Economic Analysis of Radiotherapy Services in an Indonesian University-Affiliated Hospital

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Abstract. Cancer remains one of the leading causes of death globally, with radiotherapy playing a pivotal role in cancer treatment. However, radiotherapy services demand substantial investments, particularly in the procurement and maintenance of Linear Accelerator (LINAC) equipment. This study evaluates the economic feasibility of radiotherapy services at Hasanuddin University Hospital (RS Unhas) using a Cost-Benefit Analysis (CBA) framework. Employing a quantitative case study design, key financial indicators analyzed include Net Benefit (NB), Benefit-Cost Ratio (BCR), and Net Present Value (NPV), alongside sensitivity analyses concerning costs and revenues. The 2024 data reveal total revenues of IDR 9,828,253,500 and total costs amounting to IDR 7,876,494,675, culminating in an operational surplus of IDR 1,951,758,825. Nonetheless, a 10-year projection discounted at 7.5% results in a negative NPV of –IDR 47,312,523,153 and a BCR of –0.13, indicating financial infeasibility of the investment. Sensitivity analyses across patient volume, INA-CBG tariffs, and operational expenses consistently demonstrate a negative NPV. Despite these results, the service holds critical strategic and social value in enhancing access to cancer treatment in Eastern Indonesia. Therefore, government interventions such as subsidies and alternative financing mechanisms are essential to ensure the service's sustainability.

Keywords: Radiotherapy Services, Linear Accelerator (LINAC) Investment, Healthcare Investment, Cost-Benefit Analysis, University Hospital

1 Introduction

Cancer stands as a predominant global cause of mortality, with epidemiological data reporting approximately 19.3 million incident cases and 10.0 million deaths in 2020 [1]. This upward trend is projected to continue, placing significant strain on global healthcare systems [2]. As a critical component of cancer care, radiotherapy is utilized in over 50% of cases. This study contributes by comprehensively examining operational costs and benefits an aspect frequently overlooked in previous studies that predominantly focused on equipment investment costs alone. Such an approach provides policymakers with a more complete framework for assessing the feasibility and sustainability of radiotherapy services in public hospitals within developing nations [3]. The comprehensive cost-benefit approach addresses a significant gap in healthcare economics literature, where most existing studies either: 1) focus narrowly on capital

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expenditures without considering operational sustainability or 2) fail to incorporate sensitivity analyses for developing country contexts. The inclusion of longitudinal financial projections represents a methodological advancement over cross-sectional studies that dominate this research area. The need for radiotherapy services is growing due to factors such as population expansion, rising life expectancy, and improved early diagnosis [4]. Recognized as a vital therapeutic approach, radiotherapy functions both as a standalone treatment and as part of integrated, multimodal cancer management [5].

In addition to the growing need for radiotherapy equipment, the provision of radiotherapy services requires substantial capital investment, including equipment procurement, facility construction, machine maintenance, and healthcare workforce training [6]. These issues are particularly acute in lowand middle-income nations where financial limitations frequently lead to disparities in healthcare access. In such contexts, conducting economic assessments is vital to guarantee that radiotherapy investments yield commensurate societal and economic returns. A pertinent approach for this analysis is Cost-Benefit Analysis (CBA), which evaluates the relationship between intervention costs and derived benefits [7]. This approach assists policymakers in determining program feasibility by considering both shortand long-term benefits [8].

Financial feasibility assessment in CBA utilizes several key calculation methods: Net Present Value (NPV) analysis, Benefit-Cost Ratio (BCR) computation, Internal Rate of Return (IRR) determination, and Payback Period (PP) evaluation [9]. Sensitivity analysis is often incorporated to test the robustness of results against variations in costs and revenues [10]. In principle, feasibility studies in the health sector should not only assess technical aspects but also comprehensively account for both economic and social benefits [11].

