

Value Engineering Strategies To Obtain Cost Efficiencies Or Net Benefits In Hospital Construction Projects

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Abstract

The construction of hospital buildings in Indonesia has a high level of complexity because it must meet the aspects of safety, health, comfort, ease of access, and resource efficiency in accordance with the provisions Regulation of the Minister of Public Works and Public Housing No.22 of (2018) and Regulation of the Minister of Health No. 24 of (2022). However, in practice, there are still frequent design inefficiencies and cost wastage that have an impact on declining building functional performance. This research aims to develop an integrated Value Engineering (VE) framework based on Building Technical Standards in Indonesia to obtain the design with the lowest cost and the highest net benefit throughout the project life cycle. The research uses a descriptive-quantitative approach with a combination of surveys and case studies on the Detail Engineering Design (DED) project of hospitals in Indonesia for the period 2023–2024. Data was obtained through a Focus Group Discussion (FGD) involving experts from government elements, academics, professional associations, and hospital managers to validate the research variables and ensure their suitability with the context of the hospital project. The analysis was carried out on two main groups of variables, namely: (1) cost reduction variables (modular design, material selection, machinery/tools, work methods), and (2) benefit improvement variables (function analysis, benchmarking, function improvement, team communication and performance, and innovation). All variables were assessed using the Likert scale (1–5) and analyzed using the ratio of benefits to costs ($\Sigma \text{Benefits} - \Sigma \text{Costs}$). The results of the study show that the implementation of Value Engineering, with an example simulation in the DED of the hospital building construction resulted in a cost reduction of 5.22% of the total DED Cost Budget Plan, from IDR 262.78 billion to IDR 249.06 billion, without reducing the quality or function of the building. The value of the benefit-to-cost ratio $(B-A) \geq 1$ indicates that the benefits obtained are greater than the costs incurred. These findings prove that the implementation of VE integrated with technical standards is able to increase economic efficiency while optimizing building functions. The proposed framework provides a value-based decision support mechanism that supports the implementation of sustainable construction management in health infrastructure in Indonesia.

Keywords: value engineering, hospital construction projects, cost efficiencies, net benefits.

1. Introduction

The construction of a hospital building is a construction activity that has high complexity because it must meet the aspects of safety, health, comfort, convenience, and efficiency of resource use. In Indonesia, hospital construction is required to follow the Technical Building Standards set through regulations in Indonesia, namely the Regulation of the Minister of Public Works and Public Housing Number 22 of (2018) and the Regulation of the Minister of Health Number 24 of (2022) to ensure the reliability and function of public services. Universal design principles refer to efforts to create accessible, safe, and comfortable environments for everyone, regardless of age and physical ability Adi et al. (2024). However in practice, there are still frequent discrepancies between the technical design and the expectations of the project owner, which leads to cost inefficiencies, delays, and the failure to achieve maximum benefits of the building.

The Value Engineering approach, is used as a systematic method to increase the value of functions at the lowest possible cost without degrading project quality or performance. Miles (1972) emphasizes that VE aims to achieve economical designs that meet safety and comfort standards, while Berawi (2014) defining it as a function-based multidisciplinary approach to producing the best solutions in construction projects. Dell'Isola (1993) added that VE is oriented towards Life Cycle Cost (LCC), not just initial costs, so it is relevant to achieve long-term efficiencies in hospital building projects.

Several previous studies have shown the effectiveness of VE in improving cost efficiency and project performance. Rachwan et al. (2016) proving that VE can improve project quality while saving costs. Heiza et al. (2016) and Mousakhani et al. (2017) identify the application of VE in large infrastructure projects capable of improving the function and safety of work. Latif et al. (2020) and Chen et al. (2022) emphasized that VE is effective when integrated with Life Cycle Costing and Building Information Modeling (BIM) approaches. Recent studies by Elsayed et al. (2024) even proposing a VE-BIM integration framework based on the Common Data Environment (CDE). to improve collaboration and project efficiency.

Based on the results of literature review and previous research, it was found that there have not been many studies that specifically integrate Value Engineering with Life Cycle Costing and Building Technical Standards in the context of hospital buildings in Indonesia. Therefore, this research aims to develop Value Engineering based on technical standards that produce design recommendations that have the lowest cost and highest net benefit throughout the project lifecycle.

The novelty of this study lies in: (1) the addition of new variables in the VE assessment based on the characteristics of the hospital building; (2) the implementation of VE in accordance with technical regulations, especially in the planning phase of hospital construction projects. Thus, the results of this study are expected to make a real contribution to the development of sustainable construction management in Indonesia.

