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Lean Strategy for Optimizing Response Time in Hospital Code Blue Activation: A Two-Cycle Action Research in Central Java, Indonesia

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ABSTRACT

Introduction: Inefficiencies or delays in Code Blue activation for cardiac arrest patients contribute significantly to increased mortality. Rapid response time is closely associated with better prognosis. However, no previous study has systematically addressed the problem of Code Blue activation delay using a structured approach in hospital settings. This study aimed to formulate and implement improvement strategies to minimize waste and accelerate Code Blue activation.
Methods: This research employed an action research design and adopted a two-cycle action research design to validate the application of Lean Management in optimizing Code Blue activation at a private Type D hospital in Banyumas, Central Java, Indonesia. A total of 11 consecutive Code Blue cases were observed in each cycle — 11 cases before (Cycle 1) and 11 cases after intervention (Cycle 2). Each cycle consisted of four stages: diagnosis, planning, action, and evaluation, guided by Value Stream Mapping (VSM) to identify and eliminate waste. Quantitative data (lead time, waiting time, cycle time, and Value-Added Ratio) were analyzed using Mann–Whitney tests, while qualitative insights were obtained from in depth interview and focus group discussions with 20 healthcare professionals.
Results: The top three critical wastes identified in the baseline assessment were waiting (20.7%), defects (20.4%), and transportation (17%). Thus, waiting was concluded to be the most critical waste in the Code Blue activation process. Initially, the activation process had four phases: initial assessment by inpatient nurse, assessment by ward doctor, system activation, and arrival of the secondary team. After interventions, it was streamlined to three phases by removing the ward doctor's assessment. Post-intervention, response time dropped by 92.2 % (from 122.1 to 9.5 minutes, $p < 0.001$), waiting time decreased by 91.3 % (from 50.7 to 4.4 minutes, $p < 0.001$), and the Value-Added Ratio (VAR) increased from 7 % to 39 % ($p < 0.001$).
Conclusion: The implementation of Lean Management significantly reduces response time in Code Blue activation. Sustaining these improvements requires ongoing commitment and a multidimensional approach, including training, system evaluation, and strengthening a supportive work culture.

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INTRODUCTION

Cardiac arrest is a critical medical emergency requiring immediate and appropriate intervention. Globally, it accounts for approximately 15–20% of all deaths, affecting an estimated 1 to 4 million people annually (1). In the United States alone, the number of in-hospital cardiac arrests (IHCA) is estimated to range from 250,000 to 350,000 cases each year, with survival rates varying from 0–59% depending on response time and intervention quality (2). In Indonesia, the Indonesian Society of Cardiology estimates the annual prevalence of cardiac arrest at around 10 per 100,000 individuals under the age of 35, with a total incidence of 300,000–350,000 cases annually (3).

To address such emergencies, hospitals implement a "Code Blue" system—a standardized alert activated by healthcare professionals to initiate immediate resuscitative efforts for patients experiencing cardiac or respiratory arrest (4). This system aims to foster rapid communication and coordinated response across hospital departments. Timely activation of Code Blue has been closely associated with improved patient prognosis. Conversely, delays in response have been linked to reduced survival outcomes (5). Factors contributing to such delays include limited human resources, inadequate training, poor communication, long distances between responders and patient location, and suboptimal infrastructure

While international guidelines emphasize the importance of a 3 – 5 minute response window for cardiopulmonary resuscitation (AHA, 2024), hospitals in resource-constrained settings often struggle to meet these benchmarks (6). Lean Management offers a promising solution to this issue. Originating from manufacturing industries, Lean Management focuses on maximizing value by eliminating waste, improving workflows, and enhancing staff collaboration. Its application in healthcare has been associated with reduced waiting times, improved service quality, and enhanced operational efficiency (7,8). Recent studies have demonstrated the significant potential of Lean Management in optimizing healthcare workflows across various hospital settings, including outpatient services, emergency departments, and surgical units (9–11). The Lean approach emphasizes value creation, elimination of waste, and continuous process improvement, which directly support the objectives of rapid and coordinated responses in acute-care environments. Global evidence further substantiates this potential: Lisowska et al., (2025) revealed that Lean-based interventions in emergency departments improved triage efficiency and reduced waiting times, identified key sources of waste and structural barriers that can be systematically addressed through Lean tools to enhance service quality and operational flow (12). Found that modern call response systems designed under Lean principles improved coordination during Code Blue events and significantly increased Return of Spontaneous Circulation (ROSC) rates. Despite these promising outcomes, few studies have specifically applied Lean principles to the Code Blue activation process—a critical component of hospital emergency systems where seconds determine survival. Given the time-sensitive nature of cardiac arrest and the ability of Lean tools such as Value Stream Mapping (VSM) to streamline interdepartmental coordination, this study seeks to fill that gap by evaluating the application of Lean Management to identify and reduce waste, improve workflow efficiency, and accelerate Code Blue response times in hospital settings. To strategically position Lean Management within the framework of acute healthcare process optimization, this study aims to: (1) systematically identify and quantify the critical waste elements in the Code Blue activation process using Lean principles; (2) analyze the systemic and operational factors contributing to delays in emergency response time; and (3) develop, implement, and evaluate iterative Lean-based strategies to achieve a faster, more efficient, and more robust Code Blue response workflow.

METHOD

Research Type

This study used a mixed-method, two-cycle action research design (Figure 1) consisting of diagnosing, action planning, taking action, and evaluation. Workflow inefficiencies in the Code Blue activation process were identified through Value Stream Mapping (VSM), Value Added Ratio (VAR) analysis, and Root Cause Analysis (RCA) using the Fishbone method. Improvement strategies were jointly developed and implemented with the hospital's Code Blue team to streamline activation and reduce waste. Pre- and post-intervention data were compared to measure improvement; quantitative indicators (lead time, waiting time, cycle time, VAR) were analyzed using Mann–Whitney and Wilcoxon tests, and qualitative feedback from staff informed interpretation. The first cycle focused on identifying and reducing major wastes, while the second cycle refined and confirmed the sustainability of improvements. Ethical approval was obtained before data collection.