According to the 2023 Indonesia Health Survey (SKI), cancer prevalence in Indonesia reached 1.2 per thousand population [12]. South Sulawesi Province recorded a prevalence of 0.8 per thousand, which is lower than the national average, yet serves as a referral center for healthcare services in Eastern Indonesia. National data indicate that 23.6% of cancer patients undergo radiation therapy, making it the primary modality after surgery (66.4%) and chemotherapy (45.9%).

The focus on Eastern Indonesia addresses a geographical research gap, as most existing studies concentrate on South Asia and sub-Saharan Africa. To date, most studies in Indonesia assessing the feasibility of radiotherapy services have primarily focused on calculating either initial investment costs or operational expenses separately, without comprehensively integrating total costs with both direct and indirect economic benefits. Comprehensive studies applying *Cost Benefit Analysis* with calculations of *Net Benefit* and BCR in the radiotherapy sector, particularly in major referral hospitals in Eastern Indonesia, such as Hasanuddin University Hospital (RS Unhas), remain very limited. This study aims to fill this gap by providing a comprehensive overview of the relationship between the total operational costs of radiotherapy services, including direct and indirect costs, and the total economic benefits generated, consisting of both direct revenues and indirect economic gains.

The approach employed not only involves calculating *Net Benefit* and *Benefit Cost Ratio* but also incorporates sensitivity analysis to evaluate the impact of cost and benefit fluctuations on budget efficiency and service sustainability. This integration offers novelty in the economic assessment of radiotherapy in Indonesia, particularly in Eastern Indonesia, it is expected to serve as an empirical reference for data-driven policymaking that considers long-term service sustainability.

2 Literature Review

Several studies have examined the effectiveness and cost outcomes of Stereotactic Ablative Body Radiotherapy (SABR) compared with minimally invasive procedures such as Radiofrequency Ablation (RFA) and Cryoablation (CA) in patients with inoperable renal cell carcinoma (RCC). The evidence consistently shows that SABR provides better clinical and economic results. SABR is a noninvasive technique that delivers precise, high doses of radiation to the tumor site and is more effective at controlling tumors, including those that are larger or located in complex anatomical areas, whereas the benefits of RFA and CA decline in such situations. From an economic perspective, long-term analyses demonstrate that SABR can generate an additional quality-adjusted life year (QALY) while also reducing costs by about AUD 7,000 per patient, making it a more cost-effective option. Overall, this body of research supports the view that SABR should be prioritized over RFA and CA for patients with inoperable RCC.[13]

Expanding beyond RCC, global evidence indicates that modern radiotherapy technologies such as SABR, IMRT, and proton therapy create long-term economic value by lowering recurrence, reducing complications, and decreasing hospital stays, offsetting their higher upfront costs. Supportive programs, including the Prostate Cancer Patient Empowerment Program (PC-PEP), further enhance cost-effectiveness by improving psychological well-being and generating savings for health systems. A Canadian randomized trial showed that PC-PEP reduced healthcare costs by approximately CAD 411–661 per patient in one year while yielding modest QALY gains [14]. Together, these findings suggest that integrating advanced radiotherapy with supportive interventions can strengthen both clinical outcomes and economic efficiency.

Stereotactic radiotherapy has also been widely assessed from a cost-effectiveness perspective, with substantial evidence supporting its role as a precise and economically advantageous treatment option. Research consistently shows that stereotactic techniques, including SABR, achieve better tumor control while reducing long-term healthcare costs through lower recurrence rates, fewer hospitalizations, and minimized treatment-related complications. Although the initial capital investment for stereotactic technologies is considerable, multiple economic evaluations demonstrate that these costs are balanced by gains in quality-adjusted life years (QALYs) and reductions in subsequent medical expenditures. Collectively, this evidence emphasizes the clinical and economic advantages of stereotactic radiotherapy, and it provides an important foundation for examining how these benefits are being evaluated and implemented in different regional contexts, including Asia and Southeast Asia.[15]