2. Method

2.1 Research Design

This study uses a descriptive-quantitative approach with a combination of survey methods and case studies to obtain hospital building design recommendations with the lowest cost and highest net benefit. The descriptive approach is used to describe the variables of Value Engineering, which affect cost efficiency and benefit increase, while the quantitative approach is used to measure the influence between variables through descriptive statistical analysis and benefit-to-cost ratio tests.

This research follows the stages of the VE job plan which consist of: (1) information stage, (2) function analysis, (3) creative stage, (4) evaluation stage, and (5) recommendation stage. The analysis was carried out using the main variables: Manpower, Money, Material, Machine, Method, and Time, which were validated through a Focus Group Discussion (FGD) with experts in the field of hospital planning and construction.

2.2 Research Location and Time

The research was conducted in Indonesia based on data from the Electronic Procurement Service (LPSE) of the Ministry of Health of the Republic of Indonesia for the Detailed Engineering Design (DED) package for the 2023–2024 period. The implementation of the research lasted for one year, from September 2024 to September 2025.

2.3 Population and Sample

The determination of the number of participants for the FGD follows the principle of data saturation, which is data collection until significant new themes do not emerge (Hennink et al., 2019;2022) As a reference, empirical research shows that 4-8 discussion groups can be enough in a relatively homogeneous population. M. M. Hennink et al. (2019). The number of participants in one FGD session is one of the important things that need to be considered, namely 4-7 people. Koentjoro (2005) or 6-8 people. Krueger & Casey (2015)

- a) Determining Population is the entire subject or unit that is the target of the research. The population of this study consists of professionals involved in hospital construction projects in Indonesia, including elements of users, academics, professional associations, and construction management. Sampling aimed at qualitative data collection and analysis states that qualitative sampling selects "information-rich cases" from relevant populations (Palinkas et al., 2015)
- b) Specifies The sample is a portion of the population selected for inclusion in the study (in the context of FGD: participant group). A technique that is often used: purposive sampling, to get participants who are "rich in information"Palinkas et al. (2015). Sampling was carried out with the following criteria: having ≥5 years of experience, planning or construction construction and management in hospital construction and having a professional certificate.
- c) The respondents here are individuals who will be invited to the FGD, representing a predetermined sample:

Table 1 Determination of Participants for FGD

No	Participants	Sum (person)
1.	Project Leader of the Hospital Construction Project User/Owner	1
2.	Project Management Experts and Academics	1
3.	Project Management Expert and Hospital Construction Project Practitioner	1
4.	Senior Architect on Hospital Project Construction	1
5	Professional Team Expert in the field of Electrical Mechanics	1

No	Participants	Sum (person)
Total Amount		5

2.4 Research Variables

The research variables are divided into two main groups, namely:

- 1) Variable Cost Reduction, Some recommendations to achieve the lowest cost in Value Engineering have been obtained from several sources of the following literature:

Table 2 Cost Reduction Recommendation Variables

No	Source	Variable
1.	Lee & Kang (2025)	Modular Design
2	(Robbins & Judge, 2019), (Terry, 1998)	Man Power
3	(Brigham & Houston, 2019)	Capital
4	Uğural (2023), Bajwa et al. (2025)	Material Selection
5	(Heizer et al., 2019), (Stevenson, 2020)	Machinery /Tools
6	(Hersey et al., 2012), (Surbakti, 2017)	Method
7.	Dell'Isola (1982)	Duration of Time
8	Mc George D and Palmer (1997), Connaughton (1996), Lin (2009), Robinson (2008)	Cost Optimization and Efficiency

- 2) Variable of benefit increase, Some recommendations for Value Increase in Value Engineering obtained from several Literature sources, as follows:

Table 3 Recommended Variables for Benefit Enhancement

No	Source	Variable
1	Miles (1972), Jeong et al. (2024), Al Salmawi & Al Eqabi (2024)	Function Analysis
2	Camp (1989), Sik Wah Fong et al. (2001)	Benchmarking
3	Dell'Isola (1982), Mc George D and Palmer (1997), Connaughton (1996), Fang He & Cheng Toa (2016)	Improve Project value and performance
4	Dell'Isola (1982), Mc George D and Palmer (1997), Connaughton (1996), Lin (2009), Mousa et al. (2022)	Improve More Functionality
5	Connaughton (1996), Lin (2009), Usman et al. (2018)	Improve Team Communication and Performance
6	Connaughton (1996), Lin (2009), Elsonoki et al. (2020), Al-Salmawi & Al-Eqabi (2024)	Mencapai Value For Money
7	Dell'Isola (1982), Connaughton (1996), Robinson (2008), Lin (2009), Spiekermann & Winkler (2022)	Creating a lot of creative ideas and innovations

Each variable was measured using a Likert scale (1–5) based on the criteria of relevance to the Building Technical Standards in Indonesia. Validation of variables is carried out through FGD to ensure suitability with the context of the hospital project.

