, immunotherapy, and even surgical interventions. The primary expenses associated with radiotherapy are capital investments, which include the construction of specialized treatment bunkers,

acquisition of treatment machines, planning systems, dosimetry and quality assurance equipment. After the establishment of a radiotherapy center, ongoing operational costs remain relatively low in comparison to other medical expenditures, primarily consisting of equipment maintenance. A megavoltage radiotherapy unit can treat about 500–600 patients annually and over 5,000 during its typical ten-year lifespan.

Despite local control and survival benefit provided by radiotherapy, there is a huge gap in radiotherapy services between the high-income (HIC) and low and middle-income (LMIC) countries, due to the need for expensive initial investment, complexity of the radiotherapy processes and maintenance, coupled with lack of trained radiotherapy staff. The report of the Global Taskforce in Radiotherapy for Cancer Control (GTRCC) Lancet Commission by Atun et al. presented that scaling-up of radiotherapy capacity in 2015-35 from current levels with an investment of 96.8 billion USD could lead to saving of 26.9 million life-years in LMICs over the lifetime of the patients who received treatment³. The economic benefits of investment in radiotherapy are very substantial⁴.

The establishment and operation of a radiotherapy center necessitate the expertise of a multidisciplinary team comprising managers, radiation oncologists (RO), medical physicists (MP), radiotherapy technologists (RTT), nurses, maintenance engineers, social workers, and other professionals.

According to a survey conducted by FARO—the Federation of Asian Organizations for Radiation Oncology—one megavoltage (MV) machine serves approximately 300,000 people in HICs, compared to 2–5 million individuals per machine in LICs within the RCA region⁵. Furthermore, the radiotherapy requirements of each country may be influenced by demographic factors, the level of public awareness, and the overall effectiveness of cancer control measures.

While numerous studies, including those cited above, have assessed the burden of cancer requiring radiotherapy, as well as the associated costs and benefits of investment in radiotherapy at global or national levels, there is currently a lack of such research specific to the RCA region.

3. Objective of the project

The RCA Research Project Theme (RPT) titled 'RCARP03 - Closing the Gap in Access to Radiotherapy' aims to assess disparities in radiotherapy services within the region and to estimate both the potential economic impact and loss of life if these gaps are not addressed. The primary objective is to underscore the critical need for radiotherapy in the region and to develop strategies that will strengthen service capacity.

4. Submission and selection of national projects

The projects proposed by the RCA GPs are intended to address three primary objectives:

- Calculating burden to national health systems of cancer incidence requiring radiation therapy (RTU-radiotherapy utilization rate)
- Estimating core investment required for radiotherapy (Cost of radiotherapy)
- Assessing the outcome (Benefits of radiotherapy)

The study was announced for submissions in, resulting in the selection of eight projects from Australia, Indonesia, Malaysia, Mongolia, the Philippines, Korea, Thailand and Vietnam¹. The selected projects were:

- Australia: Evaluation of current gaps in radiotherapy services and an analysis of life years lost due to these gaps in the **Asia Pacific region**.
- Indonesia: Addressing disparities in **Radiotherapy Access** in Indonesia.
- Malaysia: Analysis of the radiotherapy **utilization rate** at **public oncology centers** in Malaysia.
- Mongolia: **Estimation of Radiotherapy** services in Mongolia and identification of steps for **roadmap planning** to enhance them.
- The Philippines: Overview of modern radiotherapy **accessibility and development** in the Philippines.
- Korea: Review of the **status of radiotherapy** in Korea.
- Thailand: Assessment of **image-guided brachytherapy** availability for gynaecologic cancer in Northern and Northeastern Thailand.
- Vietnam: **Estimated core investment** requirements for developing radiotherapy technology infrastructure and human resources in Vietnam, along with potential benefits.

The project of each country focused on a different goal having common objectives as stated above and a common methodology.

Australia Project: Assessment of the existing gaps in radiotherapy services and the costs in lost life years due to not closing the gaps in the Asia Pacific region.

Aims:

- To calculate the demand, gap in supply, required investments and potential outcome benefits for radiotherapy for each of the GPs in the Asia-Pacific region, based on the cancer case mix and presentation stage (where these data are available) for each country.

Expected outputs:

- Formation of a health services research consortium involving research centres from several RCA GPs across the Asia Pacific

¹ Korea and Vietnam withdrew their participation in the project in 2023.

- Research abstracts and presentations at local and international conferences

Indonesia project: Closing the Gap in Radiotherapy Access in Indonesia

Aims:

- To measure the gap in radiotherapy services in Asia, specifically in Indonesia, and to estimate the potential economic and life loss upon failure to close the gap. As the project theme's originator, Indonesia will also be the lead country in this research.

Expected outputs:

- Comprehensive white paper of Indonesia for radiotherapy
- Similar white paper for RCA GPs
- Regional collaborative publications

Malaysia project: Radiotherapy utilisation rate in public oncology centers in Malaysia

Aims:

- To calculate the optimal RTU (oRTU) and actual RTU (aRTU) in public oncology centers
- To evaluate the projected outcome based on actual RTU data

Expected outputs:

- Data to be presented at local and international meetings and conferences, and also published in reports and journals
- Results to be used as benchmark for future development of radiotherapy services in Malaysia

Mongolia project: Estimation of Radiotherapy service in Mongolia and defining roadmap planning to improve it

Aims:

- To describe the status of radiotherapy in Mongolia
- Define the problems and needs in improving the status of radiotherapy
- To measure the impact on patient survival and economic loss

Expected outputs:

- Using the results of the study to for the support of financial investment to enhance radiotherapy in Magnolia
- Roadmap planning to improve radiotherapy in the NCCP

Philippines project: Modern Radiotherapy Accessibility and Evolution in the Philippines

Aims:

- Calculating the burden of cancer requiring radiotherapy (RTU, equipment, available technologies, human resources, training centers)
- Estimating the core investment required for radiotherapy (cost for equipment, human resources)
- Assessing the outcome (return on investments in terms of life-years)

Expected outputs:

- Roadmap planning, recommendations for PhilHealth coverage
- Preparation for the national Integrated Cancer Act and the Universal health care Law in the PHI
- Future directions in modern radiotherapy education and training

Korea project: Assessment of the status of radiotherapy in the ROK

Aims:

- To assess the RTU for indications using the big healthcare data in Korea
- To investigate radiotherapy infrastructure in Korea
- To define the needs/gaps of hypofractionated radiotherapy

Expected outputs:

- RTU for important cancers using the big data of the National Health Insurance Service
- The most recent status of the radiotherapy infrastructure in ROK
- The needs/gaps of hypofractionated radiotherapy of LMIC in the RCA region

Thailand project: Filling the gap of image-guided brachytherapy for gynaecologic cancer in Northern and Northeastern Thailand

Aims:

- Evaluation of image-guided brachytherapy (IGBT) utilization in Thailand and its cost and benefits

Expected outputs:

- Enhancement of knowledge of the participating centers in IGBT for cervical cancer and solutions matching to their infrastructures
- Providing the sustainability of IGBT procedure in their centre

Vietnam project: Estimated core investment for the development of radiotherapy technology infrastructure and human resources in Vietnam and its beneficial effects

Aims:

- Describe the current state of radiotherapy technology infrastructure and human resources in Vietnam
- Estimate the core investment required for radiotherapy development in Vietnam
- Assess the estimated outcome of these investment

Expected outputs:

- Provide evidence-based data to support the national radiation therapy
- Policies and circulars aimed at developing the field of radiotherapy

5. Study Design:

An online pre-project meeting was held by the RCARO in December 2021 with participants including the Indonesian team led by Prof. Soehartati Gondhoviardjo and Dr. Mayang Permata, who are responsible for the main project theme; the Australian team led by Dr. Mei Ling Yap and Prof. Geoff Delaney, who developed the CCORE method for calculating radiotherapy utilization rate (RTU); Dr. Eduardo Zubizarreta, former Applied Radiation Biology and Radiotherapy (ARBR) section head of the IAEA and developer of the costing model for radiotherapy; Prof. Yavuz Anacak, TO of the project; Mr. Prinath Dias, Chair of the RCA Programme Advisory Committee; as well as RCARO team.

As described previously, all sub-projects within the main project are structured into three phases addressing the following pillars:

- **Phase-1: Radiotherapy utilization:** The burden of cancer cases requiring radiation therapy (RTU – radiotherapy utilization rate) will be calculated with input from the Australian team using **CCORE** models.
- **Phase-2: Cost of radiotherapy:** The core investment needed for radiotherapy will be determined with guidance from Dr. Zubizarreta using the **IAEA costing model**.
- **Phase-3: Outcome & impact assessment: Benefit of radiotherapy:** The benefit of radiotherapy will be assessed with support from Dr. Danielle Rodin using the **GTFRCC model**.

All projects, except for Australia, will utilize national data. The Australia project, however, encompasses all countries within the RCA region. Consequently, other GPs will be encouraged to contribute data for the Australia project. GPs interested in additional parameters (such as brachytherapy in Thailand, waiting times in Mongolia, or data on nasopharyngeal and cervical cancer in Malaysia) are expected to integrate these elements into the base protocol to develop their respective protocols. Dr. Yavuz Anacak will oversee and monitor the progress of each protocol. Where necessary, GPs will receive training for RTU calculations, as well as cost and benefit analyses.

6. Study Workflow:

The study is structured into three phases over a period of three years (2022-2024), with one phase scheduled for completion each year. Each phase included a Review and Coordination Meeting (RCM) and a dedicated training workshop. The detailed workplan is outlined in Figure 1. Figure-1: Workplan of the project

3. 2022-2024 Work Plan												
Activity/Schedule	2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Preparation												
Preparatory Meetings												
1 st Research Coordination Meeting												
Research Protocol Finalization												
RP03 - Phase 1												
Situation Analysis												
1 st Regional Training/Workshop (RTU)												
Research Implementation (RTU)												
Submission of the Progress Report												
RP03 - Phase 2												
Needs and Gap Calculation												
2 nd Regional Training/Workshop (Cost)												
Research Implementation (Cost)												
2 nd Research Coordination Meeting												
Submission of the Progress Report												
RP03 - Phase 3												
3 rd Regional Training/Workshop (Impact)												
Research Implementation (Impact)												
Evaluation and Roadmap Planning												
3 rd Research Coordination Meeting												
Submission of the Final Report												

The three phases of the project were structured as follows:

Phase 1: Calculating burden of cancer requiring radiation therapy

The first phase involved a situation analysis that included data collection on cancer patients, radiotherapy facilities and equipment, human resources, education and training, social security and referral systems, and reimbursement. This was followed by calculation of the RTU and estimation of the number of cancer patients who would require radiotherapy in 2030 and 2040.

1.A. Situational Analysis: Data collecting by surveys/questionnaires:

Data sources include the national cancer registry or national surveys, Ministries of Health, and other government bodies. Data on cancer patients was usually obtained from the national cancer registry; if this was not feasible, a national survey was conducted among hospitals with radiotherapy facilities (using 2019, pre-pandemic data). A minimum coverage of 70% of cancer patients through the survey or cancer registry was targeted, based on the assumption that this level would be sufficient to represent national data, especially in settings where most RCA GPs are LMICs facing data limitations. Below is the data collected by the surveys:

- Cancer patients
 - Annual number of cancer patients
 - Age, gender
 - Diagnoses
 - Tumor stages
 - Oncologic treatment (surgery, chemo)
- Current number of rRadiotherapy machines and centers
 - Public, Private, NGO
 - University, MoH
 - Hospital based, stand alone
 - Number of bunkers
 - Number of RT patients per year
- Equipment
 - Teletherapy machines
 - Brachytherapy afterloaders
 - Simulators and CT simulators
 - TPS
 - Dosimetry systems
 - Patient stabilisation equipment
- Human resources
 - Radiation oncologists
 - Medical physicists
 - Dosimetrists
 - Radiotherapy technologists
 - Oncology Nurses
 - Maintenance staff availability, training centers and system
- Education & training
 - Core curriculum
 - National regulations
 - Diploma & certification
 - CME
- Social security & Levelling or referralReferral system for radiotherapy
 - Number of patients covered by security systems
 - Number of patients paying out of pocket
 - Number of patients treated abroad
 - Patient referral systems & regulations
- Reimbursement
 - Reimbursement systems by country
 - Reimbursement per patient for main cancers
 - Human resources availability, training centers and system
 - Working system available, etc.

1.B. Calculation of Radiotherapy Utilization Rate (RTU):

National registry data and survey findings were utilized to estimate future cancer incidence. Projections for the total number of cancer patients in 2030 and 2040 were based on IARC -Globocan 2020 estimates. The RTU was calculated using the CCORE methodology developed by the Australian team.

- Current and projected cancer incidence for 2030–2040 (sourced from National Registry and Globocan)
- RTU calculation (CCORE methodology)

1.C. Estimation of Cancer Patients Requiring Radiotherapy in 2030–2040

The projected demand for radiotherapy in 2030 and 2040 was calculated based on the RTU and the total number of cancer patients.

Table-1: To calculate the human resources needed within the country (based on the IAEA staffing guidelines):

Category	Number needed
Radiation oncologist	One additional for each 200–250 patients treated annually.
Medical Physicist	1 full-time equivalent (FTE) medical physicist per 400 patients, or 1.7 FTE medical physicists per linear accelerator
Radiation therapy technologists (RTTs)	Two per megavoltage unit up to 25 patients treated daily per unit, 4 per megavoltage unit up to 50 patients
Nurse	One per center for up to 300 patients treated annually and an additional one per 300 patients treated annually.

Table-2: To calculate the gap analysis (staff and equipment):

Steps	Data	Formula
1	Number of existing machines	National data / DIRAC database of the IAEA
2	Number of presently required	(Number of radiotherapy fractions in a year/9600) with the assumptions 1 x 9600 fractions/year and 10 operating hours/day)
3	Additional machines needed	(Number of presently required – number of existing machines)
4	Percentage of present deficit	$[(\text{Number presently required} - \text{Number presently available}) / \text{Number presently required}] \times 100$
5	Percentage of additional required	$[(\text{Number required in certain year} - \text{Number presently available}) / \text{Number presently available}] \times 100.$
6	Machine need-availability ratio	(Number of the required machines/number of machine available)
7	Staff need-availability ratio	(number of the required certain staff category/number of staff available)

Phase 2: Calculating core investment required for radiotherapy

The second phase involves assessing the requirements and investment necessary to operate a nationwide radiotherapy service in 2030 and 2040. Estimates will be made regarding infrastructure, staffing, and costs.

2.A. Estimation of future facility, equipment, and human resources needs

Several indicators can be used to estimate the radiotherapy (RT) capacity required in a country:

- Megavoltage/Million (Mv/M)

For countries that have not yet determined either the number of radiotherapy units or cancer incidence, the Megavoltage/Million (Mv/M) method (radiotherapy unit per one million population)—is a commonly used and straightforward indicator for estimating RT requirements.

- ESTRO-Quarts Method

The ESTRO QUARTS Method offers a more detailed alternative. According to the European Society for Radiotherapy and Oncology (ESTRO), the Quantification of Radiation Therapy Infrastructure and Staffing Needs (QUARTS) research recommends one MV machine for every 450 cancer patients, one radiation oncologist per 200–250 patients, and one medical physicist per 450–500 patients. The estimation of RT facilities using this method follows these steps:

Optimal Fraction Needed Method

Wong et al. developed a model that integrates the calculation of the RTU with retreatment requirements. Their findings indicate that 9,768 radiotherapy fractions are required for every 1,000 new cancer patients. Additionally, Zubizarreta et al. estimated that the capacity per linear accelerator is 9,600 fractions per year, based on 10 operational hours per day. The following are the steps to estimate the necessary radiotherapy facilities based on the optimal number of fractions:

Mean Fraction Method

The Mean Fraction Method is an alternative model for estimating the radiotherapy (RT) requirements within a specific region. This approach, introduced by Zubizarreta et al. in their publication "Need for Radiotherapy in Low- and Middle-Income Countries: The Silent Crisis Continues," develops an estimation framework that integrates radiotherapy utilization (RTU), retreatment rates, and mean fraction values from each continent. For example, RTU rates vary among continents: Europe and Central Asia (50.05%), Africa (54.3%), Asia Pacific (49.49%), Latin America (53.27%), and across all low- and middle-income countries (LMICs) (50.53%). Similarly, there are differences in mean fraction values: Europe and Central Asia (15.95), Africa (16.44), Asia Pacific (16.29), Latin America (16.56), and all LMICs (16.31).

2.B. Radiotherapy cost calculation

The calculation of radiotherapy costs developed on the data collected by the GPs using the RT cost estimator and staffing calculator.

- Data collecting by questionnaires to all RT centers in the country
- Data Entry using the RT Cost Estimator (RRCC) and RT Staffing Calculator
- Data Analysis

2.B.1: Data Collecting

Questionnaires were used by the GPs to collect the below data of all RT centers in the country:

- Resources (Building, Equipment (each equipment, cost of additional equipment, yearly maintenance, QA/QC) Personnel (RO, Medical physicist, RTT, nurse, administrative personnel), working hours)
- Activities (intake (first contact with the patient and evaluation of RT indication), treatment preparation, planning, treatment delivery)
- Products (number of radiation fractions)

Table-3: Data collected for the cost calculation

Steps	Data	Formula
	PERSONNEL DATA	
1	Full Monthly Salaries of: <ul style="list-style-type: none"> • Radiation Oncologist • Medical Physicist • Radiation Technologies • Nurse • Admin 	National/Institutional data
	WORKING TIME	
2	Working Hours per day	National/Institutional data
3	Working Days per week	National/Institutional data
4	Linac/EBRT Working Hours per Day	National/Institutional data
5	Linac/EBRT Working Days per Week	National/Institutional data
6	Paid Holidays per Year for personnel	National/Institutional data
7	Annual Leave per Year for personnel	National/Institutional data
8	Training days per Year for personnel	National/Institutional data
9	Proportion of patients treated with 2D (%)	National/Institutional data
10	Proportion of patients treated with 3D (%)	National/Institutional data
11	Proportion of patients treated with IMRT-IGRT (%)	National/Institutional data
12	Average number of pts treated per hour for 2D	National/Institutional data
13	Average number of pts treated per hour for 3D	National/Institutional data
14	Average number of pts treated per hour for IMRT-IGRT	National/Institutional data
15	Mean number of treatment for long radiation treatment (more than 25)	National/Institutional data
16	Mean number of treatment for intermediate radiation treatment (11-25)	National/Institutional data
17	Mean number of treatment for short radiation treatment (less than 10)	National/Institutional data
18	Percentage of treatments with block for each radiation treatment: a. Long b. Intermediate c. Short	National/Institutional data
19	Percentage of treatments with immobilization for each radiation treatment: a. Long b. Intermediate c. Short	National/Institutional data

20	Overhead percentage time for each personnel for department management	National/Institutional data
21	Overhead percentage time for each personnel for follow-up consultations	National/Institutional data
22	Overhead percentage time for each personnel for teaching and general cancer control	National/Institutional data
	BUILDING COST*	
23	Room / bunker costs per m2 for: <ul style="list-style-type: none"> • Patient Service Area • Cobalt • Linac • Orthovoltage • Simulator • TPS • Mould Room 	Local Cost Data
24	Area Provided (m2) for : <ul style="list-style-type: none"> • Patient Service Area • Cobalt • Linac • Orthovoltage • Simulator • TPS • Mould Room 	Institutional Plan Data
	EQUIPMENT COST*	
25	Capital Cost for: <ul style="list-style-type: none"> • Cobalt • Linac • Orthovoltage • Simulator • TPS • Mould Room 	Target Provider Cost Data
26	Maintenance Cost yearly for: <ul style="list-style-type: none"> • Cobalt • Linac • Orthovoltage • Simulator • TPS • Mould Room 	Target Provider Cost Data
27	Upgrade Cost for: <ul style="list-style-type: none"> • Cobalt • Linac • Orthovoltage • Simulator • TPS • Mould Room 	Target Provider Cost Data
28	Source Cost (if using cobalt)	Target Provider Cost Data
29	Film Developer	Target Provider Cost Data
30	Portal Imaging	Target Provider Cost Data
31	Dosimetry	Target Provider Cost Data
32	Calibration	Target Provider Cost Data

	Additional Cost for Equipment	
33	Additional item cost for Gamma Alarm	Target Provider Cost Data
34	Additional item cost for Lasers	Target Provider Cost Data
35	Additional item cost for CCTV	Target Provider Cost Data
36	Additional item cost for Audio	Target Provider Cost Data
37	Additional item cost for Lead Glass Window	Target Provider Cost Data
38	Number of equipment anticipated: <ul style="list-style-type: none"> • Cobalt • Orthovoltage • Linac 	National/Institutional data
39	Proportion of patients using the equipment: <ul style="list-style-type: none"> • Cobalt • Orthovoltage • Linac 	National/Institutional data

To estimate radiotherapy cost investment, the collected data was used for calculation. For countries that have not initiated radiotherapy development, the estimation data in section 2.A served as a basis for calculating the required investment

2.B.2: Data Entry

The collected data input into the IAEA's Radiotherapy Cost Estimator and Radiation Oncology Staffing Calculator. The steps of this process is presented in Table-4, and figure -2 presents the entrance page of the online Radiotherapy Cost Estimator:

Table-4: The steps to calculate the estimation of radiotherapy cost

Steps	Data	Formula
1	Download the excel file about Cost Estimator and its user manual in IAEA	https://humanhealth.iaea.org/HHW/RadiationOncology/Makingthecaseforradiotherapyinyourcountry/Roleofradiotherapyincancercare/Staffingan dcostcalculation/index.html
2	Set up the parameters, and input all the data collected: <ul style="list-style-type: none"> • Currencies • Personnel • Working Time • Building & Equipment . 	Data Collection
3	After finishing the data entry, the radiotherapy cost that consists of: productivity, operating cost, capital cost, and product cost could be downloaded by clicking the excel button.	Download Excel Report of : <ul style="list-style-type: none"> • Productivity, • Operating cost, • Capital cost, • Product cost

Figure-2: Main page of RTE cost estimator excel file

 IAEA International Atomic Energy Agency <i>Atoms For Peace</i>		2014 Radiotherapy Cost Estimator NAHU-ARBR 2014 06 06 test		
Country for Cost Evaluation: Indonesia		Currency Unit Used: Rupiah	Conversion for 1 US \$: 14.500,00	Conversion Valid as of: 15-Dec-21
<h3>Brachytherapy</h3>		<h3>Teletherapy</h3>		
Setting and Adjusting Parameters		Setting and Adjusting Parameters		
<input type="button" value="Currencies"/>	HDR Mixed Bag <input type="button" value="Costing Summary"/>	<input type="button" value="Currencies"/>	Cost Overviews <input type="button" value="Productivity / Utilization"/>	
<input type="button" value="Personnel"/>	<input type="button" value="Costing Overview"/>	<input type="button" value="Personnel"/>	<input type="button" value="Operating Costs"/>	
<input type="button" value="Working Time"/>		<input type="button" value="Working Time"/>	<input type="button" value="Capital Costs"/>	
<input type="button" value="Protocols"/>		<input type="button" value="Protocols"/>	<input type="button" value="Product Costs"/>	
<input type="button" value="Building & Equipment"/>		<input type="button" value="Building & Equipment"/>		

Phase 3: Assessing the outcome

The third phase of the project focused on evaluating the potential losses associated with unmet demand and assessing the benefits derived from investments. In this stage, we the hypothesis that radiotherapy is a cost-effective long-term cancer management strategy was assessed, drawing upon the findings from phases one and two.

3.A. Potential loss upon failure to close the gap

- Economic Loss
- Life Loss

3.B. Return on investments in terms of life-years and financial values

- Economic Benefit
- Health Benefit

3.C. Evaluation and Roadmap planning

The data collected for phase-3 is presented in Table-5, and the steps in phase-3 is presented in table-6:

Table-5: Data collected for the calculation of phase-3

Steps	Data	Formula
1	<p>Basic data:</p> <ul style="list-style-type: none"> a. Cancer incidence in particular country and year b. Cancer mortality in particular country and year c. Proportion of unmet radiotherapy needs d. Radiotherapy cost/fraction in the country e. Life expectancy f. Labour force participation rate g. Annual wage h. Currency conversion to USD 	Source: national data
2	<p>Economic Loss</p> <ul style="list-style-type: none"> A. The direct medical cost to account for unmet RT needs from payer's perspective B. The indirect cost as represented by the mortality-related productivity loss <p>The indirect costs as represented by mortality-related productivity loss (MRPL) are estimated through the age-adjusted present value of future lifetime earnings for paid work, which are calculated from life expectancy, wage and labour force participation rates (Menzin et al., 2012)</p>	To be calculated by experts from IAEA (not the national team)
3	<p>Life loss</p> <p>3A. 5-year overall survival shortfall is defined as number of people not surviving for 5-years due to lack of RT services</p> <p>Survival shortfall (in person) = benefit proportion X shortfall proportion X number of new cases with cancer</p> <p>3B. YPLL = survival shortfall X estimated years of life lost per person (overall life expectancy median age at death for specific cancer).</p> <p>(Batumalai et al., 2018)</p>	<ul style="list-style-type: none"> a. Benefit Proportion = absolute proportion of patients in the cancer population alive at 5 years due to radiotherapy (Source of data: national data) b. Shortfall proportion = [(optimal-actual RTU)/optimal RTU] proportion X No. of new cases] c. Number of new cases with cancer (Source of data: national data) <ul style="list-style-type: none"> a. Survival shortfall from 3A data b. Year of life lost = (life expectancy - median age at death)

Table-6: Phase 3.B- Return on investments in terms of life-years and financial values

Steps	Data	Notes
1	<p>Population benefits</p> <p>A. Estimation of population benefits = (proportion of patients with each radiotherapy indication X the associated benefit for that indication)</p> <p>B. These benefits were then summed to determine the radiotherapy population benefit, which described the absolute proportion of the population achieving a benefit from radiotherapy delivered according to guidelines compared with those receiving no radiotherapy (Atun et al., 2015)</p>	
2	<p>Economic benefit will be estimated with both human-capital approach and full-income approach.</p> <p>Using a human-capital approach, the economic value of life according to a person's economic contribution to the gross domestic product will be calculated (for example: the contribution that a working individual is expected to make through the extra life-years provided by radiotherapy for her/his cancer)</p> <p>The full-income approach, in which a multidimensional view of human welfare beyond an individual's capacity to generate a sufficient livelihood is taken, takes into account societal benefits of radiotherapy investment. It recognizes the intrinsic personal or societal value of a life-saving intervention, even if the recipient is no longer able to contribute to the workforce. It is rooted in analyses of willingness to pay by a society or individual to avoid potential reduction in life expectancy, which was estimated in The Lancet Commission Global Health 2035 to be 2.3 times the gross domestic product per person in a given year.</p> <p>(Atun et al., 2015)</p>	<p>To be calculated by experts from IAEA (not the national team)</p>
3	<p>Health benefits</p> <p>Life-year gain</p>	<p>the additional discounted life-years gained through scaled-up radiotherapy capacity (Atun et al., 2015)</p> <p>(life expectancy x number of lives saved)</p> <p>Number of lives saved = absolute proportion of patients in the cancer population alive at 5 years due to radiotherapy (Source of data: national data)</p>

Reporting and Publications

Participating teams and the TO are required to present a progress report at the end of phase-1 and phase-2, and a final report at the end of the project.

The results will include:

- Analysis of the current number of cancer patients, RT machines and centers and human resources
- Calculation of RTU
- Identification of gaps between the current and optimal levels of RT machines and human resources
- Calculation of costs associated with RT investment in participating countries
- Evaluation of potential loss and return on investment related to RT investment

The findings will be disseminated through:

- RCA publications
- Peer-reviewed publications
- Congresses, meetings
- National reports

Financial Support

This study is supported by the RCA Regional Office.

Implementation

The project commenced in January 2022. Korea and Vietnam decided not to continue the project. The final list of the participating countries were Australia, Indonesia, Malaysia, Mongolia, Philippines and Thailand.

Preparation and finalization:

- The first quarter of 2022 involved individual and group consultations, coordination meetings among TO, RCARO, research teams, and experts, as well as review and finalization of questionnaires and the study protocol.
- The initial RCM (kick-off meeting) was held online in March, during which national adaptation and team setup were completed.

Phase 1:

- Phase 1 began in the second quarter of 2022 with data collection and situation analysis.
- The first regional training/workshop focusing on RTU calculation took place online in Q2-2022.
- Data analysis and RTU calculation continued through the end of the second quarter of 2023.

Phase 2:

- Needs and gap analysis started in Q2-2022.
- A second regional training/workshop on cost calculation was conducted online in Q3-2022.
- Radiotherapy cost calculation and analysis continued until the end of Q2-2023.
- The second RCM was held in Bali, Indonesia in June 2023.

Phase 3:

- The third regional training/workshop on impact and benefit was held online in Q2-2023.
- Impact and benefit analysis continued until Q2-2024.

Final Review Meeting:

- The final meeting took place in the third quarter of 2024.

Results

Phase-1: Access to radiotherapy (Radiotherapy Utilization)

Table-7 presents a general overview of the data collected and calculated that influence access to and delivery of radiotherapy. The data for cancer burden, equipment and staff, and RTU were collected and calculated by all countries, whereas data for radiotherapy technique, waiting time and distance was collected depending on the necessity of the sub-project.

