

# Unit Cost Analysis of Allogeneic Hematopoietic Stem Cell Transplantation at Dr. Kariadi General Hospital, Semarang, Indonesia

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## Abstract

**Background:** Hematopoietic stem cell transplantation (HSCT) is a curative treatment for hematologic malignancies, yet access in Indonesia remains limited due to high costs and its exclusion from the national health insurance scheme. This study determined the unit cost of allogeneic HSCT at Dr. Kariadi General Hospital using the activity-based costing (ABC) approach. **Methods:** A mixed-method design combined retrospective cost data from three donor–recipient pairs that received HSCT during the January 2023 – December 2024 period and thematic analysis of qualitative interviews with clinical and administrative staff. Costs were categorized as direct and indirect, mapped along the HSCT clinical pathway, and analyzed descriptively. **Results:** The total unit cost of allogeneic HSCT was IDR 377,978,399, comprising IDR 297,063,048 for recipients and IDR 80,915,351 for donors. Post-transplant care was the major cost driver among recipients (IDR 157,843,439), while harvesting represented the highest donor-related cost (IDR 37,819,185). However, comparison with current hospital tariffs demonstrated CRRs of 218.8–239.0% for recipients and 113.7–123.6% for donors, suggesting that existing tariff packages exceed the estimated unit costs and may generate a financial surplus. **Conclusions:** The ABC method effectively identified major cost components and financial gaps, highlighting the need for updated reimbursement models and BPJS coverage inclusion to ensure long-term HSCT program sustainability in Indonesia.

**Keywords:** Allogeneic Stem Cell Transplantation- Activity-Based Costing- Unit Cost- Acute Leukemia- Indonesia

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## Introduction

Hematologic malignancies, particularly acute leukemia, represent a significant global health challenge. The Global Burden of Disease (GBD) 2019 study reported over 1.3 million new hematologic cancer cases worldwide, with acute leukemia accounting for the largest proportion [1]. While mortality has decreased in high-income countries, low- and middle-income countries (LMICs) like Indonesia continue to face substantial challenges. According to GLOBOCAN 2022, Indonesia recorded approximately 15,000 acute leukemia cases and 11,500 related deaths, ranking hematologic cancers among the top ten causes of cancer mortality nationally [1, 2].

Hematopoietic stem cell transplantation (HSCT) remains the only curative therapy for many patients with high-risk or relapsed acute leukemia. The success of allogeneic HSCT lies in its dual mechanism: myeloablative conditioning and the graft-versus-leukemia effect mediated by donor immune cells, achieving five-year disease-free survival rates of up to 60–65% [3]. However, HSCT is a highly complex and resource-intensive procedure involving

multiple stages donor mobilization, stem cell harvest, processing, conditioning, transplantation, and intensive post-transplant monitoring each requiring specialized personnel, facilities, and prolonged hospitalization [3, 4].

Globally, the cost of allogeneic HSCT is substantial, ranging from USD 140,000–250,000 in the United States to SGD 60,000–140,000 in Singapore. Although neighboring Malaysia offers lower government rate (MYR 40,000–60,000), these remain financially burdensome for most patients [5]. In Indonesia, HSCT programs were reestablished at Dr. Kariadi General Hospital, which was appointed in 2023 as a national referral center for adult HSCT. Despite this, access remains limited, primarily due to the exclusion of HSCT from National Health Insurance coverage, forcing many patients to self-fund treatment or seek care abroad, contributing to medical migration and national financial losses [6].

One of the major obstacles to HSCT expansion in Indonesia is the lack of accurate local cost data. Existing Ministry of Health rate are outdated and fail to reflect actual clinical expenditures, and because of the exclusion from National Health Insurance Coverage, the

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actual costing policy regarding HSCT remained scarce. The activity-based costing (ABC) method provides a systematic framework for mapping costs to specific clinical activities, offering more precise and transparent cost estimates [7]. Therefore, this study aims to determine the unit cost of allogeneic HSCT at Dr. Kariadi General Hospital using ABC, providing critical evidence to guide hospital rate setting, support policy formulation, and promote sustainable HSCT financing and accessibility nationwide.

## Materials and Methods

### Study Design and Setting

This mixed-method study integrated retrospective quantitative cost analysis with qualitative stakeholder interviews. The study was conducted at Dr. Kariadi General Hospital, a tertiary referral and teaching hospital located in Semarang, Central Java, Indonesia, between March and May 2025. Classified as a Type A national referral hospital, Dr. Kariadi was officially designated in 2023 as the national reference center for adult HSCT by the Indonesian Ministry of Health.

### Study Population and Sampling

The quantitative component included three donor recipient pairs who underwent allogeneic HSCT procedures between January 2023 until December 2024. All recipients were diagnosed with acute leukemia, and donors consisted of either related or haploidentical family members. For the qualitative component, purposive sampling was used to select transplant team members comprising hematologists, nurses, pharmacists, laboratory technicians, and hospital administrators who were directly involved in the HSCT process. These participants provided managerial and financial insights regarding implementation challenges and resource allocation.