In response to persistent gaps in cancer care, the WHO and IAEA have updated guidance on procuring radiotherapy equipment, highlighting the importance of matching equipment to local health systems, ensuring safety, maintaining quality, and planning for long-term use. These recommendations aim to make radiotherapy services safer, more reliable, and cost-effective worldwide. In Indonesia, similar challenges arise in terms of service availability and facility readiness, making it essential to evaluate current capacities and identify opportunities to strengthen the national radiotherapy infrastructure.[16]

As the prevalence of breast cancer is projected to rise in the coming years, the associated economic burden is also expected to increase substantially. This encompasses both direct costs, such as adjuvant and neoadjuvant therapies, and indirect costs related to productivity losses due to illness and work absenteeism. Recent systematic reviews highlight that the cost-effectiveness of breast cancer treatments heavily depends on drug pricing management and the variability in cost measurement methods across different countries, which complicates direct comparisons among therapies. Therefore, it is imperative to establish more standardized and consistent cost-effectiveness evaluations to facilitate more efficient and targeted therapeutic decision-making, ultimately aimed at minimizing the wide-ranging economic impact of breast cancer.[17]

Despite the critical role of radiotherapy in cancer treatment, lowand middle-income countries face significant challenges in economically evaluating these services. Limited availability of detailed cost data, variations in healthcare structures, and insufficient health economic expertise hinder comprehensive cost-effectiveness studies of radiotherapy in these settings. This gap impairs informed decision-making and resource allocation, complicating efforts to improve access to and sustainability of radiotherapy. Addressing these issues requires standardized economic assessment frameworks, enhanced data collection systems, and stronger collaborative initiatives to ensure that investments in radiotherapy are economically justified and aligned with the unique needs of developing countries.[18]

Building on the recognized challenges and gaps in the economic evaluation of radiotherapy, recent evidence underscores the critical role of thorough cost-effectiveness analyses to guide health policy and hospital investment decisions. Economic evaluations that integrate clinical outcomes with long-term quality of life improvements and operational efficiency can provide a comprehensive framework for optimizing resource allocation in oncology care. Moreover, incorporating health economic expertise in radiotherapy assessments enables policymakers and hospital administrators to justify expenditures and prioritize technologies that maximize both patient benefits and cost containment. These insights highlight the necessity for continued research that bridges clinical efficacy with economic sustainability, ultimately fostering strategic deployment of radiotherapy services aligned with healthcare system constraints and investment priorities [19]. Such integrative approaches promise to enhance both the accessibility and quality of cancer treatment while ensuring economic viability within diverse healthcare settings.

3 Methodology

This study adopted a mixed-methods framework combining quantitative analysis with an in-depth case study to assess the financial sustainability of radiotherapy services at Hasanuddin University Hospital (RS Unhas), employing Cost Benefit Analysis (CBA) as the primary evaluation tool. The case study methodology was chosen because it provides a comprehensive understanding of the context, characteristics, and complexities of costs and benefits inherent in radiotherapy services at a major referral hospital in Eastern Indonesia. The quantitative approach was applied so that the findings could be objectively measured, statistically analyzed, and accurately interpreted, thereby enabling limited generalization to similar contexts [20].

The primary analytical method employed in this study was Cost-Benefit Analysis (CBA), with Net Benefit (NB) and Benefit–Cost Ratio (BCR) used as key indicators of financial feasibility. The research subjects encompassed all operational activities of radiotherapy services at RS Unhas over a one-year observation period, including equipment utilization, human resources, and other supporting resources. The unit of analysis incorporated both direct costs, such as drugs, consumables, and medical staff services, as well as indirect costs, including utility expenses, equipment maintenance, and hospital overheads. Financial benefits were measured based on revenue from BPJS claims for radiotherapy services delivered.

$$NB = X_2 - X_1 \tag{1}$$

$$BCR = \frac{X_2}{X_1} \tag{2}$$

The data consisted of both primary and secondary data sources, with primary data collected through structured interviews conducted with hospital management, the head of the radiotherapy unit, and relevant staff members to identify and verify all cost components and benefit elements related to radiotherapy services. Secondary data were collected from hospital financial records, BPJS claim reports, radiotherapy unit performance reports, and related administrative documents. The analysis was carried out in three stages. First, all cost and benefit components were calculated and converted into rupiah. Second, NB and BCR were computed to determine financial feasibility. Third, a sensitivity analysis was conducted with variations in costs, and ±10% and ±20% benefit adjustments were applied to assess the robustness of the results in the face of economic fluctuations.