Table-7: General Overview of data collected by the countries

	Cancer Burden	Equipment	Staff	RTU	RT Technique	Waiting Time	Distance to RT center	Cost
Australia	+	+	+	+		+		+
Indonesia	+	+	+	+	+			+
Malaysia	+	+	+	+		+		
Mongolia	+	+	+			+		+
Philippines	+	+	+	+	+		+	+
Thailand	+	+	+	+	+			+

Table-8 provides a comparative overview of the estimated number of cancer patients across countries, using data from two sources: Globocan 2022 and RCARP03. The table presents figures for all patients, as well as separate counts for males and females, highlighting the differences between the two data sets. It is not surprising to see different numbers between two data sets, since the year of data collection and the sources may result in different numbers. In any case, countries pick one of the data sets to be used in this project. The Philippines and Indonesia used only Globocan data, while others used national data for cancer burden. Notably, data for Thailand is not included due to the study's specific focus on brachytherapy, which did not collect overall cancer patient numbers. The number of patients were used for RTU and cost calculations.

Table-8: Number of cancer patients: Comparison of Globocan 2022 and RCARP03 data

	All patients			Males			Females		
	Globocan	RCARP03	Diff.	Globocan	RCARP03	Diff.	Globocan	RCARP03	Diff.
Australia	200021	162163	-37858	109018	88982	-20036	91003	73181	-17822
Indonesia	396914	<i>Globocan data used</i>		183368	<i>Globocan data used</i>		213546	<i>Globocan data used</i>	
Malaysia	48639	28269	-20370	23052	12398	-10654	25587	15871	-9716
Mongolia	5987	6885	+898	3018	3604	+586	2696	3281	+585
Philippines	153751	<i>Globocan data used</i>		67267	<i>Globocan data used</i>		86484	<i>Globocan data used</i>	
Thailand	<i>Brachy study – no data collected</i>								

Table-9 presents a comparative analysis of radiotherapy infrastructure, using data from two key sources: DIRAC and national database. The table details the number of radiotherapy centers, megavoltage (MV) machines, and brachytherapy units reported by each dataset, highlighting differences between the sources for each country. The DIRAC data is collected by the IAEA and includes all radiotherapy centres worldwide, which is regularly updated, whereas national databases are usually operated by government agencies which can provide better updated data. Australia has the largest number of radiotherapy infrastructure with more than 200 machines in more than 100 centers, whereas Mongolia operates only one radiotherapy center. Thailand has the largest number of brachytherapy equipment.

Table-9: Radiotherapy infrastructure: Comparison of DIRAC data and RCARP03

	RT centers			MV machines			Brachy			DIRAC date
	DIRAC	RCARP 03	Diff.	DIRAC	RCARP 03	Diff.	DIRAC	RCARP 03	Diff	
Australia	104	102+	+2	224	230	+6	11	11	-	2021
Indonesia	55	54	-1	85	88	+3	15	22	+7	2023
Malaysia	32	29	-3	69	64	-5	11	17	+6	2023
Mongolia	1	1	-	6	4	-2	1	1	-	2023
Philippines	50	51	+1	73	61	-8	17	26	+9	2023
Thailand	47	43	-4	125	98	-27	29	32	+3	2023
Total	289	280	+9	582	545	+37	84	109	-25	

Table-10 presents an overview of staffing data, detailing the distribution of key personnel in radiation oncology centers. The table lists the number of Radiation Oncologists (RO), Medical Physicists (MP), and Radiation Therapists (RTT) for each country, along with important indexes such as MP/RO, RTT/RO, and staff per center (RO/CNTR, MP/CNTR, RTT/CNTR). A typical radiotherapy center in the region is not a large facility, employing less than 4 radiation oncologists and medical physicists, and around 10 RTTs, which indicates a fragmentation of the radiotherapy services within the countries. Staffing numbers per center is especially low in Indonesia and the Philippines.

Configuration of staff is also varying among countries, in average there are less than 4 RTTs and less than one medical physicist for each radiation oncologist working in the departments, where more than 6 RTTs for each radiation oncologist in Australia, but close to one in the Philippines, Mongolia, Malaysia and Thailand. These variations underscore differences in healthcare infrastructure, resource allocation, and possibly patient load, emphasizing the need for strategic workforce planning tailored to each country's specific context.

Table-10: Staffing data

	RO	MP	RTT	MP/RO	RTT/RO	RO/CNT R	MP/CNT R	RTT/CNT R
Australia	412	396	2640	0,96	6,40	4,04	3,88	25,9
Indonesia	153	120	363	0,78	2,37	2,83	2,22	2,35
Malaysia	101	86	131	0,85	1,29	3,48	2,96	4,51
Mongolia	9	4	12	0,44	1,33	9	4	12
Philippines	112	103	200	0,91	1,78	2,19	2,02	3,92
Thailand	200	154	340	0,77	1,70	4,65	3,58	7,9
RCA	987	863	3686	0,87	3,73	3,53	3,08	13,2

Table-11 presents RTU among the countries in the project. Optimal RTU were calculated by the Australian team using CCORE method except Indonesia, where the calculation was done by the Indonesian team; and Thailand team calculated only the image-guided brachytherapy (IGBT) utilization rate among all brachytherapy applications. The mean O-RTU is 52.3% (47-55%) among the project countries, so the number of patients who need radiotherapy is 390,000; however only 172,000 patients receive radiotherapy, the mean A-RTU is 23%. Although in Australia and the Philippines A-RTU is very high, access to radiotherapy is extremely low in Indonesia where only 6% of all cancer patients receive radiotherapy. As a result 217,000 patients have no access to radiotherapy in those countries, where 207,000 of them live in Indonesia.

Table-11: The number of patients requiring and receiving radiotherapy and the gap in access to radiotherapy.

	# cancer pats.	O- RTU	# pats. need radiotherapy	A- RTU	# pats. receive radiotherapy	Gap in radiotherapy access
Australia	162,163	47.3%*	76,704	47%	76,217	487
Indonesia	396,914	55.7%**	221,082	8.2%	13,486	207,596
Malaysia	28,269	50.6%*	14,305	29.2%	8,254	6,051
Mongolia	6,885	32.0%*	2,204	12%	827	1,377
Philippines	153,751	49.2%*	75,646	48%	73,801	1,845
Total	747,982	52.3%	390,941	23%	172,585	217,356

*Data from AUL-RCARP03, **Data from INS-RCARP03

Phase-2: Estimating core investment required for radiotherapy (Cost of radiotherapy)

Table-12 presents the existing and the additional costs required and the operation costs. Capital costs include building and equipment; operating costs include maintenance and amortization of building and equipment, salaries, and overhead costs. As visible from the table Australia has a high value of capital and needs around 20% additional capital costs, whereas Indonesia needs at least 10 times capital costs than present. Mongolia needs no capital investment.

Table-12: Existing and the additional costs required and the operation costs

	Capital costs (existing)	Capital costs (additional needed)	Capital costs (for final capacity)	Operating costs for final capacity
Australia	1,304,651,802	284,780,660	1,589,432,462	574,880,477
Indonesia	144,084,283	1,974,010,747	2,118,095,031	540,091,849
Malaysia	81,622,254	19,731,159	101,353,413	30,668,539
Mongolia	47,398,600	0	47,398,600	10,96,625
Philippines	363,403,920	744,323,320	1,113,727,240	221,154,597
Thailand*	59,509,397	89,512,665	149,022,062	30,800,600

**brachytherapy only*

Table-13 presents the costs of radiotherapy per fraction and per course, the total investment to run an efficient radiotherapy service and the additional investment required for the access of all patients to radiotherapy.

Costs per radiotherapy are fraction between 122.15 USD (Indonesia) to 428.75 USD (Australia). Since the cost of equipment is relatively similar in all countries the differences in cost per fraction are mostly due to salaries, construction and maintenance costs. The average number of fractions per treatment course are 11-19 among countries due to case mix (tumor types, ratio of palliative/curative), treatment techniques and reimbursement policies. Finally cost per treatment course is between 2,8852-6,860 USD in five countries and 10,441 USD for brachytherapy in Thailand. The total investment to provide full access patients to radiotherapy depends on the number of those patients who require radiotherapy.

This is less than 50 million USD for Mongolia, however higher than 2 billion USD in Indonesia. Mongolia already has adequate investment to cover all patients, however other five countries need a substantial investment for a total of around 3.2 billion USD.

Table-13: Costs of radiotherapy per fraction and per course, total investment and additional investment required

	¹ Cost per RT course	² Cost for 1 fx (USD/fx)	³ Total investment to bring to full access (existing + additional)	⁴ Additional investment to bring to full access
Australia	6,860	428.75	1,763,588,822	312,656,870
Indonesia	2,852	129.66	2,118,095,031	1,974,010,747
Malaysia	4,332	208.71	144,803,809	66,855,918
Mongolia	3,929	157.17	47,398,600	0
Philippines	2,877	143.84	1,114,611,365	745,023,045
Thailand*	10,441	401.57	149,022,062	89,512,665

¹total operating costs/RT course, ²total operating costs/fx, ³total capital costs + total training costs, ⁴additional capital costs + additional training costs, *brachytherapy only

Phase-3: Assessing the outcome

The goal was to evaluate the potential losses due to unmet demand and to assess the benefits derived from investments. However, Phase-3 was the most challenging part of the due to several reasons: no single valid model and no solid (objective) data to be used. In the first two phases the numeric data used were either adapted from open sources or collected by the participants, however the estimating the losses due to unmet demand was very hypothetical and although there were several models available, it was challenging to adapt for all countries in this research project, thus a simple model was required, which would be applicable for all RCARP03 countries. Furthermore, there was no ready-to-use template such as cost-calculator of phase-2. After consultations with the participating countries, it was agreed to provide a standardized template (excel sheet) with the list of data to be collected and relevant guidelines to the CSIs by 20 May 2024. However, the 3rd RCM and the associated workshop for the training of data collection for the 3rd phase were decided to be done online which impaired the 3rd phase. Online training was not satisfactory to adequately train the participating centers on this relatively complex and not medically oriented field. As a result, only Indonesia provided reasonable data for phase-3 (Table-14).

Table-14: Phase-3 data from Indonesia

Radiotherapy Benefit (improvement in survival due to radiotherapy)	Years of Life Lost (YLL) (average number of years lost due to premature death)	Years of Potential Life Lost (YPLL) (YPLL integrates cancer incidence and YLL to estimate total potential life lost)	Productivity Losses (Economic productivity losses due to mortality)
Breast: 0.0238 Cervical: 0.1056 Prostate: 0.0011 Rectal: 0.0029 Leukemia: 0.0099 Lymphoma: 0.9164 Lung: 0.0061 Nasopharynx: 0.3635	Highest: Lymphoma- 32.25 years Lowest: Prostate- 2 years	Lymphoma: 221,648.15 years Breast: 8,245.55 years Nasopharynx: 103,311.48 years Prostate: 30.25 years.	63.4 – 66.3 million USD

7. Final Reports by the GPs:

Australia:

Major results

- Optimal RTU of 47.31%, 66,800 patients with cancer that would benefit from RT, and a further eight more megavoltage machines are needed to cater to the predicted demand.
- the cost per RT course is approximately \$6,860 USD, and the cost per fraction is \$428.75 USD. Salaries are the main cost contributor

Achievements/success stories

- Global dissemination of results of the project with presentations and a publication in the Lancet Oncology, featuring CSIs from RCA as co-authors.
Editorial written in the Lancet Oncology “Modelling radiotherapy availability in the Asia-Pacific region” by Yolande Lievens: “The strength of this Article lies in providing granular estimates, not only for the entire region, but also per country, which are extremely important to support policy making, investment planning, educational programmes, and practical implementation... it provides an excellent example of how health services research can support policy”.
- The other major success story has been the increase in collaboration and capacity building in health services research in the RCA region.

Publications and conferences

- Lancet oncology paper (Abu Awwad et al., 2024) <https://pubmed.ncbi.nlm.nih.gov/38301690/>
- European Society for Radiotherapy and Oncology (ESTRO) conference poster (Abu Awwad et al., 2024)
- Global Breast Cancer Conference (GBCC) oral presentation (Yap, 2024)
- Article on RCARP03 work for RCA Newsletter (Abu Awwad, 2024).
- Indonesian International Cancer Conference (invited oral presentation, Yap 2024).

Indonesia:

Major results

- Estimated optimal radiotherapy utilization rate was 55.7%, while actual radiotherapy utilization rate was 8.21
- There is a clear gap between the calculation of number of machines needed and the actual utilization of the machines.
- Years life lost was ranging from 2 years (Prostate Cancer) to 32.25 years (Leukemia), reflecting significant disparities in life expectancy loss across cancer types.
- Economic productivity losses due to mortality were calculated 63.4 – 66.3 million USD

Achievements/success stories

- Along the study, advocacy efforts are continuously being done.
- Even early in Year 1, with the preliminary data of the big gap of optimal and actual RTU in Indonesia was realized, this was quickly conveyed to the Minister of Health, who has taken up

the importance of this gap and has deployed many developments of new centers in Indonesia, more importantly in the provinces without access to radiotherapy at all.

- This study analysis has also explore more on efficiency and found out that even the limited number of available machines are not being utilized efficiently in cities, which should have less barriers to access, which triggered the Indonesian team to work more on the multidisciplinary team and advocacy, and to work more closely to stakeholders in the health system.
- The analysis and approach have been highlighted by the IAEA and invited to be presented at the high-level Rays of Hope Forum, commemorating the World Cancer Day February 2024 at the IAEA Headquarter, Vienna.

Publications and conferences

- University of Indonesia G20 conference, June 2022, Jakarta
- Advocacy Meetings series with Minister of Health, beginning on June 18th, 2022
- Oral presentation in FARO-KOSRO Meeting, October 12th, 2023, Seoul – Korea: “Radiotherapy in Asia: Current Issues & Strategies”
- Invited speech, IAEA Rays of Hope Forum, 1-2 February 2024. <https://www.iaea.org/events/rays-of-hope/2024>
- WHO South-East Asia Regional workshop on scaling up services for cancer and implementing South-East Asia Cancer Grid, Kathmandu, Nepal, 14-17 May, 2024. Report: <https://iris.who.int/handle/10665/378069>
- Best abstract, Oral presentation for Colorectal RTU by our research team Dr. Vito Jayalie, at the FARO-ESTRO Meeting, Kuala Lumpur, 23 – 25 August 2024 <https://www.estro.org/About/Newsroom/Newsletter/Congresses/Rate-of-Use-of-Radiotherapy-to-Treat-Colorectal-Ca>
- Rapid-fire oral presentation for Breast cancer RTU in World Cancer Congress, Geneva Abstract available at: <https://onlinelibrary.wiley.com/doi/10.1002/ijc.35123>
- Indonesia International Cancer Conference (IICC), 2 – 5 October 2024, Bali Program book available at: [https://www.inainternationalcancerconference.org/img/Flyer%20Program%20Book%20\(as%20of%201%20Okt\).pdf](https://www.inainternationalcancerconference.org/img/Flyer%20Program%20Book%20(as%20of%201%20Okt).pdf)

Malaysia:

Major results

- Significant discrepancy between the optimal Radiotherapy Utilization (RTU) and the actual RTU, with optimal RTU at 52% compared to the current 25%.
- Another pressing issue emphasized was the shortage of clinical oncologists which is a critical concern that requires attention to ensure the effective delivery of oncology services.

Achievements/success stories

- In the third quarter of 2023, the results were presented in the Malaysia National Specialties/Subspecialties Meeting for the Ministry of Health were presented, with a primary focus on the demand and needs of Radiotherapy (RT) and Oncology Services.

- The meeting aimed to draw attention to these issues and encourage policy changes to address both equipment needs and workforce gaps in radiotherapy and oncology.

Publications and conferences

- The data only presented to the steering committee and stakeholders in Ministry of Health Malaysia as mentioned above. Source of reference: Dr Ros Suzanna binti Ahmad Bustamam, Head of Radiotherapy and Oncology Specialty, Ministry of Health. Email: ros.suzanna@moh.gov.my
- Since the data used was for the year 2018(more than 5 years), there will be no publication now unless there is revision of the result using the updated data

Mongolia:

Major results

- Calculated waiting time was 30 days for 1st calendar year period including 2nd half of 2022 and first half of 2023 and 14 days for 2nd calendar year period in 2024. Related with increased capacity of radiotherapy unit, waiting time was reduced 2 times in 2024 compare with 2023.
- Optimal RTU has been calculated with Australian team support using LMIC RTU model and it is 32% for all cancers.

Achievements/success stories

- Findings of the study have been used to provide evidence based information to Ministry of Health of Mongolia and other stakeholders such as IAEA Rays of Hope initiative since their visit to Mongolia in August 2023, and IAEA's imPACT Review Mission in May 2024. The IAEA is committed to supporting Mongolia expand their capacities in terms of nuclear medicine, medical physics and radiation oncology through the planned technical cooperation project.
- Ministry of Health and NCCM is developing a roadmap and action plan which is National Cancer Control Programme to scaling up radiotherapy services to align with Mongolia's broader healthcare strategy-Vision 2050 plan.
- By introducing IMRT/VMAT in 2022, SBRT and respiratory motion management in 2024 which have been used since 2000 internationally, we have brought 20 years of progress to radiation therapy in Mongolia. With improved capacity, radiotherapy access increased by 25% and waiting time reduced 2 times. Stereotactic Body Radiation Therapy (SBRT) has been opened new treatment option for liver and lung cancer patients since June 2024.

Publications and conferences

- CSI Dr.Minjmaa Minjee presented lecture on "Current situation of Radiotherapy in Mongolia - Achievements and Challenges" at the "Emerging Issues of Oncology" Conference 2022. Representatives from the Ministry of Health and Nuclear Energy Commission and Hospital managers who have oncology services were attended.
- -Open lecture was organized among Ministry of Health, hospital administration and oncology specialists in cooperation with FNCA Radiation Oncology meeting which was held in Ulaanbaatar, 1st Oct 2022.

- International Workshop on Modern Radiotherapy Techniques: IMRT/VMAT was organized on 10 November 2023. CSI Dr.Minjmaa Minjee is going to presented lecture on “Current Radiotherapy service in Mongolia and its future trend” at the workshop.
- 40 minutes TV content is under preparation to raise public and decision makers’ awareness of radiation therapy benefits and our future aims. Newspaper article with same content was published in Apr 2023.
- CSI Dr.Minjmaa Minjee presented on “Current situation of Radiotherapy in Mongolia - Achievements and Challenges” during visit of Rays of Hope initiative of IAEA on August 2023.
- An international symposium on International Symposium to Launch Linac Based Stereotactic Radiation Therapy and Neuro-Navigation Surgery of Cerebrospinal Tumors, It’s Opening Ceremony was held on 1 March 2024 and approximately 120 people form 16 institutions participated in the new technology launch event and symposium. Co-investigator Enkhtsetseg presented “Innovation of Radiotherapy in Mongolia”
- <https://www.iaea.org/newscenter/news/mongolia-takes-steps-to-enhance-cancer-detection-and>
- <https://news.mn/en/799884/>
- <https://ikon.mn/n/204q>
- <https://news.mn/r/2757646/>
- <https://ikon.mn/n/337b>
- <https://www.tac.mn/article/120404>

Philippines:

Major results

- RTU data shows a significant gap between the actual and optimal RTU rates. In 2020, the actual RTU was at a mere 4.5%, a drop from 10.3% in 2012. This is starkly lower than the optimal RTU rate of 48% in 2020, which itself decreased from 53% in 2012. This gap highlights a critical underutilization of radiotherapy services, which is detrimental to patient outcomes and indicative of broader accessibility issues.
- Our projections indicate that to meet the optimal RTU, the Philippines needs to significantly expand its radiotherapy infrastructure. Specifically, we require an additional 132 radiotherapy departments equipped with 262 more megavoltage (MV) units. This expansion will necessitate a corresponding increase in human resources, including 409 radiation oncologists, 451 medical physicists, and over 1,026 radiation technologists.
- On a per-patient basis, the cost for a complete course of radiotherapy is approximately 2,877 USD, with each fraction costing about 144 USD. These figures are crucial for budgeting and financial planning, as they help health financing agencies and policy-makers allocate resources more effectively.

Achievements/success stories

- Meeting with Vice Consul of the Philippine Embassy to the United Nations in Vienna, Austria regarding various gaps in PH cancer care specifically in radiotherapy and how to contribute

significantly to the alleviation of the cancer burden in the Philippines. Current strong collaboration with the Department of Science and Technology-Philippine Nuclear Research Institute, Department of Health and our team

- Philhealth increase in radiotherapy reimbursements (30 percent increase): Less to none out of pocket payments

Publications and conferences

- Published paper: we have successfully published a paper "Radiotherapy services in the Philippines: exploring geographical barriers to improve access to care" in the Lancet Western Pacific journal.
- Accepted paper entitled "Radiotherapy Services in the Philippines: Exploring Geographical Barriers to Improve Access to Care" to ESTRO 2024: Radiation Oncology: Bridging the Care Gap.

Thailand:

Major results

- Actual RTU of image-guided brachytherapy in 2019 for cervical cancer was 33%
- From RRCC ver. 2021, The data showed shortage of the manpower approximately in 40% for RO, 60% in MP, and 60% in RTT
- Brachytherapy counted 7% of capital cost for radiotherapy.
- For the benefit model IGBT yielded higher income gain (around 1m USD gained) and less cost to treat toxicity.

Publications and conferences

- Oral Presentation in Research Section of THASTRO annual meetings – ADUTHAYA in 22-24 March 2024 in the Topic of "prediction of requirement of RT in GYN cancers"
- Poster Presentation in ESTRO meets ASIA in Kuala Lumpur, Malaysia, 22-25 August 2024 in the topic of "Image-guided brachytherapy (IGBT) utilization rate from 14 radiotherapy centres from Thailand"
- Poster Presentation in MESTRO in Riyadh, Saudi Arabia, 27-29 November 2024 in the topic of "Image-guided brachytherapy utilization in uterine cancer; a survey from 14 centres of Thailand"
- Submitted manuscript of "Unlocking Economic Gains: The Impact of Image-Guided Brachytherapy on Cervical Cancer Treatment in Thailand" to submit to International Journal.

8. Limitations/challenges/suggestions for future research

As with any international research project, there were several challenges, including unreliable demographic, equipment, and cost data, as well as methodological differences across countries. Data collection was also difficult. Additionally, the COVID pandemic limited in-person meetings and workshops—only the Bali meeting was held live; the rest, including the initial meeting and two RCMs with training sessions, were conducted online. Consequently, the third phase of the project experienced setbacks due to insufficient training.

Despite challenges, the project should be seen as a success. RCRP03 raised awareness of radiotherapy among health authorities in participating countries, leading to new regulatory measures and projects to strengthen radiotherapy capacity.

Radiotherapy represents a cost-effective approach to cancer management. This project provided an overview of the current status of radiotherapy within the region, and its findings may serve as a foundation for subsequent research and strategic planning of radiotherapy services in RCA countries.

9. Conclusions:

RCARP03 project - Closing the Gap in Radiotherapy Access in RCA Government Parties evaluated the current situation of radiotherapy in 6 RCA countries (Australia, Indonesia, Malaysia, Mongolia, Philippines and Thailand). Every country created its own sub-project, but all projects shared three main pillars in common: Calculating burden to national health systems of cancer incidence requiring radiation therapy (RTU-radiotherapy utilization rate), estimating core investment required for radiotherapy (Cost of radiotherapy), assessing the outcome (Benefits of radiotherapy).

The results demonstrated that there is a gap in access to radiotherapy in the region. This gap is more evident in larger LMIC countries such as Indonesia, Philippines and Malaysia. The gap in access to radiotherapy is relatively low in Australia – a high-income country, and Mongolia – a country with a small population and very low need for radiotherapy.

The cost to close the gap depends on the number of cancer patients needing radiotherapy, existing capital costs and operating costs. The total investment required for radiotherapy is less than 50 million USD for Mongolia, however higher than 2 billion USD in Indonesia. The need for additional investment is 312 million USD for Australia, 1,9 billion USD for Indonesia, 67 million USD for Malaysia, 745 million USD for the Philippines, and 89 million USD for Thailand - to implement image-guided brachytherapy. No additional investment is required for Mongolia.

The cost-benefit data is limited only to Indonesia which demonstrated that radiotherapy could save up to 221 thousand years for lymphoma, 103 thousand years for nasopharynx, and 8 thousand years for breast cancer patients.

The project draw attention to the situation of radiotherapy in the project countries, and the needs and solutions were presented and discussed at high-level government meetings and several international scientific meetings. A number of scientific papers on the assess to radiotherapy either in the whole RCA region or in individual countries were published or submitted for publication already.

The project also raised awareness and enhanced the capacity of the radiation oncology communities in the project countries for nationwide evaluation and planning of radiation oncology services.

10. References:

1. RCA regional office [Internet]. [cited 2022 Jan 2]. Available from: <https://www.rcaro.org/>
2. World Health Organization. Global cancer observatory [Internet]. [cited 2020 Jun 23]. Available from: <https://gco.iarc.fr/>
3. Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, et al. Expanding global access to radiotherapy. *Lancet Oncol.* 2015;16(10):1153–86.
4. Yap ML, Hanna TP, Shafiq J, Ferlay J, Bray F, Delaney GP, et al. The benefits of providing external beam radiotherapy in low- and middle-income countries. *Clin Oncol.* 2017;29(2):72–83.
5. Gondhowiardjo SA, Handoko, Tham I, Giselvania A, Bilimangga RS, Octavianus S, et al. Regional collaboration to improve quality of radiation therapy in Asia. *J Med Imaging Radiat Oncol.* 2021;65(4):424–30.
6. Gondhowiardjo S, Sekarutami SM, Giselvania A, Octavianus S, Assegab MI. Improving access to radiation therapy in Indonesia. *Appl Radiat Oncol.* 2019;17–21.

11. Annexes:

Final Reports of Participated Countries

Annex 1. Australia



RCA Regional Office

c/o Korea Atomic Energy Research Institute
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Final Report for Research Agreement

(Please complete all sections and send your report electronically to: kelly@rcaro.org)

Title of the Research Project under which this Research Agreement is implemented: Closing the Gap in Radiotherapy Access in RCA Government Parties	
Title of the Research Agreement Project: Assessment of the existing gaps in radiotherapy services and the costs in lost life years due to not closing the gaps in the Asia Pacific region	
Institute Name: Ingham Institute	
CSI Name: Mei Ling Yap	Alternate CSI Name:
Period Covered: January 2022-December 2024	

<p>1. Final work plans for 2022, 2023 and 2024:</p> <p>2022 – worked on literature search to find cancer stage data from Asia-Pacific countries. 2023 – adjusted CCORE models using LMIC cancer staging data and assessed the optimal RTU for every country in the Asia-Pacific region 2024 – worked on cost calculator and economic benefit excel templates for Australia</p>
<p>2. Summary which describes in brief form the experimental method, major results:</p> <p>Australia: optimal RTU of 47.31%, 66,800 patients with cancer that would benefit from RT, and a further eight more megavoltage machines are needed to cater to the predicted demand. In terms of the cost calculator, in Australia, the cost per RT course is approximately \$6,859.99 USD, and the cost per fraction is \$428.75 USD. Salaries are the main cost contributor.</p>
<p>3. Detailed results achieved against work plans for 2022, 2023 and 2024, including quantitative data, if applicable (<i>please attach technical documents if needed</i>):</p> <p>See above.</p>

4. Achievements/success stories resulted from the project

Global dissemination of results of the project with presentations and a publication in the Lancet Oncology, featuring CSIs from RCA as co-authors.

Editorial written in the Lancet Oncology “Modelling radiotherapy availability in the Asia-Pacific region” by Yolande Lievens: “The strength of this Article lies in providing granular estimates, not only for the entire region, but also per country, which are extremely important to support policy making, investment planning, educational programmes, and practical implementation... it provides an excellent example of how health services research can support policy”.

The other major success story has been the increase in collaboration and capacity building in health services research in the RCA region.

5. Publications and conferences including stakeholder meetings held on the work performed under this Project (peer-reviewed journals, conferences proceedings, international and national conference contributions, stakeholder meetings, national/technical reports, *please enter web-link or attach copies to this report*):

Lancet oncology paper (Abu Awwad et al., 2024)

European Society for Radiotherapy and Oncology (ESTRO) conference poster (Abu Awwad et al., 2024)

Global Breast Cancer Conference (GBCC) oral presentation (Yap, 2024)

Article on RCARP03 work for RCA Newsletter (Abu Awwad, 2024).

Indonesian International Cancer Conference (invited oral presentation, Yap 2024).

6. Suggestions for future research in the relevant field/sustainability of the project

Will continue to work to calculate phase II and phase III estimates for other Asia-Pacific countries—specifically aiming to estimate values for low and middle-income countries.

