Impacts of the COVID-19 Pandemic on the CODE ST-Segment Elevation Myocardial Infarction Program: A Quantitative and Qualitative Analysis

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ABSTRACT

Background: *The CODE ST-segment elevation myocardial infarction (STEMI) program is an operational standard of integrated service for STEMI patients carried out by Dr. Cipto Mangunkusumo Hospital. The emerging coronavirus disease 2019 (COVID-19) outbreak brought about many changes in the management of healthcare services, including the CODE STEMI program. This study aimed to evaluate the healthcare service quality of the CODE STEMI program during the COVID-19 pandemic based on the Donabedian concept.* ***Methods:*** *This was a mixed-methods study using quantitative and qualitative analyses. It was conducted at the Dr. Cipto Mangunkusumo Hospital, a national referral hospital in Indonesia. We compared the data of each patient, including response time, clinical outcomes, length of stay, and cost, from a two-year period between 2018–2020 and 2020–2022 as the pre-COVID-19 CODE STEMI and COVID-19 CODE STEMI periods, respectively. Interviews were conducted to determine the quality of services from the perspectives of stakeholders.* ***Results:*** *A total of 195 patients participated in the study: 120 patients in pre-COVID-19 CODE STEMI and 75 patients in COVID-19 CODE STEMI. Our results showed that there was a significant increase in patient's length of stay during the COVID-19 pandemic (4 days vs. 6 days, $p < 0.001$). Meanwhile, MACE (13% vs. 11%, $p = 0.581$), the in-hospital mortality rate (8% vs. 5%, $p = 0.706$), door-to-wire crossing time (161 min vs. 173 min, $p = 0.065$), door-to-needle time (151 min vs. 143 min $p = 0.953$), and hospitalization cost (3,490 USD vs. 3,700 USD, $p = 0.945$) showed no significant changes. In terms of patient satisfaction, patients found CODE STEMI during COVID-19 to be responsive and excellent.* ***Conclusion:*** *The implementation of the CODE STEMI program during the COVID-19 pandemic revealed that modified pathways were required because of the COVID-19 screening process. According to the Donabedian model, during the pandemic, the CODE STEMI*

program's healthcare service quality decreased because of a reduction in efficacy, effectiveness, efficiency, and optimality. Despite these limitations attributed to the pandemic, the CODE STEMI program was able to provide good services for STEMI patients.

Keywords: *COVID-19, STEMI, CODE STEMI, health care service, Donabedian component.*

INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) is the most lethal emergency condition of acute coronary syndrome.[1] Immediate reperfusion plays an important role in preventing further damage to the myocardium. It is commonly known that the earlier STEMI is treated, the better the clinical outcome.[2] Regarding the management of STEMI patients, Dr. Cipto Mangunkusumo Hospital has implemented the CODE STEMI program. This program established a collaborative system for treating STEMI by evaluating its management starting from emergency department admission to definitive revascularization. Various benefits of the program have been obtained, both by patients and health care personnel, including improved service quality, reduced major adverse cardiac events (MACEs) and mortality rates, and reduced costs.[3] However, the emergence of coronavirus disease 2019 (COVID-19) brought about many changes in the management of healthcare services, particularly at the beginning of the pandemic.[4,5] Health services must change and modify services, including the CODE STEMI program, to prevent nosocomial transmission. This may have had an influence on the quality of services during that time.

Thus, in this study, we evaluated the healthcare service quality of the CODE STEMI program at Dr. Cipto Mangunkusumo Hospital during the COVID-19 pandemic by using Donabedian's concept.

METHODS

Study Design and Setting

This was a mixed-methods research using quantitative and qualitative methods. It compared the service quality of the CODE STEMI program before and during the COVID-19 pandemic using Donabedian's concept. The quantitative method was adopted by comparing the medical data of CODE STEMI patients before and during the COVID-19 pandemic. The qualitative method was applied through interviews to determine the quality of services from the perspectives of stakeholders. This research was conducted at the National Referral Center General Hospital, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia.

In 1966, Avedis Donabedian introduced an evaluation method using structure, process, and outcome elements, also known as the SPO model. Then, through the book *Introduction to Quality Assurance in Health Care*, published in 2003, Donabedian explained seven main components that can be used to assess the quality of health services: efficacy, effectiveness, efficiency, optimality, acceptability, legitimacy, and equity.[6] In this study, we used Donabedian's concept to evaluate the impact of the COVID-19 pandemic on the quality of services of the CODE STEMI program.