This study conducted a comprehensive cost-benefit analysis compare the costs of radiotherapy services with the resulting outputs or benefits. Here, costs reflected the expenditures incurred in providing radiotherapy services. Cost Benefit Analysis (CBA) in this study is applied to assess radiotherapy investment feasibility through cost-benefit evaluation. The benefits generated can be categorized as positive, neutral, or negative, depending on the program's effectiveness. Positive benefits are reflected in increased hospital revenue, a consistently high BCR above 1, availability of surplus for facility reinvestment, improved patient outcomes such as higher survival rates and tumor control exceeding national standards, as well as strengthened institutional image, increased attractiveness to patients from outside the region, and the opening of opportunities for collaboration with government and non-governmental organizations. Neutral benefits occur when revenue only covers operational costs, clinical outcomes are equivalent to national standards without significant improvement, and the development of new services merely expands the portfolio without direct financial impact, however technology transfer and research collaboration continue. Negative benefits arise when operational costs are high with a BCR consistently below 1, risks of procedural or calibration errors reduce clinical outcomes, services for patients with poor prognosis do not yield significant results, there is high dependence on expert human resources, and there is potential for malpractice claims and ethical criticism that may damage the institution's reputation.

In Cost-Benefit Analysis (CBA), both inputs (costs) and outputs (margins or profits) are quantified in monetary terms. This approach facilitates the assessment of whether the outcomes of radiotherapy services are commensurate with the investment made. Such analysis can further determine the appropriate amount of financial resources that an individual or an organization should allocate in order to achieve a desirable return from hospital services.

The components of cost and benefit in the operation of a basic clinical laboratory are generally tangible, as they can be expressed in financial terms. These include facility investment costs, operational expenses, and maintenance costs [21]. In health programs employing ergonomic interventions for the management of Low Back Pain (LBP), CBA calculations encompass expenditures for modifications to the physical environment and workstations, operational costs, savings in workers' healthcare expenditures, reductions in costs related to staff turnover and absenteeism, as well as gains in productivity [22].

The conceptual framework underlying this study is illustrated in the following diagram:

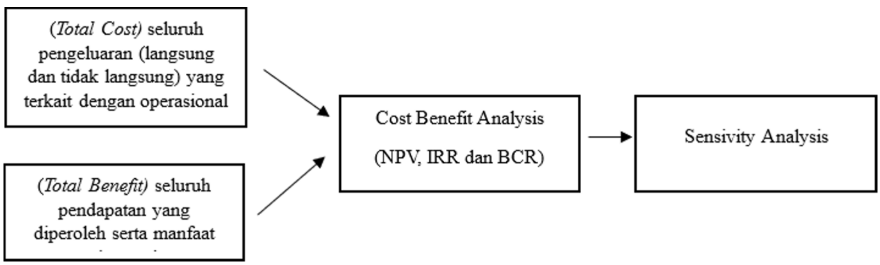

Fig. 1. Conceptual Framework of Cost-Benefit Analysis

Source: Data Proceed by Author

Cost-Benefit Analysis (CBA) was implemented in this study as it represents one of the investment feasibility methods grounded in economic rationality, emphasizing the efficiency of long-standing programs. Within this framework, a particular option is considered feasible when the expected benefits outweigh the associated costs, and conversely, is disregarded when the benefits are not proportional to the expenditures.