Contributions to the Project

Country	Australia
Reporting Period	2022-2024

1. Contribution to the Project on Phase 1, 2, and 3

Phases	Contributions
<p>Phase 1. Calculation of Burden of Cancer Requiring Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a Summary of the calculated RTU * Please submit detailed data separately as Annex 1 <p>Australia: optimal RTU of 47.31%, 66,800 patients with cancer that would benefit from RT, and a further eight more megavoltage machines are needed to cater to the predicted demand.</p>
<p>Phase 2. Summary of Estimating Core Investment Required for Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the future facility, additional equipment and human resources - Provide a summary of radiotherapy cost calculation - Submit detailed data in separately as Annex 2 <p>In terms of the cost calculator, in Australia, the cost per RT course is approximately \$6,974.73 USD, and the cost per fraction is \$435.92 USD. Salaries are the main cost contributor.</p>
<p>Phase 3. Assessing the outcome -Application of an investment framework</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the economic analysis - Submit detailed data in separately as Annex 3 <p>With no scale-up, and using the costs from phase 2, the total cost for treatment in Australia is \$433.9 million USD.</p> <p>With longer hours (increased by 50%) of machine use or bulk purchasing of machine (machine cost down by 30%) the cost goes down to 376.8 and 368.3 million USD respectively. With both subsidies applied, the cost of radiation treatment is estimated as 338.6 million USD.</p>

2. Additional information on the use of the project result and capacity building of the personnel (outcome)

Use of the project result	Contributions
Possible use of analytical data by stakeholders and governmental agencies involved in policy and strategy design in the field of health or cancer control	<p>- Specific information on stakeholders and governmental agencies possibly use the analytical data of the project in relation to policy and strategy design</p> <p>- If the project results were delivered to the stakeholders (government agencies or related institutes, please provide the list of recipients)</p> <p>The main way these results will be shared publicly would be through research publications in the hopes of attracting attention from key stakeholders and governmental agencies. A breakdown of costs, personnel needed, and economical savings will be detailed in future publications to share the analytical data that would be useful in any policy/strategy.</p>

2-1 Assessment of Research Capabilities in comparison of 2022

Please tick(✓) where relevant and provide descriptions on the self-assessment of your team’s research capabilities before and after participation in the project

	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	
Research Management and support	✓	✓	✓	✓	Lots of support from the project members, particularly Zubi and Yavuz. Dr Dania Abu Awwad provided important leadership together with CSI.
Attainment and application of new research skills and knowledge	✓	✓	✓	✓	
Research collaboration	Same	Minimal Improvement	Moderate	Significant	Built a new health services research

	(Not Improved)		Improvement	Improvement	network between RCA participants and built a new Australian collaboration between CCORE and University of Sydney
	✓	✓	✓	✓	
Knowledge transfer/take up by relevant stakeholders	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Phase I of the study has been shared through publication/conference presentations and we plan to do the same for phase II/III in the next 12 months.
	✓	✓	✓	✓	

3. Success Stories

- Please provide success stories from the project (2022-2024) to demonstrate achievement and impact of the project in your country (attach pictures, website link, MoU, or other evidences)

The work has led to a number of research outputs including presentations, journal articles and an Editorial. Importantly, it has also helped build the research profile of Dr Dania Abu Awwad, who had not worked with CCORE prior to this and has now developed unique expertise in radiotherapy health services research.

ESTRO poster:

Journal article in the Lancet Oncology and subsequent editorial written on paper:

Articles

Current and projected gaps in the availability of radiotherapy in the Asia-Pacific region: a country income-group analysis



Dania Abu Awwad, Jesmin Shafiq, Geoffrey Paul Delaney, Yavuz Anacak, Freddie Bray, Jerickson Abbie Flores, Soehartati Gondhowiardjo, Minjmaa Minjgee, Tiara Bunga Mayang Permata, Jaffar C Pineda, Suhana Yusak, Eduardo Zubizarreta, Mei Ling Yap

Summary

Background Cancer incidence and mortality is increasing rapidly worldwide, with a higher cancer burden observed in the Asia-Pacific region than in other regions. To date, evidence-based modelling of radiotherapy demand has been based on stage data from high-income countries (HIC) that do not account for the later stage at presentation seen in many low-income and middle-income countries (LMICs). We aimed to estimate the current and projected demand and supply in megavoltage radiotherapy machines in the Asia-Pacific region, using a national income-group adjusted model.

Lancet Oncol 2024; 25: 225-34

See [Comment](#) page 152

Faculty of Medicine and Health, University of Sydney, Sydney, Australia (D Abu Awwad PhD); Collaboration for Cancer Outcomes, Research and Evaluation, Liverpool Hospital, Ingham Institute, University of New South Wales, Liverpool, NSW, Australia

Methods Novel LMIC radiotherapy demand and outcome models were created by adjusting previously developed models that used HIC cancer staging data. These models were applied to the cancer case mix (ie, the incidence of



Modelling radiotherapy availability in the Asia-Pacific region

Dr P Manzar/Science Photo Library



See [Articles](#) page 225

Radiotherapy is a cornerstone in the multidisciplinary approach to cancer care. In 2012, the Global Task Force on Radiotherapy for Cancer Control estimated that, if all patients with cancer with an evidence-based indication for radiotherapy worldwide had access to radiotherapy, more than 580 000 patients would be cured each year, amounting to 1 million by 2035.¹ These figures pertain to the global cancer population, including patients that receive palliative radiotherapy, for whom long-term benefits are not anticipated, and even those for whom radiotherapy is not indicated.²

The need for radiotherapy is increasing in parallel with growing cancer incidence and varies by region;

due to the demographic transition, higher increases in incidence and radiotherapy needs are predicted in low-income and middle-income countries than in high-income countries.^{1,3} Previous modelling showed that radiotherapy needs are more affected by the proportional distribution of cancer types than by stage distribution, which accounts for only a few percent in variation.⁴ Small changes in percentile radiotherapy needs might however have a major effect on absolute radiotherapy courses and resources required, especially in large populations or countries.⁴ Moreover, radiotherapy is a high-tech, resource-demanding specialty for which investment in equipment and

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www.thelancet.com/oncology Vol 25 February 2024

RCA Newsletter – September Issue:

RCA Projects

The current status on radiation therapy availability in the Asia-Pacific

- **Dr Dania Abu Awwad** | Discipline of Medical Imaging Sciences, University of Sydney, Australia



factor in any national cancer control plan.

Cancer is increasing worldwide, and while there have been improvements in treatment and survival, there persists inequity in access to treatment around the world. This extends to access to radiation therapy, which is an essential component of comprehensive cancer care, making it a necessary

CCORE model was updated using cancer staging from a LMIC and this version was used in conjunction to the original model to apply to different countries based on their income level.

Using CCORE's radiation therapy utilisation model, we can estimate the number of cancer patients that would benefit from radiation therapy, calculate the number of megavoltage machines needed to meet that demand, and assess the percentage of patients that would obtain local control or survival benefits. The datasets used to calculate these findings include publicly available cancer incidence data from the Global Cancer Observatory (GLOBOCAN), megavoltage machine availability from the Directory of Radiotherapy Centres (DIRAC), and income classifications from the World Bank.

As well, one of the biggest success stories of this project has been increasing collaboration amongst the RCA countries in health services research and policy impact.

Since this project began, Australia and Indonesia in particular have increased collaboration. CSI Yap was invited as speaker to the Indonesian International Cancer conference in October 2024 to discuss modelling relating to this RCA project. She returned to Indonesia in December 2024 as an invited expert to another RCA meeting in Jakarta, and also met the Indonesia minister of health to discuss cancer services modelling in Dec 2024



CSI Yap meeting Indonesian Minister of Health Budi Gunadi Sadikin to discuss cancer services modelling in Indonesia

CSI Yap was also awarded a New South Wales Premier Cancer research Award for “Improving Equitable Outcomes in Cancer”, for work which included that relating to this RCA project

<https://www.cancer.nsw.gov.au/what-we-do/events/nsw-premier-s-awards-for-outstanding-cancer-resear/2024/improving-equitable-outcomes-award>



CSI Yap with Indonesian CSI and team in Jakarta Dec 2024

4. Synergies/interactions among the participating countries

Countries	Synergy/interactions
Philippines, Indonesia, Mongolia, Malaysia	Co-authors on paper on optimal RTU across Asia-Pacific countries.
Philippines, Indonesia, Mongolia, Malaysia	Co-authors on paper on conference paper for ESTRO
Indonesia	<p>Ongoing collaborations beyond the project, with regards to aiding with cancer services planning more broadly and supporting health services research (Dr Ben Pragogi from Indonesia planning a PhD in health services research).</p> <p>The Indonesian team also invited CSI Yap as International Faculty to the Indonesian International Cancer conference in Bali and the RAS6098 course on palliative radiotherapy as well as the Ministry of Health in Indonesia in Dec 2024. Undoubtedly RCARP03 was the catalyst for these collaborations.</p>

5. Limitations

As is the case with many countries (including in Australia), detailed cancer registry data is a challenge to find

6. Lessons learned

Usage of Zubi's cost calculator and Danielle's template for economic benefit. That the cost of radiotherapy differs in each country and income level, but ultimately radiotherapy is cost effective and an important investment for the region.

7. Suggestions for future research/sustainability of the project

Will work to estimate values of low and middle-income countries across the Asia-Pacific countries using the cost calculator and economic benefit templates, and disseminate the results on this via presentation and/or publication.

8. Conclusions

Summary of the outcomes, achievements, impact of the project, success stories, remarks, etc.

We updated the CCORE model with cancer staging data from Malaysia as it had the most robust cancer staging data from LMICs in the Asia-Pacific region and used it to estimate optimal RTU values across all Asia-Pacific countries. This work resulted in successful publication and multiple presentations.

We also mentored an Australian radiographer early career research, Dr Dania Abu-Awwad in cancer health systems research (which was a new area of research for her), and extended CCORE's collaboration with the University of Sydney.

Importantly, this project has led to increased cooperation and capacity building in health services research across the RCA. This has led to ongoing collaboration with our partners across the RCA.

We will continue to estimate costs and economic benefit for LMICs as well with the intention of increasing output/publication on this matter as well.

Attachments:

Annex 1 Results/Data of Phase 1
Annex 2 Results/Data of Phase 2
Annex 3 Results/Data of Phase 3
publications, pictures, etc.

CSI Name and Signature	Mei Ling Yap 
Date and Place	Sydney 19/12/2024

Annex 2. Indonesia



RCA Regional Office

c/o Korea Atomic Energy Research Institute
 989-111 Daedeok-daero, Yuseoung-gu, Dae-jeon, 34057, Korea
 Tel: +82 42 868 2776~8,8223
 Fax: +82 42 864 1626
<http://www.rcaro.org>

Final Report for Research Agreement

(Please complete all sections and send your report electronically to: kelly@rcaro.org)

Title of the Research Project under which this Research Agreement is implemented: Closing the Gap in Radiotherapy Access in RCA Government Parties	
Title of the Research Agreement Project: Closing the Gap in Radiotherapy Access in Indonesia	
Institute Name:	
CSI Name: Tiara Bunga Mayang Permata	Alternate CSI Name: Soehartati Gondhowiardjo
Period Covered: January 2022-December 2024	

7. Final work plans for 2022, 2023 and 2024:

No.	Activity	2022				Expected outputs	Progress of the activities
		Q1	Q2	Q3	Q4		
1	Situational Analysis: Colecting data by surveys/ questionnaires		V	V		Obtain an overview of the condition of the radiotherapy center, equipment, human resources, education, health system, and payment methods for radiotherapy services.	Completed
2	Calculating of RTU			V	V	Optimal and actual RTU for the top 10 cancer incidents in Indonesia	Completed

3	Estimation of number of cancer patients requiring radiotherapy in 2030 - 2040			V	V	Number of patient requiring RT in 2030-2040 (based on optimal RTU and Globocan data for cancer Incident)	Completed
4	Estimation of future facility, equipment, and human resources needs			V	V	Number of facility, equipment, human resource and cost of expanding services to unmet need	Completed
5	Radiotherapy cost calculation			V	V	Cost/fraction in Indonesia	Completed
6	<i>Submission of annual progress report</i>				V	Submission	Completed

No.	Activity	2023				Expected Outputs	Progress of the activities
		Q1	Q2	Q3	Q4		
1	<i>Evaluation of RTU and Cost findings</i>		V			Consultation to Experts	Completed
2	<i>Research Coordination Meeting Bali</i>		V				Completed
3	<i>Submission of annual progress report</i>				V	Submission	Completed

No.	Activity	2024				Expected outputs	Progress of the activities
		Q1	Q2	Q3	Q4		
1	<i>Learn/Workshop of Phase 3: Impact</i>	V					Completed
2	<i>Data collection for Phase 3</i>		V	V		Obtain RTU components for calculating impact/benefits	Completed

3	<i>Do the analysis of economic and life loss, return on the investment</i>			V	V	Economic and life benefit	On progress
4	<i>Submission of final report</i>				V	Submission	Completed

8. Summary which describes in brief form the experimental method, major results:

The method of this study was collecting data from participating centers in Indonesia, with various variables that was detailed in the protocol developed together for the study.

Phase 1: Calculating burden of cancer requiring radiation therapy (Year 1)

1.A. Situational Analysis

1.B. Radiotherapy Utilization Rate (RTU)

1.C. Estimation of number of cancer patients requiring radiotherapy in 2030-2040

Phase 2: Estimating core investment required for radiotherapy (Year 2)

2.A. Estimation of future facility, equipment and human resources needs

2.B. Radiotherapy cost calculation

Phase 3: Assessing the outcome (impact) (Year 3)

3.A. Potential loss upon failure to close the gap

3.B. Return on investments in terms of life-years and financial values

3.C. Evaluation

9. Detailed results achieved against work plans for 2022, 2023 and 2024, including quantitative data, if applicable (*please attach technical documents if needed*):

Situational analysis and estimated number of cancer patients requiring radiotherapy in 2030 - 2040 is taken from the GLOBOCAN 2020 and Indonesian Radiation Oncology Society (IROS) database.

For RTU calculation, we received data from 38 hospitals, but only 34 centers were able to be analyzed. Exclusion criteria were centers not operational in 2019 or whose data were incomplete. From the 34 centers, 17 centers collected cancer report from all departments, while the other 17 only submitted data from radiotherapy department.

Based on available data, we have calculated optimal (oRUR) and actual radiotherapy utilization rate (aRUR) in Indonesia, shown in Table 2 below.

Table 1. Actual and Optimal Radiotherapy Utilization Rate (RUR) for 10 types of Cancer

Cancer Type	aRUR	oRUR
Colon	5,30%	3,30 (3,00-3,70)%
Rectum	19,50%	41,00 (28,00-66,00)%
Cervix	56.47%	97,20 (90,90-97,40)%
Ovary	4.108%	1,89 (1,39-4,60)%
Nasopharynx	53,22%	100,00%
Prostate	18,55%	73,10 (66,50-74,10)%
Leukaemia	0.74%	9,94 (9,52-10,37)%
Lymphoma	12.80%	79,31 (53,75-87,15)%
Breast	35,64%	66,33 (50,70-78,20)%
Lung	21,09%	86,97 (72,85-90,25)%
For 10 Cancers Above	26.16%	62,32 (52,11-69,26)%

By extrapolating to the incidence of other cancers according to GLOBOCAN 2020 data, for all cancers in Indonesia, the estimated optimal radiotherapy utilization rate is **55.7%**, while actual radiotherapy utilization rate is **8.21%**.

Through this analysis, we realized that there is a clear gap between the calculation of number of machines needed (by Zubizaretta method, 2015) and the actual utilization of the machine. And this should be highlighted in terms of white papers or advocacy efforts to decision makers, to optimize utilization and to be careful to not to invest more money if existing machines are still underutilized.

b. Phase 2. Summary of Estimating Core Investment Required for Radiotherapy

Radiotherapy's current availability were listed, while the recommended or ideal number of equipment and human resources, were assessed using the Radiotherapy Resources and Cost Calculator (RRCC) version 21, which was created by Eduardo Zubizaretta. Radiotherapy cost calculation was also performed using the same calculator. For the second phase of our study, out of the 46 hospitals that had initially been provided with questionnaires, data was collected from 29 hospitals. It's important to note that the data utilized in this research pertains to the year 2019.

Product Cost	
Cost per RT course	US\$ 2,852
Cost per fraction	US\$ 129.66

c. Phase 3. Summary of Estimating Benefit of Radiotherapy (Preliminary result)

Years of Life Lost (YLL)

YLL reflects the average number of years lost due to premature death: YLL ranges from 2 years (Prostate Cancer) to 32.25 years (Leukemia), reflecting significant disparities in life expectancy loss across cancer types.

Years of Potential Life Lost (YPLL)

YPLL integrates cancer incidence and YLL to estimate total potential life lost:

- Lymphoma: 221,648.15 years (highest)
- Breast Cancer: 8,245.55 years
- Nasopharynx Cancer: 103,311.48 years
- The lowest is for Prostate Cancer with 30.25 years.

These results emphasize the large societal burden of high-incidence cancers like Lymphoma and Cervical Cancer.

Productivity Losses

Economic productivity losses due to mortality were calculated IDR 1,060,233,522,942 - IDR 1,108,081,420,418 (1.06 - 1.108 trillion Indonesia Rupiah)

10. Achievements/success stories resulted from the project

Along the study, advocacy efforts are continuously being done led by Prof. Soehartati Gondhowiardjo. Even early in Year 1, where we already got the preliminary data of RTU and realized the big gap of optimal and actual RTU happening in Indonesia, this was quickly conveyed to the Minister of Health. He has taken up the importance of this gap and has deployed many developments of new centers in Indonesia, more importantly in the provinces without access to radiotherapy at all.

This study analysis has also led us to explore more on efficiency and found out that even the limited number of available machines are not being utilized efficiently in cities, which should have less barriers to access. This triggered us to work more on the multidisciplinary team and advocacy, and to work more closely to stakeholders in the health system.

Our analysis and approach have been highlighted by the International Atomic Energy Agency (IAEA) and invited to be presented at the high-level Rays of Hope Forum, commemorating the World Cancer Day February 2024 at the IAEA Headquarter, Vienna.

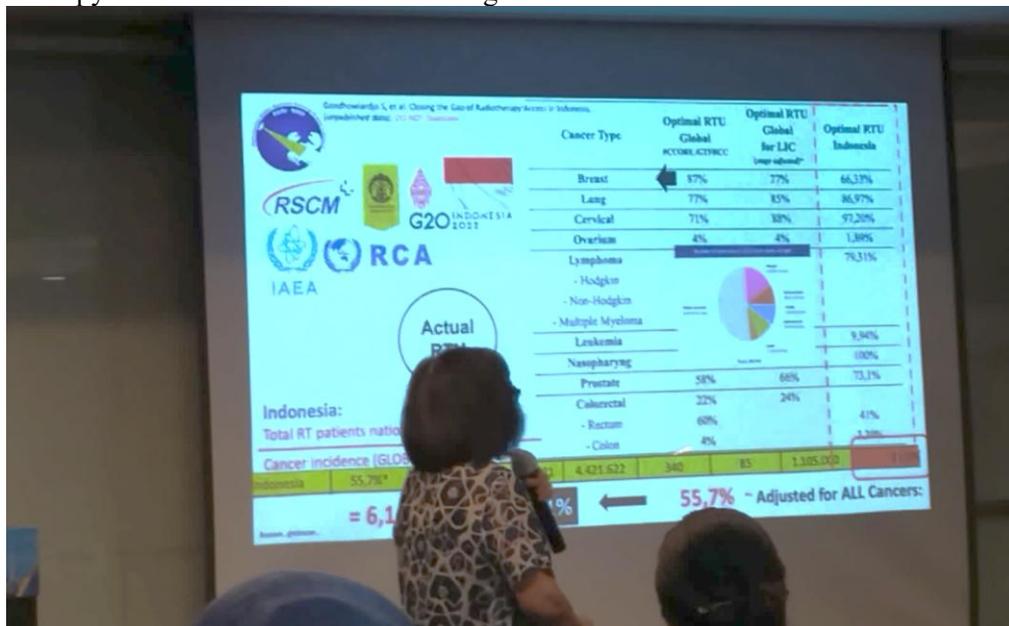
11. Publications and conferences including stakeholder meetings held on the work performed under this Project (peer-reviewed journals, conferences proceedings, international and national conference contributions, stakeholder meetings, national/technical reports, *please enter web-link or attach copies to this report*):

- University of Indonesia **G20 conference**, June 2022, Jakarta
- **Advocacy Meetings series** with Minister of Health, beginning on June 18th, 2022



1st meeting Prof. Soehartati with the Minister of Health, Mr. Budi Gunadi Sadikin, June 2022

- Oral presentation in **FARO-KOSRO Meeting**, October 12th, 2023, Seoul – Korea: “Radiotherapy in Asia: Current Issues & Strategies”



- Invited speech, **IAEA Rays of Hope Forum**, 1-2 February 2024: <https://www.iaea.org/events/rays-of-hope/2024>



- Joint publication, led by the Australian team: Abu Awwad D, et al. Current and projected gaps in the availability of radiotherapy in the Asia-Pacific region: a country income-group analysis. **Lancet Oncol 2024**; 25: 225-34. <https://pubmed.ncbi.nlm.nih.gov/38301690/>
- **WHO South-East Asia Regional workshop on scaling up services for cancer and implementing South-East Asia Cancer Grid**, Kathmandu, Nepal, 14-17 May, 2024 Report: <https://iris.who.int/handle/10665/378069>



- Best abstract, Oral presentation for Colorectal RTU by our research team Dr. Vito Jayalie, at the FARO-ESTRO Meeting, Kuala Lumpur, 23 – 25 August 2024
<https://www.estro.org/About/Newsroom/Newsletter/Congresses/Rate-of-Use-of-Radiotherapy-to-Treat-Colorectal-Ca>



- Rapid-fire oral presentation for Breast cancer RTU in **World Cancer Congress**, Geneva
Abstract available at: <https://onlinelibrary.wiley.com/doi/10.1002/ijc.35123>



- **Indonesia International Cancer Conference (IICC)**, 2 – 5 October 2024, Bali
Program book available at:
[https://www.inainternationalcancerconference.org/img/Flyer%20Program%20Book%20\(as%20of%201%20Okt\).pdf](https://www.inainternationalcancerconference.org/img/Flyer%20Program%20Book%20(as%20of%201%20Okt).pdf)

12. Please provide a short financial overview on how the RCARO contribution to this Project was used and if other contributions from other sources of funding, were used for implementation of the project:

RCARO Contribution

Activity	Expenditures	Balance
Year 1		€ 7,000
<u>Research permit administrative fee:</u> - 10 academic centers @ € 327,8 - 29 non-academic centers @ € 131,1	€ 3,278 € 3,802	
<i>Note: Currency in EURO (€). 1 Euro = 15,246 IDR</i>		
TOTAL		- (€ 80) <i>borne by IROS</i>
Year 2		€ 7,000
<u>Research permit administrative fee:</u> - 10 academic centers @ € 303,2 - 29 non-academic centers @ € 151,6	€ 3,032 € 4,397	
<i>Note: Currency in EURO (€). 1 Euro = 16,490 IDR</i>		
TOTAL		- (€ 429) <i>borne by IROS</i>
Year 3		€ 7,000
<u>Research permit administrative fee:</u> - 10 academic centers @ € 296,6 - 29 non-academic centers @ € 148,3	€ 2,966 € 4,301	
<i>Note : Currency in EURO (€). 1 Euro = 16,856 IDR</i>		
TOTAL		- (€ 267) <i>borne by IROS</i>

In each participating institution, there is an annual administrative fee to be paid for conducting research. This fee is part of the requirement while processing the Ethical clearance (mandatory for any kind of research) and research permit (from the research committee in each hospital). Without a research permit, it is not allowed to take any data from hospitals and conduct analysis. From all radiotherapy centers who agreed to participate in the study, there are 10 academic centers (affiliated with universities), and 29 others. The fee is higher for academic hospitals. There was a rise in the fee for the non-academic centers from Year 2 of the study.

The difference in the fee in Euro is caused by the difference in exchange rate from IDR to Euro each year.

Other financial contributions, if any:

(Including in-house staff, equipment, facilities/meeting rooms of the institute, outsourcing contracts, etc.)

Activity/Year	Expenditures
Year 1	
National ethical clearance administrative fee	€ 197
Fee for data collectors: (39 persons) <i>(co-founded by IROS and the 39 respective centers listed below)</i>	€ 5,113
TOTAL	€ 5,310

Note : Currency in EURO (€). 1 Euro = 15,246 IDR

Year 2	Expenditures
National coordination meeting 50 pax meeting package @ €27	€ 1,350
Fee for data collectors: (38 persons) <i>(co-founded by IROS and the respective centers listed below, except Bali Mandara Hospital)</i>	€ 4,518
TOTAL	€ 5,868

Note : Currency in EURO (€). 1 Euro = 16,490 IDR

There were no other financial contributions in Year 3.

List of participating and co-founding centers and their city:

No	Hospital Name, City	Participation in Study			Co-founding	
		Phase 1	Phase 2	Phase 3	Year 1	Year 2
1	H. Adam Malik Hospital, Medan	✓	✓	✓	✓	✓
2	Murni Teguh Memorial Hospital, Medan	✓	✓	✓	✓	✓
3	Dr. M. Djamil Hospital, Padang	✓	✓	✓	✓	✓
4	Universitas Andalas Hospital, Padang	✓	✓	✓	✓	✓
5	Awal Bros Hospital, Pekanbaru	✓	✓	✓	✓	✓

6	Arifin Achmad Hospital, Pekanbaru	✓	✓	✓	✓	✓
7	Dr. Mohammad Hoesin Hospital, Palembang	✓	✓	✓	✓	✓
8	Dr. H. Abdoel Moeloek Hospital, Lampung	✓	✓	✓	✓	✓
9	MRCCC Siloam Hospitals Semanggi, Jakarta	✓	✓	✓	✓	✓
10	Dr. Cipto Mangunkusumo Hospital, Jakarta	✓	✓	✓	✓	✓
11	Gading Pluit Hospital, Jakarta	✓	✓	✓	✓	✓
12	Persahabatan Hospital, Jakarta	✓	✓	✓	✓	✓
13	Mayapada Lebak Bulus Hospital, Jakarta	✓	✓	✓	✓	✓
14	Gatot Soebroto Hospital, Jakarta	✓	✓	✓	✓	✓
15	Santosa Kopo Hospital, Bandung	✓	✓	✓	✓	✓
16	Dr. Hasan Sadikin Hospital, Bandung	✓	✓	✓	✓	✓
17	Al-Ihsan Hospital, Bandung	✓	✓	✓	✓	✓
18	Dr. Sardjito Hospital, Yogyakarta	✓	✓	✓	✓	✓
19	JIH Hospital, Yogyakarta	✓	✓	✓	✓	✓
20	Prof Dr. Margono Soekarjo Hospital, Purwokerto	✓	✓	✓	✓	✓
21	Dr. Kariadi Hospital, Semarang	✓	✓	✓	✓	✓
22	Dr. Moewardi Hospital, Solo	✓	✓	✓	✓	✓
23	Ken Saras Hospital, Semarang	✓	✓	✓	✓	✓
24	Tugurejo Hospital, Semarang	✓	✓	✓	✓	✓
25	Indriati Hospital, Solo	✓	✓	✓	✓	✓
26	Dadi Keluarga Hospital, Purwokerto	✓	✓	✓	✓	✓
27	PKU Muhammadiyah Gombong Hospital, Kebumen	✓	✓	✓	✓	✓
28	Dr. Syaiful Anwar Hospital, Malang	✓	✓	✓	✓	✓
29	Dr. Soetomo Hospital, Surabaya	✓	✓	✓	✓	✓
30	Dr. Ramelan Hospital, Surabaya	✓	✓	✓	✓	✓
31	Adi Husada Hospital, Surabaya	✓	✓	✓	✓	✓
32	Lavalette Hospital, Malang	✓	✓	✓	✓	✓
33	Prof. Ngoerah (Sanglah) Hospital, Denpasar	✓	✓	✓	✓	✓
34	Bali Mandara Hospital, Denpasar	✓	✓	✓	✓	X
35	Provinsi Nusa Tenggara Barat Hospital, Lombok	✓	✓	✓	✓	✓
36	Abdoel Wahab Sjahranie Hospital, Samarinda	✓	✓	✓	✓	✓
37	Dr. Wahidin Sudirohusodo Hospital, Makassar	✓	✓	✓	✓	✓

38	Universitas Hasanuddin Hospital, Makassar	✓	✓	✓	✓	✓
39	Prof. Dr. R.D. Kandou Hospital, Manado	✓	✓	✓	✓	✓
<p>13. Suggestions for future research in the relevant field/sustainability of the project</p> <ul style="list-style-type: none"> • Further explorations on factors determining low actual RTU to the community level, and also inefficiency of available machines (Access barriers) • Development of radiotherapy roadmap, including costing analysis 						