Study Participants

The research sample was obtained using a total sample technique according to the specified time limit. The participants were STEMI patients undergoing the CODE STEMI program. The CODE STEMI program is designed for STEMI patients who arrive at the hospital < 12 hours after the onset of symptoms. This time frame follows the recommendations of the European Society of Cardiology.[7] The management of the CODE STEMI program primarily consists of fibrinolytic and primary percutaneous coronary intervention (PPCI).

The exclusion criteria included STEMI patients with MACEs as comorbidities at admission and severe comorbidities, which could potentially influence the observed variables. Major adverse cardiac events at hospital

admission were defined as patients with STEMI presenting with stroke, acute decompensated heart failure, lethal arrhythmia, cardiac tamponade, pericarditis, cardiogenic shock, and death. Severe comorbidities included acute stroke, liver cirrhosis, chronic inflammation, sepsis, autoimmune disorders, and malignancies. In addition, patients with incomplete medical record data were excluded from the study.

The participants were divided into two groups: the pre-pandemic period group (September 15, 2018 to March 15, 2020) and the pandemic period group (March 16, 2020 to December 31, 2022). The duration of the pre-pandemic and pandemic periods was based on the day that the Indonesian government declared COVID-19 a national disaster in Indonesia.

The interview participants were determined using a purposive sampling approach to obtain the perspectives and experiences of health workers and patients. Six informants were interviewed in this study.

Assessment of Variables

We collected data on the basic characteristics of the CODE STEMI patients, including gender, age, cardiovascular risk factors, and CODE STEMI treatment options. The evaluation variables included categorical variables, such as clinical outcomes (MACEs and mortality), and numerical variables, such as door-to-needle time, door-to-balloon time, length of stay, and costs.

We collected data on the basic characteristics of the interview participants, including gender, age, education, and occupation. The data obtained from the interviews were processed based on the context of Donabedian's evaluation components. Each informant was asked different questions regarding their role in the program.

Data Analysis

The data were analyzed using the Stata program version 15.1. We compared the patient baseline characteristics and the assessment variables before and during the COVID-19 period. Chi-square and Mann–Whitney tests were used to analyze categorical and numerical variables, respectively. The interview data were grouped into structure, process, and outcome components. We used the triangulation method to confirm the validity of the information obtained.

Ethical Consideration

This research followed the guidelines of the Helsinki Declaration and was approved by the Ethics Committee of the Faculty of Medicine, Universitas Indonesia, under number KET-883/UN2.F1/ETIK/PPM.00.02/2021.

RESULTS

Quantitative Analysis

A total of 195 patients met the inclusion criteria, with 120 STEMI patients who underwent the CODE STEMI program before the COVID-19 pandemic and 75 STEMI patients who underwent the CODE STEMI program during the COVID-19 pandemic. **Table 1** presents the baseline patient characteristics of both groups, including gender, age, cardiovascular risk factors, and CODE STEMI treatment choices. The proportions of gender and age between the groups were found to be similar. There was a significant increase in hypertension as a cardiovascular risk factor in the pandemic period (54% vs. 79%, $p = 0.035$). Other cardiovascular risk factors showed no significant differences. In this study, fibrinolytic percentage was found to be significantly increased (3% vs. 16%, $p = 0.002$) along with a significant decrease in PPCI percentage (97% vs. 84%, $p = 0.002$).

During hospitalization, the clinical outcomes between the two groups showed no statistical significance for in-hospital MACE (13% vs. 11%, $p = 0.581$) and in-hospital mortality rate (7% vs. 5%, $p = 0.706$) (**Table 2**). The result for response time showed no statistically significant differences in door-to-wire crossing time (161 min vs. 173 min, $p = 0.065$) and door-to-needle time (151 min vs. 143 min $p = 0.953$). Hospitalization cost also showed no statistically significant difference (3,490 USD vs. 3,700 USD, $p = 0.945$). Meanwhile, the length of stay was significantly longer during the COVID-19 pandemic (4 days vs. 6 days, $p < 0.001$) (**Table 3**).

Qualitative Analysis

The qualitative method was carried out through interviews to determine the quality of services from the perspectives of stakeholders. **Table 4** shows the characteristics of the informants.

Table 1. CODE STEMI patients' baseline characteristics.

Characteristics	Pre-COVID-19 CODE STEMI (n = 120)	COVID-19 CODE STEMI (n = 75)	*p*-value
Gender - n (%)			
Male	102 (85)	64 (85)	0.949
Female	18 (15)	11 (15)	
Age - median (range)	53 (48-61)	55 (48–61)	0.670
Risk factors n (%)			
Diabetes	55 (46)	32 (43)	0.665
Hypertension	65 (54)	52 (79)	0.035*
Dyslipidemia	43 (36)	30 (40)	0.559
Obesity	13 (10.8)	7 (9.3)	0.737
Acute Kidney Injury	22 (18)	15 (20)	0.773
Chronic Kidney Disease	12 (10)	9 (12)	0.661
CODE STEMI treatment - n (%)			
Primary PCI	116 (97)	63 (84)	0.002*
Fibrinolytic	4 (3)	12 (16)	0.002*

Values are median (range) or n (%).
PCI = percutaneous coronary intervention
*Significant difference.