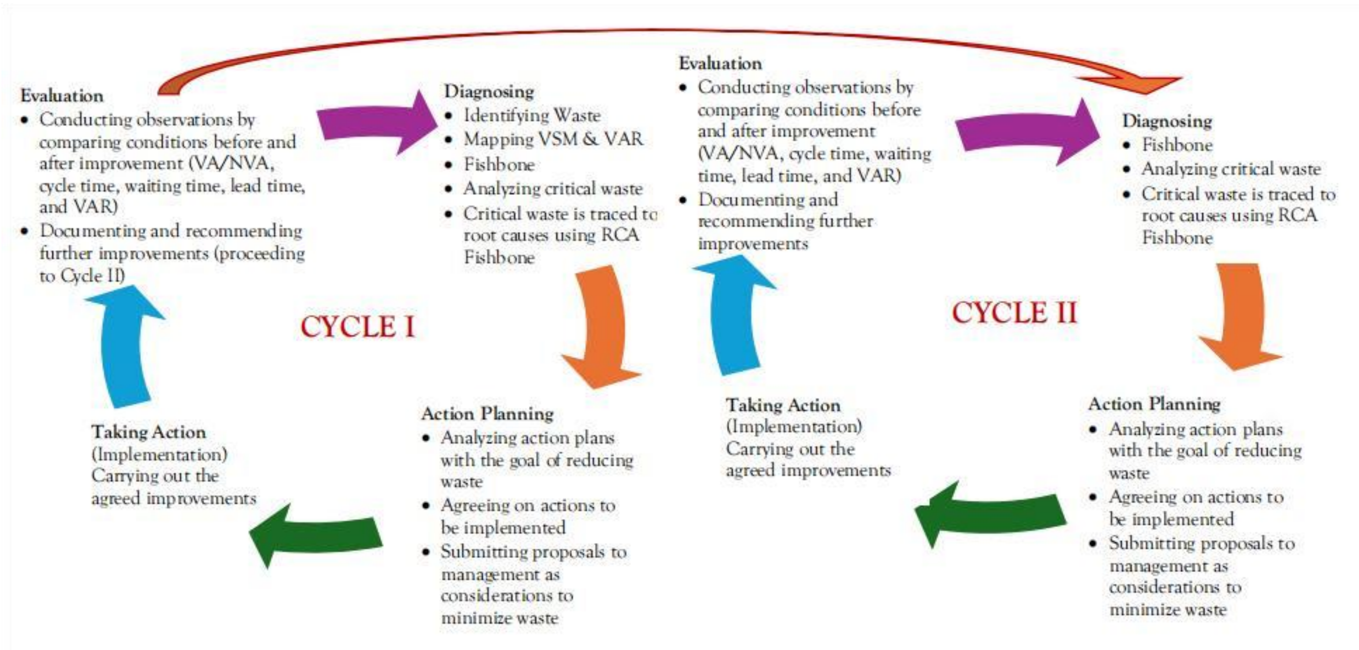

Figure 1. Action research cycle

Population and Sample/Informants

This study involved 11 code blue cases observed over two 6-week periods—before and after the Lean Management intervention—using consecutive sampling. Given the small number of available Code Blue cases in the study setting, the sample was determined based on all consecutive incidents that met the inclusion criteria rather than on statistical estimation. Although the Lemeshow formula was initially referenced to ensure proportional adequacy, the research is positioned as an exploratory action study, emphasizing process improvement rather than inferential generalization. Based on the average monthly incidence of approximately 12 Code Blue cases, with a 95% confidence level ($Z = 1.96$), a 10% margin of error ($d = 0.1$), and assuming a proportion of 0.5 to account for maximum variability, the required sample size was calculated. The result of the calculation indicated that approximately 11 patients were needed to provide reliable data for this study. Qualitative data were subsequently collected through in-depth interviews with 3 informants and focus group discussions (FGDs) involving 17 informants. Participants were selected using purposive sampling with a criterion-based approach, targeting healthcare professionals directly involved in the Code Blue activation process. Inclusion criteria included: (1) active involvement in Code Blue responses; (2) availability during the data collection period; and (3) a minimum of six months of clinical experience.

Study Setting and Context

The study was carried out at a Type D private hospital in the peripheral area of Banyumas Regency, Central Java, Indonesia. As a non-teaching hospital with limited specialist resources, it faces particular challenges in emergency response, providing a relevant setting for applying Lean Management in the Code Blue activation process.

Instrumentation or Tools

In the qualitative component of this study, the primary research instrument was the researcher, functioning as a human instrument. The researcher was responsible for determining the focus of the study, selecting informants as data sources, collecting data, assessing data quality, analyzing and interpreting the data, and drawing conclusions. In addition, the study utilized supporting instruments such as observation guidelines, FGD guides, and interview guides containing semi-structured questions posed to selected informants. Other instruments used in both the qualitative and quantitative components included Value Stream Mapping (VSM) tools, a stopwatch for time tracking, and documentation tools (e.g., audio recorders, note-taking materials).

Data Collection Procedures

Data collection involved both primary and secondary sources. Primary data were obtained through direct observation using stopwatch timing, in-depth interviews with three key informants, two focus group discussions involving 17 participants, and a checklist questionnaire analyzed using the Borda method. The Borda method is a group decision-making support technique that involves multiplying reference values by ranking weights, with the winner being the option that obtains the highest total score. Observers were trained to record the duration of each activity during Code Blue activation. Qualitative data were gathered through in-depth interviews and FGDs to explore barriers, enablers, and waste types. Secondary data were collected from hospital documents such as SOPs, process flowcharts, floor plans, and service guidelines. All stages were documented through photos, recordings, and field notes.

Data Analysis

Quantitative data were analyzed using non-parametric tests due to small sample size and non-normal distribution. The Mann–Whitney test was used to compare differences in lead time and cycle time before and after the Lean Management intervention. SPSS version 22 and Microsoft Excel were used for statistical analysis. Qualitative data were analyzed thematically through a structured process involving service mapping, classification of value-added and non-value-added activities, identification of critical wastes using the Borda method, root cause analysis with a fishbone diagram, and synthesis of improvement ideas from expert panels and focus group discussions, which informed actionable recommendations.

Ethical Approval

This study was approved by the Health Research Ethics Committee University (Approval Number: 123/KEPK/2024). All participants provided informed consent prior to data collection, and their confidentiality and anonymity were strictly maintained throughout the research process. The study did not involve any participants under the age of 18.

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RESULTS

Informants Characteristic

According to **Table 1**., the majority of informants were female (65%), while male respondents accounted for 35%. Most participants were aged ≤ 30 years (90%), with only 10% aged over 30. In terms of education, 45% held a professional degree, 40% had a diploma (D3), and 15% had completed a master's degree (S2). No respondents had education below the diploma level. Regarding work experience, 45% had worked for less than 3 years, 35% for 3–5 years, and 20% for more than 5 years.

Table 1. Characteristic Informants

Characteristics	Frequency	Percentage
Gender		
Man	7	35%
Woman	13	65%
Age		
≤ 30 years	18	90%
> 30 years	2	10%
Level of Education		
Diploma	8	40%
Professional	9	45%
Master	3	15%

Work Experience		
< 3 years	9	45%
3-5 years	7	35%
> 5 years	4	20%

First Cycle

Diagnosing

Value Stream Mapping and Value Added Assesment

According to Figure 2., the Code Blue activation process at hospital is illustrated using a Value Stream Mapping (VSM) approach. Based on the mapped process, each step was analyzed to identify its contribution to the overall value. Activities were then categorized into Value-Added (VA) and Non-Value-Added (NVA) components. The total lead time before improvement was 122 minutes with a cycle time of 71 minutes, of which only 9 minutes (7%) were value-added activities, while 63 minutes were non-value-added, mainly during the initial nurse assessment.

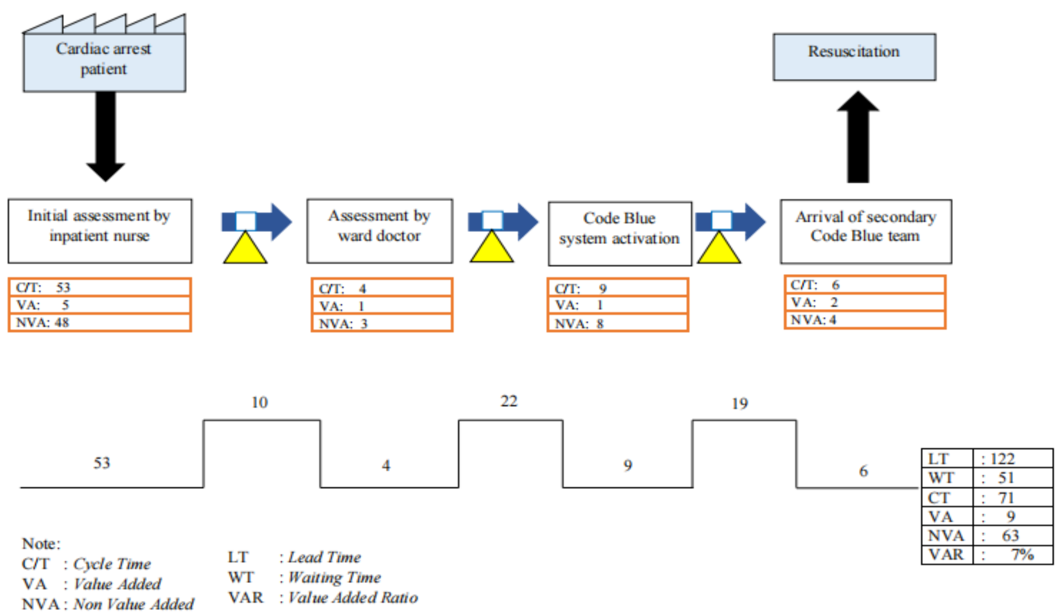

Figure 2. Value Stream Mapping of the Code Blue Activation Process Before Improvement

Table 2. presents the percentage of Value-Added (VA) and Non-Value-Added (NVA) activities in the Code Blue activation process. The percentage of Value-Added is calculated by dividing the VA time by the total time (VA + NVA) and multiplying the result by 100%. Similarly, the percentage of Non-Value-Added is obtained by dividing the NVA time by the total time (VA + NVA) and multiplying it by 100%. The highest Value-Added percentage is found in the arrival of the secondary Code Blue team (33%), while the highest Non-Value-Added percentage is during the initial assessment by the inpatient nurse (90.5%). The longest waiting time occurs during the Code Blue system activation, which takes 22 minutes. The causes of these inefficiencies in the Code Blue activation process are further analyzed to determine appropriate corrective actions.