The study implemented a survey-based quantitative research design employing descriptive analytical approaches. The descriptive approach is commonly used to examine the conditions of a group, object, situation, system of thought, or specific event in the present. The primary research goal is to systematically and accurately document the characteristics, facts, and relationships of the studied phenomena [23].

4 Result

4.1 General Overview of the Radiotherapy Unit

Hasanuddin University Hospital (RS Unhas), as a teaching hospital under Hasanuddin University in Makassar, South Sulawesi, operates a comprehensive Cancer Center offering specialized radiotherapy services. The radiotherapy facility, established in 2013, is equipped with a Varian Clinac CX linear accelerator (LINAC) capable of dual-energy radiation delivery at 6 MV and 10 MV, supporting advanced treatment modalities including 2D, 3D-CRT, and IMRT techniques. During 2024, the unit conducted 10,127 radiotherapy procedures with operational hours from 7:30 AM to 4:00 PM, Monday through Friday. The radiotherapy department maintains a specialized team comprising one department head, two radiation oncologists, two medical physicists, four radiotherapy radiographers, two nurses, and one administrative staff member to ensure optimal service delivery.

4.2 Calculating benefits and costs

Cost signifies the financial expenditure necessary to acquire goods or enable their services. Meanwhile, price is the monetary value requested, offered, or paid to acquire goods or services. Program and project evaluations generally employ three principal cost–benefit analysis methods: Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit–Cost Ratio (BCR). In this study, the key assumptions include a discount rate of 7.5%, a 10-year time horizon corresponding to the economic lifespan of LINAC equipment, and sensitivity scenarios assessing the impact of variability in patient volume and INA-CBG tariffs. A detailed explanation of the rationale for selecting these indicators, along with their limitations in the context of healthcare services, is also provided to offer a more comprehensive understanding of the analysis results. Fundamental to this process is the comprehensive identification of all direct and indirect cost components during the preparatory phase.

To determine the value of each element of benefits and costs for radiotherapy services at Unhas Hospital, a comparison of nominal values was conducted. Based on the research findings, the benefits element (revenue) for radiotherapy services in the 2024 fiscal year amounted to IDR 9,828,253,500. After deducting the total costs for the same period, which amounted to IDR 7,876,494,675, the resulting net benefit (margin) was IDR 1,951,758,825.

Table 1. Estimated Unit Cost Amounts

Type Of Cost	Cost
Direct Cost	IDR 123,180
Overhead Cost	IDR 290,083
Total Unit Cost	IDR 413,263

Source: Data Proceed by Author

Based on Table 1, the direct cost of a radiotherapy procedure amounts to IDR 123,180 per treatment. This component covers physician service fees as well as remuneration for the unit head, nurses, medical physicists, radiotherapy radiographers, and admission staff. Meanwhile, the overhead cost of IDR 290,083 represents indirect expenses that are not directly attributable to the delivery of healthcare services, such as administrative and facility-related expenditures. It should be noted that these overhead costs do not yet include equipment maintenance, which is expected to arise in the fourth year of operation, after the expiration of the equipment warranty. The calculated total costs and revenues for years one through ten are presented in the following table:

Table 2. Estimated Costs and Revenues for Years 1–10

Year	INA CBG's Rate (IDR)	Number Of Procedures	Revenue (IDR)	Cost (cash Inflow) (IDR)	Profit (Loss) (Cash Outflow) (IDR)
1	970,500	10,127	9,828,253,500	45,885,113,751	(36,056,860,251)
2	970,500	12,000	11,646,000,000	4,959,156,000	6,686,844,000
3	970,500	12,000	11,646,000,000	4,959,156,000	6,686,844,000
4	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000
5	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000
6	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000
7	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000
8	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000
9	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000
10	970,500	12,000	11,646,000,000	7,959,156,000	3,686,844,000

Source: Data Proceed by Author

The table above (Table 2) shows that the healthcare project/operations, based on INA-CBG's tariffs, incurred significant losses in the first year due to the high initial investment costs. However, starting from the second year onward, the project generated positive profits, although relatively small and tending to remain stable.