2.5 Data Collection Methods

This study uses two types of data:

- 1) Primary data: obtained through Focus Group Discussions (FGD) with experts and stakeholders, aiming to validate variables and clarify quantitative survey results.
- 2) Secondary data: collected from DED documents for hospital projects, Cost Budget Plan, architecture-structure-ME planning drawings, as well as procurement data from the Ministry of Health's Goods and Services Procurement Institution

2.6 Research Instruments

The main instrument is in the form of FGD material with open-ended questions to explore expert opinions, as well as a Likert scale assessment sheet (1–5) to assess each VE variable. FGD material includes background, supporting data, discussion framework, technical regulations, case studies, and evaluation guides.

2.7 Data Analysis Methods

Data analysis is carried out in several stages:

- 1) Descriptive statistical analysis calculates the mean value and frequency distribution of each variable.
- 2) Statistical analysis of the mean value of the Likert scale assessment (1–5) obtained the Design Strategy

with the lowest Cost / highest net benefit

The validation of the VE results was carried out by comparing the results of the FGD analysis with the empirical data of the hospital's DED project.

2.8 Research Stages

The stages of research generally include:

- 1) Identify problems and formulate research objectives.
- 2) Determination of variables and arrangement of instruments.
- 3) Primary and secondary data collection.
- 4) Validation of variables with the implementation of FGD
- 5) Statistical analysis and calculation of benefit-to-cost ratio.
- 6) Preparation of design recommendations with the lowest cost and highest net benefit.

3. Results and Discussion

3.1 General Data and Analysis

Data collection was carried out through Focus Group Discussion (FGD), namely:

- a) Initial data collection was carried out by literature study, which is in accordance with Table 4 Cost Reduction Recommendation Variables and Table 3.3 Benefits Improvement Recommendation Variables
- b) Data validation was carried out with FGD, with the participation of five speakers, namely the Determination of the Design with the lowest cost / highest net benefit, the variables of the results of the Focus Group Discussion (FGD) are as follows:

Tabel 4 Hasil Focus Group Discussion (FGD)

No	Variable	Construction Management Experts and Academics	Project Management Expert and Hospital Construction Project Practitioner	Architect and Hospital Building Design Practitioner	Project Leader of the Hospital Construction Project User/Owner	Professional Team Expert in the field of Electrical Mechanics
I	Cost Reduction					
1.	Modular Design	√	√	√	√	√
2.	Man Power	X	X	√	X	X
3.	Capital	X	X	√	-	X
4.	Material Selection	√	√	√	√	√
5.	Machinery/Tools	√	X	√	-	√
6.	Method	√	√	√	-	√
7.	Duration of Time	X	X	X	-	√
8.	Cost Optimization and Efficiency	X	X	X	-	X
II	Increased Benefits					
1.	Function Analysis	√	√	√	√	√
2.	Benchmarking	√	√	√	-	√
3.	Improve More Functionality	X	X	X	-	X
4.	Improve Team Communication and Performance	√	√	√	-	√
5.	Creating a lot of creative ideas and innovations	√	X	√	-	√
6.	Achieving Value For Money	X	X	X	-	X
7.	Creating a lot of creative ideas and innovations	√	√	√	-	√

The main objective of the FGD is to obtain hospital design recommendations with the lowest cost and highest net benefit through the application of Value Engineering (VE) principles in the planning phase.

3.2 Focus Group Discussion (FGD) Results

Based on the results of the FGD, there are two main groups of variables analyzed, namely cost reduction is Experts agree that Modular Design, Material Selection, Machinery/Auxiliary Tools, Method (Method) are the dominant factors in reducing project costs. Meanwhile, the benefit increase variable focuses on function

analysis, benchmarking, improving functions (provide more function), Providing more functionality, Improving communication and team performance, Creating many creative ideas and innovations. The results of the FGD showed that the most significant variable in improving the efficiency of hospital project values.