Tabel 2. Code Blue Activation Process Activities

Activities	Value Added	Non Value Added
Initial assessment by inpatient nurse	9.5%	90.5%
Assessment by ward doctor	25%	75%
Code Blue system activation	11%	89%
Arrival of secondary Code Blue team	33%	67%
Total	13%	87%

Identification of Critical Waste

Before determining the most critical waste among the eight types, the researcher conducted observations and in-depth interviews to identify all eight forms of waste throughout the Code Blue activation process at hospital. These waste types align with the Lean concept previously discussed in the literature review and are consistent with the operational definitions used in this study. The identified wastes along the Code Blue activation process are summarized in **Table 3.**

Table 3. Identification of Waste in Code Blue Activation

Waste	Waste Activities
Over production	1) Repeatedly activating the Code Blue system 2) Preparing equipment more than necessary
Waiting	1) Waiting for the ward doctor to arrive 2) Waiting for manual validation from the bed side monitor 3) Waiting for doctor's instruction to activate Code Blue 4) Waiting for the operator (security) to respond 5) Waiting for the security to manually activate Code Blue 6) Secondary team waiting for request of equipment and emergency drugs from the pharmacy 7) Waiting for Code Blue team to arrive
Over processing	1) Repeating assessments and checks not required 2) Re-checking due to unreliable equipment 3) Bedside team redundantly performing the same procedure 4) Equipment setup 5) Secondary team preparing unused equipment 6) Coordination between primary and secondary teams
Inventory	1) Overstock of expired supplies 2) Tools in the emergency box (Bed Side Monitor, Electrocardiogram) already expired 3) Emergency tools stored in improper places
Motion	1) Long distance between emergency action and inpatient rooms 2) Medical staff walking back and forth to find and retrieve emergency equipment
Defects	1) Tools prepared manually, potentially causing errors 2) Code Blue activation tools not working properly 3) Equipment failures during live situations 4) Equipment not matching patient's emergency needs 5) Equipment quantity not in accordance with service demand
Transportation	1) Staff moving room to room to retrieve equipment 2) Medical staff retrieving tools from another inpatient room 3) Security moving from building 1 to 2 to activate Code Blue 4) Staff heading to incorrect Code Blue location
Human potential (talent)	1) Competent medical staff not involved in Code Blue activation 2) No structured training program for Basic Life Supports, so staff are not consistently upskilled 3) Experienced Code Blue personnel (e.g. trained in cardiopulmonary resuscitation simulation) not deployed despite availability

After identifying all eight types of waste, the researcher measured which occurred most frequently—referred to as the critical waste—in the Code Blue activation process at Hospital. The Borda method was used to determine this, a group decision-making technique that assigns weighted scores based on rankings. As shown in **Table 4.,** the top three critical wastes identified were: waiting (20.7%), defects (20.4%), and transportation (17%). Thus, waiting was concluded to be the most critical waste in the Code Blue activation system at Hospital.

Table 4. Critical Waste with Borda Weighting

No	Waste	Borda Score								Total	
		1	2	3	4	5	6	7	8	Score	Proportion
1	Waiting	10	6	4	1	1	0	1	0	134	20.7%
2	Transportation	0	5	13	3	0	1	1	0	110	17.0%
3	Defect	10	6	2	3	1	0	1	0	132	20.4%
4	Inventory	0	0	0	2	12	4	5	0	57	8.8%
5	Overprocessing	0	1	1	8	4	7	2	0	71	10.9%
6	Overproduction	0	1	1	0	5	10	6	0	52	8.1%
7	Motion	3	4	2	7	0	1	6	0	91	14.1%
8	Human Potential	0	0	0	0	0	0	0	23	0	0%
	Weighting factor	7	6	5	4	3	2	1	0	647	100%

Root Cause Analysis

In determining the critical types of waste within the service process, the researcher applied Root Cause Analysis (RCA) using a fishbone diagram to identify the root causes of the critical wastes. A detailed overview of the underlying causes related to waste waiting, waste defects, and waste transportation will be identified through the fishbone diagram.

Waste Waiting

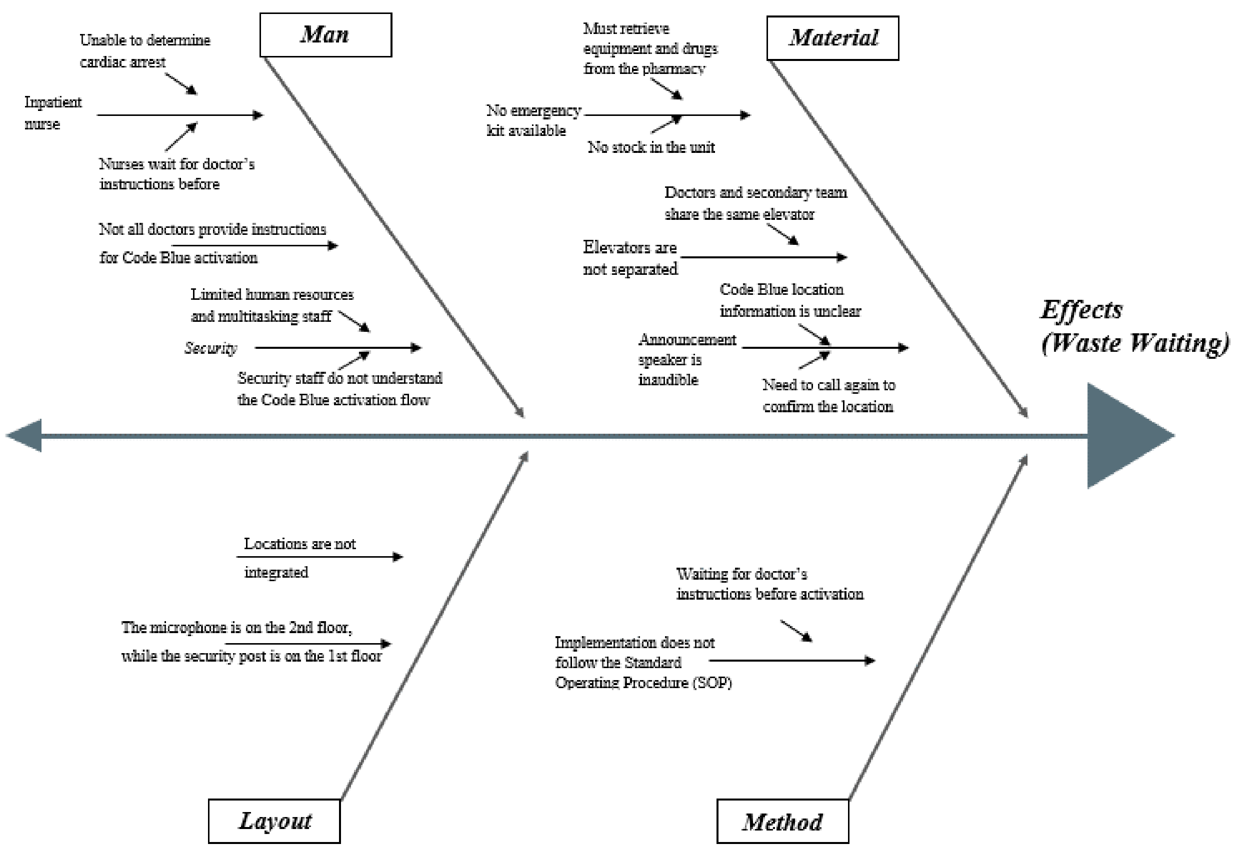

Figure 3. Fishbone Waste Waiting

According to **Figure 3.,** the main cause of waste waiting in the Code Blue activation process this hospital is delayed action due to various factors. These include staff waiting for doctors' instructions, limited understanding of the activation flow, and multitasking personnel. Equipment unavailability in patient rooms, unclear speaker announcements, and physical separation between key locations also contribute to delays. Additionally, poor SOP implementation, lack of regular evaluation, and insufficient socialization further prolong response time. These issues highlight the need for better coordination, resource placement, and adherence to procedures.