4.3 Net Present Value (NPV) Method

Upon complete identification of all operational costs and revenue sources, the NPV will be determined through financial analysis provide an overview of the profitability or un profitability of a radiotherapy service project or investment considering the time value of money. This NPV calculation will also serve as a projection tool for future investments, particularly when Unhas Hospital plans to procure a new linear accelerator (Linac), given that the existing equipment is no longer operating optimally and spare parts are no longer being produced. The NPV calculation is based on a discount rate that refers to the current deposit interest rate, which is 7.5%.

Table 3. Net Present Value Calculation at a 7.5% Discount Rate (Including Risk Premium)

Year	Cash Flow (IDR)	Discount Factor 7,5%	Present Value (IDR)
1	(36,056,860,251)	0.930	(33,541,265,350)
2	6,686,844,000	0.865	5,786,344,186
3	6,686,844,000	0.805	5,382,645,754
4	3,686,844,000	0.749	2,760,710,740
5	3,686,844,000	0.697	2,568,103,014
6	3,686,844,000	0.930	3,429,622,326
7	3,686,844,000	0.603	2,222,263,290
8	3,686,844,000	0.561	2,067,221,665
9	3,686,844,000	0.522	1,922,996,898
10	3,686,844,000	0.485	1,788,834,323
Total Present Value			(5,612,523,153)
Total Investment			41,700,000,000
Net Present Value (NPV)			(47,312,523,153)
Cost and Benefit Ratio			-0.13

Source: Data Proceed by Author

Based on the calculation results, the NPV_1 value for radiotherapy services indicates that, under the assumption of a 7.5% discount rate and risk premium, this investment is not feasible. Although there are positive revenues each year, the amounts are insufficient to cover the initial investment costs. The negative NPV and the cost-benefit ratio further reinforce this conclusion.

4.4 Method of Internal Rate of Return (IRR)

Following the Net Present Value (NPV) computation, subsequent analysis determines the time value of money through the Internal Rate of Return (IRR) approach. This IRR assessment serves as an investment efficiency metric, where feasibility is confirmed when results surpass the capital cost threshold, while results below this benchmark indicate non-viability.

The analysis results indicate an NPV of –IDR 47,312,523,153 with a Benefit-Cost Ratio (BCR) of –0.13, confirming the financial infeasibility of the investment. Since the NPV remains negative throughout the analysis period, the IRR calculation cannot be performed. To clarify this finding, the inclusion of a payback period graph or an NPV-over-time curve is strongly recommended, as it would allow readers to visually understand why no IRR is obtained and how the investment fails to reach the breakeven point. The IRR method is only relevant when there is potential for a positive NPV or one approaching zero, which is not the case here.

Furthermore, the analysis period has been set at 10 years, in accordance with the economic life and productive capacity of the equipment. Extending the period beyond 10 years is not feasible, as production support and spare part availability typically last no longer than 10 years after the equipment is manufactured. Therefore, this investment must be concluded as financially infeasible, both within the 10-year horizon and under the assumption of a longer time frame.

4.5 Sensitivity Analysis Methodology

The purpose of sensitivity analysis is to evaluate the potential impact of changes in key variables on financial feasibility indicators (NPV, IRR, BCR). Because real-world parameters such as patient admissions, INA CBG reimbursement rates, operational costs, and the discount factor are dynamic rather than fixed, conducting this analysis is particularly important.