Table 2. Comparison of clinical outcomes in CODE STEMI patients before and during the COVID-19 pandemic.

Variables	Pre-COVID-19 CODE STEMI (n = 120)	COVID-19 CODE STEMI (n = 75)	p-value
In-hospital MACE - n (%)			
Yes	16 (13)	8 (11)	0.581
No	104 (87)	67 (89)	
In-hospital mortality - n (%)			
Yes	8 (7)	4 (5)	0.706
No	112 (93)	71 (95)	

Values are means ± SDs, medians (IQR), or n (%).
MACE = Major adverse coronary event.

Table 3. Comparison of response time, length of stay, and cost in CODE STEMI patients before and during the COVID-19 pandemic.

Variables	Pre-COVID-19 CODE STEMI (n = 120)	COVID-19 CODE STEMI (n = 75)	*p*-value
Door-to-needle time (min)	151 (64-226)	143 (77-219)	0.953
Door-to-wire crossing time (min)	161 (131-220)	173 (148-238)	0.065
Length of stay (days)	4 (4-6)	6 (5-7)	<0.001*
Cost (USD)	3,490 (3,160 – 4,550)	3,700 (3,100 –5,400)	0.945

Values are means ± SDs, medians (IQR), or n (%).
*Significant difference.

Table 4. Demographic characteristics of the informants.

Number of the informant	Sex	Age	Education	Job
1	Male	50	Cardiology specialist	Physician
2	Male	39	Emergency medicine specialist	Physician
3	Female	42	Bachelor's	Nurse
4	Female	39	Bachelor's	Nurse
5	Male			Patient
6	Male			Patient

The structural components of the CODE STEMI program can be categorized into policy and operational preparedness, facility, and providers. The interview with the informants suggested that the CODE STEMI program had a good preparation in terms of policy:

Participant 1: "*There were policy changes to adjust to pandemic conditions and to avoid transmission between fellow patients and health workers."*

Participant 3: *"During the pandemic, there was a change in the flow of the CODE STEMI program, which required COVID-19 examination (i.e., polymerase chain reaction [PCR]); patients with onset of chest pain < 12 h without contraindications to fibrinolytic agents and confirmed to have COVID-19 were suggested to have fibrinolytic first."*

In terms of facilities, several obstacles were encountered during the implementation of the CODE STEMI program during the pandemic, especially during its early days, when additional tools, such as PCR tests and swabs, were still very limited, and it took days for test results to come out. In addition, the supply of personal protective equipment (PPE) was still limited, and the cardiac catheterization room was not yet negatively pressured to facilitate infectious patients.

Participant 1: "*At the beginning of the pandemic, there were difficulties in handling STEMI patients with suspected COVID-19 because they had to wait for the PCR results, which took a very long time. Alternatively, according to the guidelines of the Dr. Cipto Mangunkusumo Hospital, patients were administered thrombolytics and temporarily isolated.*"

Participant 2: "*The relatively high shortage of PPE, especially at the beginning of the pandemic, was due to people still adapting to the pandemic.*"

Participant 4: "*At the beginning of the pandemic, there were limitations to patients' life support equipment.*"

In terms of human resources, health workers were limited in the emergency department, while there was no lack of human resources in the cardiac ward.

Participant 3: "*There has never been a lack of human resources during the pandemic, especially during periods of high COVID-19 cases.*"

Participant 4: "*There were limited human resources in the emergency room, especially when there were confirmed COVID-19 patients.*"

During the COVID-19 pandemic, there were several plans in place, such as work-from-home arrangements:

Participant 1: "*The health status of medical workers remained a priority by implementing work from home, especially for the elderly.*"

The process component consisted of communication, the availability of drugs, and documentation. Based on the interviews that were conducted, communication during the COVID-19 pandemic was one of the informants' concerns:

Participant 1: "*Improving communication and coordination among health workers is important for better outcomes.*"

Participant 2: "*Getting an adequate history and physical examination, including difficulties obtaining an electrocardiogram examination, was challenging during the pandemic.*"

Most patients and their families have low to middle education levels, so some patients, especially at the beginning of the pandemic, were still in denial about COVID-19:

Participant 1: "*Patient and family responses at the beginning of the pandemic were mostly denials, but over time, after a lot of information, they understood.*"

Participant 2: "*When a patient passed away because of suspected COVID-19, the family did not accept it; there was denial, particularly when the body of the patient was treated differently.*"

Participant 3: "*Because of clinical and radiological similarities between COVID-19 and STEMI, especially in the complication stage (i.e., myocarditis and pulmonary edema), patients and families did not accept if the test results were positive for COVID-19.*"

Through a change in policy in the administration of fibrinolytic, drug availability and accessibility were ensured:

Participant 2: *"For cardiac therapy, there were no difficulties with device and drug availability."*

Participant 4: *"There are no drug limitations,*

including fibrinolytic agents."