Waste Defect

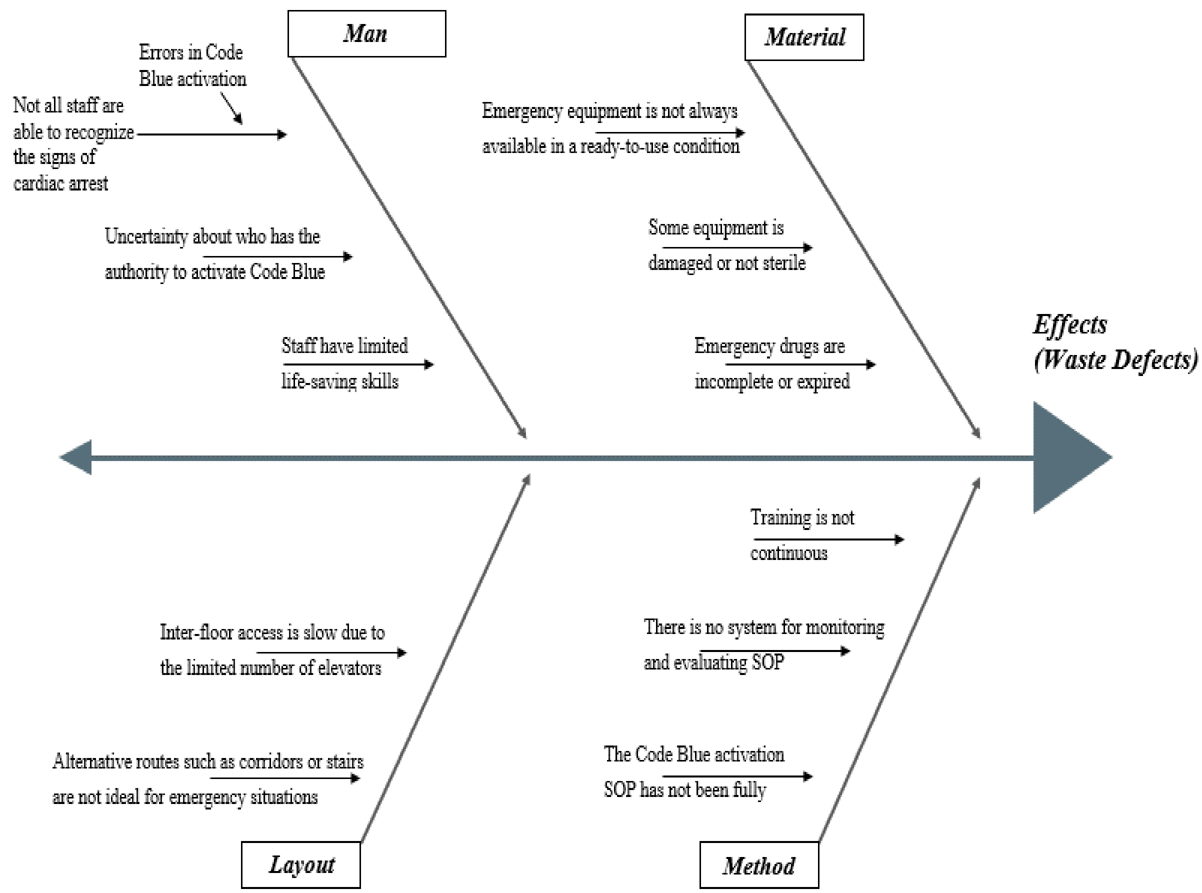

Figure 4. Fishbone Waste Defect

Figure 4. shows that waste defects in the Code Blue activation at this hospital stem from limited staff skills, unclear roles, and poor recognition of cardiac arrest. Emergency tools are often unavailable, damaged, or expired. Inadequate training, lack of SOP monitoring, and poor layout access also contribute to errors. These highlight the need for better training, equipment readiness, and SOP implementation.

Waste Transportation

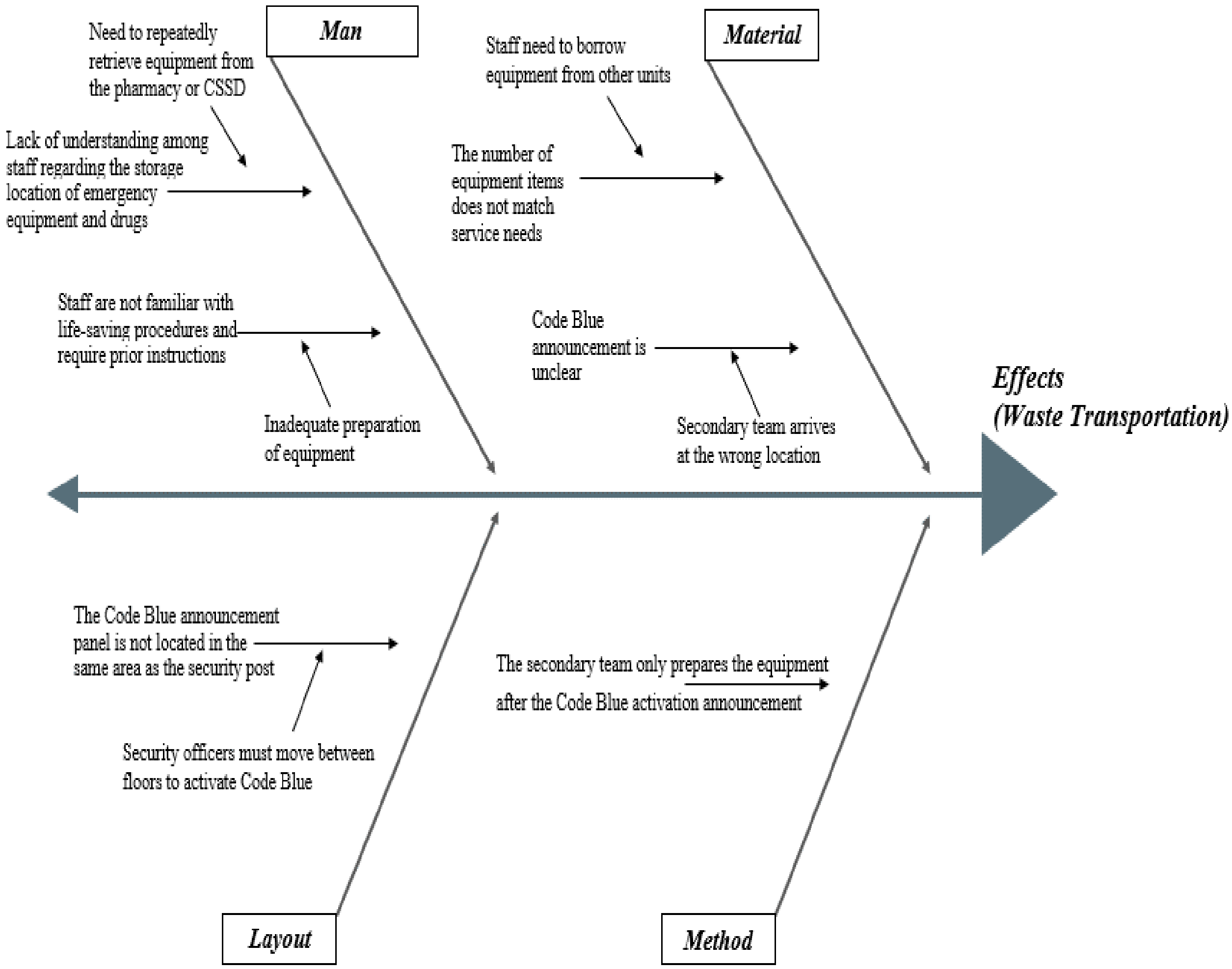

Figure 5. Fishbone Waste Transportation

Figure 5. shows that waste transportation in the Code Blue activation process is caused by unclear storage locations, unprepared equipment, and poor staff familiarity with emergency procedures. Tools often need to be retrieved from other units, while unclear announcements and separate panel-security locations lead to delays. Additionally, secondary teams only prepare equipment after activation, further slowing the response. These issues point to the need for better coordination, layout integration, and early equipment readiness.