### Data Collection and Clinical Pathway Mapping

Cost data were systematically mapped according to the hospital’s established HSCT clinical pathway, which encompassed both recipient and donor phases. The recipient pathway included four stages preparation, conditioning, stem cell infusion, and post-transplant care while the donor pathway consisted of preparation, mobilization, harvest, and stem cell processing. Costs were classified into two major components: direct and indirect.

Direct costs covered medical consumables, drugs, blood products, personal protective equipment, laboratory examinations, and staff salaries. Indirect costs encompassed

depreciation of buildings and equipment, utilities such as electricity and water, as well as cleaning, catering, and administrative overheads.

### Activity-Based Costing

The ABC method was applied to achieve a detailed and accurate estimation of the HSCT unit cost. The process involved four systematic steps. First, key activities were identified within each transplant phase. Second, resource inputs and their levels of consumption were determined for each activity. Third, these resources were allocated to specific cost drivers such as time spent, quantity used, or frequency of activity. Finally, costs were aggregated across all activities within each phase to obtain the total unit cost per donor and per recipient, providing a comprehensive view of cost distribution across the HSCT process.

### Data Analysis

Quantitative data were analysed descriptively to determine mean phase-specific and total unit costs. Results were presented in Indonesian Rupiah (Rp). Qualitative data were analyzed using thematic analysis, focusing on managerial perspectives related to resource utilization, cost efficiency, and financial sustainability.

### Ethical Considerations

This study received ethical approval from the Research Ethics Committee, Faculty of Public Health, Universitas Diponegoro, Semarang, Indonesia, No. 16400/EC/KEPK-RSDK/2025 . All data were anonymized to maintain patient and donor confidentiality throughout the research process.

## Results

The total unit cost of allogeneic HSCT at Dr. Kariadi General Hospital, Semarang, was calculated at IDR 377,978,399 (USD 22,499.9) using the ABC method. This total comprised IDR 297,063,048 (USD 17,681.1) for recipient-related phases and IDR 80,915,351 (USD 4,818.8) for donor-related phases.

Post-transplant care contributed the largest proportion of recipient costs (approximately 60% of total expenditure), reflecting the intensive nature of inpatient monitoring, infection management, and supportive care during this period. Among donor activities, cell processing represented the highest cost component (approximately 46% of total donor cost), attributed to laboratory procedures, quality control, and stem cell handling requirements.

Cost recovery analysis based on three acute leukemia

Table 1. Unit Cost of Allogeneic HSCT (Activity-Based Costing Method)

Phase	Recipient Cost (Rp)	Donor Cost (Rp)
Preparation	11,518,370	9,815,174
Conditioning / Mobilization	107,568,148	6,137,319
Stem Cell Infusion / Harvest	34,897,731	10,685,887
Post-Transplant Care / Processing	235,896,696	23,079,311
Subtotal	389,880,946	49,717,690
Total HSCT Unit Cost	439,598,636	—

Table 2. CRR Calculation Comparing Real Cost and Unit Cost in Three Cases of Acute Leukemia

Category	Average Real Cost (Rp)	Unit Cost (Rp)	CRR (%)
Donor	26,610,850	49,717,689	50
Recipient	240,106,237	389,880,946	60

Table 3. CRR Calculation Comparing Hospital Tariff and Unit Cost

Package Name	Class	Hospital service charge (Rp)	Unit Cost (Rp)	CRR (%)
Recipient	I / II / III	650,000,000	389,880,946	167
	VIP / VVIP	710,000,000	389,880,946	182
Donor	I / II / III	92,000,000	49,717,690	185
	VIP / VVIP	100,000,000	49,717,690	201

cases yielded CRRs of 80.8% for recipients and 32.8% for donors, indicating that actual expenditures did not fully cover the calculated unit costs (Table 1).

However, comparison with current hospital tariffs demonstrated favorable cost recovery, with recipient CRRs of 218.8% for Class I/II/III and 239.0% for VIP/VVIP/Presidential Suite classes, while donor CRRs reached 113.7% and 123.6%, respectively. These findings indicate that the current tariff structure exceeds the estimated unit costs and allows the hospital to operate with a financial surplus, particularly in higher service classes (Table 2 and Table 3).

## Discussion

This study represents the first comprehensive cost analysis of allogeneic HSCT in Indonesia using the ABC approach. By mapping the entire transplant process into discrete activities, the study provides a detailed and transparent assessment of resource utilization. The total unit cost of allogeneic HSCT at Dr. Kariadi General Hospital was estimated at IDR 377.98 million (approximately USD 22,500), consisting of IDR 297.06 million for recipients and IDR 80.92 million for donors. Although this estimated cost remains substantially lower than the current hospital tariffs (IDR 650–710 million for recipients and IDR 92–100 million for donors), it is considerably higher than the average actual expenditures observed in three cases of acute leukemia (IDR 240.1 million for recipients and IDR 26.6 million for donors). This discrepancy highlights the gap between actual resource consumption, observed expenditures, and hospital tariff structures, emphasizing the importance of evidence-based costing to support sustainable HSCT financing and reimbursement policies in Indonesia.