3.3 Cost Reduction

Determination of the Design with the Lowest Cost, from the Variables from the results of the Focus Group Discussion (FGD), To obtain the quantitative value of each variable with the Likert scale assessment criteria (1–5) with the following description:

Table 5 Design Assessment Strategy Score with the lowest Cost

No	Variable	Likert scale	Criterion Value
1	Modular Design Bhosekar & Marianthi G (2020), Roy & Abdul-Nour (2024), Lee & Kang (2025)	1 = 2 = 3 = 4 = 5 =	Not applying modularization, 20 Scores (20%) Limited deployment of modules, 40 Score (40%) Partly modular, medium efficiency, 60 Score (60%) Almost fully modularized, 80 Scores (80%) Fully module-based system, high manufacturing Efficiency, 100 Score (100%)
2	Material Selection Shari et al. (2021), Uğural (2023), Bajwa et al. (2025), Seethalakshmi et al. (2024)	1 = 2 = 3 = 4 = 5 =	Materials are expensive, a lot of waste <5% Standard material without efficiency <15% The material is quite efficient, the waste is reduced <5%; Material efficient, waste reduced <40%; Material efficient/recyclable, minimum waste according to the principle of material efficiency >40%
3	Machinery/Tools Formentini et al. (2022), Heizer et al. (2019), Stevenson (2020)	1 = 2 = 3 = 4 = 5 =	Machine/Tool is almost unworn, save <5%, productivity $\leq 1.1\times$, OEE <45%. Partial machinery/Tooling, saving 5–10%, productivity 1.1–1.3 $\times$, OEE 45–60%. Machine/Tool at critical stage, saving 10–20%, productivity 1.3–1.6 $\times$, OEE 60–75%. Machine/Tool dominant, saving 20–35%, productivity 1.6–2.2 $\times$, OEE 75–85%. Fully optimized machine/Tool, saving >35%, productivity >2.2 $\times$, OEE >85%.
4	Method (Hersey et al., 2012), (Surbakti, 2017)	1 = 2 = 3 = 4 = 5 =	Traditional, inefficient process, 20 scores (20%) Standard method, low efficiency, 40 score (40%) Start implementing work efficiency, 60 score (60%) Partial lean method, increased efficiency, (80 score (80%)) Lean method, value engineering, concurrent Engineering, significantly reduced costs, 100 score (100%)

Increased Benefits

Determination of the highest net benefit, Variable from the results of the Focus Group Discussion (FGD). To obtain the quantitative value of each variable with the Likert scale assessment criteria (1–5) with the following deductions:

Table 6 Value Score Benefit Improvement Criteria

No	Variable	Likert scale	Criterion Value
1	Function Analysis Reference: The layout and function of the space support safety (privacy, protection against the risk of falling), health (natural lighting and ventilation), comfort (thermal, acoustic), and ease of access. Kineber et al. (2022), Jeong et al. (2024), Al Salmawi & Al Eqabi (2024)	1 = 2 = 3 = 4 = 5 =	Very bad Bad Less good Pretty good Excellent
2	Benchmarking Reference: Conformity of hospital building design to best practices or international standards in the aspects of patient safety, infection prevention (health), healing environment (comfort), and accessibility/operation (convenience).	1 = 2 = 3 = 4 = 5 =	Very bad Bad Less good Pretty good Excellent

No	Variable	Likert scale	Criterion Value
	Brambilla et al. (2019), Camp (1989), Sik Wah Fong et al. (2001)		
3	Provide more function References: Evaluation of functions such as isolation rooms, sterile HVAC systems, living rooms—and their impact on safety (infection isolation), health (air quality), comfort (emotional support rooms), and ease of mobility. Bernhardt et al. (2022), Mousa et al. (2022)	1 = 2 = 3 = 4 = 5 =	Very bad Bad Less good Pretty good Excellent
4	Team Communication & Performance Reference: The concept of healing environments highlights the importance of an environment that reduces stress, improves concentration, and creates control all closely related to patient and staff safety and psychological comfort Arsalan et al. (2018), Usman et al. (2018)	1 = 2 = 3 = 4 = 5 =	Very bad Bad Less good Pretty good Excellent
5	Creating a lot of creative ideas and innovations Reference: In Value Engineering, think creatively and innovatively to find new, more efficient ways to achieve project goals. Spiekermann & Winkler (2022). Assessment of the application of innovations such as biophilic design, digital monitoring, and sustainability features in improving safety, health, comfort, and ease of operation. Feng et al. (2024)	1 = 2 = 3 = 4 = 5 =	Very Unused Not used Underused Simply use Highly used

Assessment of Improvement Benefits of design data including Cost Budget Plan, Planning Drawing including Architectural, Structural and Electrical Mechanical drawings.