Action Planning
Waste Waiting

After identifying the root causes of waste waiting in the Code Blue activation process, the next step was to develop a prevention or mitigation plan. In this study, action planning was formulated through a Focus Group Discussion (FGD). Several planned actions to minimize waste waiting are outlined in **Table 5.**

Table 5. Improvement Plan in Action Planning for Waste Waiting – Cycle I

No	Improvement Plan	Stakeholder Involvement	Objective
1	In-House Training (IHT) on emergency recognition and cardiac arrest	Training Division, Code Blue Coordinator, Code Blue Team Leader	To improve nurses' initial ability to recognize emergency and cardiac arrest
2	Routine Code Blue drills and simulations	Code Blue Team, Head of the Unit	To train quick response and coordination in Code Blue activation
3	Monthly scheduling for the secondary Code Blue team	ICU, ER, Code Blue Coordinator, Code Blue Team Leader	To ensure availability of the secondary team at all times
4	Elevator preparation for medical personnel during Code Blue via signage	General Affairs, Hospital Management	To speed up medical staff mobilization during Code Blue
5	Improvement and standardization of Code Blue speaker system	IT Technician, General Affairs, Security	To ensure Code Blue announcements are heard clearly in all areas
6	Emergency equipment placement in each treatment room	Pharmacy, Installation Department, Head of the Unit	To ensure equipment and drugs are readily available for rapid emergency action
7	Additional security personnel according to workload	HR Division, Head of Security	To ensure coordination and readiness of security during Code Blue activation

Waste Defect

In the diagnosing stage, several root causes of waste defects in the Code Blue activation process at the hospital were identified. The following are several planned actions to minimize waste defects, as outlined in **Table 6.**

Table 6. Improvement Plan in Action Planning for Waste Defect – Cycle I

No	Improvement Plan	Stakeholder Involvement	Objective
1	Evaluation of the Code Blue activation SOP	Quality Committee, Code Blue Team	To ensure SOP compliance with emergency care practices and service standards
2	Dissemination of Code Blue activation procedures to all hospital staff	Pharmacy Department, Unit Heads	To improve staff understanding and readiness in following Code Blue procedures
3	Placement of emergency trolleys in each unit with regular monitoring by nurses	ICU, ER, Code Blue Coordinator, Code Blue Team Leader	To ensure equipment availability and readiness during emergencies
4	Routine calibration of emergency tools (defibrillator, monitor, electrocardiogram, etc.)	Maintenance Department, Hospital Facilities, IT Technicians, Medical Team	To ensure all emergency equipment functions optimally when needed

Waste Transportation

Several root causes of waste transportation in the Code Blue activation process have been identified. The following are planned actions to minimize waste transportation, along with stakeholder involvement and the objectives of each action plan, as presented in **Table 7.**

Table 7. Improvement Plan in Action Planning for Waste Defect – Cycle I

No	Improvement Plan	Stakeholder Involvement	Objective
1	Procurement of 2 units of bedside monitors in inpatient rooms	Hospital Management, Inpatient Installation Department, ICU Team	To improve the ability to detect early signs of vital signs abnormalities in inpatients
2	Procurement of 1 unit of Electrocardiogram machine per inpatient room	Hospital Management, Inpatient Installation Department, ICU Team	To speed up the diagnosis of heart rhythm disorders and initial treatment
3	Relocation of Code Blue multifunction panel near the security post	IT/Technical Team, General Affairs Department, Head of Security	To expedite Code Blue response and reduce technical obstacles

Taking Action

In the taking action stage, the researcher was supported by hospital management in implementing several jointly agreed-upon actions. These actions were carried out based on the previously developed action plan, which focused on the identified types of waste: waste waiting, waste defects, and waste transportation.

Evaluation

After implementing the action plans for the three types of waste, all outcomes were recorded. The implementation of Lean-based improvements during Cycle I significantly enhanced the efficiency of the Code Blue activation process. Lead time was reduced from 122 minutes to 18.8 minutes and cycle time from 71 minutes to 10.9 minutes, while the Value Added Ratio increased from 7% to 21%. The greatest improvements occurred in the initial nurse assessment (from 53 to 4.6 minutes) and Code Blue activation (from 9 to 2.3 minutes).

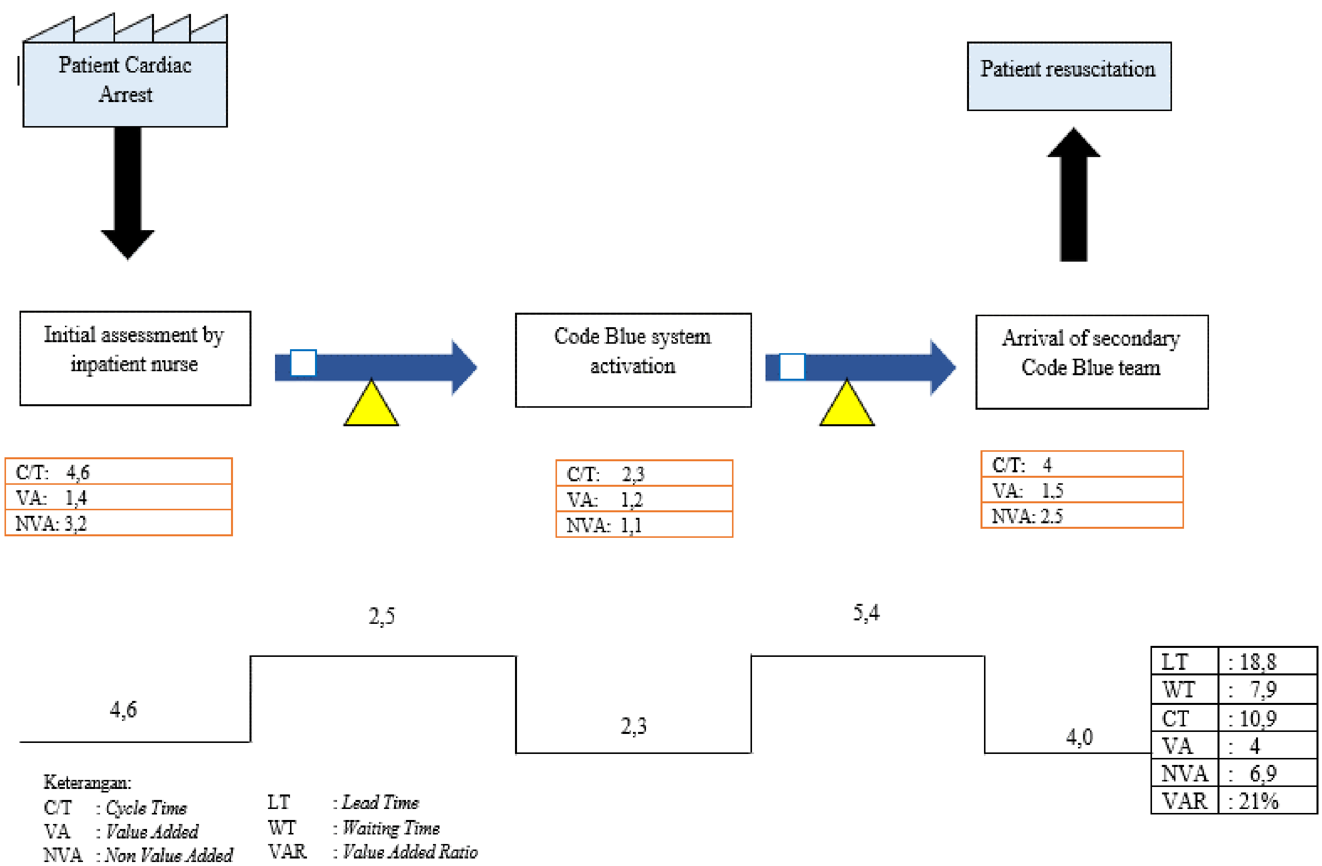

Figure 6. Value Stream Mapping After Cycle I Improvement

Table 8. shows that the highest percentage of Value Added occurs during the Code Blue system activation (52%), while the highest Non-Value Added is found in the initial assessment by the inpatient nurse (69.6%). The longest waiting time is during the arrival of the Code Blue team (5.4 minutes). The causes of these inefficiencies are further analyzed to determine appropriate corrective actions.

Table 8. Code Blue Activation Process Activities After Cycle I Improvement

Activities	Value Added (%)	Non Value Added (%)
Initial assessment by inpatient nurse	30.4%	69.6%
Code Blue system activation	52%	48%
Arrival of secondary Code Blue team	37.5%	62.5%
Total	37%	63%

Second Cycle

Diagnosing

In Cycle I, the root cause analysis revealed several sources of inefficiency. Waste of waiting was primarily due to staff spending excessive time searching for tools, caused by unfamiliarity and poor labeling of the emergency bag, an inefficient equipment layout, the absence of standardized Code Blue announcement templates, and the lack of regular emergency drills. Waste of defects during emergency responses was related to issues with the emergency trolley, including inconsistent adherence to Code Blue SOP, poorly labeled materials that caused delays, a layout that did not support a fast workflow, and the absence of routine audits to ensure compliance, all of which contributed to errors and inefficiencies. Finally, waste of transportation was identified in inpatient care, where staff had to transfer tools between rooms because of uneven equipment distribution. Storage locations were not strategically placed, and no system existed to align equipment availability with patient load, resulting in unnecessary transport and delays.

Action Planning

Waste Waiting

The following are several planned actions to minimize waste waiting based on the diagnosing results in Cycle II.