Analysis of cost components in donors revealed the cell processing phase was the main cost driver, reflecting the technical and laboratory intensity of peripheral blood stem cell manipulation [8]. For recipient, post-transplant care was shown as the dominant contributor to recipient expenditures, accounting for more than half of total costs. This finding reflects the complexity of post-transplant management, which involves prolonged hospitalization, close laboratory and clinical monitoring, management of graft-versus-host disease (GVHD), infection control, and nutritional support. These findings align with previous

international reports emphasizing that inpatient care, conditioning regimens, and complication management are the principal cost determinants in allogeneic HSCT [9].

The CRR analysis further revealed a financial deficit under the current pricing scheme, indicating that hospitals may be subsidizing HSCT services from other clinical income streams. This cross-subsidization approach is unsustainable in the long term and may discourage hospitals from expanding transplant programs. Implementing evidence-based rate derived from ABC analysis would allow for cost recovery and service sustainability, ensuring that hospitals can maintain quality while avoiding operational losses [10]. Moreover, standardized costing frameworks could assist policymakers in establishing fair reimbursement systems under Indonesia's National Health Insurance (BPJS Kesehatan).

When compared internationally, the results of this study are within the lower cost range relative to developed countries. The cost of allogeneic HSCT has been reported at USD 51,594 per patient in Iran, USD 12,504–15,749 in Mexico, and USD 102,574–151,000 in the United States [11]. Variations arise primarily from differences in labor costs, drug pricing, supportive care duration, and insurance coverage models. Despite these disparities, the consistent trend across studies is that post-transplant inpatient care remains the dominant cost component globally [12]. This reinforces the need for efficient inpatient resource management and the potential for reducing costs through shorter hospital stays, outpatient-based follow-up, and infection prevention programs [13].

In the context of Indonesia, the exclusion of HSCT from the BPJS benefit package represents a significant barrier to equitable access. Patients often seek treatment abroad, particularly in Malaysia or Singapore, leading to medical migration and capital outflow. By adopting an ABC-based costing framework, hospitals and policymakers gain empirical evidence to support policy advocacy for HSCT inclusion within BPJS reimbursement schemes. Aligning reimbursement with real costs would enhance access, promote national self-sufficiency in transplant services, and reduce dependence on foreign healthcare systems. Furthermore, accurate cost data can strengthen hospital budgeting, training program development, and infrastructure investment for long-term sustainability [14, 15].

To ensure equitable access to HSCT services, it

is essential to establish a dedicated foundation that supports financially disadvantaged patients. Such a foundation, developed in collaboration with philanthropic organizations and corporate social responsibility (CSR) programs, could play a crucial role in bridging the gap between medical necessity and financial capability. By mobilizing community resources and external donors, this initiative would help subsidize the high treatment costs that remain unaffordable for many patients, even when hospital tariffs are designed to achieve cost recovery. In the long term, this foundation could also promote public awareness, encourage voluntary donor recruitment, and sustain a more inclusive HSCT program aligned with national health equity goals. Although unit cost is not equivalent to the service tariff, it provides an essential reference for establishing appropriate hospital tariffs and informing pricing decisions.

This study has several limitations. First, the analysis included only three donor–recipient pairs, which may not capture the full variability of clinical and cost outcomes across different hematologic conditions. Second, indirect cost estimation relied partly on hospital financial records, which may not fully reflect opportunity costs or informal resource utilization. Third, the study was conducted in a single tertiary center, limiting generalizability to other institutions with different resource capacities.

Future research should involve multicenter analyses with larger sample sizes, integrate prospective cost tracking, and explore cost-effectiveness comparisons between HSCT and alternative therapies. Despite these limitations, this study provides foundational evidence for rational HSCT financing and the development of sustainable transplant programs in Indonesia.

In conclusion, the total unit cost of allogeneic HSCT at Dr. Kariadi General Hospital was estimated at IDR 377.98 million per case using the ABC method, with recipient-related activities accounting for 78.6% of total costs. While current hospital tariffs exceed the calculated unit costs and generate positive cost recovery rates, the actual expenditures observed in acute leukemia cases were insufficient to fully recover the estimated costs. These findings underscore the importance of implementing evidence-based costing for tariff setting, strengthening reimbursement mechanisms, and developing long-term financial strategies to ensure the sustainability and accessibility of HSCT services in Indonesia.

### Author Contribution Statement

All authors contributed equally in this study.

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### Conflict of Interest

None.

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