Contributions to the Project

Country	Indonesia
Reporting Period	2022-2024

1. Contribution to the Project on Phase 1, 2, and 3

Phases	Contributions																																				
Phase 1. Calculation of Burden of Cancer Requiring Radiotherapy	<p>- Provide a Summary of the calculated RTU * Please submit detailed data separately as Annex 1</p> <p style="text-align: center;">Actual and Optimal Radiotherapy Utilization Rate (RUR) for 10 types of Cancer</p> <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px auto;"> <thead> <tr> <th style="text-align: center;">Cancer Type</th> <th style="text-align: center;">aRUR</th> <th style="text-align: center;">oRUR</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Colon</td> <td style="text-align: center;">5,30%</td> <td style="text-align: center;">3,30 (3,00-3,70)%</td> </tr> <tr> <td style="text-align: center;">Rectum</td> <td style="text-align: center;">19,50%</td> <td style="text-align: center;">41,00 (28,00-66,00)%</td> </tr> <tr> <td style="text-align: center;">Cervix</td> <td style="text-align: center;">56,47%</td> <td style="text-align: center;">97,20 (90,90-97,40)%</td> </tr> <tr> <td style="text-align: center;">Ovary</td> <td style="text-align: center;">4,108%</td> <td style="text-align: center;">1,89 (1,39-4,60)%</td> </tr> <tr> <td style="text-align: center;">Nasopharynx</td> <td style="text-align: center;">53,22%</td> <td style="text-align: center;">100,00%</td> </tr> <tr> <td style="text-align: center;">Prostate</td> <td style="text-align: center;">18,55%</td> <td style="text-align: center;">73,10 (66,50-74,10)%</td> </tr> <tr> <td style="text-align: center;">Leukaemia</td> <td style="text-align: center;">0,74%</td> <td style="text-align: center;">9,94 (9,52-10,37)%</td> </tr> <tr> <td style="text-align: center;">Lymphoma</td> <td style="text-align: center;">12,80%</td> <td style="text-align: center;">79,31 (53,75-87,15)%</td> </tr> <tr> <td style="text-align: center;">Breast</td> <td style="text-align: center;">35,64%</td> <td style="text-align: center;">66,33 (50,70-78,20)%</td> </tr> <tr> <td style="text-align: center;">Lung</td> <td style="text-align: center;">21,09%</td> <td style="text-align: center;">86,97 (72,85-90,25)%</td> </tr> <tr> <td style="text-align: center;">For 10 Cancers Above</td> <td style="text-align: center;">26,16%</td> <td style="text-align: center;">62,32 (52,11-69,26)%</td> </tr> </tbody> </table> <p style="text-align: center;">By extrapolating to the incidence of other cancers according to GLOBOCAN 2020 data, for all cancers in Indonesia, the estimated optimal radiotherapy utilization rate is 55.7%, while actual radiotherapy utilization rate is 8.21%.</p> <p>More details in Annex 1.</p>	Cancer Type	aRUR	oRUR	Colon	5,30%	3,30 (3,00-3,70)%	Rectum	19,50%	41,00 (28,00-66,00)%	Cervix	56,47%	97,20 (90,90-97,40)%	Ovary	4,108%	1,89 (1,39-4,60)%	Nasopharynx	53,22%	100,00%	Prostate	18,55%	73,10 (66,50-74,10)%	Leukaemia	0,74%	9,94 (9,52-10,37)%	Lymphoma	12,80%	79,31 (53,75-87,15)%	Breast	35,64%	66,33 (50,70-78,20)%	Lung	21,09%	86,97 (72,85-90,25)%	For 10 Cancers Above	26,16%	62,32 (52,11-69,26)%
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<p>Phase 2. Summary of Estimating Core Investment Required for Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the future facility, additional equipment and human resources - Provide a summary of radiotherapy cost calculation - Submit detailed data in separately as Annex 2 <p>Data from 29 centers in 2019</p> <p>Capital Cost: Total US\$ 144 million/29 centers → US\$ 5 million/center</p> <p>Operational Cost: Hospitals' data : US\$ 684,864 - US\$3,847,323 RRCC : US\$ 371,562 - US\$ 3,870,570</p> <p>Cost/RT Course : US\$ 2,852 Cost/RT fraction : US\$ 129.66</p> <p>More details in Annex 2</p>
<p>Phase 3. Assessing the outcome -Application of an investment framework</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the economic analysis - Submit detailed data in separately as Annex 3 <p>Preliminary result for Phases 3: <i>(Analysis is still ongoing, and yet to be consulted to the study experts)</i></p> <p>Years of Life Lost (YLL) YLL reflects the average number of years lost due to premature death: YLL ranges from 2 years (Prostate Cancer) to 32.25 years (Leukemia), reflecting significant disparities in life expectancy loss across cancer types.</p> <p>Years of Potential Life Lost (YPLL) YPLL integrates cancer incidence and YLL to estimate total potential life lost:</p> <ul style="list-style-type: none"> • Lymphoma: 221,648.15 years (highest) • Breast Cancer: 8,245.55 years • Nasopharynx Cancer: 103,311.48 years • The lowest is for Prostate Cancer with 30.25 years. <p>These results emphasize the large societal burden of high-incidence cancers like Lymphoma and Cervical Cancer.</p> <p>Productivity Losses Economic productivity losses due to mortality were calculated IDR 1,060,233,522,942 - IDR 1,108,081,420,418 (1.06 - 1.108 trillion Indonesia Rupiah) Significant losses are also observed in Nasopharynx Cancer and Cervical Cancer.</p> <p>More details in Annex 3.</p>

2. Additional information on the use of the project result and capacity building of the personnel (outcome)

Use of the project result	Contributions
<p><i>Possible use of analytical data by stakeholders and governmental agencies involved in policy and strategy design in the field of health or cancer control</i></p> <p>Data from phase 1 has been presented and included in the policy brief presentations to the G20 committee from the University of Indonesia.</p> <p>Data presented in advocacy meetings to the Minister of health</p>	<ul style="list-style-type: none"> - Specific information on stakeholders and governmental agencies possibly use the analytical data of the project in relation to policy and strategy design - If the project results were delivered to the stakeholders (government agencies or related institutes, please provide the list of recipients) - Calculating the needs of radiotherapy in the country, with additional considerations (outside of study scope) of geospatial calculation, and efficiency of available equipments <p>Stakeholders:</p> <ul style="list-style-type: none"> - G20 Sherpa of Indonesian government - Ministry of health, including the minister - International Atomic Energy Agency (IAEA)
<p><i>Improved understanding and new knowledge related to research and analysis on health issues</i></p> <p>Health economics understanding in the radiation oncology field, from calculation radiotherapy utilization rate (optimal and actual), costs of investment and operational of radiotherapy, and also the benefit in terms of economics and life years.</p>	<ul style="list-style-type: none"> - Specific information on what was delivered and list of recipient institutions/personnel - RTU calculation were presented to the G20 Sherpa of Indonesian government - Ministry of health have been presented of the whole data - IAEA have also been presented of this study results, in conjunction of its collaboration with Indonesian ministry of health.

2-1 Assessment of Research Capabilities in comparison of 2022

Research Management and support	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: Through this project, we have experience multi-center studies in health economics, which were the first time done in radiation oncology field in Indonesia.
			✓		
Attainment and application	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: Our research team is now equipped with skills to

of new research skills and knowledge				✓	calculate RTU (optimal and actual), cost, human resources need and efficiency, and also benefit of RT.
Research collaboration	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: Collaboration is very much enhanced with a multi-center study in a national scope.
				✓	
Knowledge transfer/ take up by relevant stakeholders	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: This is a very significant achievement in our study, where the government (up to the Minister of Health) have heard our advocacy to improve access to radiotherapy nationwide.
				✓	

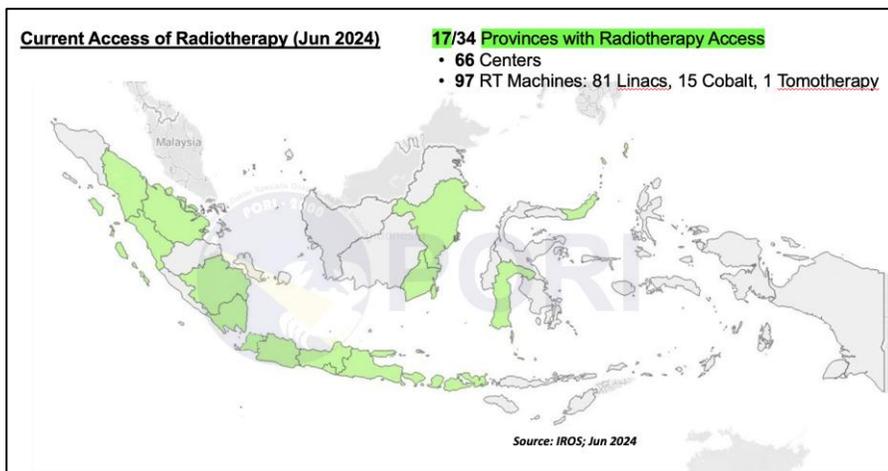
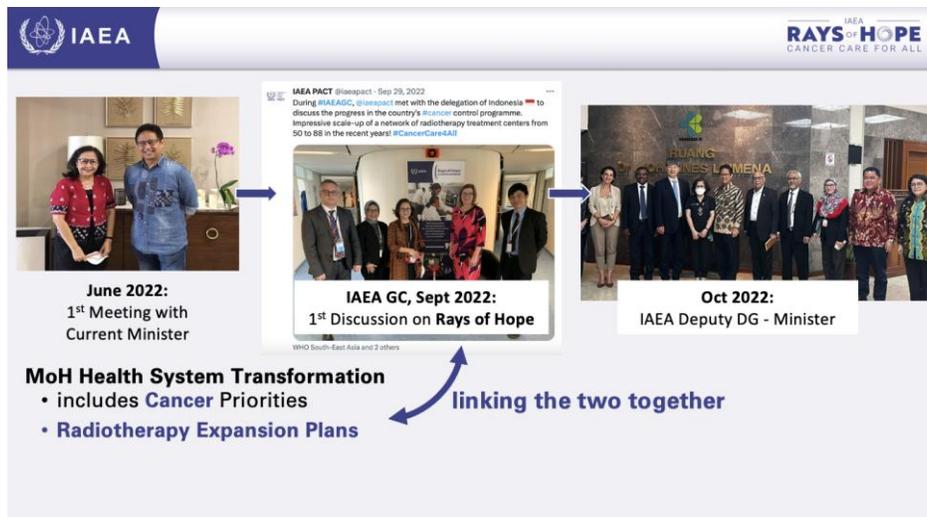
Please tick(✓) where relevant and provide descriptions on the self-assessment of your team's research capabilities before and after participation in the project.

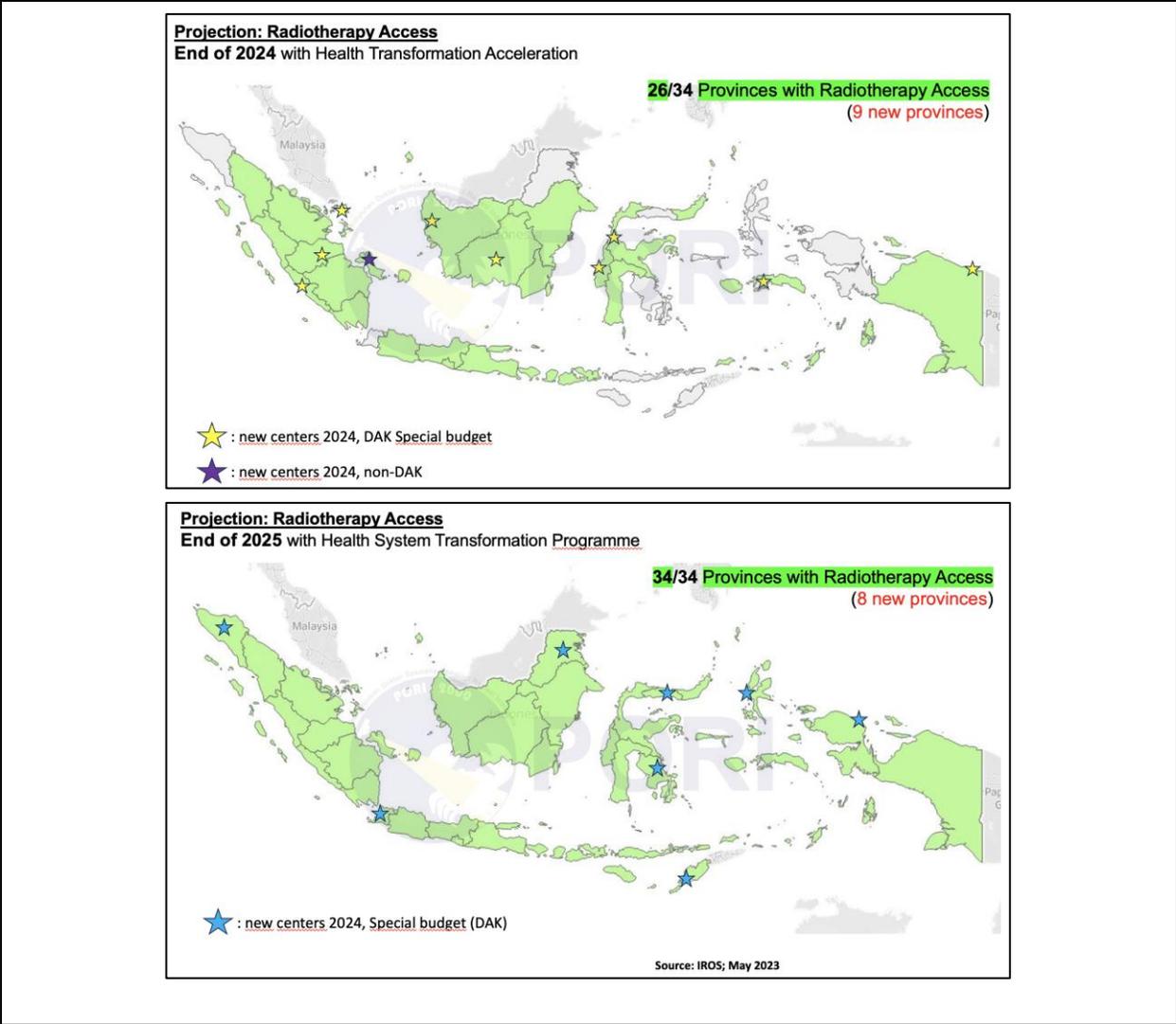
3. Success Stories

- Please provide success stories from the project (2022-2024) to demonstrate achievement and impact of the project in your country (attach pictures, website link, MoU, or other evidences)

This study has allow us to advocate the importance and need of radiotherapy in the country to the decision makers, up to the minister of health level. The data produced from this study has been presented as evidence to back up our cause for call of action.

The minister has understood the need and the gap, and therefore has included accelerating radiotherapy access in his ambitious health transformation program. The government then has decided to install new centers in 17 new provinces which has yet to have access to radiotherapy previously. The process is expected to finish by the end of 2025. With this initiative, all provinces in Indonesia will be equipped with radiotherapy centers for the first time ever.





4. Synergies/interactions among the participating countries

Countries	Synergy/interactions
Thailand, Malaysia, and Philippines	Joint data presentation at FARO-KOSRO Meeting, Seoul 2023
Australia	Leading our joint publication: Abu Awwad D, et al. Current and projected gaps in the availability of radiotherapy in the Asia-Pacific region: a country income-group analysis. <i>Lancet Oncol</i> 2024; 25: 225-34. https://pubmed.ncbi.nlm.nih.gov/38301690/

5. Limitations

The phase 3 started mid-year 2024, so there was not enough time to finalize the results and do further consultations with experts before the year end. But even after this project ends, we will continue communication and finish the analysis finalization.

6. Lessons learned

As a professional society of clinicians, this has opened our eyes to the art and science of health economics in our field, which is the required basis for advocacy. It has also elucidated to us that even though we are clinicians, these are essential tools to know how our modality should really be utilized to help cancer patients, and whether the current availability has been used effectively or not.

We will continue our strive in this field, train more of our colleagues so they can also be equipped in their own area/district to always advance the awareness and increase the access to radiotherapy everywhere.

7. Suggestions for future research/sustainability of the project

- Further explorations on factors determining low actual RTU to the community level, and also inefficiency of available machines (Access barriers)
- Development of radiotherapy roadmap, including costing analysis

8. Conclusions

Summary of the outcomes, achievements, impact of the project, success stories, remarks, etc.

As a professional society, Indonesian Radiation Oncology Society has a role in partnering and advocating for better access and utilization of radiotherapy in the country. However, as medical professionals, we were never trained or equipped with the appropriate skillset to conduct studies or produce data that could be presented well to the decision makers or stakeholders for this purpose.

This study has given us new skills and knowledge. It has also made opportunities to learn from global experts, enhance collaborations between experts and also among member countries.

The most important achievement in our country is that, supported by data results of this study, our IROS team led by Prof. Soehartati Gondhowiardjo, has successfully advocated this need and importance to close the gap of radiotherapy access to the minister of health. He has committed his full support and are installing new centers in provinces in the country which has never had access to radiotherapy before. This has also been highlighted by the IAEA where Prof. Gondhowiardjo was

invited to share Indonesia's experience in the prestigious Rays of Hope event February 2024, hosted by DG Grossi.

Attachments:

- Annex 1. Results from Phase 1
- Annex 2. Results from Phase 2
- Annex 3. Preliminary Results from Phase 3
- *Joint publication:* Abu Awwad D, et al. Current and projected gaps in the availability of radiotherapy in the Asia-Pacific region: a country income-group analysis. *Lancet Oncol* 2024; 25: 225-34.

	
CSI Name and Signature	Tiara Bunga Mayang Permata
Date and Place	6 December 2024, Jakarta - INDONESIA

Out of 46 operating centers in Indonesia by 2019, 39 centers participated for phases 1 and/or 2 data collection. Despite the number of participating centers, not all centers submitted the data for both phases 1 and 2, as follow :

Participating centers:

1. H. Adam Malik Medan Hospital
2. Murni Teguh Memorial Hospital
3. Dr. M. Djamil Padang Hospital
4. Awal Bros Pekanbaru Hospital
5. Dr. Mohammad Hoesin Palembang Hospital
6. Dr. H. Abdoel Moeloek Lampung Hospital
7. MRCCC Siloam Hospitals Semanggi
8. Dr. Cipto Mangunkusumo Hospital
9. Gading Pluit Jakarta Hospital
10. Persahabatan Jakarta Hospital
11. Gatot Soebroto Hospital
12. Santosa Bandung Kopo Hospital
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35. Al-Ihsan Bandung Hospital
36. JIH Yogyakarta Hospital

- 37. Arifin Achmad Pekanbaru Hospital
- 38. Universitas Hasanuddin Makassar Hospital
- 39. Bali Mandara Denpasar Hospital

Following this, further breakdown on the collected data will be divided into two sections.

Results on Phase 1

Situational analysis and estimation of cancer patients requiring radiotherapy in 2030-2040 will be estimated based on the GLOBOCAN and Indonesian Radiation Oncology Society database. For RTU calculation, we received data from 37 hospitals but only 33 centers were able to be analyzed. The reasons of dropped out were due to not operational in 2019 and whole-year data was not collected. From the 33 centers, 16 and 17 centers collected cancer incidence from all department and only radiotherapy department throughout one hospital, respectively. Table 1 showed the number of data collected per cancer sites.

Table 1. Recapitulation of collected data

	Total
Breast	8,462
Lung	2,062
Cervical	4,968
Ovarian	1,591
Colon	1,223
Rectal	1,774
Nasopharynx	2,462
Prostate	593
Lymphoma	1,666
Leukemia	1,978
Total	26,779

We also have done a preliminary study on the radiotherapy utilization in Dr. Cipto Mangunkusumo Hospital as part of the advocacy program to the G20 summit. There were 7,745 malignancy cases recorded in 2019 at Dr. Cipto Mangunkusumo Hospital. From the available data, we took 10 most common types of cancer in Indonesia according to GLOBOCAN data in 2020 namely breast, lung, cervical, ovarian, prostate, nasopharyngeal, colon, rectal, leukemia and lymphoma. Data from these types of cancer were 4,356 cases or equivalent to 56.24% of the total data in the hospital cancer registry. From the available data, 449 data were excluded because they were not data from 2019 cancer registry and we obtained a total of 3,907 cases or equivalent to 50.44% of the total cancer registry data in 2019.

Cancer patients in Dr. Cipto Mangunkusumo Hospital median value of age were 50 (0.3 – 92 years). Of the 3,907 patients, 1,084 were male (27.7%) and 2,823 were female (72.3%). The cancer patients were spread across 34 provinces in Indonesia with the highest number of 1,722 patients (44.1%) from DKI Jakarta, followed by West Java with 1,343 patients (34.4%) and Banten 450 patients (11.5%).

The distribution of stages from the existing data is dominated by stage IV with the number of patients reaching 845 patients (21.63%) and stage III with the number of patients 697 people (17.84%). For the record, there are certain types of malignancies such as prostate cancer and leukemia in which there are no staging system.

Table 2. Demographic Characteristics of Cancer Patients at Dr. Cipto Mangunkusumo Hospital in 2019

	Mean ± SD	Median (Min-Max)	n (%)
Age	48.96±16,12	50 (0.3-92)	-
Gender			
Male	-	-	1,084 (27.7%)
Female	-	-	2,823 (72.3%)
Province			
Aceh	-	-	5 (0.1%)
Bali	-	-	14 (0.4%)
Bangka Belitung Islands	-	-	25 (0.7%)
Banten	-	-	450 (11.5%)
Bengkulu	-	-	25 (0.6%)
Special Region of Yogyakarta	-	-	3 (0.1%)
Capital Special Region of Jakarta	-	-	1.722 (44.1%)

Gorontalo	-	-	1 (0.1%)
Jambi	-	-	13 (0.3%)
West Java	-	-	13 (0.3%)
Central Java	-	-	49 (1.3%)
East Java	-	-	22 (0.6%)
West Kalimantan	-	-	31 (0.8%)
South Kalimantan	-	-	2 (0.1%)
Central Kalimantan	-	-	3 (0.1%)
East Kalimantan	-	-	3 (0.1%)
North Kalimantan	-	-	2 (0.1%)
Riau Islands	-	-	26 (0.7%)
Lampung	-	-	50 (1.3%)
Maluku	-	-	17 (0.4%)
North Maluku	-	-	1 (0.1%)
West Nusa Tenggara	-	-	1 (0.1%)
East Nusa Tenggara	-	-	5 (0.1%)
Papua	-	-	9 (0.2%)
West Papua	-	-	4 (0.1%)
Central Papua	-	-	2 (0.1%)
Riau	-	-	30 (0.8%)
South Sulawesi	-	-	4 (0.1%)
Central Sulawesi	-	-	2 (0.1%)
Southeast Sulawesi	-	-	4 (0.1%)
North Sulawesi	-	-	2 (0.1%)
West Sumatera	-	-	5 (0.1%)
South Sumatera	-	-	8 (0.2%)
North Sumatera	-	-	13 (0.3%)
Unknown	-	-	11 (0.2%)
Stage			
I	-	-	144 (3.7%)
II	-	-	472 (12.1%)
III	-	-	697 (17.8%)
IV	-	-	845 (21.6%)
Inapplicable	-	-	571 (14.6%)
Unknown	-	-	1,178 (30.2%)

The actual and optimal radiotherapy utilization rate (RUR) for each type of cancer is shown in table 3. Of the 3,907 patients, there were 942 patients who were referred to Cipto Mangunkusumo Hospital for histopathological and radiological examination (809 breast cancer patients and 133 lymphoma patients) which we did not include. in calculating the value of the actual and optimal radiotherapy utilization rate. Number of patients diagnosed with cancer in 2019 who received radiotherapy at least once throughout the course of their disease were 963.

Based on data from 10 types of cancer, the actual utilization rate of radiotherapy in RSCM was 32.47%.

Table 3. Actual and Optimal Radiotherapy Utilization Rate (RUR) for 10 types of Cancer

Cancer Type	aRUR	oRUR
Colon	5,30%	3,30 (3,00-3,70)%
Rectum	19,50%	41,00 (28,00-66,00)%
Cervix	56.47%	97,20 (90,90-97,40)%
Ovary	4.108%	1,89 (1,39-4,60)%
Nasopharynx	53,22%	100,00%
Prostate	18,55%	73,10 (66,50-74,10)%
Leukaemia	0.74%	9,94 (9,52-10,37)%
Lymphoma	12.80%	79,31 (53,75-87,15)%
Breast	35,64%	66,33 (50,70-78,20)%
Lung	21,09%	86,97 (72,85-90,25)%
For 10 Cancers Above	26.16%	62,32 (52,11-69,26)%

By extrapolating to the incidence of other cancers according to GLOBOCAN 2020 data, for all cancers in Indonesia, the estimated optimal radiotherapy utilization rate is **55.7%**, while actual radiotherapy utilization rate nationally (based on IROS national data from all RT centers in Indonesia 2023) is **8.21%**.

Through this analysis, we realized that there is a clear gap between the calculation of number of machines needed (by Zubizaretta method, 2015) and the actual utilization of the machine. And this should be highlighted in terms of white papers or advocacy efforts to decision makers, to optimize utilization and to be careful to not to invest more money if existing machines are still underutilized.

Radiotherapy's current availability were listed, while the recommended or ideal number of equipments and human resources, were assessed using the Radiotherapy Resources and Cost Calculator (RRCC) version 21, which was created by Eduardo Zubizaretta. Radiotherapy cost calculation was also performed using the same calculator. For the second phase of our study, out of the 46 hospitals that had initially been provided with questionnaires, data was collected from 29 hospitals. It's important to note that the data utilized in this research pertains to the year 2019.

The following lists the types of machines and techniques used by the participating centers are presented in number and percentage. As can be seen in Table 1, the most widely used technique is 3D.

Table 1. Number of Machines and Available Techniques in 29 Participating Centers in Indonesia (Year 2019)

Type	Number
Cobalt	14
Single photon	11
Multiphoton	20
Fluoroscopic Simulator	12
CT simulator	19
HDR afterloader	12
C-arm	9
Number of RT courses/year	20575
Number of CT simulation	14017
Number of treatment plans	14017
Average fractions/year	22
2D	13%
2.5D	1%
3D	77%
IMRT	9%
SBRT	0%
BT simple 2D fractions/year	1903
BT complex 2D fractions/year	3674
BT simple 3D fractions/year	874
BT complex 3D CT fractions/year	1279
Immobilization simple	50%
Immobilization customized	40%
Immobilization complex	0%
Blocks/customized accessories	20%

- **Summary of the results of the future facility, additional equipments and human resources**

Table 2 below shows future facilities, additional equipment, and human resources are calculated with RRCC v.21. The calculation results found that for human resources for RO, MP, RTT, and nurse the required amount is in accordance with the current available amount. Insufficient numbers are found in IT and electrical engineering.

According to the recommended number from the RRCC v.21, in the 29 centers the number of CT simulators and radiation machines is still not sufficient and consideration for additional machines' procurement needs to be done.

Table 2. Availability and Recommended Number of Equipment and Human Resources in 29 Participating Centers

Human Resources	Availability (2019)	Recommended Number (by RRCC v.21)
Radiation Oncologist	88	88
Medical Physicist (MP)	91	91
RTT	265	265
TP-Dosimetrist	0	0
	(work performed by MP)	
Nurse	117	117
IT	8	12.85
Mechanical Engineer	38	38
Electrical Engineer	17	20.69

Equipment	Availability (2019)	Recommended Number (by RRCC v.21)
CT simulator	19	34
Cobalt	14	21
Linac single photon	11	16
Linac multi photon	20	31

Note: These calculations above applied for the 29 participating centers only.

- Summary of radiotherapy cost calculation

Based on the calculation result listed below in Table 3, the largest proportion of investment costs were made for building and equipment in any radiotherapy center.

Table 3. Radiotherapy Cost Calculated by RRCC version 21 in Indonesia

Investment Cost	Current Spending	Recommended Cost (by RRCC v.21)	Gap
Building	US\$ 16,641,703	US\$ 21,269,118	US\$ 4,627,415
Equipment	US\$ 127,442,580	US\$ 195,378,211	US\$ 67,935,631
Total	US\$ 144,084,283	US\$ 216,647,329	US\$ 72,563,046

Annual Operating Cost	Maintenance	Amortization	Total
Building	US\$ 425,382	US\$ 708,262	US\$ 1,133,644
Equipment	US\$ 20,832,660	US\$ 19,524,761	US\$ 40,357,420
Salaries			US\$ 7,417,368
Subtotal	US\$ 21,258,042	US\$ 20,233,022	US\$ 48,908,432
Overhead 20%			US\$ 9,781,686
Total			US\$ 58,690,119

Product Cost	
Cost per RT course	US\$ 2,852
Cost per fraction	US\$ 129.66

Research Methodology

For this phase 3, this study employs a systematic approach to estimate the impact of radiotherapy and cancer mortality on productivity losses in Indonesia, integrating various data sources and calculated metrics:

1. Radiotherapy Benefit Estimation

The benefit of radiotherapy was quantified as the product of the 5-year survival benefit due to radiotherapy (sourced from published studies) and the proportional change in radiotherapy utility (RTU). The proportion of RTU during the 1st and 2nd phases in Indonesia was extracted from the RTU tree to estimate how treatment availability and accessibility impact survival outcomes. The equation used was:

$$\text{Radiotherapy Benefit} = \text{5-Year Survival Benefit due to Radiotherapy} \times \left| \frac{(TURo - TURa)}{TURo} \right|$$

2. Incorporation of GLOBOCAN Data

Cancer incidence data from GLOBOCAN was a critical input for estimating survival shortfall. This global cancer database provided comprehensive cancer statistics specific to Indonesia, allowing for reliable incidence estimates.