Table 9. Improvement Plan for Waste Waiting – Cycle II

No	Improvement Plan	Stakeholder Involvment	Objective
1	Create a layout of the emergency bag in the form of a visual sticker inside the bag	Installation, Pharmacy, Head of Unit	To make it easier for nurses to identify the contents of the emergency bag quickly
2	Socialize the contents and function of emergency bags to all nurses	Code Blue Team, Head of Unit, PKRS	To increase knowledge and readiness of nurses in using emergency equipment
3	Perform routine inspections and quick drills (e.g., "quick bag access drill") in each unit	Code Blue Team, Head of Unit, Training Division	To ensure physical readiness of emergency bags and quick access during real emergencies
4	Provide a template for code blue announcements near microphones	*Security, Code Blue Team*	To help staff quickly and clearly deliver announcements during emergencies
5	Conduct brief training and roleplay for security teams on code blue handling and panic situations	*Security, Code Blue Team, Training Division*	To improve security's alertness and coordination during emergency conditions
6	Conduct simulated spontaneous Code Blue scenarios in several units	Code Blue Team, Head of Unit	To evaluate real-time readiness of teams in responding to spontaneous Code Blue calls

Waste Defect

The following are several planned actions to minimize waste defect based on the diagnosing results in Cycle II.

Table 10. Improvement Plan for Waste Defect – Cycle II

No	Improvement Plan	Stakeholder Involvment	Objetive
1	Evaluation and internal audit of Code Blue activation SOP implementation at least once every 3 months	Quality Committee, Code Blue Team, Head of Unitk, Hospital Management	To assess the consistency of SOP implementation and identify areas for improvement
2	Standardization of the contents and layout of emergency trolleys across all inpatient rooms	Code Blue Team, Pharmacy Department, Head of Inpatient Installation	To ensure uniformity, organization, and readiness of emergency equipment in every unit

Waste Transportation

The following are several planned actions to minimize waste transportation based on the diagnosing results in Cycle II.

Table 11. Improvement Plan for Waste Transportation – Cycle II

No	Improvement Plan	Stakeholder Involvment	Objective
1	Develop a rotation/shared device pool system for rarely used Bed Side Monitor, equipment	Inpatient Installation, Logistics Department, ICU Team, IT Team	To optimize the use of Bed Side Monitor equipment and minimize idle resources
2	Reassess Bed Side Monitor and Electrocardiogram needs based on the number of active beds, bed occupancy rate (BOR), and patient type	Code Blue Team, Hospital Management, Inpatient Installation	To develop a more efficient and appropriate medical equipment plan based on actual needs

Taking Action

During the taking action stage, the researcher, with support from hospital management, implemented a series of mutually agreed-upon actions. These actions were based on the action plan developed from the results of Cycle I, which identified the critical wastes in the Code Blue activation process: waste waiting, waste defects, and waste transportation.

Evaluation

After the taking action stage for the three types of waste in Cycle II, observations and time recordings were conducted for each Code Blue case post-intervention. The results were presented in the post-improvement VSM and compared between Cycle I and Cycle II (**Figure 7**). Progressive improvements were observed across both intervention cycles. Compared to the baseline process, lead time decreased from 122 minutes to 18.8 minutes after Cycle I and further to 9.5 minutes after Cycle II. Cycle time also dropped from 71 minutes to 10.9 minutes and then to 5.2 minutes. Non-value-added activities were significantly reduced from 63 minutes at baseline to 6.9 minutes in Cycle I and 1.5 minutes in Cycle II, while the Value Added Ratio increased steadily from 7% to 21% and ultimately to 39%.

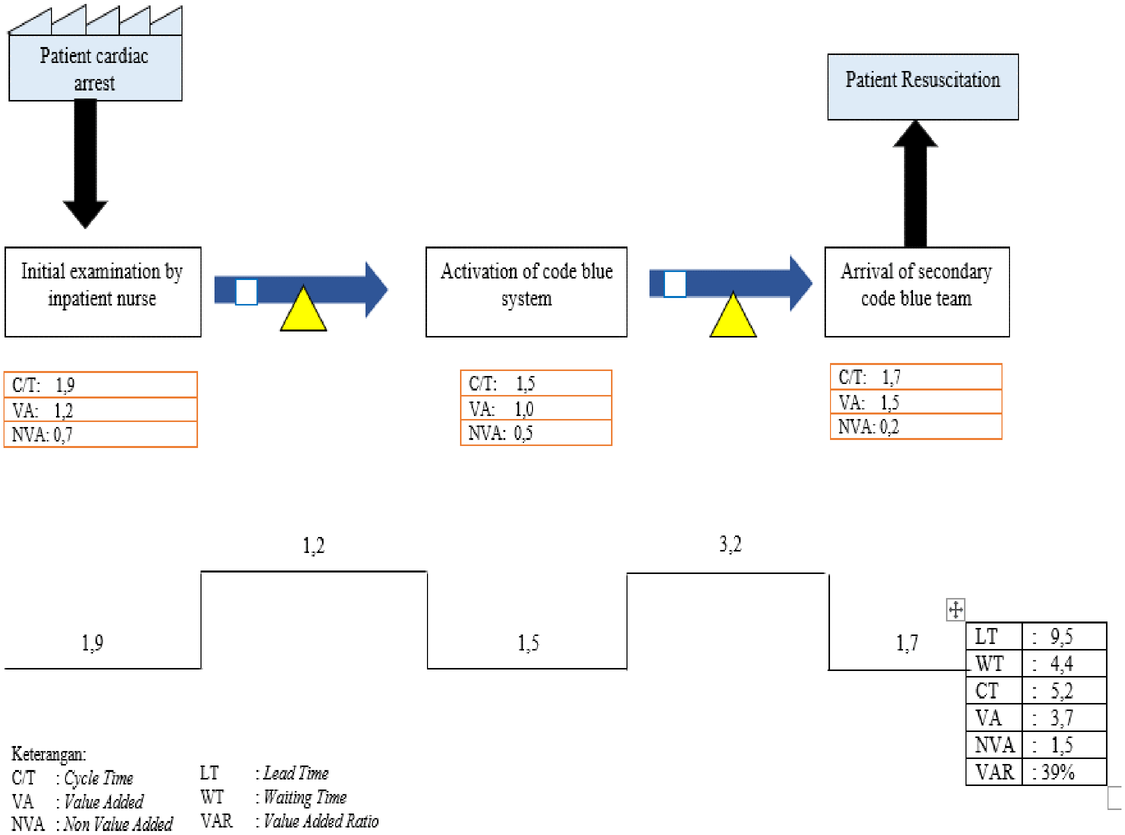

Figure 7. VSM of the Code Blue Activation Process After Cycle II Improvement

Table 12. shows the highest Value Added percentage in the arrival of the secondary Code Blue team (88%) and the highest Non-Value Added in the initial assessment by the inpatient nurse (37%). The longest waiting time was during team arrival (3.2 minutes). These inefficiencies were further analyzed to determine corrective actions.

Table 12. Code Blue Activation Process Activities After Cycle II Improvement

Activities	Value Added (%)	Non Value Added (%)
Initial assessment by inpatient nurse	63%	37%
Code Blue system activation	66%	34%
Arrival of secondary Code Blue team	88%	22%
Total	71%	29%

Based on observations from Diagnosing I to Evaluation II, there was a significant reduction in lead time, as shown in **Table 13.** This table presents changes in Code Blue activation lead time across two intervention cycles. The initial phase (Diagnosing I) reflects the baseline, followed by Evaluation I after the first cycle, which also served as the starting point for Cycle II. Further improvements are seen in Evaluation II, representing the final outcome of the Lean intervention. Before the Lean management intervention (Diagnosing I), the average lead time was 122.1 minutes. After Cycle I, it dropped to 18.8 minutes—a reduction of 74.5 minutes or about 80%. Continued improvements in Cycle II reduced it further to 9.5 minutes in Evaluation II, totaling an average decrease of 83.8 minutes or approximately 89.8% from baseline.

Table 13. Lead Time (Minute) Code Blue Activation

Case	Lead time (minutes)		
	Diagnosing I	**Evaluation I/ Diagnosing II**	**Evaluation II**
1	122	23	9
2	118	23	11
3	129	21	10
4	119	22	9
5	127	17	11
6	122	18	9
7	118	17	9
8	105	16	10
9	126	17	10
10	107	17	8
11	146	16	9
Mean	**122.1**	**18.8**	**9.5**

Based on the time distribution analysis in the Value Stream Mapping of the Code Blue activation process (Table 4.16), the average lead time decreased from 122.1 to 9.5 minutes—a reduction of 112.6 minutes (92.2%; $p < 0.001$). Waiting time dropped from 50.7 to 4.4 minutes (91.3%; $p < 0.001$), and cycle time from 38.9 to 5.1 minutes (86.8%; $p < 0.001$). Average value-added time decreased from 6.2 to 3.7 minutes (40.3%; $p < 0.001$), while non-value-added time fell from 36.5 to 1.5 minutes (95%; $p < 0.001$). The Value-Added Ratio increased from 7% to 39%, representing a 32% improvement in process efficiency ($p < 0.001$). All changes were statistically significant.