Value Engineering Analysis

The next phase is the simulation of assessment of the project, which will be carried out by Value Engineering to get the Design with the lowest price / highest net benefit is:

Sample Project Information Data

1.	Project Name	Detail Engineering Design Hospital
2.	Building Area	18.000 M2
3.	Number of Floors	4 Floors
4.	DED Planning Cost Budget Plan	IDR 262,782,000,000,00

Design Assessment

a) Cost Budget Plan, Self-Forecast Price (HPS)

To calculate the value of the self-forecast price (HPS), using data Information: Year of proposed development, Number of floor levels, Total area of hospital buildings, Building class, Building coefficient, Price per m2 according to the determination of government unit price standards in a Regency/City/Province. Furthermore, it can be seen in Analysis Table 3.7 Building Components for Construction Work as follows:

Table 7 Building Components for Construction Work

Budget Year		: 2025		
Number of Floors		: 4 Floors		Floor coefficient: 1.135
Building Area		: 18.000 M2		
Building Classes		: Buildings Are Not Simple		
Price per m2 according to the determination of government unit price standards in a Regency/City/Province area		: Districts in Indonesia		Rp. 7.815.994,-
A. Building Component Analysis for Standard Work				
No	Standard Building Components	Weight %	Stages %	
		Against the entire building (a)	What will be built (b)	Value (c = a x b)

1	Structure	10,00	100,00	10,00	
2	Foundation	28,00	90,00	26,00	
3	Roof	10,00	100,00	10,00	
4	Langit langit	8,00	100,00	8,00	
5	Wall	10,00	96,00	9.60	
6	Floor	10,00	100,00	10,00	
7	Ultilitas	8,00	100,00	8,00	
8	Finishing	15,00	98,75	14.81	
Number of Standard Job Values		100,00		96.51	
Standard Unit Work Fee Preparation Fee Amount (d)		Value (c)% x Floor coefficient x 1.10 x Unit Price per m2 = 96,51% x 1,135 x 1,10 x Idr. 7.815.994,-= Idr. 9,417,704.94 = 5.00 % x Idr. 9,417,704.94 = Idr 470,885.25 IDR 9,888,590.18			
Amount of Standard Work Costs (I)		= Building Area x Total (d) = 18.000 M2 x IDR 9,888,590.18 = IDR 177,994,623,328.88			
B. Building Component Analysis for Non-Standard Work					
No	Non-Standard Components	Against the entire building %		Stages %	
		Min	Max	Built weight	Value (f)
1	Air conditioning (AC)	7.00	15.00	40.00	6.00
2	Elevator/escalator	8.00	14.00	30.00	4.20
3	Sound System	2.00	4.00	5.00	0.20
4	Telephone and PABX	1.00	3.00	5.00	0.15
5	IT Installation	6.00	11.00	5.00	0.55
6	Electrical (Including Genzet)	7.00	12.00	50.00	6.00
7	Fire Protection System	7.00	12.00	20.00	2.40
8	Special Lightning Suppression System	1.00	2.00	10.00	0.20
9	Wastewater Treatment Plant	1.00	2.00	10.00	0.20
10	Interior (including furniture)	15.00	25.00	30.00	7.50
11	Combustion Gas	1.00	2.00	10.00	0.20
12	Medical Gas	2.00	4.00	10.00	0.40
13	Prevention of termite hazards	1.00	3.00	6.00	0.18
14	Deep foundation	7.00	12.00	59.00	7.08
15	Disabled facilities	3.00	8.00	10.00	0.80
16	Environmental Facilities	3.00	8.00	15.00	1.20
17	Quality improvement	15.00	30.00	1.00	0.30
18	Licensing Other than PBG (Building Approval)	0.00	1.00	-	-
19	Land Preparation and Maturation	0.00	3.50	15.00	0.53
20	Fulfillment of BGH Requirements (Green Building Building)	0.00	9.50	25.00	2.38
Number of Non-Standard Job Scores		Max 150%			40.46
Non-Standard Work Unit Costs (g)		Value (f) % x Floor coefficient x 1.10 x Unit Price per m2 = 46.46% x 1,135 x 1,10 x Idr. 7.815.994,-= Idr 3.948.094,-			
Amount of Non-Standard Work Costs (II)		= Building Area x Total (g) = 18.000 M2 x Idr 3.948.094,-= IDR 71,064,000,000			
Total Cost of Construction Work					
– Amount of Standard Work Costs (I)		= IDR 177,994,623,328.88			
– Amount of Non-Standard Work Costs (II)		= IDR 71,064,000,000,00			
		= IDR249,058,623,328.88			

From Table 7 Analysis of Building Components for Construction Work above, compared to the cost reduction, are as follows:

DED Planning Value cost budget plan : IDR 262,782,000,000,00
 HPS Score Cost Budget Plan : IDR 249,058,623,328,88
 Deviation : (IDR. 13.723.376.671,12)
 Percentage Cost Reduction : 5,22 %

With the pareto distribution law, 80% of the total cost can be determined from 20% of the work item

that has a high cost. Function analysis is only performed on 20% of those job items. The rest of the work items only have low costs, so no studies are conducted on the work items. Rani (2022). Value Engineering implementations generally result in around 5–15% of total project cost savings (across project types). Elhegazy (2022).