3. Survival Shortfall

The survival shortfall, representing the gap between potential and actual survival due to cancer, was calculated by multiplying the radiotherapy benefit by the cancer incidence data from GLOBOCAN:

$$\text{Survival Shortfall} = \text{Radiotherapy Benefit} \times \text{Cancer Incidence (GLOBOCAN)}$$

4. Life Expectancy

Life expectancy in Indonesia was set at 68 years, based on national statistics. The median age of death due to cancer was extrapolated using published studies, given the limited availability of Indonesia-specific data.

$$\text{Life Expectancy Adjustment} = 68 - \text{Median Age of Death (Cancer)}$$

5. Years of Life Lost (YLL)

The Years of Life Lost (YLL) metric measures the average number of years a person would have lived had they not died prematurely from cancer. It was calculated as:

$$YLL = 68.25 - \text{Median Age of Death (Cancer)}$$

6. Years of Potential Life Lost (YPLL)

The YPLL metric extends YLL by incorporating the survival shortfall to estimate the total potential life years lost due to radiotherapy inadequacy:

$$YPLL = \text{Survival Shortfall} \times YLL$$

7. Productivity Losses Due to Mortality

To estimate the economic impact of cancer-related mortality, the average monthly wage in Indonesia was used as a proxy for economic productivity. Productivity losses were computed as:

$$\text{Productivity Losses} = \text{Average Monthly Wage} \times YPLL$$

Results (Preliminary): Radiotherapy Benefits, Life Lost, and Productivity Impact results

This analysis quantifies the radiotherapy benefits, years of life lost (YLL), potential life lost (YPLL), and the economic impact due to cancer mortality in Indonesia, focusing on multiple cancer types.

1. Radiotherapy Benefit

Radiotherapy benefit measures the improvement in survival due to radiotherapy across various cancer types:

- Breast Cancer: 0.0238
- Cervical Cancer: 0.1056
- Prostate Cancer: 0.0011
- Rectal Cancer: 0.0029
- Leukemia: 0.0099
- Lymphoma: 0.9164
- Lung Cancer: 0.0061
- Nasopharynx Cancer: 0.3635

Lymphoma demonstrates the highest radiotherapy benefit, highlighting the critical role of radiotherapy in managing this cancer type.

2. Years of Life Lost (YLL)

YLL reflects the average number of years lost due to premature death: YLL ranges from 2 years (Prostate Cancer) to 32.25 years (Leukemia), reflecting significant disparities in life expectancy loss across cancer types.

3. Years of Potential Life Lost (YPLL)

YPLL integrates cancer incidence and YLL to estimate total potential life lost:

- Lymphoma: 221,648.15 years (highest)
- Breast Cancer: 8,245.55 years
- Nasopharynx Cancer: 103,311.48 years
- The lowest is for Prostate Cancer with 30.25 years.

These results emphasize the large societal burden of high-incidence cancers like Lymphoma and Cervical Cancer.

4. Productivity Losses

Economic productivity losses due to mortality were calculated IDR 1,060,233,522,942 - IDR 1,108,081,420,418 (1.06 - 1.108 trillion Indonesia Dollar)

Significant losses are also observed in Nasopharynx Cancer and Cervical Cancer.

Data Sources and Limitations

Data Sources:

- Survival benefits and median age of death due to cancer were extrapolated from various publications due to limited Indonesia-specific data.
- Prostat: Hanna TP, Shafiq J, Delaney GP, Vinod SK, Thompson SR, Barton MB. The population benefit of evidence-based radiotherapy: 5-Year local control and overall survival benefits. *Radiotherapy and Oncology*. 2018 Feb 1;126(2):191–7.
- Ovarium: Hanna TP, Delaney GP, Barton MB. The population benefit of radiotherapy for gynaecological cancer: Local control and survival estimates. *Radiotherapy and Oncology*. 2016 Sep 1;120(3):370–7.
- Nasopharynx: Hanna TP, Shafiq J. Estimating the Population Benefit of Radiotherapy: Using Demand Models to Estimate Achievable Cancer Outcomes. *Clin Oncol*. 2015 Feb 1;27(2):99–106.
- Breast, Colon, Rectum, Lung, Leukemia, Lymphoma, Cervix: Shafi RJ. Model of Estimation of Local Control and Survival Benefit of External Beam Radiotherapy for Selected Cancer. 2016; Available from: <https://doi.org/10.26190/unsworks/19299>
- Indonesia Monthly wage: <https://www.bps.go.id/id/statistics-table/2/MTUyMSMy/rata-rata-upah-gaji.html>
- Median Age Death: <https://seer.cancer.gov/statfacts/html>
- GLOBOCAN provided reliable cancer incidence data.

Assumptions and Extrapolations:

- The study acknowledges the reliance on global and regional publications to approximate local statistics, which may introduce variability in the results.
- This methodology integrates survival metrics, cancer incidence, and economic data to comprehensively assess the impact of radiotherapy and cancer mortality on societal productivity losses in Indonesia.

Annex 3. Malaysia



RCA Regional Office

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Fax: +82 42 864 1626
<http://www.rcaro.org>

Final Report for Research Agreement

(Please complete all sections and send your report electronically to: kelly@rcaro.org)

Title of the Research Project under which this Research Agreement is implemented: Closing the Gap in Radiotherapy Access in RCA Government Parties	
Title of the Research Agreement Project: Radiotherapy Utilisation Rate in Public Oncology Centers in Malaysia	
Institute Name: National Cancer Institute	
CSI Name: Dr Suhana Yusak	Alternate CSI Name: Mr Rahmatfadli bin Marzuki
Period Covered: January 2022-December 2024	

<p>1. Final work plans for 2022, 2023 and 2024: Access towards radiotherapy is very important for local tumor control and patient's survival.</p> <p>Knowing the gap between optimal radiotherapy utilisation rate (oRTU) and actual radiotherapy utilisation rate (aRTU) may help our stakeholders to have a better understanding regarding the needs of proper development and sustainability of radiotherapy services in the future.</p> <p>The results obtained will be the benchmark for further development of radiotherapy services in our country and can be also further utilise for any cancer-related activity at the national level</p> <p>The specific objectives include:</p>

1. To estimate the optimal radiotherapy utilisation rate in public oncology centres
2. To measure the actual rate of radiotherapy utilisation in public oncology centres
3. To measure the potential outcome based on actual radiotherapy utilisation rate.
4. To identify the characteristics of the patient's demographic, disease burden and human resources, and also radiotherapy facilities available.
5. To identify the referral system and workflow process including simulation and starting of treatment time and duration.

The data collection related to the radiotherapy treatment from **6 public oncology centres** will be performed. The contribution from private centres also were encouraged.

These data will be utilised to produce both *optimal and actual utilisation rate and finally, the gap between them will be generated.

The expected outputs

1. Identify all the newly diagnosed cancer patients from 6 public oncology centres
2. Identify the data required for radiotherapy utilisation rate (epidemiological and clinical data)
3. Identify the high-level evidence regarding the role of radiotherapy for the cancer treatment
4. Research links and networking and co-operative schemes establishment
5. Identify the oRTU, aRTU, and the gap between these data
6. The result obtained will be presented at local and international meetings and conferences and published in reports and journal
7. The result obtained will be used as a benchmark for the future development of radiotherapy services in Malaysia

Initial work plan

Activity/ Schedule	Year 2022				Year 2023				Year 2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
RP03 PHASE 1												
Finalising project proposal												
Registration to NMRR and submission to MREC												
Data collection												
Analysis of data												
Evaluation of data												
Progress report and submission												
RP03 PHASE 2												
Needs and gap calculation												
2 nd Regional Training/Workshop (Cost)												
Research Implementation (Cost)												
2 nd Research Coordination Meeting												
Submission of the Progress Report												
RP03 PHASE 3												
3 rd Regional Training/Workshop (Impact)												
Research Implementation (Impact)												
Evaluation of Roadmap Planning												
Progress report and submission												
Submission of the Progress Report												

1. Summary which describes in brief form the experimental method, major results:

The data will be using the newly diagnosed cancer patients in year 2018.

The details that will be captured will comprise of (but not limited to)

1. Epidemiology (including the patient's demography)
2. Cancer staging
3. Treatment intention
4. Details of radiation treatment given (simulation, planning system, technique, date of start treatment, etc.).
5. Patients' outcome at certain interval

The data collection related to the radiotherapy treatment from **6 public oncology centres** will be performed. The contribution from private centres and universities were also encouraged.

Source of data

1. **National Cancer Registry**
2. **Public oncology centers (as mentioned above)**

2. Detailed results achieved against work plans for 2022, 2023 and 2024, including quantitative data, if applicable (*please attach technical documents if needed*):

Data capture for year 2018:

Malaysia population: 32, 382, 300 which comprises of

- Malaysian Citizens : 29,059,600
- Non-Malaysian Citizens : 3,322,700

Annual number of cancer patients : **28,269**

Radiotherapy centers

- Public hospital: 5 (total are 6 but only 5 centers are equipped with radiotherapy facilities)
- Private hospitals: 24
- University: 3 (total are 4 centers, Only 3 are equipped with radiotherapy facilities)

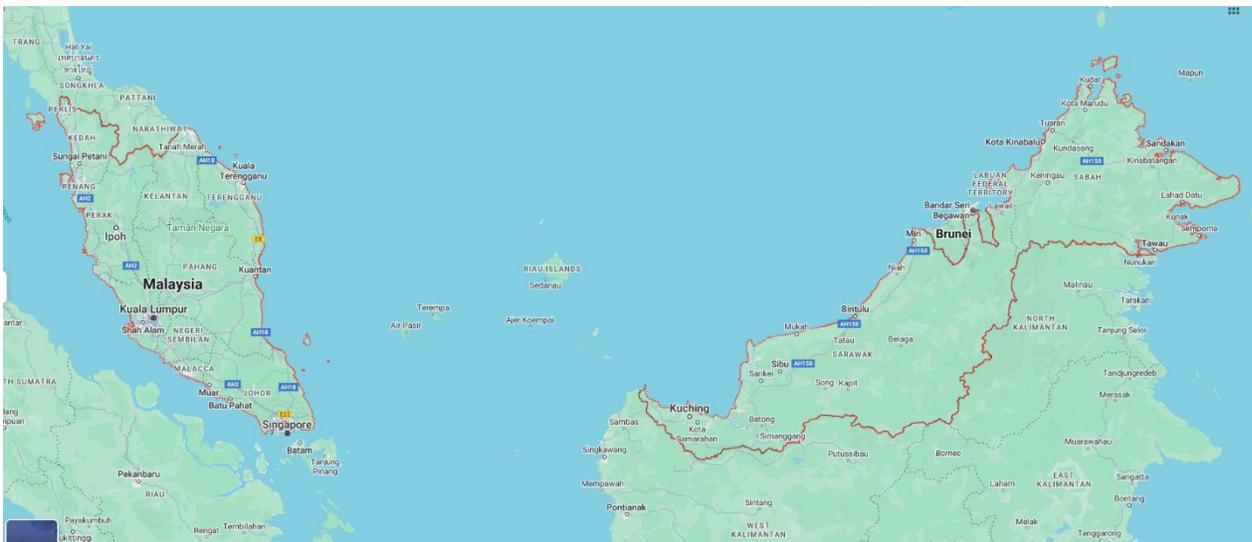


Figure 1: Distribution of public oncology centers

A. Demographic findings

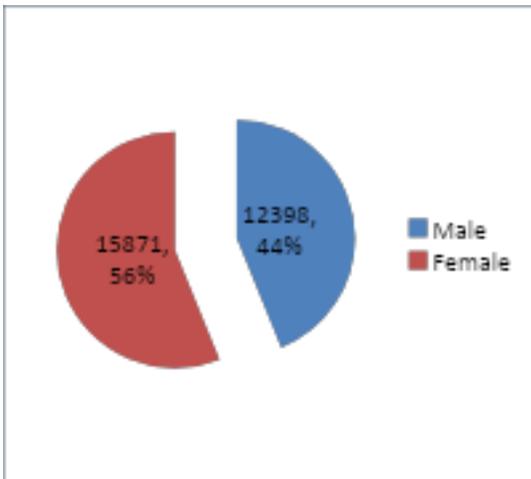


Figure 2: case distribution by gender.

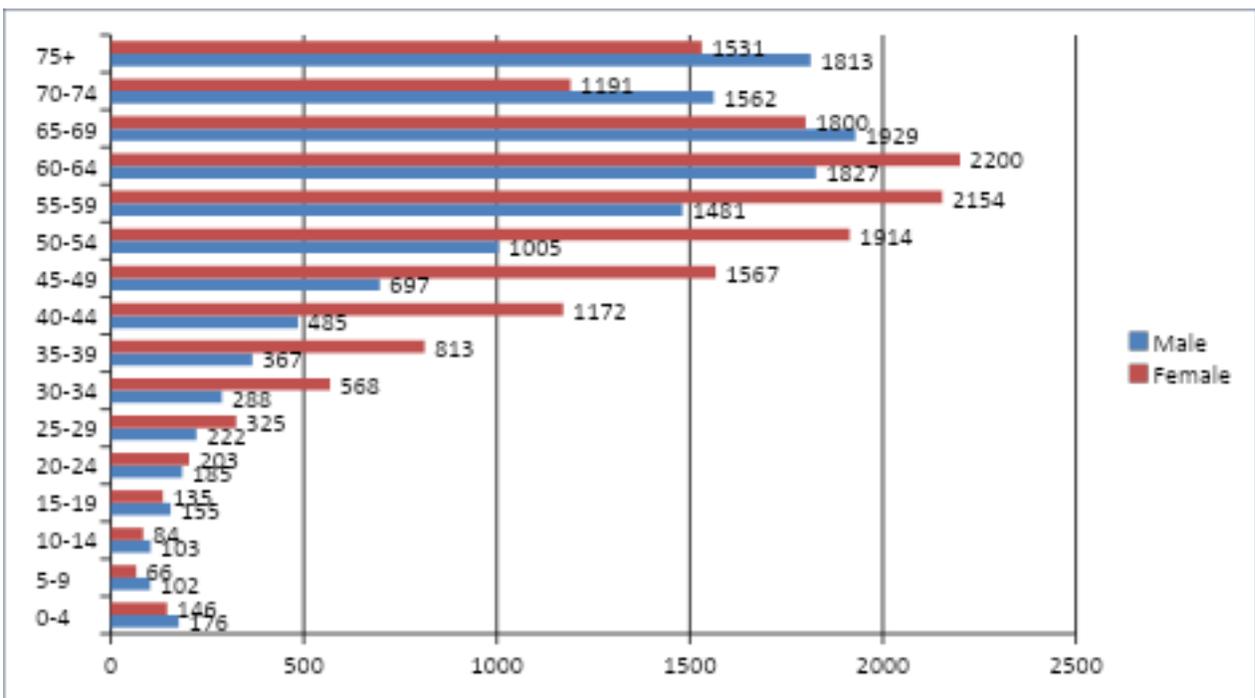


Figure 3: case distribution based on age group

B. Tumor sites and cancer staging

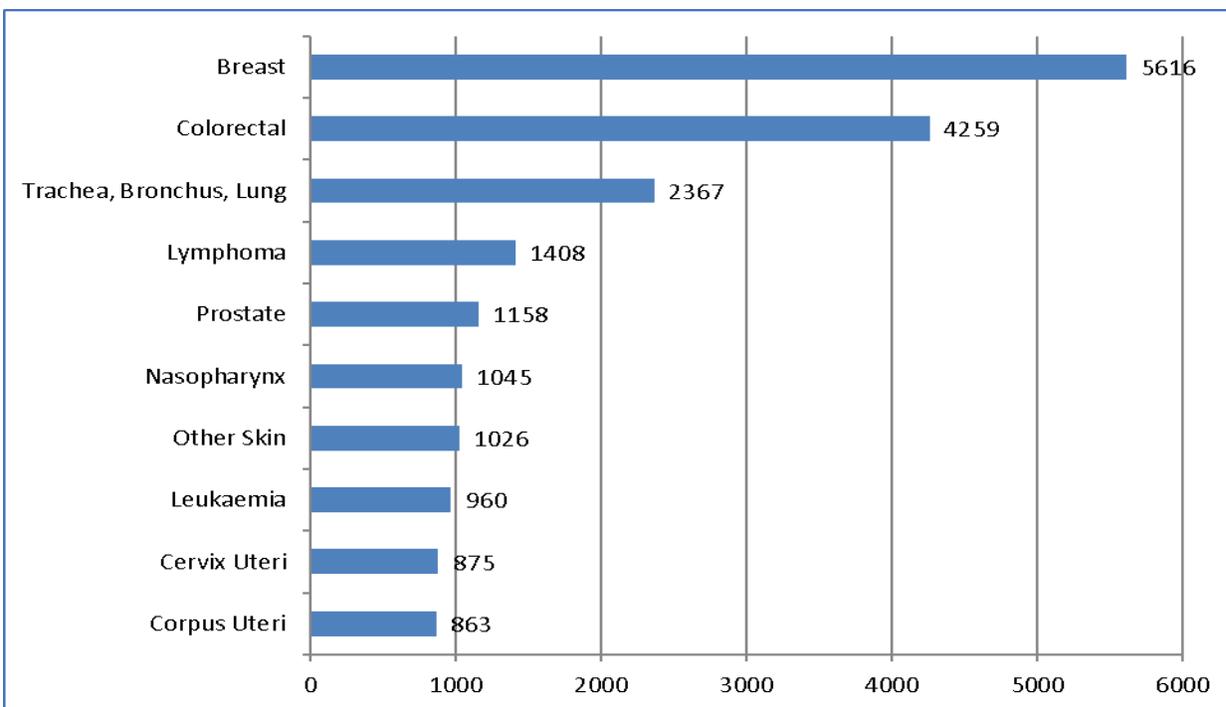


Figure 4:10 leading sites of cancer for year 2018

Stage	Male	Female	Total	%
Stage I	511	1254	1765	6.2
Stage II	726	1735	2461	8.7
Stage III	1123	1791	2914	10.3
Stage IV	2546	2185	4731	16.7
Not specified	7492	8906	16398	58.0
Total	12398	15871	28269	100.0

Table 1: Tumor staging using the AJCC 7th edition

C. Cancer treatment

TREATMENT TYPE	NUMBER
Radiotherapy	2798
Surgery	8284
Cytotoxic	6292
Immunotherapy	7
Hormonal	723

Table 2: Summary of treatment modalities within 6 months after the diagnosis

3. Achievements/success stories resulted from the project

In the third quarter of 2023, the results were presented in the Malaysia National Specialties/Subspecialties Meeting for the Ministry of Health were presented, with a primary focus on the demand and needs of Radiotherapy (RT) and Oncology Services.

Key findings was the significant discrepancy between the optimal Radiotherapy Utilization (RTU) and the actual RTU, with optimal RTU at 52% compared to the current 25%. This gap indicate the urgent need for a strategic and continuous plan to replace and upgrade essential equipment, particularly Linear Accelerators (Linac), which are critical for radiotherapy services. These insights were presented as evidence to policymakers and their steering committees to advocate for necessary changes.

Another pressing issue emphasized was the shortage of clinical oncologists. This shortage is a critical concern that requires attention to ensure the effective delivery of oncology services. The meeting aimed to draw attention to these issues and encourage policy changes to address both equipment needs and workforce gaps in radiotherapy and oncology.

4. Publications and conferences including stakeholder meetings held on the work performed under this Project (peer-reviewed journals, conferences proceedings, international and national conference contributions, stakeholder meetings, national/technical reports, *please enter web-link or attach copies to this report*):

The data only presented to the steering committee and stakeholders in Ministry of Health Malaysia as mentioned above. Source of reference: Dr Ros Suzanna binti Ahmad Bustamam, Head of Radiotherapy and Oncology Specialty, Ministry of Health. Email: ros.suzanna@moh.gov.my

Since the data used was for the year 2018 (more than 5 years), there will be no publication now unless there is revision of the result using the updated data. The latest and updated result also very crucial to represent current situation and to monitor progress and development in oncology services for Malaysia especially in the public hospitals.

5. Suggestions for future research in the relevant field/sustainability of the project

To use another revision of the results by using the updated data such as for the year 2024. This will allow for a clearer understanding of the current state of Radiotherapy and Oncology Services, helping to better assess the achievements made since the 2018 data and identify areas that still require improvement.

Key actions to consider for this updated analysis include:

1. **Incorporating the Latest Data (eg 2024):** The latest data will provide a more accurate picture of the progress and current situation in radiotherapy and oncology services. It will also highlight any improvements or challenges faced by the sector over the past five years.
2. **Comprehensive Research Team:** Involving a wider group of researchers, including those from the Ministry of Health, registries, and other relevant stakeholders, will help ensure a more comprehensive and nuanced analysis. These experts can provide insights into policy implementation, healthcare trends, and data collection methods, improving the quality and reliability of the findings.
3. **Engagement with Private Centers:** The participation of private healthcare centers will be crucial, as they can provide additional data and perspectives on the disparities in facilities and resources between the public and private sectors. This collaboration will help identify gaps in service delivery, equipment availability, and workforce distribution, which may differ significantly between the two sectors..
4. **Discrepancies in Facilities:** The updated research should focus on the disparities in the availability of facilities and services between public and private hospitals, as this could have a significant impact on patient outcomes. Understanding these discrepancies will allow policymakers to address them more effectively, ensuring that public hospitals have access to the same level of care and resources as their private counterparts.

Contributions to the Project

Country	Malaysia
Reporting Period	2022-2024

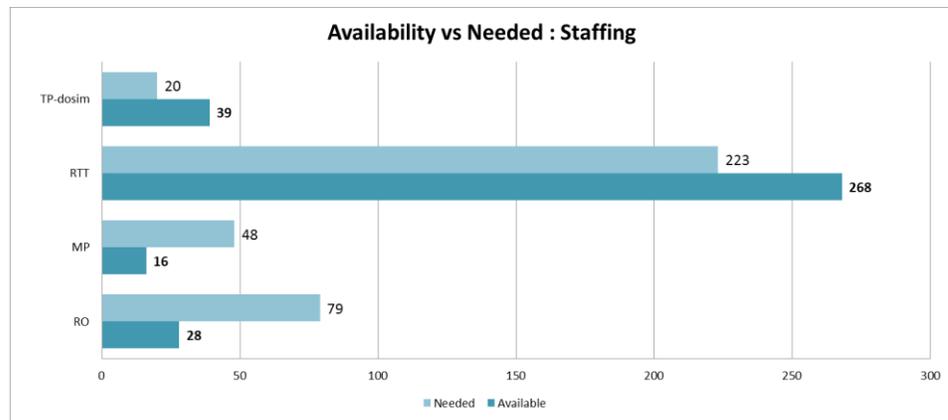
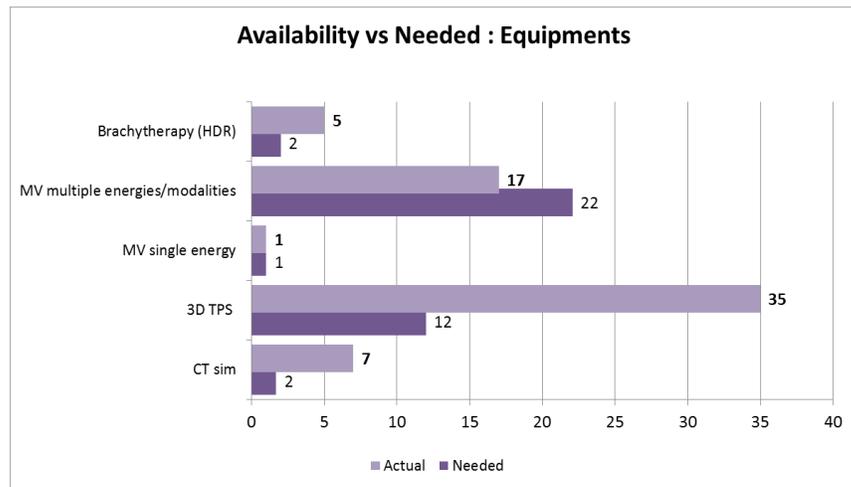
1. Contribution to the Project on Phase 1, 2, and 3

Phases	Contributions																					
Phase 1. Calculation of Burden of Cancer Requiring Radiotherapy	<p>- Provide a Summary of the calculated RTU</p> <p>* Please submit detailed data separately as Annex 1</p> <p>Radiotherapy centers</p> <ul style="list-style-type: none"> ● Public hospital: 5 (total are 6 but only 5 centers are equipped with radiotherapy facilities) ● Private hospitals: 24 ● University: 3 (total are 4 centers, Only 3 are equipped with radiotherapy facilities) <p>Number of new radiotherapy patients in public hospitals for year 2018</p> <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th style="width: 33%;">Centers</th> <th style="width: 33%;">RT new case</th> <th style="width: 33%;">No. of LINAC</th> </tr> </thead> <tbody> <tr> <td>1. IKN</td> <td style="text-align: center;">1493</td> <td style="text-align: center;">4</td> </tr> <tr> <td>2. HKL</td> <td style="text-align: center;">2062</td> <td style="text-align: center;">5</td> </tr> <tr> <td>3. HIS</td> <td style="text-align: center;">1554</td> <td style="text-align: center;">3</td> </tr> <tr> <td>4. HWKSS</td> <td style="text-align: center;">654</td> <td style="text-align: center;">2</td> </tr> <tr> <td>5. HUS</td> <td style="text-align: center;">1317</td> <td style="text-align: center;">4</td> </tr> <tr> <td>TOTAL</td> <td style="text-align: center;">7080</td> <td style="text-align: center;">18</td> </tr> </tbody> </table> <p>**actual RTU: 25.0%</p>	Centers	RT new case	No. of LINAC	1. IKN	1493	4	2. HKL	2062	5	3. HIS	1554	3	4. HWKSS	654	2	5. HUS	1317	4	TOTAL	7080	18
Centers	RT new case	No. of LINAC																				
1. IKN	1493	4																				
2. HKL	2062	5																				
3. HIS	1554	3																				
4. HWKSS	654	2																				
5. HUS	1317	4																				
TOTAL	7080	18																				

**Total number of cancer incident in 2018 = 28,269

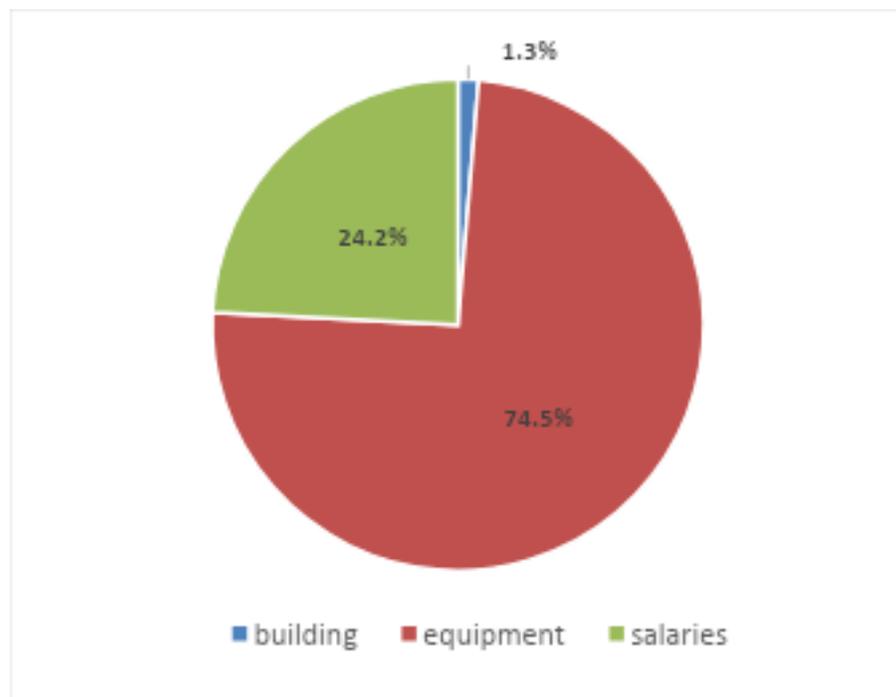
Phase 2.
Summary of
Estimating Core
Investment
Required for
Radiotherapy

- Provide a summary of the results of the future facility, additional equipment and human resources
- Provide a summary of radiotherapy cost calculation
- Submit detailed data in separately as Annex 2



Staff	Utilisation
RO	282.0%
MP	298.4%
RTT	83.2%
TP-dosim	50.4%

Operating Costs per Year



Total cost = 30,668,539 USD

Cost / RT course = 4,331.71 USD

<p>Phase 3.</p> <p>Assessing the outcome</p> <p>-Application of an investment framework</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the economic analysis - Submit detailed data in separately as Annex 3 <p>Using the costs calculation from phase 2, Malaysia needs additional 20 linacs and 5 RT departments with capital cost \$144.7 million USD. However the data only included the public oncology centers. Thus, it needs to be interpreted carefully since it is going to be the key reference for our stakeholders.</p>
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2. Additional information on the use of the project result and capacity building of the personnel (outcome)

<p>Use of the project result</p>	<p>Contributions</p>
---	-----------------------------

<p>Possible use of analytical data by stakeholders and governmental agencies involved in policy and strategy design in the field of health or cancer control</p>	<ul style="list-style-type: none"> - Specific information on stakeholders and governmental agencies possibly use the analytical data of the project in relation to policy and strategy design - If the project results were delivered to the stakeholders (government agencies or related institutes, please provide the list of recipients) <p>These data will be utilised as the reference in the development Malaysia National Strategic Planning Cancer Control Program, 4th Edition. They will provide critical insights to guide the steering committee in identifying and prioritising the necessary step to be taken, ensuring that the program is aligned with current needs and challenges in cancer control.</p> <p>Source of reference:</p> <p>Dr Ros Suzanna binti Ahmad Bustamam, Head of Radiotherapy and Oncology Specialty, Ministry of Health. Email: ros.suzanna@moh.gov.my</p> <p>https://www.moh.gov.my/moh/resources/Penerbitan/Rujukan/NCD/Kanser/National_Strategic_Plan_for_Cancer_Control_Programme_2021-2025.pdf</p>
<p>Improved understanding and new knowledge related to research and analysis on health issues</p>	<ul style="list-style-type: none"> - Specific information on what was delivered and list of recipient institutions/personnel <p>The updated results are crucial for several reasons:</p> <ol style="list-style-type: none"> 1. Accurate representation of the current situation: The healthcare landscape, particularly in public hospitals, may have undergone significant changes since 2018. New policies, technological advancements, and shifts in demand or infrastructure could impact the situation, and it is important to account for these updates. 2. Monitoring Progress and Development: Updated data would allow for the assessment of progress in oncology services, helping policymakers and healthcare administrators track improvements or areas that still require attention. This monitoring is vital for shaping future investments and policy decisions. 3. Informed Decision-Making: With current data, evidence-based decisions can be made regarding resource allocation, workforce development, and equipment upgrades, particularly in light of the critical needs identified, such as the shortage of clinical oncologists and outdated radiotherapy equipment.