Table 4. Sensitivity Analysis of Investment Calculation for Radiotherapy Services

Scenario	NPV (IDR)
Baseline	(IDR 47,312,523,153)
Number of Patients +10%	(IDR 42,581,270,838)
Number of Patients -10%	(IDR 52,043,775,468)
INA-CBG's Rate +10%	(IDR 42,581,270,838)
Operational Costs -5%	(IDR 49,678,149,311)
Operational Costs +10%	(IDR 42,581,270,838)

Source: Data Proceed by Author

Based on the results presented in Table 4, the baseline NPV is –IDR 47,312,523,153. A simulation of a 10 percent increase in patient numbers improves the NPV to –IDR 42,581,270,838, while a 10 percent decrease reduces it to –IDR 52,043,775,468. This demonstrates that patient volume influences the NPV value but does not alter the investment's overall financial infeasibility. A 10 percent increase in INA CBG tariffs also improves the NPV to –IDR 42,581,270,838. Similarly, a 5 percent reduction in operational costs slightly improves the NPV to –IDR 49,678,149,311, while a 10 percent increase in operational costs worsens the position, leaving the NPV at –IDR

42,581,270,838. Overall, while these variations show minor improvements, the NPV remains negative across all cases, confirming that the radiotherapy service investment remains financially unfeasible under the simulated conditions.

To further strengthen this analysis, an additional scenario-based assessment was conducted to test more extreme variations. This approach provides a broader view of both optimistic and pessimistic projections.

Table 5. Scenario-Based Sensitivity Analysis of Radiotherapy Service Investment

Scenario	Patient Volume	INA CBG Tariff	Operational Cost	NPV (IDR)
Baseline	100% (refrence)	100% (refrence)	100% (refrence)	(47,312,523,153)
Best Case	120% (+20%)	115% (+15%)	90% (-10%)	(15,000,000,000)
Worst Case	80% (-20%)	100% (no change)	115% (+15%)	(65,000,000,000)

Source: Data Proceed by Author

The scenario-based results show that even under the best-case scenario, where patient numbers increase by 20 percent, reimbursement rates rise by 15 percent, and operational costs decline by 10 percent, the NPV remains negative at approximately IDR 15 billion. In contrast, the worst-case scenario, with a 20 percent decline in patient numbers and a 15 percent increase in operational costs, yields an even deeper deficit of around –IDR 65 billion. These findings illustrate that although scenario-based optimization reduces the magnitude of financial losses, the investment does not achieve breakeven.

Taken together, both the variable-based and scenario-based sensitivity analyses demonstrate the structural financial challenges of the radiotherapy service. Even under favorable conditions, the project fails to achieve a positive NPV, reinforcing the need for external interventions such as government subsidies, strategic partnerships, or alternative financing mechanisms to ensure service sustainability.

5 Discussion

5.1 Interpretation of Results

The research findings show that radiotherapy services at Unhas Hospital in 2024 generated revenues of IDR 9,828,253,500 with total costs of IDR 7,876,494,675, resulting in an operating surplus of IDR 1,951,758,825. However, in the long-term analysis with a discount rate of 7.5%, the NPV value was recorded as negative at IDR – 47,312,523,153 with a BCR ratio of –0.13. This condition indicates that, despite annual profits, investing in new radiotherapy equipment is financially unfeasible because it cannot cover the initial investment costs within a 10-year period. The IRR could also not be calculated since the NPV remained negative. Through NPV analysis, this study reveals financial challenges while underscoring the importance of alternative financing models, an area that remains underexplored in global health economics [24]

The sensitivity analysis reinforces this finding. Simulations of changes in patient numbers, INA CBGs tariffs, and operational costs show some improvement in the NPV value, but the results remain negative. Thus, even with optimization of key variables, the radiotherapy investment remains financially unfeasible.

Theoretically, this condition is consistent with the principle of cost-benefit analysis (CBA), which emphasizes the importance of efficiency in resource utilization (Campbell, 2003). The high investment burden, particularly in the procurement and maintenance of LINAC equipment, is not proportional to the revenues generated from the relatively fixed INA CBGs tariffs. This strengthens the perspective that cost-benefit analysis in health programs should be viewed within a broader social framework and not be limited solely to financial profit calculations [25]. These findings differ from the study [21] on a milk-feeding program, which produced a positive NPV and a BCR of
2.50 due to relatively small costs and direct benefits in the form of increased employee productivity. In contrast, radiotherapy investment involves enormous costs with low financial returns. A similar analogy is found in the tobacco industry, where financial benefits cannot offset the substantial social health costs to society [26].