Table 8 Cost Assessment Score Scores

No	Self-Forecast Price (HPS)/ Owner Estimate	Likert scale	Criterion Value
1	Detail Engineering Design (DED)	1 = 2 = 3 = 4 = 5 =	Savings Value <3 % of HPS value Savings Value <6 % of HPS value Savings Value <9 % of HPS value Saving Value <12 % of HPS value Saving Value <15 % of HPS value

Based on the results of the cost budget plan value between Cost budget plan Detail Engineering Design (DED) and Self-Forecast Price Cost Budget Plan (HPS), a decrease of 5.22% was obtained, according to Table 3.8 The Cost Assessment Score value is 2 = Savings Value <6% of the HPS value

Net Benefit Value

Determination of the highest net benefit in the design of the Detail engineering design (DED), To obtain the quantitative value of each variable with the Likert scale assessment criteria (1-5) with the following description:

Table 9 Assessment of Benefit Enhancement Criteria

Increased Benefits			Level Fulfillment	Criterion Value					Sum
No	Variable	Operational Definition		1	2	3	4	5	
1	Function Analysis	The layout and function of the space support safety (privacy, protection against the risk of falling), health (natural lighting and ventilation), comfort (thermal, acoustic), and ease of access.	Support level 1 = Very bad 2 = Not good 3 = Poor 4 = Good enough 5 = Excellent			√			3
2	Benchmarking	The suitability of hospital building design to best practices or international standards in the aspects of patient safety, infection prevention (health), healing environment (comfort), and accessibility/operation (convenience).	Customization Level 1 = Very bad 2 = Not good 3 = Poor 4 = Good enough 5 = Excellent		√				2
3	Provide more function	Evaluation of functions such as isolation rooms, sterile HVAC systems, living rooms and their impact on safety (infection isolation), health (air quality), comfort (emotional support room), and ease of mobility	Function Improvement Rate: 1 = Very bad 2 = Not good 3 = Poor 4 = Good enough 5 = Excellent			√			3
4	Team Communication & Performance	Adaptation of hospital buildings to the concept of healing environments, increasing concentration, and Creating control is all closely related to patient	Customization Level 1 = Very bad 2 = Not good 3 = Poor 4 = Good enough 5 = Excellent			√			3

		and staff safety as well as psychological comfort							
5	Creating a lot of creative ideas and innovations	In VE, think creatively and innovatively to find new, more efficient ways to achieve project goals Assessment of the application of innovations such as biophilic design, digital monitoring, and sustainability features in improving safety, health, comfort, and ease of operation	Usage Rate 1 = Very Unused 2 = Unused 3 = Underused 4 = Enough to use 5 = Highly used				√		4
Number of Σ Design Assessments with Increased Benefits									15
Total Mean Score									3

The results of the Assessment of the Benefit Improvement Criteria from table 3.9 above, are: Number Σ Design Assessment with Benefit Increase = 15 and Number of Average Value (Mean) = 3

Benefit-to-Cost Ratio

In order to try to get a design with the highest cost reduction and net benefit increase, the results of the calculation of the ratio between the cost reduction results in table 3.8, and the increase in benefits in table 3.9. Alternative comparisons of the ratio of benefits to costs are:

Increase functions or benefits and Reduce costs (Total Number of Functions / Benefits +) – (Total amount of costs -) = 3-2= +1

Recommendation Strategy

1) Cost Reduction Recommendation Strategy

Based on the data of the Detail Engineering Design (DED), an assessment was carried out on the Design Strategy Score with the lowest cost, with the following:

Table 10 Results of the Lowest Cost Design Assessment Strategy Score

No	Variabel	Information	Value Criteria					Sum
			1	2	3	4	5	
1.	Modular Design	Not applying modularization, 20 Scores (20%)	√					1
2.	Material Selection	Materials are quite efficient, waste is reduced $\pm 25\%$			√			3
3.	Machinery/Tools	Machine/Tool dominant, saving 20–35%, productivity 1.6–2.2 $\times$, OEE 75–85%.				√		4
4.	Method	Partial lean method, increased efficiency, (80 score (80%))				√		4