2-1 Assessment of Research Capabilities in comparison of 2022

Please tick(✓) where relevant and provide descriptions on the self-assessment of your team's research capabilities before and after participation in the project

Research Management and support	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: Received good support from all the participating public hospitals and RCA team
				✓	
Attainment and application of new research skills and knowledge	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: Better understanding of analysis method and the needs of standard data collection
				✓	
Research collaboration	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description Received good cooperation from all the participated public hospitals
				✓	
Knowledge transfer/take up by relevant stakeholders	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description: Presentation during National Medical Specialty/Subspecialty meeting (MOH Malaysia)
				✓	

3. Success Stories

- Please provide success stories from the project (2022-2024) to demonstrate achievement and impact of the project in your country (attach pictures, website link, MoU, or other evidences)

1. Comprehensive Planning by Ministry of Health for replacement and upgrading radiotherapy equipment

The table below are the details regarding the planning on replacement and upgrading of radiotherapy equipment in public oncological centers.

The cost for the replacement and upgrading will be fully subsidised by Ministry of Health

Until December 2024, the progress are according to the plan. In fact, replacement for CT sim in IKN was brought forward for year 2026.

PELAN PERANCANGAN PENGGANTIAN PERALATAN RADIOTERAPI KEBANGSAAN BAGI TEMPOH 2019-2028

TAHUN	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
HOSPITAL										
HKL	-Pertambahan CT Simulator ²	-Penggantian Linac (1997) ¹ -Pertambahan TPS				-Penggantian CT simulator (2002) -Pertambahan Linac ke 6 -Pertambahan TPS		-Penggantian 2 Linac (2002 & 2009) -Pertambahan TPS		-Naiktaraf sistem brakiterapi (2015)
IKN				-Pertambahan Linac ke 5 (Bunker ready) -Pertambahan TPS		-Penggantian Linac (2013) 2 unit -Pertambahan TPS	-Naiktaraf sistem brakiterapi (2013)		-Penggantian Linac (2013) 2 unit -Pertambahan TPS -Penggantian CT sim - 1 unit (2013)	
HSIJB	-Penggantian HDR Brachytherapy (2004)		-Penggantian Linac (2005) ³ -Pertambahan TPS (melalui RTM)	-Penggantian Linac (2005) ³ -Pertambahan TPS				-Pertambahan 1 CT sim -Pertambahan Linac ke 4		
HUS		-Penggantian Linac (2005) ¹ -Pertambahan TPS		-Penggantian sistem brakiterapi (2001)		-Penggantian 2D sim (2001) dengan CT sim -Penggantian Linac di HUS (2007) -Pertambahan TPS		-Penggantian CT sim (2008) -Penggantian Linac -Pertambahan TPS		
HWKKS LIKAS						-Pertambahan CT sim -Penggantian Linac -Pertambahan TPS		-Pertambahan 1 Linac	-Naiktaraf sistem brakiterapi (2013)	

Slides borrowed from Dr Ros Suzanna binti Ahmad Bustamam, Head of Radiotherapy and Oncology Specialty, Ministry of Health, Malaysia

Table 3: Planning for Replacement and Additional (Upgrading) Radiotherapy Equipment in Public Oncology Centers

In align with the data and outcome, the Malaysia Government also announced another 2 cancer institutes will be developed to cater certain region i.e Northern and East Malaysia (refer to the map above)

This cancer institute are

- Northern Cancer Centre (will be located in Kedah)

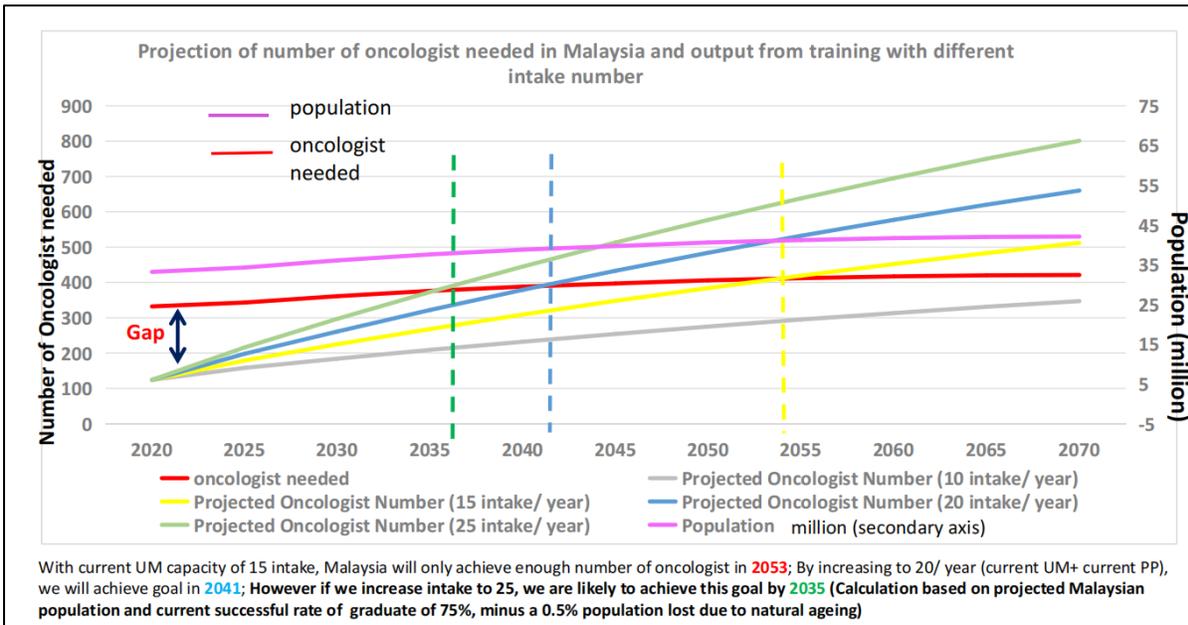
- ii. Sarawak Cancer Center (will be located in Sarawak – East Malaysia)

2. Strengthening the human capacity mainly the number of oncologists in public oncology centers

The current gap in the number of oncologists has been confirmed based on the result of phase 2 of this project. To address the growing demand for oncologists in Malaysia, particularly with a projected shortage of approximately 400 oncologists by 2040, the Ministry of Health is taking significant steps to strengthen human capacity for radiotherapy and oncological services.

In response, the government is expanding its focus on postgraduate training programs. While local universities have been the primary source for oncologist training through master's programs, the Ministry is now also exploring international qualifications, such as the Fellowship of the Royal College of Radiologists (FRCR). This initiative will be supported by full scholarships for trainees, allowing them to gain specialized qualifications and expertise needed to meet the growing demand for oncological services in the country.

Additionally, Malaysia will be hosting the FRCR Part 1 examination at the National Cancer Institute (NCI) starting in September 2024. This development signifies a significant step in advancing the training and certification of oncologists in the country, helping to build a sustainable workforce that can support the increasing need for specialized cancer care.



Slides borrowed from Dr Soo Hoo Hwoie Fern, Consultant Clinical Oncologist, Chaiman, Parallel Pathway for Clinical Oncology, Ministry of Health, Malaysia

Table 4: Projection of number of oncologist needed in Malaysia

Press statement by the Health Minister on 5th October 2024.

Number of oncologists in Malaysia to reach 400 by 2040, says Dr Dzul



NATION

Saturday, 05 Oct 2024

1:42 PM MYT

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PUTRAJAYA: The number of oncologists in Malaysia is expected to increase to 400 by 2040, up from the current 175, said Health Minister Datuk Seri Dr Dzulkefly Ahmad (pic).

Press statement by Deputy Prime Minister on 5th October 2024

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Govt to expand cancer centre network in Malaysia - DPM Fadillah

By Bernama - October 5, 2024 @ 12:27pm



Memorandum of understanding between Malaysian Oncological Society and Royal College of Radiologist (RCR), signing ceremony on 11th October 2024



4. Synergies/interactions among the participating countries

Countries	Synergy/interactions
Australia team	Optimal RTU calculation

5. Limitations

1. The data used is based on the incidence and prevalence of cancer that occur more than 5 years ago.
2. Limited data from private centre that might contribute some discrepancies in the outcome
3. Not adequate manpower to embark on comprehensive data collection and analysis

6. Lessons learned

-

7. Suggestions for future research/sustainability of the project

To obtain more accurate findings and ensure meaningful comparisons, it is essential to use updated data, such as for the year 2024. This will allow for a clearer understanding of the

current state of Radiotherapy and Oncology Services, helping to better assess the achievements made since the 2018 data and identify areas that still require improvement.

Key actions to consider for this updated analysis include:

1. **Incorporating the Latest Data (2024):** Using data from 2024 will provide a more accurate picture of the progress and current situation in radiotherapy and oncology services. It will also highlight any improvements or challenges faced by the sector over the past five years.
2. **Comprehensive Research Team:** Involving a wider group of researchers, including those from the Ministry of Health, registries, and other relevant stakeholders, will help ensure a more comprehensive and nuanced analysis. These experts can provide insights into policy implementation, healthcare trends, and data collection methods, improving the quality and reliability of the findings.
3. **Engagement with Private Centers:** The participation of private healthcare centers will be crucial, as they can provide additional data and perspectives on the disparities in facilities and resources between the public and private sectors. This collaboration will help identify gaps in service delivery, equipment availability, and workforce distribution, which may differ significantly between the two sectors. Private centers may also contribute insights into innovative practices or technologies that could be adapted to the public healthcare system.
4. **Discrepancies in Facilities:** The updated research should focus on the disparities in the availability of facilities and services between public and private hospitals, as this could have a significant impact on patient outcomes. Understanding these discrepancies will allow policymakers to address them more effectively, ensuring that public hospitals have access to the same level of care and resources as their private counterparts.

By updating the data, expanding the research team, and involving both public and private sectors, the study will produce more accurate and actionable findings. This will help to monitor the progress in oncology services in Malaysia and guide necessary reforms to address the evolving challenges and improve patient care.

8. Conclusions

Summary of the outcomes, achievements, impact of the project, success stories, remarks, etc.

The data and results generated from this project have become a reference point for the development of radiotherapy and oncology services in Malaysia. The information is being used to guide strategies and policies aimed at enhancing the quality and accessibility of cancer care across the country.

The involvement of policymakers and stakeholders has significantly strengthened the project's credibility, and their contributions have played a key role in shaping its direction.

However, the need for updated data remains critical to assess the effectiveness of the current initiatives and to identify areas for improvement. Regular updates will help track progress, measure the success of implemented strategies, and highlight any gaps that need to be addressed.

Continuous data collection and analysis will ensure that the radiotherapy and oncology sectors in Malaysia remain responsive to emerging challenges and evolving healthcare needs.

Attachments:

~~Annex 1 Results/Data of Phase 1~~

Annex 2 Results/Data of Phase 2

Annex 3 Results/Data of Phase 3

publications, pictures, etc.

CSI Name and Signature	DR.SUHANA BINTI YUSAK 
Date and Place	20TH DEC 2024

Annex 4. Mongolia



RCA Regional Office

c/o Korea Atomic Energy Research Institute
989-111 Daedeok-daero, Yuseong-gu, Dae-jeon, 34057, Korea
Tel: +82 42 868 2776~8,8223
Fax: +82 42 864 1626
<http://www.rcaro.org>

Final Report for Research Agreement

(Please complete all sections and send your report electronically to: kelly@rcaro.org)

Title of the Research Project under which this Research Agreement is implemented: Closing the Gap in Radiotherapy Access in RCA Government Parties	
Title of the Research Agreement Project: Estimation of Radiotherapy service in Mongolia and defining roadmap planning to improve it	
Institute Name: National Cancer Center of Mongolia (NCCM)	
CSI Name: Minjmaa Minjgee	Alternate CSI Name: Enkhtsetseg Vanchinbazar
Period Covered: January 2022-December 2024	

<p>1. Final work plans for 2022, 2023 and 2024:</p> <p>Phase 1: Calculating burden of cancer requiring radiation therapy in 2022</p> <p>1.A Situational Analysis (Data collecting by surveys/questionnaires) in Q2 and Q3, 2022</p> <p>1.B Calculation of radiotherapy utilization rate (RTU) in Q4, 2022 and Q1, 2023</p> <p>1.C Estimation of number of cancer patients requiring radiotherapy in 2030 – 2040 in Q1, 2023</p> <p>Phase 2: Estimating core investment required for radiotherapy in 2023</p> <p>2.A. Estimation of future facility, equipment, and human resources needs – inputs in Q3 and Q4, 2023</p> <p>2.B Radiotherapy cost calculation – inputs in Q1 and Q2, 2024</p> <p>Phase 3: Assessing the outcome in 2024</p> <p>3.A. Potential loss upon failure to close the gap, Q3 and Q4</p> <p>3.B. Return on investments in terms of life-years and financial values, Q3 and Q4</p> <p>3.C. Evaluation and Roadmap planning, Q3 and Q4</p>
<p>2. Summary which describes in brief form the experimental method, major results:</p> <p>Experimental methodology:</p> <ul style="list-style-type: none">- National cancer registry data, Ministry of Health, Hospital based data, Hospital information system and Radiotherapy (RT) track on Aria system used to collect data for cancer patients.- Hospital information system and RT track on Aria system used to calculate actual waiting time.- CCORE methodology of the Australian team used for Radiotherapy utilization (RTU) calculation. National data from registry used to calculate the cancer incidence in near future.- Globocan used to estimate the total number of cancer patients in 2030 and 2040.- International Atomic Energy Agency (IAEA), ESTRO-HERO and used to calculation of radiotherapy infrastructure and staff needs in 2024 and 2023.- GTFRC used to calculation of economic and life loss. <p>Major results:</p>

- Data collection of cancer patients and radiotherapy statistics was held during project implementation from mid-2022 to mid-2024 and optimal RTU and waiting time could be calculated first time for Mongolia.
- We could see waiting time could be reduced 2 times in 2024 compared to 2023 because of increased capacity with additional one Linear accelerator and enhanced capability of human resource.
- Estimation of number of cancer patients requiring radiotherapy in 2030 – 2040, helped us to calculate future facility, equipment, and human resource needs and radiotherapy cost calculation.
- By calculating economic and life loss and health benefit, required data was collected and evaluation will be done.
- We could have evidence based data convince decision makers such as Ministry of Health and hospital administrations in developing policy and investing in this field to close the gap in radiation therapy.

3. Detailed results achieved against work plans for 2022, 2023 and 2024, including quantitative data, if applicable (*please attach technical documents if needed*):

Phase 1: Calculating burden of cancer requiring radiation therapy

1.A Situational Analysis (Data collecting by surveys/questionnaires)

- Data collection survey/questionnaire of radiation therapy including cancer patient, radiotherapy centres, equipment, human recourse, Education & training, Social security & Referral systems and Reimbursement was done and is attached. (Annex 1. Questionary)
- Data collection for situation analysis related to the cancer patients such as tumour site and stage, age and gender, treatment modality etc. has been completed and has been used for in further calculations.
- Calculated waiting time was 30 days for 1st calendar year period including 2nd half of 2022 and first half of 2023 and 14 days for 2nd calendar year period in 2024. Related with increased capacity of radiotherapy unit, waiting time was reduced 2 timed in 2024 compare with 2023.

1.B. Calculation of radiotherapy utilization rate (RTU)

Optimal RTU has been calculated with Australian team support using LMIC RTU model and it is 32% for all cancers.

1.C. Estimation of number of cancer patients requiring radiotherapy in 2030 – 2040

Globocan estimation of new cancer cases is 8270 in 2030 and is 13000 in 2024.

Cancer patients requiring radiotherapy will be 2646 in 2030 and 4160 in 2040.

Phase 2: Estimating core investment required for radiotherapy

2.A. Estimation of future facility, equipment, and human resources needs – inputs.

Currently we have only one RT center with 3 linacs, 1 HDR afterloader for brachytherapy, 9 ROs 6 MPs, 10 RTTs, 3 nurses, 1 IT and 1 mechanical engineer. Based on calculation, our needs in 2024 would be 2 RT center with 4 linacs, 1 HDR afterloader for brachytherapy, 9 ROs, 11 MPs, 17 RTTs, 3 nurses, 1 IT and 1 mechanical engineer.

Needs in 2030 would be 4 RT center with 12 linacs, 1 HDR afterloader for brachytherapy, 18 ROs, 28 MPs, 55 RTTs, 3 nurses, 2 IT and 4 mechanical engineers. It means we need 4 times

more RT center and linacs, 2 times more ROs, 4.7 times more MPs, 5.5 times more RTTs, 2 times more IT and 4 times more mechanical engineers than existing number in 2024.

2.B Radiotherapy cost calculation - inputs

- Current capital cost is 17,882,760 USD, operating cost 4,741,331 USD, product cost is 5268.15 USD.
- Capital cost would be USD 22,399,080, operating cost would be USD 4,824,401, and product cost would be USD 5,363.78 in 2024. So the estimated gap in capital cost is USD 4,516,320, in operating cost USD 83,070, and product cost is USD 96.63
- Capital cost would be USD 43,534,264, operating cost would be USD 11,646,369, and product cost would be USD 4,404.50 in 2030. So the estimated gap in capital cost is USD 25651504, in operating cost USD 6905038. But product cost is reduced by USD 863.65

Phase 3: Assessing the outcome

Required data to evaluate potential loss upon failure to close the gap and return on investments in terms of life-years and financial values have been collected.

3.C. Evaluation and Roadmap planning

Ministry of Health and NCCM is developing a roadmap and action plan which is National Cancer Control Programme to scaling up radiotherapy services to align with Mongolia's broader healthcare strategy-Vision 2050 plan.

4. Achievements/success stories resulted from the project

Findings of the study have been used to provide evidence based information to Ministry of Health of Mongolia and other stakeholders such as IAEA Rays of Hope initiative since their visit to Mongolia in August 2023, and IAEA's imPACT Review Mission in May 2024. The IAEA is committed to supporting Mongolia expand their capacities in terms of nuclear medicine, medical physics and radiation oncology through the planned technical cooperation project.

The study run successfully in-line with government developmental activities in radiotherapy field. Our study already started to provide decision makers with evidences for actions in closing the Gap in Radiotherapy Access. As result of this, Ministry of Health and NCCM is developing a roadmap and action plan which is National Cancer Control Programme to scaling up radiotherapy services to align with Mongolia's broader healthcare strategy-Vision 2050 plan.

The research study findings is significantly contributing to establishment-feasibility studies and construction of second National Cancer Center (NCC2) and Radiotherapy Western Branch.

The past 3 years have been quite successful, bringing 4 major technological advances on the linear accelerator to get close to the developed world.

The IAEA's and Government projects give us an opportunity to initiate Intensity Modulated Radiotherapy and Volumetric Modulated Arc Therapy (IMRT/VMAT). To date, Linac based radiation therapy has been performed in about 4500 patients and the access to radiation therapy increased by 25 percent. In one year time from 2022 to 2023 amount of patients benefited from IMRT/VMAT increased by 32% and 47% of brain, 78% of head and neck, 49% of breast cancer

patients received IMRT/VMAT. Improvement of treatment results of cancer patients, improved survival time and quality of life could be expected now.

Stereotactic Body Radiation Therapy (SBRT) has been opened new treatment option for liver and lung cancer patients since June 2024.

It was important to provide information about the new technology to radiation therapy workers, hospital management, relevant ministries and departments, and the public by conducting personnel training, obtaining expert advice, and organizing a national seminar.

By introducing IMRT/VMAT in 2022, SBRT and respiratory motion management in 2024 which have been used since 2000 internationally, we have brought 20 years of progress to radiation therapy in Mongolia. With improved capacity, radiotherapy access increased by 25% and waiting time reduced 2 times.

5. Publications and conferences including stakeholder meetings held on the work performed under this Project (peer-reviewed journals, conferences proceedings, international and national conference contributions, stakeholder meetings, national/technical reports, *please enter web-link or attach copies to this report*):

- CSI Dr.Minjmaa Minjee presented lecture on “Current situation of Radiotherapy in Mongolia -Achievements and Challenges” at the “Emerging Issues of Oncology” Conference 2022. Representatives from the Ministry of Health and Nuclear Energy Commission and Hospital managers who have oncology services were attended.
- Open lecture was organized among Ministry of Health, hospital administration and oncology specialists in cooperation with FNCA Radiation Oncology meeting which was held in in Ulaanbaatar, 1st Oct 2022.
- *We organized INTERNATIONAL WORKSHOP ON MODERN RADIOTHERAPY TECHNIQUES: IMRT/VMAT* on 10 November 2023. Audience was representative from the Ministry of Health, Nuclear Energy Commission, Radiological technologist Association, hospital administration and oncology specialists and Radiotherapy team. 1 Radiation oncologist from Washington University in St. Louis, 1 medical physicist from Baylor College of Medicine, USA, 2 Radiotherapy technicians from Australia are invited to give lecture. CSI Dr.Minjmaa Minjee is going to presented lecture on “Current Radiotherapy service in Mongolia and its future trend” at the workshop.
- 40 minutes TV content is under preparation to raise public and decision makers’ awareness of radiation therapy benefits and our future aims. Newspaper article with same content was published in Apr 2023.
- CSI Dr.Minjmaa Minjee presented on “Current situation of Radiotherapy in Mongolia - Achievements and Challenges” during visit of Rays of Hope initiative of IAEA on August 2023.
- An international symposium on **INTERNATIONAL SYMPOSIUM TO LAUNCH LINAC BASED STEREOTACTIC RADIATION THERAPY AND NEURO-NAVIGATION SURGERY OF CEREBROSPINAL TUMORS, IT’S OPENING CEREMONY** was held on 1 March 2024 and approximately 120 people from 16 institutions participated in the new technology launch event and symposium. Co-investigator Enkhtsetseg presented “Innovation of Radiotherapy in Mongolia”

All those activity has been helpful to improve understanding and rise awareness of radiation therapy needs and problems, as well as future trends to decision makers.

<https://www.iaea.org/newscenter/news/mongolia-takes-steps-to-enhance-cancer-detection-and-treatment-capacities>

<https://news.mn/en/799884/>

<https://ikon.mn/n/204q>

<https://news.mn/r/2757646/>

<https://ikon.mn/n/337b>

<https://www.tac.mn/article/120404>

6. Suggestions for future research in the relevant field/sustainability of the project

We look forward to continuing to collaborate with the RCA Regional Office to develop future potential actions to improve patients' lives.

We would seek assistance from the project experts to publish our results in locally and internationally.

Contributions to the Project

Country	Mongolia
Reporting Period	2022-2024

1. Contribution to the Project on Phase 1, 2, and 3

Phases	Contributions
Phase 1. Calculation of Burden of Cancer Requiring Radiotherapy	<p>- Provide a Summary of the calculated RTU * Please submit detailed data separately as Annex 1</p> <p>1.A Situational Analysis (Data collecting by surveys/questionnaires)</p> <ul style="list-style-type: none"> - Data collection survey/questionnaire of radiation therapy including cancer patient, radiotherapy centres, equipment, human recourse, Education & training, Social security & Referral systems and Reimbursement was done and is attached. (Annex 1. Questionary) - Data collection for situation analysis related to the cancer patients such as tumour site and stage, age and gender, treatment modality etc. has been completed and has been used for in further calculations. - Calculated waiting time was 30 days for 1st calendar year period including 2nd half of 2022 and first half of 2023 and 14 days for 2nd calendar year period in 2024. Related with increased capacity of radiotherapy unit, waiting time was reduced 2 timed in 2024 compare with 2023. <p>1.B. Calculation of radiotherapy utilization rate (RTU) Optimal RTU has been calculated with Australian team support using LMIC RTU model and it is 32% for all cancers.</p> <p>1.C. Estimation of number of cancer patients requiring radiotherapy in 2030 – 2040</p> <p>Globocan estimation of new cancer cases is 8270 in 2030 and is 13000 in 2024. Cancer patients requiring radiotherapy will be 2646 in 2030 and 4160 in 2040.</p>

<p>Phase 2. Summary of Estimating Core Investment Required for Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the future facility, additional equipment and human resources - Provide a summary of radiotherapy cost calculation - Submit detailed data in separately as Annex 2 <p>2.A. Estimation of future facility, equipment, and human resources needs – inputs. Currently we have only one RT center with 3 linacs, 1 HDR afterloader for brachytherapy, 9 ROs 6 MPs, 10 RTTs, 3 nurses, 1 IT and 1 mechanical engineer. Based on calculation, our needs in 2024 would be 2 RT center with 4 linacs, 1 HDR afterloader for brachytherapy, 9 ROs, 11 MPs, 17 RTTs, 3 nurses, 1 IT and 1 mechanical engineer. Needs in 2030 would be 4 RT center with 12 linacs, 1 HDR afterloader for brachytherapy, 18 ROs, 28 MPs, 55 RTTs, 3 nurses, 2 IT and 4 mechanical engineers. It means we need 4 times more RT center and linacs, 2 times more ROs, 4.7 times more MPs, 5.5 times more RTTs, 2 times more IT and 4 times more mechanical engineers than existing number in 2024.</p> <p>2.B Radiotherapy cost calculation - inputs</p> <ul style="list-style-type: none"> - Current capital cost is 17,882,760 USD, operating cost 4,741,331 USD, product cost is 5268.15 USD. - Capital cost would be USD 22,399,080, operating cost would be USD 4,824,401, and product cost would be USD 5,363.78 in 2024. So the estimated gap in capital cost is USD 4,516,320, in operating cost USD 83,070, and product cost is USD 96.63 - Capital cost would be USD 43,534,264, operating cost would be USD 11,646,369, and product cost would be USD 4,404.50 in 2030. So the estimated gap in capital cost is USD 25651504, in operating cost USD 6905038. But product cost is reduced by USD 863.65
<p>Phase 3. Assessing the outcome -Application of an investment framework</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the economic analysis - Submit detailed data in separately as Annex 3 <p>Required data to evaluate potential loss upon failure to close the gap and return on investments in terms of life-years and financial values have been collected as follows.</p> <ul style="list-style-type: none"> - With no scale-up, and using the costs from phase 2, the total cost for treatment in Mongolia is \$4.5 million USD. With longer hours (increased by 50%) of machine use or bulk purchasing of machine (machine cost down by 30%) the cost goes down to 3.9 and 3.4 million USD respectively.