Table 14. Average Time Distribution in Value Stream Mapping of Code Blue Activation Process (in minutes)

Time in Value Stream Mapping	Pre (n=11)	Post (n=11)	Differences (minutes/%)	p-value
Lead Time (minutes)	122.1	9.5	(-) 112.6/92.2%	0.001
Waiting Time (minutes)	50.7	4.4	(-) 46.3/91.3%	0.001
Cycle Time (minutes)	38.9	5.1	(-) 33.8/86.8%	0.001
Value Added (minutes)	6.2	3.7	(-) 2.5/40.3%	0.001
Non Value Added (minutes)	36.5	1.5	(-) 35/95%	0.001
Value Added Ratio (%)	7%	39%	(+) 32%	0.001

The mean difference test (**Table 15**) shows significant changes in Stage 2 (Code Blue system activation) and Stage 3 (arrival of the secondary team), with p-values of 0.006 and 0.000, respectively. Stage 1 (initial nurse assessment) showed no significant difference. These findings suggest that Stages 2 and 3—both major contributors to total cycle time—still hold potential for further waste reduction and efficiency improvement.

Table 15. Detailed Percentage of Cycle Time to Total Waiting Time in the Code Blue Activation Process

Activities	Pre	Post	p-value
Initial assessment by inpatient nurse	48.7%	45%	0.548
Code Blue system activation	17.6%	35.9%	0.006
Arrival of secondary Code Blue team	12.8%	39.5%	0.001

Based on observations in the Value Stream Mapping (**Table 16**), the total process time decreased by 33.8 minutes after the intervention. The initial nurse assessment time dropped by 22.1 minutes ($p < 0.001$), Code Blue system activation by 7.2 minutes ($p < 0.001$), and secondary team arrival by 4.5 minutes ($p = 0.161$). These results indicate that most subprocesses achieved time efficiency, with statistically significant improvements.

Table 16. Detailed Percentage of Cycle Time to Total Waiting Time in the Code Blue Activation Process

Activities	Pre (minutes) (n=11)	Post (minutes) (n=11)	Difference (minutes)	*p-value*
Initial assessment by inpatient nurse	24	1.9	22.1	0.001
Code Blue system activation	8.7	1.5	7.2	0.001
Arrival of secondary Code Blue team	6.2	1.7	4.5	0.001
Total	38.9	5.1	33.8	

DISCUSSION

As one of the first studies in Indonesia to apply Lean Management in the context of Code Blue activation, this research aimed to evaluate process efficiency and identify areas of waste that hinder timely emergency response. This study revealed that the Code Blue activation process at the hospital was initially inefficient, with the majority of the timeline occupied by non-value-added (NVA) activities. The Value Stream Mapping (VSM) analysis conducted before the intervention recorded a total Lead Time (LT) of 122 minutes and a Cycle Time (CT) of 71 minutes, of which only 9 minutes (13%) were categorized as value-added (VA) activities. The remaining 87% represented various forms of inefficiencies. The Value Added Ratio (VAR) showed a substantial improvement following the Lean Management interventions. Initially, the VAR was only 7%, indicating a very low proportion of value-added activities compared to non-value-added time and falling far below the Process Cycle Efficiency (PCE) standard of more than 30%, which is commonly used to evaluate service flow efficiency in healthcare. After the interventions, the VAR increased significantly to 39%, reflecting a marked reduction in waste and a shift toward more value-focused, patient-centered processes. The present findings align with global evidence demonstrating that Lean-based interventions can significantly improve the timeliness and coordination of resuscitation workflows. By eliminating redundant verification steps, standardizing communication channels, and clarifying team responsibilities, Lean Management not only enhances procedural efficiency but also reduces cognitive overload among emergency staff during high-stress situations. Similar outcomes have been reported by Lisowska et al., (2025), who observed substantial workflow improvements in emergency departments following Lean-based reorganization (12), and by Gedikli (2025) who emphasized that identifying and addressing waste in emergency processes leads to better situational awareness and teamwork under pressure (13). Furthermore, Sutaşır et al., (2025) found that modern, Lean-oriented call response systems in Blue Code applications increased Return of Spontaneous Circulation (ROSC) rates, underscoring how Lean tools contribute to faster cognitive and procedural alignment among multidisciplinary teams (14). Thus, Lean implementation in this study appears to strengthen both the operational and cognitive dimensions of Code Blue team performance, fostering more synchronized, efficient, and outcome-driven emergency responses.

One of the most notable bottlenecks was the initial assessment conducted by inpatient nurses, which had the longest CT (53 minutes), yet only 5 minutes of that time were classified as VA. In addition, the Code Blue activation stage was identified as another critical area, with 22 minutes spent primarily on waiting. Although the hospital's SOP explicitly allows nurses to initiate Code Blue upon recognizing cardiac arrest, in practice, many nurses delayed activation while waiting for ward doctors to confirm the situation. This discrepancy between policy and practice has been shown to compromise response time and patient outcomes. The American Heart Association (2024) emphasizes that for every minute of delay in initiating cardiopulmonary resuscitation (CPR), a patient's survival chance decreases by 7–10% (15). The findings are consistent with Fadilah et al., (2024) who reported a statistically significant association between rapid response time and successful cardiac arrest management ($p = 0.008$), and Mitcel (2022), who underlined that Code Blue responses must ideally occur within five minutes for optimal patient outcomes (16,17).

Through a comprehensive waste analysis using the Borda method, the study identified the most critical types of waste as waste waiting (20.7%), waste defect (20.4%), and waste transportation (17%) before improvements were made. Waste waiting was the most dominant inefficiency, which included delays due to waiting for doctors, medical equipment retrieval, operator responses, Code Blue announcements, and team arrival. These findings are in line with research by Kusdarmadji et al., (2021) who found that waste waiting accounted for 26% of inefficiencies in a hospital's hemodialysis service (18). Such excessive waiting not only prolongs clinical processes but also leads to dissatisfaction among patients and families (19).

The second type of critical waste, waste defect, was associated with errors in recognizing cardiac arrest, uncertainty in activation procedures, and lack of competence in performing life-saving interventions. These issues reflect both knowledge and resource gaps. Nurvidyaningrum (2021) found similar challenges in emergency services, where patients received insufficient information and medical devices were not always in proper condition, leading to compromised care (20). Additionally, waste transportation appeared in cases where staff had to travel between units to retrieve tools or where security personnel moved across floors to make announcements, showing that poor spatial planning and tool distribution added to the delays. These challenges mirror those described by Usman (2020) and Bhosekar et al., (2023) who emphasized the need for system-based, lean-oriented improvements to reduce unnecessary motion in hospital settings (21,22).

Following the root cause analysis, the hospital implemented multiple interventions under Planning Action I. These included in-house emergency training for nurses, regular Code Blue simulations, the procurement of emergency equipment such as crash carts and bedside monitors in each ward, layout adjustments to ensure faster access to tools, and updates to the Code Blue SOP. As a result, significant improvements were observed. Lead Time was reduced by 84.5% (from 122 to 18.8 minutes), and Cycle Time dropped by 84.6% (from 71 to 10.9 minutes). Waiting time decreased by 43.1 minutes, and NVA activities dropped from 63 minutes to only 6.9 minutes, a reduction of 89%. The VAR increased from 7% to 21%, marking a substantial shift toward a more value-focused and patient-centered response system. These outcomes align with findings from Souza et al., (2021)who reported that Value Stream Mapping-based lean interventions in healthcare settings can significantly reduce delays and streamline emergency workflows (23). Jacquet et al., (2018)similarly found that the provision of well-equipped and accessible emergency carts could reduce intervention time by 46–60%, directly improving survival rates in critical conditions (24). However, during the second diagnostic cycle, new issues emerged, including underutilization of emergency bags, unstandardized announcements by security, and mismatches between tool allocation and ward needs. These findings were consistent with previous studies showing that irrelevant or poorly designed Standard Operating Procedures (SOPs), lack of regular evaluation, and insufficient communication and socialization can lead to inefficiency and reduced healthcare effectiveness (25,26). Consequently, further improvements were implemented through Planning Action II. These included focused socialization of emergency bag contents, quick-access drills, sudden Code Blue simulations, standardized layouts and labeling of emergency equipment, scheduled SOP evaluations, and dynamic redistribution of bedside monitors and ECG machines based on real-time demand.