From table 10, the results of the Design Assessment Strategy score with the lowest cost were obtained. Furthermore, to obtain a Design Recommendation Strategy at the lowest cost price, as follows:

Table 10 Lowest Price Design Recommendation Strategy

No	Variabel	Value	Recommendations
1.	Modular Design	1	Improve (4) Almost fully modularized, 80 Score (80%)
2.	Material Selection	3	Improve (4) Efficient/recyclable materials, minimal waste
3.	Machinery/Tools	4	Upgrade (5) Fully optimized Machine/Tool, saving >35%, productivity >2.2 $\times$, OEE >85%.
4.	Method	4	Lean method, value engineering, concurrent Engineering, significantly reduced costs, 100 score (100%)

Recommended Strategy to achieve the lowest cost in Value Engineering, the variables are: Modular Design,

Material Selection, Machine/Auxiliary Tools, Methods. With a likert scale value (1-5), the minimum mean value is 3 (three)

2) Benefit Enhancement Recommendation Strategy

Based on the data of the Detail Engineering Design (DED), an assessment has been carried out on the Assessment Score of the Benefit Improvement Criteria according to Table 10 above. Furthermore, to obtain the Design Recommendation Strategy for the highest increase in net benefits, according to table 11 as follows:

Table 11 Design Recommendation Strategy Highest net benefit enhancement

No	Variabel	Value	Recommendations
1	Function Analysis	3	Improve support, Quite good (4), The layout and function of the space support safety (privacy, protection against the risk of falls), health (natural lighting and ventilation), comfort (thermal, acoustic), and ease of access.
2	Benchmarking	2	Improve Conformity, Fairly Good (4), Conformity of hospital building design to best practices or international standards in aspects of patient safety, infection prevention (health), healing environment (comfort), and accessibility/operation (convenience).
3	Provide more function	3	Functional Improvement Level, Quite Good (4), Evaluation of functions such as isolation rooms, sterile HVAC systems, family rooms and their impact on safety (infection isolation), health (air quality), comfort (emotional support room), and ease of mobility
4	Team Communication & Performance	3	Improve Suitability, Quite Good (4) The suitability of hospital buildings for the concept of healing environments, increasing concentration, and creating control are all closely related to patient and staff safety and psychological comfort
5	Creating a lot of creative ideas and innovations	4	Increase Usage, Highly Used (5), In VE, think creatively and innovatively to find new, more efficient ways to achieve project goals. Assessment of the application of innovations such as biophilic design, digital monitoring, and sustainability features in improving safety, health, comfort, and ease of operation

Value Engineering, Value Engineering, Benchmarking, Provide more function, Team, Creative Ideas and Innovations. With a likert scale value (1-5), the minimum mean value is 3 (three).

Discussion of Research Results

The discussion of this research is comprehensive. which focuses on the analysis of the relationship between research variables and interpretation of the results of the Focus Group Discussion (FGD) with its theoretical and practical implications for the concept of Value Engineering in hospital construction projects

Cost Reduction Aspects,

The results of the Focus Group Discussion (FGD) identified four main variables in cost reduction, namely: Modular Design, Material Selection, Machine/Tool, and Method. Value Engineering implementations generally generate around 5–15% Total project cost savings (across project types). Elhegazy (2022). In the cost reduction from Detail Engineering Design (DED) and Cost Budget Plan Self-forecast price, a decrease of 5.22% was obtained, according to Table 11. The Cost Assessment Score value is 2 = Savings Value <6% of the Self-forecast prices value. To get Design Recommendations at the lowest price, it can be achieved with the following cost reduction Recommendation Strategy:

1.	Modular Design	Improve (5) High Manufacturing Displacement, 100 Score (100%)
2.	Material Selection	Improve (5) Principle of material efficiency .40%
3.	Machinery/Tools	Level (5) Use of Machines / Tools at critical stages, saving 10–20%, productivity 1.3–1.6×, OEE 60–75%.
4.	Method	Level (5), With lean method, value engineering, concurrent engineering, significantly reduced costs, 100 score (100%)

Recommended Strategy to achieve the lowest cost with variables: Modular Design, Material Selection, Machine/Auxiliary Tools, Method. With a likert scale value (1-5), the minimum mean value is 3 (three) with the highest mean value of 5 (five).