	<p>With both subsidies applied, the cost of radiation treatment is estimated as 3.1 million USD.</p> <ul style="list-style-type: none"> - GDP per capita calculated in year of 2020-2040 - Median age at diagnosis cancer until death was collected - Evaluation of potential loss upon failure to close the gap and return on investments in terms of life-years and financial values is very crucial component of the project. However we could not complete this part due to lack of GTFRCC. <p>3.C. Evaluation and Roadmap planning Ministry of Health and NCCM is developing a roadmap and action plan which is National Cancer Control Programme to scaling up radiotherapy services to align with Mongolia’s broader healthcare strategy-Vision 2050 plan.</p>
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2. Additional information on the use of the project result and capacity building of the personnel (outcome)

Use of the project result	Contributions
Possible use of analytical data by stakeholders and governmental agencies involved in policy and strategy design in the field of health or cancer control	<ul style="list-style-type: none"> - Specific information on stakeholders and governmental agencies possibly use the analytical data of the project in relation to policy and strategy design <ol style="list-style-type: none"> 1. Newly developing Cancer Control Programme 2. Mongolia’s broader healthcare strategy-Vision 2050 plan. 3. Feasibility study of Establishment of a second National Cancer Center (NCC2) 4. Feasibility study of Establishment of Radiotherapy Western Branch under MOH’s decision to decentralize cancer care <ul style="list-style-type: none"> - If the project results were delivered to the stakeholders (government agencies or related institutes, please provide the list of recipients) <ol style="list-style-type: none"> 1. Mr. Munkhsaikhan Togtmol, Minister of Health, Member of Parliament 2. Mr. Chinburen Jigjidsuren, Member of Parliament 3. Mr. Tumurbaatar Luvsansambuu, Adviser of Minister of Health 4. Mr. Manlaijav Gunaajav, Secretary and Head of the Nuclear Commission Energy 5. Dr. Odontuya Gonchig, President of Mongolian Society for Radiation Oncology 6. Prof. Erdenekhuu Nansalmaa, General Director of National Cancer Center of Mongolia

	<p>7. IAEA Rays of Hope initiative group visit in August 2023</p> <p>8. IAEA’s imPACT Review Mission, in May 2024</p> <p>9. WHO representative on May 2024</p>
<p>Improved understanding and new knowledge related to research and analysis on health issues</p>	<p>Specific information on what was delivered and list of recipient institutions/personnel</p> <ul style="list-style-type: none"> - CSI Dr.Minjmaa Minjee presented lecture on “Current situation of Radiotherapy in Mongolia -Achievements and Cahllenges” at the “Emerging Issues of Oncology” Conference 2022. Representatives from the Ministry of Health and Nuclear Energy Commision and Hospital manager who have oncology services were attended. - Open lecture was organized among Ministry of Health, hospital administration and oncology specialists in cooperation with FNCA Radiation Oncology meeting which was held in in Ulaanbaatar, 1st Oct 2022. - <i>We organized INTERNATIONAL WORKSHOP ON MODERN RADIOTHERAPY TECHNIQUES: IMRT/VMAT on 10 November 2023.</i> Audience was represintetive from the Ministry of Health, Nuclear Energy Commision, Radiological technologist Association, hospital administration and oncology specialists and Radiotherapy team. 1 Radiation oncologist from Washington University in St. Louis, 1 medical physicist from Baylor College of Medicine, USA, 2 Ratiotherapy technicians from Australia are invited to give lecture. CSI Dr.Minjmaa Minjee is going to presented lecture on “Current Radiotherapy service in Mongolia and its future trend” at the workshop. - 40 minutes TV content is under preparation to raise public and decision makers’ awareness of radiation therapy benefits and our future aims. Newspaper article with same content was published in Apr 2023. - CSI Dr.Minjmaa Minjee presented on “Current situation of Radiotheray in Mongolia -Achievements and Challenges” during visit of Rays of Hope initiative of IAEA on August 2023. - An international symposium on INTERNATIONAL SYMPOSIUM TO LAUNCH LINAC BASED STEREOTACTIC RADIATION THERAPY AND NEURO-NAVIGATION SURGERY OF CEREBROSPINAL TUMORS, IT’S OPENING

	CEREMONY was held on 1 March 2024 and approximately 120 people from 16 institutions participated in the new technology launch event and symposium. Co-investigator Enkhtsetseg presented “Innovation of Radiotherapy in Mongolia”
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2-1 Assessment of Research Capabilities in comparison of 2022

Please tick(✓) where relevant and provide descriptions on the self-assessment of your team’s research capabilities before and after participation in the project

Research Management and support	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
				✓	
Attainment and application of new research skills and knowledge	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
			✓		
Research collaboration	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
				✓	
Knowledge transfer/take up by relevant stakeholders	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
				✓	

3. Success Stories

- Please provide success stories from the project (2022-2024) to demonstrate achievement and impact of the project in your country (attach pictures, website link, MoU, or other evidences)

Our research study that titled “Estimation of Radiotherapy service in Mongolia and defining roadmap planning to improve it”, was conducted to deal with the problems identified through calculating the burden of cancer requiring radiation therapy, estimate core investment required

for radiotherapy and assess the outcome. Our study already started to provide decision makers with evidences for actions in closing the Gap in Radiotherapy Access.

The past 3 years have been quite successful, bringing 4 major technological advances on the linear accelerator to get close to the developed world.

The IAEA's and Government projects give us an opportunity to initiate IMRT/VMAT. To date, Linac based radiation therapy has been performed in about 4500 patients and the access to radiation therapy increased by 25 percent. In one year time from 2022 to 2023 amount of patients benefited from IMRT/VMAT increased by 32% and 47% of brain, 78% of head and neck, 49% of breast cancer patients received IMRT/VMAT. Improvement of treatment results of cancer patients, improved survival time and quality of life could be expected now.

Next goal has become to start SBRT/SRS. It was impossible to treat liver cancer by existing radiation treatment technology which is the first leading cancer in our country. By this reason it was necessary to provide the stereotactic radiation treatment in Mongolia in the short term development plan.

Therefore government project was implemented in 2022-2023 and high precision linear accelerator-True Beam was installed. As a result, increased access to radiotherapy and improved capacity to use of advanced techniques could be expected.

SBRT has been opened new treatment option for liver and lung cancer patients since June 2024 with shorter treatment time and short stay in Ulaanbaatar capital city made patients from countryside more comfortable. Moreover, citizens of our country who need to undergo advanced radiation therapy had a great financial burden to have this treatment abroad, and now they will be able to benefit from technological progress in their own country.

Respiratory motion management such as DIBH and DEBH has been initiated in 2024 and 4D gating is planned next year.

IAEA Technical Cooperation projects had a strong impact on training of staff on the advanced techniques and in the improvement in radiation control and protection. Improved knowledge and skills in advanced radiotherapy of the professionals engaged in this field established, leading to better competency and work efficiency.

It was important to provide information about the new technology to radiation therapy workers, hospital management, relevant ministries and departments, and the public by conducting personnel training, obtaining expert advice, and organizing a national seminar.

By introducing IMRT/VMAT in 2022, SBRT and respiratory motion management in 2024 which have been used since 2000 internationally, we have brought 20 years of progress to radiation therapy in Mongolia. With improved capacity, radiotherapy access increased by 25% and waiting time reduced 2 times.

The study run successfully in-line with government developmental activities in radiotherapy field such as contribute to establishment of a second National Cancer Center (NCC2) and

Radiotherapy Western Branch as part of the decentralize cancer care policy, following further feasibility studies, the construction.

<https://www.iaea.org/newscenter/news/mongolia-takes-steps-to-enhance-cancer-detection-and-treatment-capacities>

<https://news.mn/en/799884/>

<https://ikon.mn/n/204q>

<https://news.mn/r/2757646/>

<https://ikon.mn/n/337b>

<https://www.tac.mn/article/120404>

4. Synergies/interactions among the participating countries

Countries	Synergy/interactions
Australia	Mongolian radiotherapy demand/RTU was calculated by the Australian team using previously developed models that used Malaysian cancer staging data. We are co-author of the publication “Current and projected gaps in the availability of radiotherapy in the Asia-Pacific region: a country income-group analysis”, Dania Abu Awwad et al.
Indonesia	Indonesian Radiotherapy expansion and development is good model for future projects in capacity building to close the gap in the region.

5. Limitations

It was challenging to understand comprehensive research methods via virtual training courses. Limitation of lacking CCORE and GTFRCC.

6. Lessons learned

- This work would not have been as successful without support received from the RCA Regional Office, technical officer and experts of the project, and other participating countries.
- Project run successfully if it is of national importance and in-line with government developmental objectives.
- Recruit more staff to work in radiation therapy and human resource training and increase their experience is essential to in increasing national capacity and close the gap.

- We have come to believe that professionals all over the world are ready to work with their hearts and talents to help people with cancer and it inspires us a lot.
- Timely communication with technical officer and experts is crucial for successful progress of the project.

7. Suggestions for future research/sustainability of the project

We look forward to continuing to collaborate with the RCA Regional Office to develop future potential actions to improve patients' lives.

We would seek assistance from the project experts to publish our results in locally and internationally.

8. Conclusions

Summary of the outcomes, achievements, impact of the project, success stories, remarks, etc.

Our research study titled “Estimation of Radiotherapy service in Mongolia and defining roadmap planning to improve it”, was conducted to solve with the problems identified through calculating the burden of cancer requiring radiation therapy, estimate core investment required for radiotherapy and assess the outcome.

Data collection of cancer patients and radiotherapy statistics was held during project implementation from mid-2022 to mid-2024 and optimal RTU and waiting time could be calculated first time for Mongolia.

We could see waiting time could be reduced 2 times in 2024 compared to 2023 because of increased capacity with additional one Linear accelerator and enhanced capability of human resource.

Estimation of number of cancer patients requiring radiotherapy in 2030 – 2040, helped us to calculate future facility, equipment, and human resource needs and radiotherapy cost calculation. We need to further evaluate economic and life loss and health benefit together with project experts.

Findings of the study have been used to provide evidence based information to Ministry of Health of Mongolia and other stakeholders such as IAEA Rays of Hope initiative since their visit to Mongolia in August 2023, and IAEA's imPACT Review Mission in May 2024. The IAEA is committed to supporting Mongolia expand their capacities in terms of nuclear medicine, medical physics and radiation oncology through the planned technical cooperation project.

The research study findings is significantly contributing to establishment-feasibility studies and construction of second National Cancer Center (NCC2) and Radiotherapy Western Branch.

The past 3 years have been quite successful, bringing 4 major technological advances on the linear accelerator to get close to the developed world.

The IAEA's and Government projects give us an opportunity to initiate IMRT/VMAT. To date, Linac based radiation therapy has been performed in about 4500 patients and the access to radiation therapy increased by 25 percent. In one year time from 2022 to 2023 amount of patients

benefited from IMRT/VMAT increased by 32% and 47% of brain, 78% of head and neck, 49% of breast cancer patients received IMRT/VMAT.

SBRT has been opened new treatment option for liver and lung cancer patients since June 2024. By introducing IMRT/VMAT in 2022, SBRT and respiratory motion management in 2024 which have been used since 2000 internationally, we have brought 20 years of progress to radiation therapy in Mongolia. With improved capacity, radiotherapy access increased by 25% and waiting time reduced 2 times. Improvement of treatment results of cancer patients, improved survival time and quality of life could be expected now.

It was important to provide information about the new technology to radiation therapy workers, hospital management, relevant ministries and departments, and the public by conducting personnel training, obtaining expert advice, and organizing a national seminar.

In conclusion, this research run successfully in-line with government developmental activities in radiotherapy field. Our study already started to provide decision makers with evidences for actions in closing the Gap in Radiotherapy Access. As result of this, Ministry of Health and NCCM is developing a roadmap and action plan which is National Cancer Control Programme to scaling up radiotherapy services to align with Mongolia’s broader healthcare strategy-Vision 2050 plan.

Attachments:

Annex 1 Results/Data of Phase 1

Questions	Answers
country name	Mongolia
population in your country	3.3 million
number of cancer patients diagnosed per year in your country?	6072 as of 2020
how many of them are being treated with RT in your country?	812 as of 2020
number of cancer patients diagnosed per year in your hospital?	6072 as of 2020
how many of them are being treated with RT in your hospital?	812 as of 2020
number of Radiotherapy centres	1
Number of Public	1
Number of Private	0
Number of bunkers in public hospital	3 for linac, 3 for telecobalt
number of linacs in the country	2
number of Co-60 in the country	2
linac models (e.g. Varian TrueBeam)	Varian Unique and Clinac iX

EPID models (aS500, aS1000, or aS1200, etc)	EPID model is aS500 for Clinac iX and Unique
treatment planning system (Eclipse/Aria, etc)	Eclipse 15.6 and Aria 15.6
number of HDR Brachytherapy unit in the country	1
number of LDR Brachytherapy unit in the country	0
HDR Afterloader model	GyneSource
LDR Afterloader model	0
Type of HDR radioactive course	Co-60
Type of LDR radioactive course	0
treatment planning system for brachytherapy	Sagiplan
number of Simulators in the country	1
Simulator model	Imagin, Bhabhatron
number CT simulators in the country	1
CT simulators model	Somaton emotion 16, Siemens
Patient immobilization devices	adequate
who is doing treatment planning (physicist or dosimetrists)	physicist
Plan to install new linacs in your hospital in the next 5 years (if yes, how many?)	1
Will other hospitals or centers purchase linacs within 5 years?	don't know
use of IMRT (if yes how many in percentage)	yes, just started
use of VMAT	yes, just started
use of SBRT or SRS	not yet
use of 3D IGBT (if yes, how many in percentage)	yes, 70%
use of interstitial BT? (if yes, how many in percentage)	not yet
HUMAN RESOURCE & EDUCATION AND TRAINING	
any medical physics training program in the country (if yes, how many?)	not yet

how long is the medical physics training program? (e.g. 2 years)	not applicable
number of medical physicists in the country	8
number of medical physicists in your hospital	4
training level of medical physicists	There is no formal education system for the Medical Physicists in Mongolia. Certification, and accreditation is not available. MPs background is nuclear technology and prepared as a medical physicist through on the job training. Most have attended a Physics fellowship programme of 3-12 months duration conducted through the auspices of the IAEA in an overseas centre. This has included some training in basic and advanced technologies. Masters' programme for Medical Physics has been developed in conjunction with the National University Mongolia in 2015. Unfortunately, the programme was unable to proceed due to the small overall number of students and lack of a qualified Professor at the University. There is opportunity for MPs and Dosimetrists to improve our medical knowledge (including anatomy, radiographic anatomy, imaging-based knowledge and competency, radiology and clinical oncology) at the local Bio-Medical University that helps to coordinate a 6-months training course targeted to specific local needs.
How many MSc? How many PhD? How many physicists with residency training?	1 MSc in Nuclear technology, do not have a PhD and physics resident
any radiation oncologists training program in the country (if yes, how many?)	1
how long is the radiation oncologists training program? (e.g. 2 years)	6 months
number of radiation oncologists in the country	12
number of radiation oncologists in your hospital	10
How many MSc? How many PhD? How many radiation oncologists with residency training?	3 PhDs, 3 MSc and 3 residents

any Radiotherapy technologists training program in the country (if yes, how many?)	not yet
how long is the Radiotherapy technologists training program? (e.g. 2 years)	not applicable
number of Radiotherapy technologists in the country	10
number of Radiotherapy technologists in your hospital	10
How many MS? How many PhD? How many Radiotherapy technologists with residency training?	none
any Oncology Nurses training program in the country (if yes, how many?)	1
how long is the Oncology Nurses training program? (e.g. 2 years)	3 months
number of Oncology Nurses in the country	190
number of Oncology Nurses in your hospital	170
How many MS? How many PhD? How many Oncology Nurses with residency training?	8 MSc
any dosimetrist training program in the country (if yes, how many?)	not yet
how long is the dosimetrist training program? (e.g. 2 years)	not applicable
number of dosimetrist in the country	3
number of dosimetrist in your hospital	2
How many MS? How many PhD? How many dosimetrist with residency training?	none
average number of treatments per day on a linac	35-40
linac treatment hours (e.g. from 6 am to 7 pm)	from 8.30am to 16.00pm

QA equipment (water tank, IC, array?)	PTW MP3 water tank, Ovtavious 729 and Startrack iba array
QA protocoal (e.g. TG-142)	TG-142, TRS 398
how long does it take to do daily QA?	30 min
daily QA equipment? What tests are being used	Front pointer, spirit level, graphpaper, PTW Quickcheck and Beamchecker. Function check, Gantry, collimator 0, laser and field size accuracy, ODI and X-ray output constancy test are performed
how long does it take to do weekly QA?	30-45 min
what tests are being performed in weekly QA? And what equipment?	Front pointer, spirit level, graphpaper, PTW Quickcheck and Beamchecker, solid water phantom and Simiflex 0.123cc are used. More comprehansive mechanical test than daily QA, output constancy test by ion chamber in solid water and MLC shape test are being performed
how long does it take to do annual QA?	1-1.5 days
what tests are being performed in monthly QA? And what equipment?	Front pointer, spirit level, graphpaper, radiochromic film, small water phantom and Farmer 0.66cc and Advanced marcus, IAEA TRS-398 spread sheet and Las Vegas are used. More comprehansive mechanical test than weekly QA including couch test, rotational accuracy radiation field size accuracy, spoke shot and dosimetry test including output in water by farmer 0.6cc, TPR20/10, Linearity, MLC test and EPID test are being performed.
do you do TPS QA?	Currently, TPS dose verification measurement performed by Thorasic IMRT phantom and ion chamber. We are setting up Diamond, it will used for TPS QA soon.

how do you perform IMRT QA? (equipment)	yes
how long does it take for each IMRT or VMAT QA?	1-5 hours
how do you perform dosimetry audit? (e.g. IAEA TLD)	Audited by IAEA RPLDs
how often is the audit? (e.g. once a year)	every 2 years
how long does it take for you to receive the audit report?	8 weeks
Social security & Referral systems	
Number of patients covered by public health care insurance system	99%
Number of patients covered by private health insurance/employer insurance	0%
Number of patients paying out of pocket	1%
Number of patients treated abroad	N/A
Patient referral systems & regulations for referral	Tertiary level hospital doctors can refer to radiotherapy
Reimbursement systems by country, including public and private systems	Radiotherapy is fully reimbursed by National Medical Insurance System (public)
Reimbursement per patient for main cancers and specific radiotherapy techniques	All types of radiotherapy are reimbursed with same estimation
Waiting time for palliative patient	2-3 weeks
Waiting time for curative patient	4-6 weeks

The summary of the results March 2024 (Updated)

	Existing	Needs in 2023	Needs in 2030
RT center	1	2	4
Equipment			
Flourosc sim	1	1	1
CT sim	2	2	4
4D CT	1	1	1
MRI	0	0	1
PET	0	0	0
3D TPS	4	5	7
4D TPS	1	1	1
Cobalt	2	2	0
Mould room	1	2	0
Single photon linac	1	2	4
Multi photon linac	2	2	8
R&V-OMS	1	2	4
HDR afterloader	1	1	1
C-arm	1	1	1
Dosimetry QA tools	1	2	4
Staff			
RO	9	9	18
MP	6	11	28
RTT	10	17	55
TP-dosi	0	4	13
Nurse	3	3	3
IT	1	1	2
Mec eng	1	1.55	4.02
elect eng	0	2.38	6.05
Cost			
Capital cost (Building and equipment)	17,882,760	22,399,080	43,534,264
Operating costs (salaries, maintenance, amortization)	4,741,331	4,824,401	11,646,369
Product costs (cost per patient)	5268.15	5,363.78	4,404.50

Annex 3 Results/Data of Phase 3

Excel sheet “Template-23.June_circulate_Mongolia” is attached.
Publications, pictures, etc.

Annex 5. Philippines



RCA Regional Office

c/o Korea Atomic Energy Research Institute
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Tel: +82 42 868 2776~8,8223
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<http://www.rcaro.org>

Final Report for Research Agreement

(Please complete all sections and send your report electronically to: kelly@rcaro.org)

Title of the Research Project under which this Research Agreement is implemented: Closing the Gap in Radiotherapy Access in RCA Government Parties	
Title of the Research Agreement Project: <i>Modern Radiotherapy Accessibility and Evolution in the Philippines</i>	
Institute Name: Jose R. Reyes Memorial Medical Center- Department of Radiotherapy	
CSI Name: Jerickson Abbie S. Flores	Alternate CSI Name: Miriam Joy C. Calaguas
Period Covered: January 2022-December 2024	

14. Final work plans for 2022, 2023 and 2024:

- Phase I: 2022
 - a. *Current and prediction of cancer incidence*
 - b. *Radiotherapy utilization rate (RTU)*
 - c. *Current number and evolution (increase comparison 2015 versus 2021) of radiotherapy machines and available technologies, Current available technologies*
 - d. *2022 Accessibility: Distance (in kilometers by road) and travel-time (in minutes) from each province to the nearest radiotherapy center*
 - e. *Human resources availability in Radiation Oncology in the Philippines*
 - f. *Training centers/institutions*
- Phase II: 2023
 - a. *Calculation or estimation of future facility, equipment in the Philippines*
 - b. *Human resources need in Radiotherapy in the Philippines*
 - c. *Estimation of radiotherapy cost: capital and construction costs, personnel costs, educational costs; capital and operational expenses in the Philippines*
- Phase III: 2024
 - a. *Calculation of Return on investments in terms of life-years and financial values*

- b. *Potential loss upon failure to close the gap*
- c. *Roadmap planning for Radiotherapy*
- d. *Recommendation for Philhealth insurance/HMO coverage*
- e. *Future directions in modern radiotherapy and education/training*
- f. *Latest Data on Accessibility (2024): Distance (in kilometers by road) and travel-time (in minutes) from each province to the nearest radiotherapy center and Evolution (increase comparison 2021 and 2024) of radiotherapy machines and available technologies*
- g. *Evaluation and Roadmap planning*

15. Summary which describes in brief form the experimental method, major results:

The CCORE Stage Adjusted Model (2023) was used to calculate RTU rates, while data from Globocan 2020, the DIRAC database, and national facility surveys informed projections. Major results highlighted a pressing need for increased radiotherapy facilities and skilled personnel to meet the country's cancer treatment demand.

16. Detailed results achieved against work plans for 2022, 2023 and 2024, including quantitative data, if applicable (*please attach technical documents if needed*):

2022- On our update on RTU, data shows a significant gap between the actual and optimal RTU rates. In 2020, the actual RTU was at a mere 4.5%, a drop from 10.3% in 2012. This is starkly lower than the optimal RTU rate of 48% in 2020, which itself decreased from 53% in 2012. This gap highlights a critical underutilization of radiotherapy services, which is detrimental to patient outcomes and indicative of broader accessibility issues.

2023- Our projections indicate that to meet the optimal RTU, the Philippines needs to significantly expand its radiotherapy infrastructure. Specifically, we require an additional 132 radiotherapy departments equipped with 262 more megavoltage (MV) units. This expansion will necessitate a corresponding increase in human resources, including 409 radiation oncologists, 451 medical physicists, and over 1,026 radiation technologists.

The financial aspect of these expansions is substantial. Our cost analysis reveals that the total capital cost required for additional buildings and equipment amounts to approximately 1.1 billion USD. Operating costs, including salaries, maintenance, and amortization, add up to around 221 million USD annually. The total investment needed to achieve full access is estimated at 2.4 billion USD, which includes capital, operating, and training costs.

On a per-patient basis, the cost for a complete course of radiotherapy is approximately 2,877 USD, with each fraction costing about 144 USD. These figures are crucial for budgeting and financial planning, as they help health financing agencies and policy-makers allocate resources more effectively.

2024- Ongoing

<p>17. Achievements/success stories resulted from the project</p> <ul style="list-style-type: none"> a. Published paper: we have successfully published a paper "Radiotherapy services in the Philippines: exploring geographical barriers to improve access to care" in the Lancet Western Pacific journal. b. Accepted paper entitled "Radiotherapy Services in the Philippines: Exploring Geographical Barriers to Improve Access to Care" to ESTRO 2024: Radiation Oncology: Bridging the Care Gap. c. Meeting with Vice Consul of the Philippine Embassy to the United Nations in Vienna, Austria regarding various gaps in PH cancer care specifically in radiotherapy and how to contribute significantly to the alleviation of the cancer burden in the Philippines. Current strong collaboration with the Department of Science and Technology-Philippine Nuclear Research Institute, Department of Health and our team d. Philhealth increase in radiotherapy reimbursements (30 percent increase): Less to none out of pocket payments
<p>18. Publications and conferences including stakeholder meetings held on the work performed under this Project (peer-reviewed journals, conferences proceedings, international and national conference contributions, stakeholder meetings, national/technical reports, <i>please enter web-link or attach copies to this report</i>):</p> <ul style="list-style-type: none"> a. Published paper: we have successfully published a paper "Radiotherapy services in the Philippines: exploring geographical barriers to improve access to care" in the Lancet Western Pacific journal. b. Accepted paper entitled "Radiotherapy Services in the Philippines: Exploring Geographical Barriers to Improve Access to Care" to ESTRO 2024: Radiation Oncology: Bridging the Care Gap.
<p>19. Suggestions for future research in the relevant field/sustainability of the project</p> <ul style="list-style-type: none"> - Continued support of radiotherapy sustainability and capacity building projects

Contributions to the Project

Country	Philippines
Reporting Period	2022-2024

1. Contribution to the Project on Phase 1, 2, and 3

Phases	Contributions
<p>Phase 1. Calculation of Burden of Cancer Requiring Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a Summary of the calculated RTU * Please submit detailed data separately as Annex 1 <p>2022- On our update on RTU, data shows a significant gap between the actual and optimal RTU rates. In 2020, the actual RTU was at a mere 4.5%, a drop from 10.3% in 2012. This is starkly lower than the optimal RTU rate of 48% in 2020, which itself decreased from 53% in 2012. This gap highlights a critical underutilization of radiotherapy services, which is detrimental to patient outcomes and indicative of broader accessibility issues.</p>
<p>Phase 2. Summary of Estimating Core Investment Required for Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the future facility, additional equipment and human resources - Provide a summary of radiotherapy cost calculation - Submit detailed data in separately as Annex 2 <p>2023- Our projections indicate that to meet the optimal RTU, the Philippines needs to significantly expand its radiotherapy infrastructure. Specifically, we require an additional 132 radiotherapy departments equipped with 262 more megavoltage (MV) units. This expansion will necessitate a corresponding increase in human resources, including 409 radiation oncologists, 451 medical physicists, and over 1,026 radiation technologists.</p> <p>The financial aspect of these expansions is substantial. Our cost analysis reveals that the total capital cost required for additional buildings and equipment amounts to approximately 1.1 billion USD. Operating costs, including salaries, maintenance, and amortization, add up to around 221 million USD annually. The total investment needed to achieve full access is estimated at 2.4 billion USD, which includes capital, operating, and training costs.</p> <p>On a per-patient basis, the cost for a complete course of radiotherapy is approximately 2,877 USD, with each fraction costing about 144 USD. These figures are crucial for budgeting and financial planning, as they help health financing agencies and policy-makers allocate resources more effectively.</p>

<p>Phase 3. Assessing the outcome -Application of an investment framework</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the economic analysis - Submit detailed data in separately as Annex 3 <p>Ongoing</p>
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2. Additional information on the use of the project result and capacity building of the personnel (outcome)

<p>Use of the project result</p>	<p>Contributions</p>
<p>Possible use of analytical data by stakeholders and governmental agencies involved in policy and strategy design in the field of health or cancer control</p>	<ul style="list-style-type: none"> - Specific information on stakeholders and governmental agencies possibly use the analytical data of the project in relation to policy and strategy design - If the project results were delivered to the stakeholders (government agencies or related institutes, please provide the list of recipients) <ul style="list-style-type: none"> a. Meeting with Vice Consul of the Philippine Embassy to the United Nations in Vienna, Austria regarding various gaps in PH cancer care specifically in radiotherapy and how to contribute significantly to the alleviation of the cancer burden in the Philippines. Current strong collaboration with the Department of Science and Technology-Philippine Nuclear Research Institute, Department of Health and our team b. Philhealth increase in radiotherapy reimbursements (30 percent increase): Less to none out of pocket payments; https://mb.com.ph/2024/2/23/phil-health-raises-coverage-rates-of-most-benefit-packages-by-30-1#google_vignette c. Another Philhealth Increase (30%) reimbursement before the end of the year. https://www.gmanetwork.com/news/topstories/nation/919254/philhealth-30-hike-end-2024/story/; https://www.pna.gov.ph/articles/1232613

Improved understanding and new knowledge related to research and analysis on health issues	- Specific information on what was delivered and list of recipient institutions/personnel
--	---

2-1 Assessment of Research Capabilities in comparison of 2022

Please tick(✓) where relevant and provide descriptions on the self-assessment of your team's research capabilities before and after participation in the project

	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
Research Management and support				✓	Great team work and collaboration
Attainment and application of new research skills and knowledge				✓	Useful to stakeholders and policy makers
Research collaboration				✓	Thank you for RCA and experts (Prof Yavuz, Dr. Zubi Mei Ling,) and colleagues With stakeholders, policy makers and professional societies
Knowledge transfer/take up by					

relevant stakeholders				✓	Useful to stakeholders and policy makers
-----------------------	--	--	--	---	--

3. Success Stories

- Please provide success stories from the project (2022-2024) to demonstrate achievement and impact of the project in your country (attach pictures, website link, MoU, or other evidences)

<p>d. Published paper: we have successfully published a paper "Radiotherapy services in the Philippines: exploring geographical barriers to improve access to care" in the Lancet Western Pacific journal.</p> <p>e. Accepted paper entitled "Radiotherapy Services in the Philippines: Exploring Geographical Barriers to Improve Access to Care" to ESTRO 2024: Radiation Oncology: Bridging the Care Gap.</p> <p>f. Meeting with Vice Consul of the Philippine Embassy to the United Nations in Vienna, Austria regarding various gaps in PH cancer care specifically in radiotherapy and how to contribute significantly to the alleviation of the cancer burden in the Philippines. Current strong collaboration with the Department of Science and Technology-Philippine Nuclear Research Institute, Department of Health and our team</p> <p>g. Philhealth increase in radiotherapy reimbursements (30 percent increase): Less to none out of pocket payments; https://mb.com.ph/2024/2/23/phil-health-raises-coverage-rates-of-most-benefit-packages-by-30-1#google_vignette</p> <p>h. Another Philhealth Increase (30%) reimbursement before the end of the year. https://www.gmanetwork.com/news/topstories/nation/919254/philhealth-30-hike-end-2024/story/; https://www.pna.gov.ph/articles/1232613</p>

4. Synergies/interactions among the participating countries

Countries	Synergy/interactions
Philippines	Australia team – helped with optimal and actual RTU calculations.

5. Limitations

Availability of national cancer registry

6. Lessons learned

7. Suggestions for future research/sustainability of the project

8. Conclusions

Summary of the outcomes, achievements, impact of the project, success stories, remarks, etc.

Attachments:

- Annex 1 Results/Data of Phase 1
- Annex 2 Results/Data of Phase 2
- Annex 3 Results/Data of Phase 3
- publications, pictures, etc.