These actions led to further improvements. Lead Time decreased by 92.2%, waiting time dropped by 91.3%, and NVA activities were reduced by 95%, with all changes being statistically significant ($p < 0.001$). While the final response time of 9.5 minutes has not yet met the optimal standard of <5 minutes, the transformation of the system toward better coordination, preparedness, and staff confidence is evident. Fernandez Castelao et al., (2013) emphasized that rapid access to tools, clear communication, and teamwork are essential for efficient resuscitation. Additionally (27), regular simulations as promoted by Weaver et al., (2014) and Matson (2023) were shown to significantly improve the clinical performance of nursing teams under high-pressure conditions (28,29). However, while the magnitude of improvement is remarkable, several contextual factors must be considered when interpreting these results. The study involved a relatively small number of Code Blue events within a single-site hospital, which may limit the statistical power and external validity of the findings. The hospital's moderate size, cohesive emergency response team, and supportive leadership may have uniquely facilitated rapid implementation, meaning that similar outcomes may not be immediately replicable in larger or more complex institutions. Additionally, the short observation period captures early improvements but not long-term sustainability.

The application of Lean Management principles and Value Stream Mapping at Hospital significantly enhanced the efficiency of the Code Blue activation process. Through structured problem-solving, targeted training, tool standardization, and layout optimization, the hospital developed a safer and more responsive system that holds the potential to improve outcomes and save lives in critical care situations. A similar study by Meidawati & Arini (2024) demonstrated that the implementation of Lean Management in an emergency department successfully reduced physician response time by an average of 1 minute and 29.82 seconds (30). Their findings highlight how Lean methods effectively identify and eliminate non-value-adding activities (waste), supporting the transformative impact observed at hospital. Furthermore, improving awareness, continuous training, and adequate resource allocation is essential to overcoming complex systemic hurdles and ensuring the sustainability of healthcare quality improvements.

Strengthening these aspects not only enhances staff competency and preparedness but also supports the creation of a more resilient and adaptive healthcare system (25,31).

This study makes a distinctive contribution to the international literature on Lean Management in emergency care by applying a structured, two-cycle action research model within a resource-limited hospital context—an approach rarely documented in global Lean scholarship. While most existing studies have focused on Lean applications in high-income settings such as emergency departments, outpatient flow, and surgical units, the integration of Lean principles into Code Blue or in-hospital cardiac arrest (IHCA) systems remains limited (7,22). Recent research, such as that by Alamri et al., (2024) in Saudi Arabia and Nelson et al., (2024) in the United States, underscores the urgency of optimizing emergency response structures through workflow redesign and nurse-led rapid interventions (32,33). Similarly, Han & Cheng, (2024) highlight the value of integrated pre-hospital alert systems to reduce activation delays, reinforcing the global movement toward rapid-response efficiency (34). Distinct from these initiatives, the present study advances the discourse by combining Lean tools—namely Value Stream Mapping and the Borda prioritization method—within a participatory action research framework to optimize both procedural and cognitive dimensions of emergency response. This approach redefines Lean not merely as a cost-efficiency mechanism but as a holistic systems-thinking strategy that strengthens communication, coordination, and situational awareness in high-pressure medical environments. Consequently, the study contributes a replicable model for developing countries seeking sustainable, evidence-based Lean interventions in critical care operations.

Limitations and Cautions

Despite its positive outcomes, this study has several limitations. First, it was conducted in a single-site setting, which may not reflect variations in organizational culture, resources, or workflows across different hospitals. Second, the relatively short intervention period may not fully capture the long-term sustainability of the improvements achieved. These factors may restrict the generalizability of the findings to broader healthcare settings.

Recommendations for Future Research

Future research should build on this study by examining the impact of Lean Management on key clinical outcomes such as Return of Spontaneous Circulation (ROSC), survival-to-discharge, and post-resuscitation neurological recovery in cardiac arrest cases. Future investigations could also explore how Lean-driven process optimization influences interprofessional communication, cognitive workload, and decision-making accuracy during emergency events. The integration of Lean principles with digital health technologies—such as real-time Code Blue dashboards, automated alert systems, electronic incident logs, and AI-based patient monitoring—represents a promising avenue for enhancing both responsiveness and data-driven decision-making. Beyond Code Blue, Lean methods could be systematically applied to other time-sensitive hospital processes, including emergency triage, operating room turnover, medication administration in critical care, and intensive care unit (ICU) transition workflows, all of which share similar challenges in coordination, handover accuracy, and timeliness. In addition, simulation-based and virtual reality (VR) training environments could be used to strengthen team readiness, reinforcing procedural standardization while fostering situational awareness under realistic high-pressure conditions. Larger-scale, multicenter quantitative studies are warranted to validate the generalizability of Lean-based interventions and to examine cross-institutional variations in implementation outcomes. Finally, extending the action research into a third or continuous cycle could support sustainability testing, ensuring that activation response times remain consistently under five minutes—an international benchmark for high-performing resuscitation systems—and enabling hospitals to embed Lean principles into long-term patient safety culture.

CONCLUSION

This study demonstrated that the implementation of lean management significantly improved the efficiency of Code Blue activation response time at hospital. The most critical forms of waste identified were waiting (20.7%), defects (20.4%), and transportation (17%), largely caused by inadequate staff competencies, undefined roles, unavailability of emergency equipment, and suboptimal spatial layout. The success of the intervention was supported by strong managerial commitment, multidisciplinary team collaboration, and the presence of an existing SOP, while key challenges stemmed from the process inefficiencies themselves. Through two action research cycles, various targeted improvements were implemented, including emergency response training, equipment availability optimization, layout adjustments, and enhanced communication systems. These interventions resulted in a substantial reduction in response time from 122.1 minutes to 9.5 minutes ($p < 0.00$), with significant decreases in waiting time (91.3%), total cycle time (86.8%), and non-value-added activities (95%), alongside an improvement in the value-added ratio from 7% to 39%. These findings imply that lean management can serve as a practical and effective strategy for improving emergency response processes in hospital settings, with potential policy implications for broader healthcare quality improvement initiatives.

Despite its positive outcomes, the study was limited by its single-site focus and relatively short intervention period, which may restrict the generalizability of results. Future research is recommended to examine the impact of lean management on clinical outcomes, such as Return of Spontaneous Circulation (ROSC) rates and cardiac arrest mortality. Integrating lean approaches with real-time monitoring technologies—such as AI-based dashboards to track equipment readiness, staff availability, and response durations—presents a promising direction. The development of immersive training methods using digital simulation or virtual reality could further strengthen team readiness, particularly in early recognition and management of cardiac arrest. Large-scale, multi-center studies are needed to assess Code Blue effectiveness at the national level. Additionally, future researchers may consider extending the intervention into a third cycle to further reduce response time to below five minutes. Beyond its immediate operational gains, the sustainability of Lean implementation depends on continuous staff engagement, leadership commitment, and institutional integration into hospital quality assurance frameworks. Embedding Lean principles into staff training, performance evaluation, and hospital policy can ensure long-term adherence and cultural transformation toward continuous improvement. Policymakers and hospital administrators are encouraged to adopt Lean-based standard operating procedures (SOPs) and performance indicators at the institutional and regional levels to strengthen system-wide emergency response readiness and resilience.

AUTHOR'S CONTRIBUTION STATEMENT

Author 1 served as the lead investigator, preparing ethical clearance documents, developing implementation frameworks and draft instruments, training observers, collecting and analyzing data, and drafting the manuscript. Author 2 acted as the principal supervisor, coordinating the research proposal, overseeing all stages of diagnosing, planning, action, and evaluating, validating instruments and data analysis, guiding manuscript preparation, and reporting progress to institutional and funding bodies. Both authors reviewed and approved the final manuscript.

CONFLICTS OF INTEREST

All of the authors declare that they have no conflicts of interest. No financial or personal relationships with entities that might unduly affect the authors' objectivity were identified. The authors have no financial or personal relationships with entities that might unduly affect their objectivity. The authors confirm that there are no known conflicts of interest associated with this publication.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors made limited use of ChatGPT (OpenAI) to assist with language refinement, sentence restructuring, and improvement of clarity and readability. The tool was not employed to create scientific content, generate ideas, analyze data, or interpret findings. All core components of the study, including the research design, analysis, and conclusions, were independently developed by the authors, ensuring compliance with academic integrity and ethical standards in scientific publishing.

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