Benefit Enhancement Aspects

In terms of benefits, five variables: Function Analysis, Benchmarking, Improving Functions, Communication & Team Performance, and Innovation. The results of the assessment show all variables in ensuring the suitability of the design with the needs of users. Safety standards, as well as international quality. Miles (1972), Jeong et al. (2024). To get Design Recommendations with the highest net benefits, it can be achieved with the following Benefit Enhancement Recommendation Strategy:

1	Function Analysis	Improve support, Excellent (5), The layout and function of the space support safety (privacy, protection against the risk of falls), health (natural lighting and ventilation), comfort (thermal, acoustic), and ease of access.
2	Benchmarking	Improve Conformity, Excellent (5), Conformity of hospital building design to best practices or international standards in aspects of patient safety, infection prevention (health), healing environment (comfort), and accessibility/operation (convenience).
3	Provide more function	Functional Improvement Level, Excellent (5), Evaluation of functions such as isolation rooms, sterile HVAC systems, family rooms and their impact on safety (infection isolation), health (air quality), comfort (emotional support room), and ease of mobility
4	Team Communication & Performance	Improve Suitability, Excellent (5) Suitability of hospital buildings for the concept of healing environments, increasing concentration, and creating control are all closely related to patient and staff safety and psychological comfort
5	Creating a lot of creative ideas and innovations	Increase Usage, Highly Used (5), In VE, think creatively and innovatively to find new and more efficient ways in achieving project goals. Assessment of the application of innovations such as biophilic design, digital monitoring, and sustainability features in improving safety, health, comfort, and ease of operation

Determination of the highest net benefit from the Assessment of the Benefit Improvement Criteria from the Design Assessment on a scale of 1-5, with a minimum Average (Mean) = 3 (Three)

Benefit-to-Cost Ratio

The results of the ratio comparison show that all alternatives meet the requirements of Benefit Increase (B) - Cost Reduction (A) ≥ 1 , which means that the minimum benefit is equal to or greater than the cost, namely: Improving the function or benefit and reducing the cost (Total Number of Functions / Benefits +) - (Total amount of cost -) = +2

These findings strengthen the argument that the application of Value Engineering strategies in hospital design results in cost efficiencies as well as increased benefits. The best alternative is the one that produces the highest ratio value, which is a combination of improved functionality and reduced costs. A good construction project is one that strikes the optimal balance between cost reduction and functional value. Connaughton (1996) Al-Salmawi & Al-Eqabi (2024).

The results of the study show that the planning phase is the most strategic stage in the implementation of Value Engineering. From the example simulation in the DED Planning of the hospital building construction project, it resulted in a cost efficiency of 5.22% of the total RAB Detail Engineering Design of Rp 262,782,000,000.00 to Rp 249,058,623,328.88 This percentage is still in the ideal efficiency range (5–15%), so it can be concluded that the implementation of VE provides significant efficiency without sacrificing the quality and function of the building.

Getting the Lowest Cost Design Recommendations / Highest Net Benefit

Design recommendations through a Value Engineering (VE) approach, which focuses on achieving maximum cost/net benefit optimization. By combining the FGD method and the analysis of benefits and costs, the recommendations provided not only lower construction costs but also improve the quality and function of buildings. This ensures that each design alternative is evaluated holistically, so that the decisions made by stakeholders can be economically efficient as well as functionally optimal.

4. Conclusion

Based on the formulation of the problem, the purpose of the research, the main conclusions were obtained as follows:

1. Recommended Strategy to achieve the lowest cost with variables: Modular Design, Material Selection, Machine/Auxiliary Tools, Method. With a likert scale value (1-5), a mean value of at least 3 (three) with the highest mean value of 5 (five).

2. The increase in net benefits is obtained from Variables: Function Analysis, Benchmarking, Provide more function, Improve Communication and Team Performance, Creation and design innovation. With a likert scale value (1-5), a minimum mean value of 3 (three) with the highest mean value of 5 (five).
3. Recommendations for Lowest-Cost/Highest-Benefit Designs, Through Value Engineering (VE) analysis, this study recommends designs that are able to reduce costs while increasing functional benefits. The results of the calculation showed that the benefit-to-cost ratio (A) was $(B-A) \geq 1$ on all alternatives, with the best strategy being a combination of improved functionality and cost reduction.
4. Based on the simulation of the Detailed Engineering Design (DED) of the construction of the hospital building, the resulting Cost Assessment Score is 2 (two) = Savings Value < 6% of the Self-forecast price (HPS) value. The application of Value Engineering is able to reduce construction costs by 5.22% without reducing quality. The results of the assessment of the criteria for improving benefits are Average Value = 3 (three) Thus, the resulting design is not only economically efficient but also functionally optimal. Increase functions or benefits and Reduce costs (Total Number of Functions / Benefits+) – (Total amount of costs -) = $3-2= +1$

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