CSI Name and Signature	Jerickson Abbie S. Flores
Date and Place	Oct 31, 2024; Manila, Philippines

Annex 6. Thailand



RCA Regional Office

c/o Korea Atomic Energy Research Institute
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Final Report for Research Contract

(Please complete all sections and send your report electronically to: kelly@rcaro.org)

Title of the Research Project under which this Research Agreement is implemented: Closing the Gap in Radiotherapy Access in RCA Government Parties	
Title of the Research Agreement Project: Filling The gap of image-guided brachytherapy for gynaecologic cancer Thailand	
Institute Name: Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand	
CSI Name: Prof Imjai Chitapanarux	Alternate CSI Name: Prof Ekkasit Tharavichitkul
Period Covered: January 2022-December 2024	

20. Final work plans for 2022, 2023 and 2024:

Thailand is a country in southeast Asian. With a population of almost 70 million, it spans 513,120 square kilometres. Thailand is bordered to the north by Myanmar and Laos, to the east by Laos and Cambodia, to the south by the Gulf of Thailand and Malaysia, and to the west by the Andaman Sea; it also shares maritime borders with Vietnam to the southeast, and Indonesia and India to the southwest. Bangkok is the nation's capital and the largest city. Cancer is one of the most important healthcare issues in Thailand. Nowadays, cancer is the major cause of death in Thai people. Radiotherapy is one of the treatment options in cancer. Radiotherapy has a role in primary treatment, adjuvant treatment, and palliative treatment. Radiotherapy is composed of two parts; external beam radiotherapy (EBRT) and brachytherapy (BT) which is used widely in Gynaecological cancers. Radiotherapy technology improves to improve the treatment quality by increasing the target dose while sparing the normal tissue. In THA, Gynaecological cancers are the only one that EBRT and BT play the role together as curative intent. For brachytherapy, image-guided brachytherapy (IGBT) is the standard in high-income countries. The publication of the EMBRACE-1 by Potter et al. reported the promising results of image-guided brachytherapy in cervical cancer using MRI. However, image-guided brachytherapy needs much more resources both in manpower and equipment. This project aims to evaluate the gap of image-guided brachytherapy for Gynaecologic cancer in Thailand.

21. Summary which describes in brief form the experimental method, major results:

This project aims to fill the gap of IGBT for GYNE cancer in Thailand, to measure the gap in IGBT and to estimate the potential economic and life loss upon failure to close the gap. This project proposed by the RCA GPs designed to research three main points:

- a) Calculating burden of cervical cancer treated by IGBT to the national health systems

b) Estimating core investment required for IGBT

c) Assessing the outcome of IGBT in Thailand

The targets of our study include fourteen radiation oncology centers represented in 4 regions of Thailand as follows

- Northern: Chiang Mai (2), Lampang (1)
- Central: Lopburi (1), Bhutthachinnaraj (1), Bangkok (3), Chonburi (1) Ratchaburi (1)
- Northeastern: Udonthani (1), Nakornrachaseema (1), Khon Kaen University (KKU) (1)
- Southern: Prince of Songkhla University (PSU) (1)

The data from 2019-2020 will be collected from all 14 centres by online surveys to calculate the data of the equipment, manpower, gynaecologic cancers, and brachytherapy utilization. The whole data will be calculated and analysed to answer the three main objectives.

22. Detailed results achieved against work plans for 2022, 2023 and 2024, including quantitative data, if applicable (*please attach technical documents if needed*):

From our surveys, the data from our review in 2024 showed the surveys from our 14 cents accounting around 1/3 of radiotherapy centres in Thailand as followings

1. From our data, the actually image-guided brachytherapy in 2019 for cervical cancer was 33%
2. From RRCC ver. 2021, The data showed shortage of the manpower approximately in 40% for RO, 60% in MP, and 60% in RTT
3. For the benefit model, IGBT gained higher total income than 2DBT and lower cost to toxicity management

23. Achievements/success stories resulted from the project

From this project, we can identify the actually image-guided brachytherapy utilization in 14 centres who joined in our surveys. There was around 60% to fill the gap to use IGBT. The RRCC showed shortage of our workforces. Brachytherapy counted 7% of capital cost for radiotherapy. For our economic model, IGBT yielded higher income gain (around 1m USD gained) and less cost to treat toxicity.

24. Publications and conferences including stakeholder meetings held on the work performed under this Project (peer-reviewed journals, conferences proceedings, international and national conference contributions, stakeholder meetings, national/technical reports, *please enter web-link or attach copies to this report*):

For the academic activities related to this survey, the list showed as followed.

1. Oral Presentation in Research Section of THASTRO annual meetings – ADUTHAYA in 22-24 March 2024 in the Topic of “prediction of requirement of RT in GYN cancers”
2. Poster Presentation in ESTRO meets ASIA in Kaula Lumpur, Malaysia, 22-25 August 2024 in the topic of “Image-guided brachytherapy (IGBT) utilization rate from 14 radiotherapy centres from Thailand”
3. Planned Poster Presentation in MESTRO in Riyad, Saudi Arabia, 27-29 November 2024 in the topic of “Image-guided brachytherapy utilization in uterine cancer; a survey from 14 centres of Thailand”
4. Planned manuscript of “Unlocking Economic Gains: The Impact of Image-Guided Brachytherapy on Cervical Cancer Treatment in Thailand” to submit to International Journal.

25. Suggestions for future research in the relevant field/sustainability of the project

To further evaluation of process of implementation of IGBT in the bigger scale such as country or region can be encouraged.

Contributions to the Project

Country	THAILAND
Reporting Period	2022-2024

1. Contribution to the Project on Phase 1, 2, and 3

Phases	Contributions
<p>Phase 1. Calculation of Burden of Cancer Requiring Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a Summary of the calculated RTU * Please submit detailed data separately as Annex 1 <p>In our 14 centers, we had 11 fluoroscope simulators, 17 CT simulators, 1 MRI simulator, 32 linear accelerators, 75 treatment planning workstations, 14 HDR machines, and 8 C-arms. The full-time staff consisted of 65 Radiation Oncologists (ROs), 44 Medical Physicists (MPs), and 121 Radiation Therapy Technologists (RTTs).</p> <p>This survey recorded a total of 6,232 fractions, with 33% of these involving IGBT using CT or MRI. According to the RRCC version 21, the available workload coverage for ROs, MPs, and RTTs was 58%, 37%, and 39%, respectively.</p>
<p>Phase 2. Summary of Estimating Core Investment Required for Radiotherapy</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the future facility, additional equipment and human resources - Provide a summary of radiotherapy cost calculation - Submit detailed data in separately as Annex 2 <p>Brachytherapy accounted for 7% of the total capital costs per activity. For operational costs in HDR brachytherapy, the highest expense was associated with treatment delivery in brachytherapy, comprising 54%.</p>
<p>Phase 3. Assessing the outcome -Application of an investment framework</p>	<ul style="list-style-type: none"> - Provide a summary of the results of the economic analysis - Submit detailed data in separately as Annex 3 <p>Our economic analysis, based on data from the publications of Lorvidhaya et al. and Tharavichitkul et al., as well as our surveys of patients admitted to MED-CMU from 2013 to 2023, indicated that IGBT yielded a total income of approximately 6 million USD. Additionally, IGBT demonstrated lower treatment costs for managing severe toxicity.</p>

2. Additional information on the use of the project result and capacity building of the personnel (outcome)

Use of the project result	Contributions
Possible use of analytical data by stakeholders and governmental agencies involved in policy and strategy design in the field of health or cancer control	<p>- Specific information on stakeholders and governmental agencies possibly use the analytical data of the project in relation to policy and strategy design</p> <p>- If the project results were delivered to the stakeholders (government agencies or related institutes, please provide the list of recipients)</p> <p>This survey received contributions from</p> <ol style="list-style-type: none"> 1. 14 centres around Thailand composed of <ul style="list-style-type: none"> • Northern: Chiang Mai (2), Lampang (1) • Central: Lopburi (1), Bhutthachinnaraj (1), Bangkok (3), Chonburi (1) Ratchaburi (1) • Northeastern: Udonthani (1), Nakornrachaseema (1), Khon Kaen University (KKU) (1) • Southern: Prince of Songkhla University (PSU) (1) 2. The statistical data of THASTRO from 2012-2022 with courtesy by Associate Professor Temsak Phungrassami
Improved understanding and new knowledge related to research and analysis on health issues	<p>- Specific information on what was delivered and list of recipient institutions/personnel</p> <p>The supports from the consultants from the RCARP-03 as followings</p> <p>Prof. Yavus Anacak</p> <p>Dr. Eduardo Zubizaretta</p> <p>Dr. Mei Ling Yap</p> <p>Dr. Danielle Rodin</p>

2-1 Assessment of Research Capabilities in comparison of 2022

Please tick(✓) where relevant and provide descriptions on the self-assessment of your team’s research capabilities before and after participation in the project

Research Management and support	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
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	✓	✓	✓	✓	
Attainment and application of new research skills and knowledge	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
	✓	✓	✓	✓	
Research collaboration	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
	✓	✓	✓	✓	
Knowledge transfer/take up by relevant stakeholders	Same (Not Improved)	Minimal Improvement	Moderate Improvement	Significant Improvement	Description
	✓	✓	✓	✓	

3. Success Stories

- Please provide success stories from the project (2022-2024) to demonstrate achievement and impact of the project in your country (attach pictures, website link, MoU, or other evidences)

<p>Our surveys showed</p> <ol style="list-style-type: none"> 1. The actually image-guided brachytherapy utilization in 14 centres who joined in our surveys was 33%. The trends of gynaecologic cancers in our country increased, especially in endometrial cancer. This was around 60% to fill the gap to use IGBT. 2. The RRCC showed shortage of our workforces. Brachytherapy counted 7% of capital cost for radiotherapy. 3. For our economic model, IGBT yielded higher income gain (around 1m USD gained) and less cost to treat toxicity in cervical cancer patients who were treated by IGBT.
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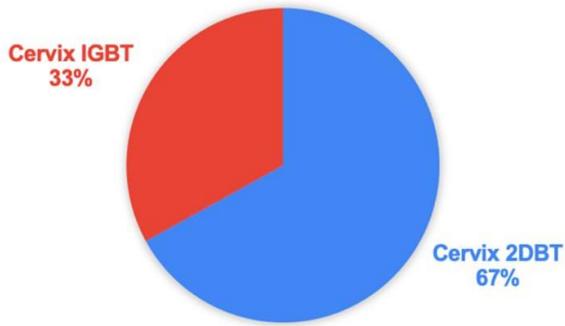


Figure 1 Actually IGBT utilization for cervical cancer from our survey availability/needs

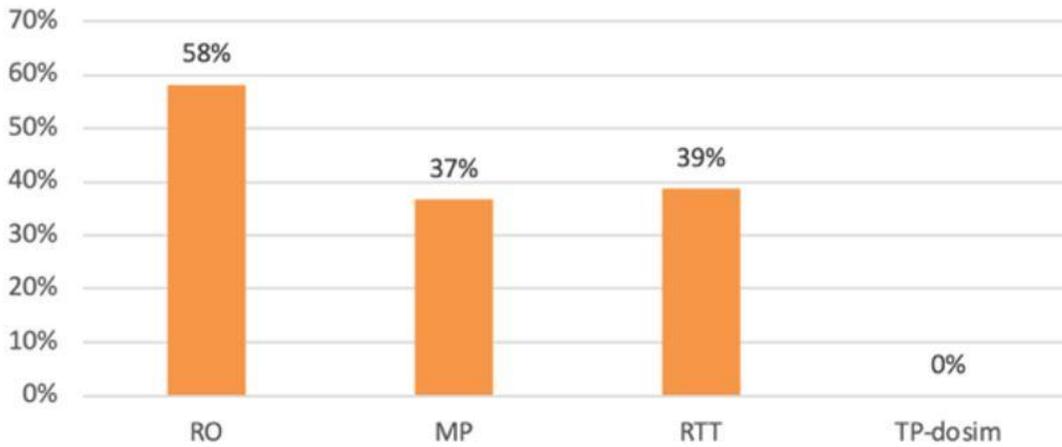
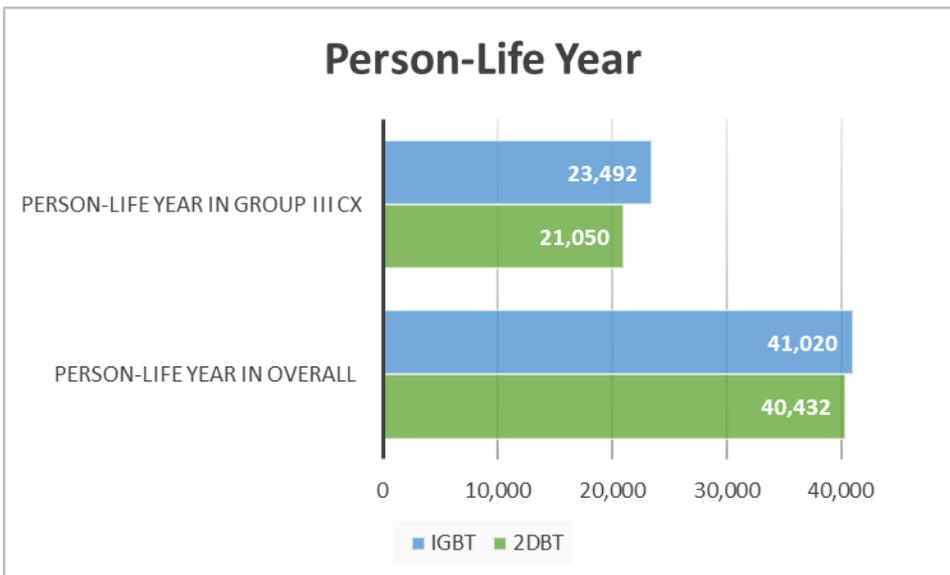


Figure 2 The availability of RO, MP, and RTT



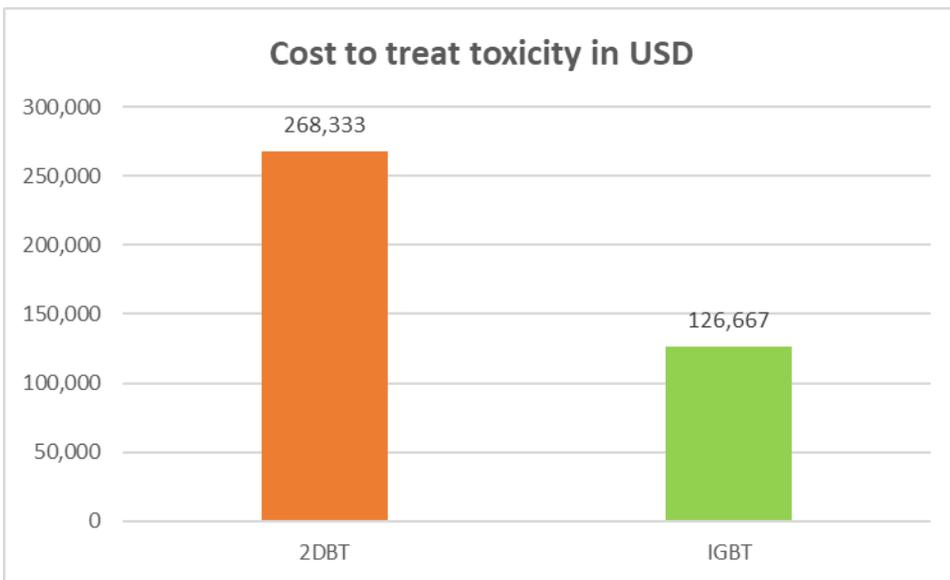
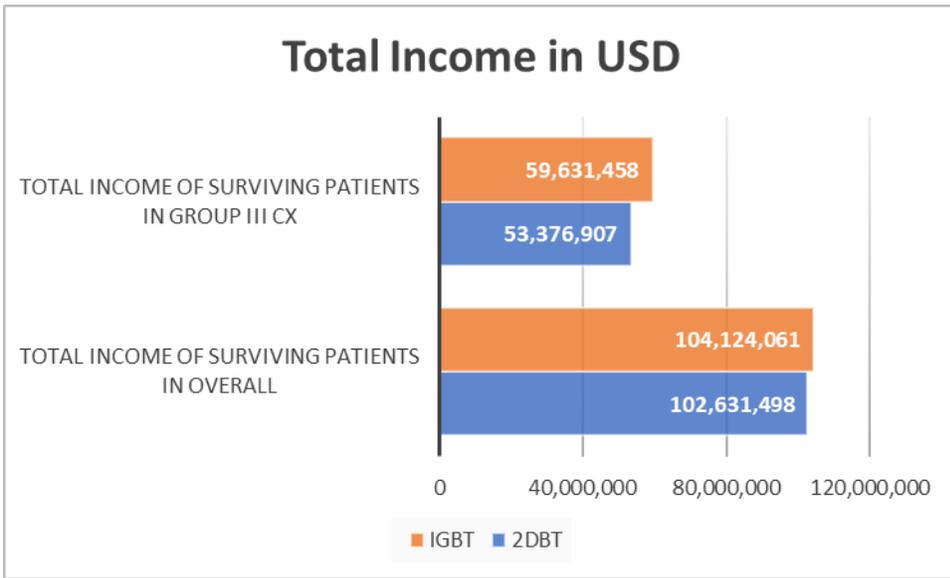


Figure 3.a Person Life-year of IGBT versus 2DBT in years

Figure 3.b Total income of IGBT versus 2DBT in USD

Figure 3.c Cost to treat toxicity of IGBT versus 2DBT in USD

4. Synergies/interactions among the participating countries

Countries	Synergy/interactions
THAILAND	14 centres from THAILAND joined this survey

5. Limitations

Our report had some limitations;

1. This analysis was performed in 14 centres around Thailand
2. This study is retrospective approach. Some data was recorded manually
3. Some data regarding survival increase and toxicity was collected from a single centre limiting transferability

6. Lessons learned

Your analysis demonstrated the economic benefits of IGBT. Considering the cost of a brachytherapy unit at 883,000 USD, it is clear that brachytherapy is a valuable investment. However, the actual utilization of IGBT for cervical cancer was only 33%, and the RRCC indicated a shortage of manpower.

7. Suggestions for future research/sustainability of the project

To expand the study to larger scale such as country or region may be useful.

8. Conclusions

Summary of the outcomes, achievements, impact of the project, success stories, remarks, etc.

Our report revealed that 1) The actual utilization of image-guided brachytherapy (IGBT) in the 14 centers that participated in our survey was 33%. The incidence of gynecologic cancers in our country has been increasing, particularly endometrial cancer, highlighting a 60% gap in the utilization of IGBT. 2) The RRCC indicated a workforce shortage. Brachytherapy accounted for 7% of the capital cost for radiotherapy. 3) Our economic model demonstrated that IGBT generated a higher income gain of approximately 6 million USD and reduced the cost of treating toxicity in cervical cancer patients treated with IGBT.

These findings reflect the current status of IGBT in our country. Although the 14 centers participating in our survey represent only one-third of the total centers in the country, this survey covers the entire region of Thailand. Implementing IGBT for cervical cancer patients could potentially increase national income. Moreover, IGBT incurs lower reimbursement costs for treating toxicity. Further large-scale evaluations at the national or regional level are warranted to validate these results.

Attachments:

Annex 1 Results/Data of Phase 1

Annex 2 Results/Data of Phase 2

Annex 3 Results/Data of Phase 3

publications, pictures, etc.

CSI Name and Signature	Prof. Imjai Chitapanarux
Date and Place	November 2024

Step 1.1: Facility of 14 RT centers

Our facilities included 11 fluoroscope simulators, 17 CT simulators, 1 MRI simulator, 32 linear accelerators, 75 treatment planning workstations, 14 HDR machines, and 8 C-arms. One CT scanner was specifically designated for brachytherapy. The 'full-time' staff comprised 65 radiation oncologists (RO), 44 medical physicists (MP), and 121 radiation technologists (RTT). The average number of fractions for gynecologic cancer treatments was 26. Details of the infrastructure characteristics are shown in Figure 1.

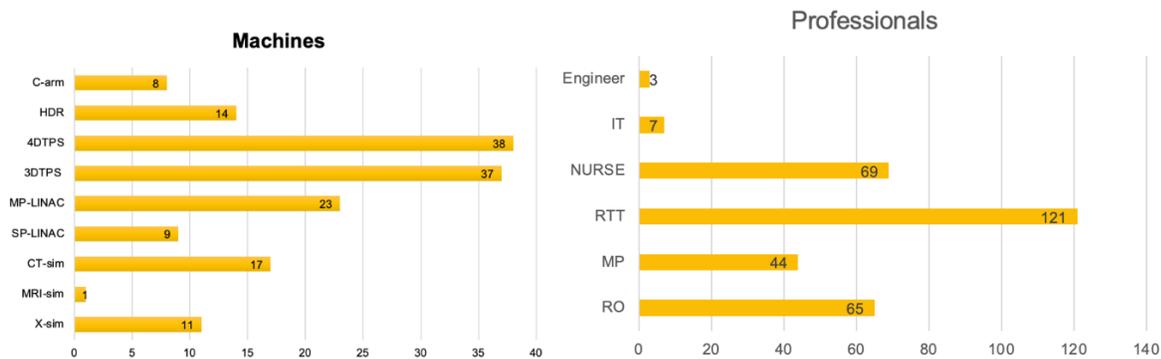


Fig 1. The quantities of machines, the number of professionals, and their salaries

Step 1.2: Actual IGBTU

Of the 14 centers, a total of 18,024 patients were treated with RT, including 2,950 with gynecological cancers. Of these, 2,081 patients underwent a combination of external beam radiotherapy and brachytherapy, with 72% of this group diagnosed with cervical cancer.

In 2019, the brachytherapy techniques across 14 RT centers were as follows: 4 centers used 2D-BT techniques, 5 centers used IGBT techniques, and 5 centers employed a mix of 2D-BT and IGBT techniques. To assess A-IGBTU, the number of fractions was selected since a mixed technique could be applied to the same patient. Details of brachytherapy utilization in cervical cancer are presented in Figure 2.

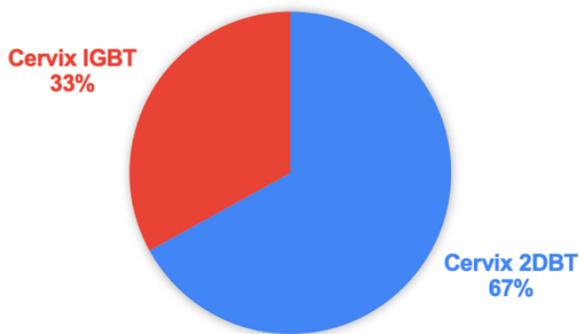


Fig 2. The actual IGBT utilization rate for cervical cancer

Step 1.2 The prediction of the requirement of RT for cervical cancer in 2040

Using the data from the THASTRO database, the requirement for RT for cervical cancer shows a tendency to decrease from 2012 to 2040 while the RT requirement for GYN will slightly increase (Figure 6). The increasing requirement of RT for GYN is likely to be dependent on the increasing incidence of corpus cancer. From the THASTRO database, cervical cancer shows a projected tendency to decrease in the future based on the data available from 2012 to 2018 (the Cancer in Thailand report volume VIII-X, supplementary Figure 1). This may be due to the efficacy of the screening programs that have become widespread in Thailand since 2005

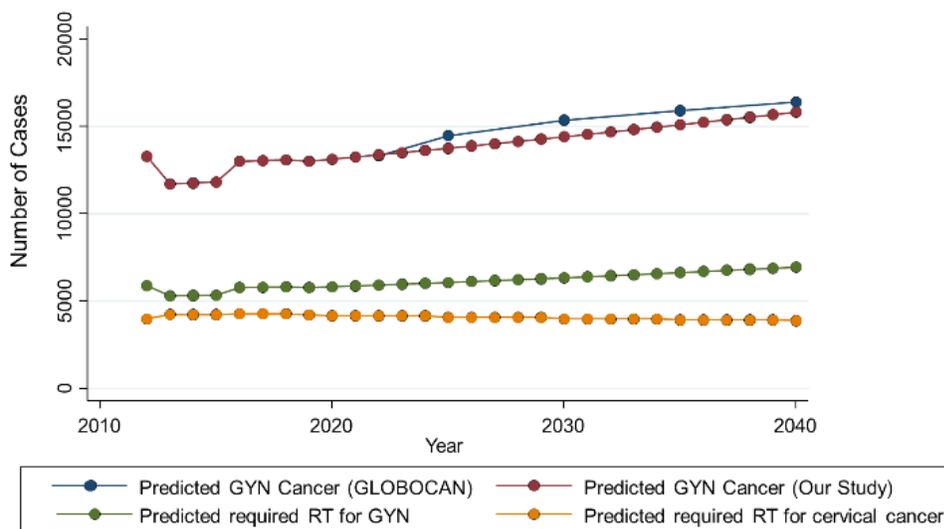


Fig. 6 Prediction of cervical cancer in Thailand projections to 2040

Step 2: Shortage Evaluation by RRCC v21

Using RRCC v21, the evaluations revealed a shortfall of personnel relative to the workload. The available workload coverage for RO, MP, and RTT was 58%, 37%, and 39%, respectively. These findings highlight the deficiency in radiotherapy staff as evidenced by our analysis. Figure 1 provides details on the current shortages and the ideal staffing levels needed to meet the workload.



Fig 1. Available percentage of radiotherapy personnel

Regarding the capital costs, brachytherapy accounted for 7% of the total expenditure. For operational costs, the highest expense was associated with treatment delivery in brachytherapy, comprising 54%. Details of these costs are illustrated in Figure 2.

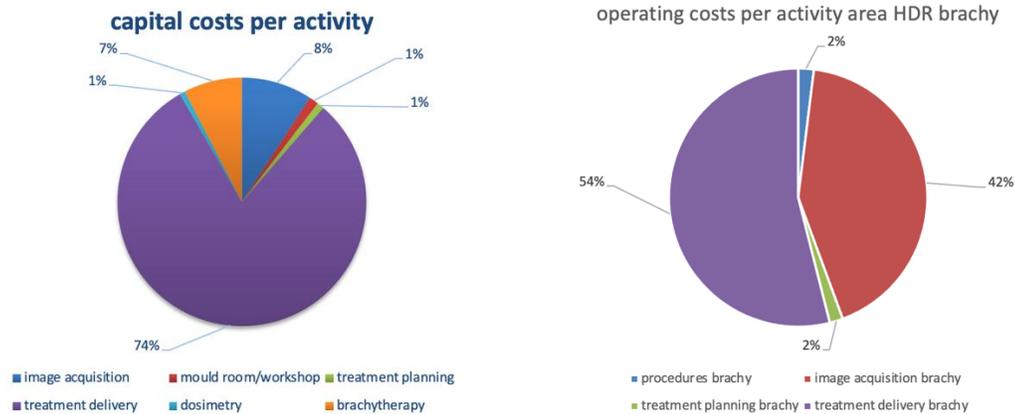


Fig 2. Percentages of capital costs and breakdown of operational costs for brachytherapy

Step 3.1 The Clinical Outcome Model

We analyzed our outcomes for 2D-BT and IGBT within our institution. The treatment outcomes for 2D-BT were reported by Lorvidhaya et al. in 2000 (IJROBP 2000), while the data for IGBT, reported by Tharavichitkul et al. in 2022 (JRR 2022), were used for calculations. The results are presented in Table 1. Although, the difference of overall survival (OS) rates between 2D-BT and IGBT was roughly 1% (68.2% vs. 69%), differences were observed in advanced stages: a 4% increase in OS for stage IIB and a 10% increase in OS for stage IIIB.

To calculate the “person-life year” and “total income of surviving patients”, we used the following data: 1) the average age of cervical cancer in the Thai population, 2) the national income of Thai people per person and 3) the survival outcome from Lorvidhaya et al. and Tharavichitkul et al. From our cohort, cervical cancer counted for 72% of all gynecological cancers (2,124 patients) and 59% of cervical cancer (1,253) were group III (stage IB3 to stage IVA). The most common age group in our cohort of cervical cancer was 51-60 years (30%) then the time to retirement was 10 years. The average annual income for the Thai population was 255,868 THB per person per year. The details of person-life years and total income of surviving patients are shown in table 1. From our calculation, especially in the locally advanced group (IIB-IVA) who strongly need brachytherapy, IGBT yielded the difference in total income of surviving patients of 6+ million USD.

Table 1 Person-life year and total incomes of 2DBT versus IGBT

Parameters	2DBT	IGBT	Difference
Person-life year in overall	40,432 life year	41,020 life year	588 years
Person-life year in group III Cx	21,050 life year	23,492 life year	2442 years
Total income of surviving patients in overall	102,631,498 USD	104,124,061USD	1,492,563USD
Total income of surviving patients in group III Cervical cancer	53,376,907USD	59,631,458USD	6,24,551USD

Step 3.2 The toxicity model

Three-hundred and ninety-five episodes underwent brachytherapy; in our analysis. Table 1 shows the distribution of strategies by toxicity grade while assessing each patient. The most frequent toxicity was fistula, which was followed by proctitis. 58 patients had 3DBT treatment, whereas 124 patients received 2DBT treatment. Our evaluation found that all instances of proctitis and cystitis were classified as grade 2 toxicity, while other complications such as hematochezia, hematuria, bowel obstruction, and fistula were categorized as grade 3 or 4 toxicity.

As shown in Table 2, patients with Grade 3-4 side effects from two-dimensional brachytherapy (2D-BT) experienced 161 episodes, while those undergoing three-dimensional brachytherapy (3D-BT) experienced 76 episodes. If the cost to treat serious toxicity was per admission was calculated, image-guided brachytherapy (IGBT) demonstrated a lower treatment cost for managing severe toxicity.

Table 2 Complications per episode and patient

Complications per Episode	Grade 3	Grade 4
2DBT	41	120
IGBT	32	44
Complications per Patient	Grade 3	Grade 4
2DBT	21	54
3DBT	17	23