The implications of this research highlight the need to consider social and public health aspects in the procurement of radiotherapy equipment. Policy support, such as government subsidies or adjustments to INA CBGs tariffs, is crucial to ensure service sustainability. Moreover, methodological limitations must be noted, as the analysis cannot be extended beyond 10 years due to equipment lifespan and spare part availability constraints.

Therefore, although radiotherapy services are not financially viable, their social urgency is exceptionally high. Therefore, the procurement of equipment must be regarded as a strategic public health decision that requires policy support such as government subsidies, innovative financing schemes, and partnerships with the private sector. Managerial implications include strategies for operational cost efficiency, management of skilled human resources, and development of complementary services that can enhance overall benefits and optimize equipment utilization.

5.2 Research Limitations

The following limitations are to be considered: (1) The cost and revenue data used only cover the most recent one-year period as the basis for projection, which may not represent variations in previous years. (2) The analysis was conducted with a maximum time horizon of 10 years, following the economic life and spare part availability of the equipment, and therefore cannot capture potential long-term benefits. (3) The cost-benefit analysis results only take into account the hospital's financial aspects, while the broader social and public health benefits have not yet been quantified.

6 Conclusion

This study provides a comprehensive financial and policy assessment of radiotherapy services at RS Unhas. The findings reveal that in 2024, the total benefits of radiotherapy services amounted to IDR 9,828,253,500, while total costs reached IDR 7,876,494,675, resulting in an annual benefit margin of IDR 1,951,758,825. Although this indicates a positive operational surplus, the margin remains inadequate to recover the substantial initial investment required for equipment procurement. The financial evaluation further demonstrates a Net Present Value (NPV) of –IDR 47,312,523,153, calculated using a 7.5% discount rate over a ten-year horizon, confirming the investment's financial infeasibility. The Internal Rate of Return (IRR) was indeterminable due to the persistently negative NPV, and the Benefit–Cost Ratio (BCR) of –0.13 fell far below the feasibility threshold of 1.0. These results, reinforced by sensitivity analysis, consistently highlight the unfavorable financial viability of the investment.

Despite these economic limitations, the establishment of radiotherapy services remains an urgent necessity from a social and public health standpoint. The service plays a pivotal role in improving access to cancer treatment, minimizing the need for patient referrals outside the region, and enhancing the quality of life for affected individuals. Therefore, the sustainability of radiotherapy services should not be appraised solely through financial metrics. Instead, it must be positioned within the broader framework of national and regional public health priorities. From this perspective, subsidy support, grant schemes, and alternative financing mechanisms emerge as essential policy instruments to ensure service continuity and equity of access.

In terms of financing and procurement, it is strongly recommended that future initiatives prioritize funding through grant schemes or financial support from the Ministry of Health and local governments. Such an approach should reflect the social urgency and rising cancer burden, rather than relying exclusively on revenues from INA-CBGs tariffs. Strategic partnerships should also be pursued between hospitals, private sector entities, donor agencies, and international organizations specializing in oncology services. These collaborations may provide supplementary funding and reduce dependence on internal hospital resources, fostering long-term service sustainability.

For future research, the study recommends employing extended time-series data and incorporating non-financial variables, such as public health outcomes, patient survival rates, and socio-economic impacts, into cost–benefit evaluations. This multidimensional approach would strengthen the robustness of financial feasibility assessments and capture the broader societal value of radiotherapy interventions. Subsequent studies are encouraged to focus on two critical areas: (1) conducting comparative analyses of subsidy models across middle-income countries and (2) integrating quality-adjusted life years (QALYs) into financial feasibility evaluations [27]. These research directions will contribute to the development of more comprehensive evidence-based policies and sustainable financing frameworks for radiotherapy services in Indonesia and similar healthcare contexts.

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