An aspect that was improved during the pandemic was the data recording process. Enhanced electronic-based recording was successfully implemented to reduce the risk of infection exposure:

Participant 1: "*Recording and documentation were accelerated through electronic medical records [EMRs]. Communication was accelerated through online platforms.*"

The outcome component consisted of the patient's clinical outcomes and satisfaction levels. Based on the interviews conducted, one informant said that the condition of a patient was worsened by the presence of COVID-19 infection.

Participant 4: "*During the COVID-19 pandemic, the condition of a STEMI patient was exacerbated by a positive COVID-19 diagnosis."*

From the perspective of patient satisfaction, it was found that the patients felt that the CODE STEMI program during COVID-19 was responsive and provided good service.

Participant 5: "*Based on my experience as a patient, pandemic conditions did not complicate patient care. The services provided by the ER were swift. I did not have to wait for a long time. The medical staff who served me were very helpful and provided quite comprehensive information. The funding was done using National Health Insurance, so there were no additional costs that needed to be paid by patients."*

Participant 6: "*In my experience as a patient, the services provided were good. Nothing was difficult when I arrived in the ER. At that time, the ER was very full and chaotic, but I realized that all procedures had to be carried out to determine whether a patient had COVID-19. In my opinion, additional examinations, such as the PCR swab, are necessary. I'm not bothered by that."*

DISCUSSION

The CODE STEMI program at the Dr. Cipto Mangunkusumo Hospital has been in operation since 2017 and is constantly being improved. In previous studies, we evaluated the service quality of the CODE STEMI program by demonstrating numerous benefits from both clinical and managerial aspects.[3] Nonetheless, many changes in the CODE STEMI program during the COVID-19 pandemic could have made an impact on service quality. **Figure 1** illustrates the changes in the algorithm before and during the COVID-19 pandemic.

In this study, fewer patients met the inclusion criteria for the CODE STEMI program in the pandemic period compared to the pre-pandemic period (120 vs. 75, $p = 0.949$). This could be due to a decrease in the total number of patients who visited the Dr. Cipto Mangunkusumo Hospital during the COVID-19 pandemic. The same conditions were also experienced in various health centers during the COVID-19 pandemic worldwide.[8–11] Limited access because

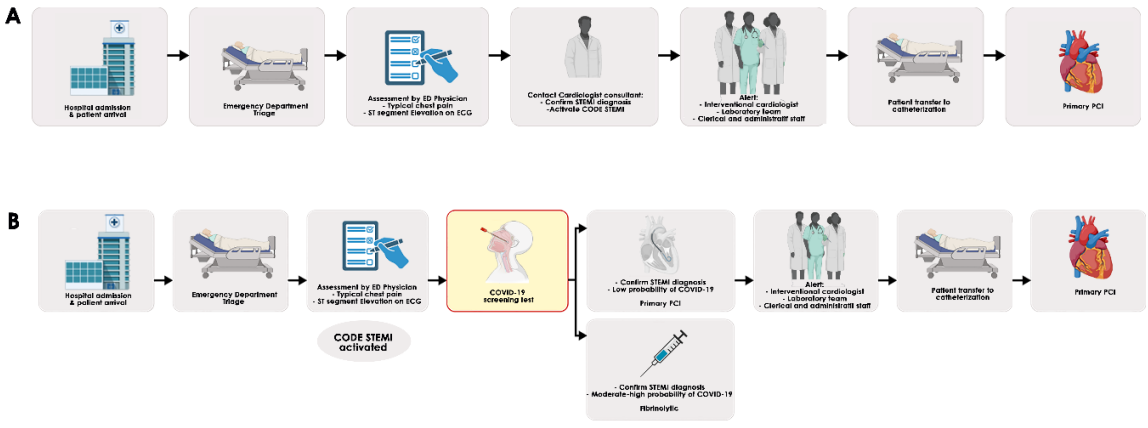

Figure 1. Illustration of the algorithm of the CODE STEMI program before the COVID-19 pandemic (A) and during the COVID-19 pandemic (B). Created with Biorender.com premium license by Eka Ginanjar.

of lockdowns and the fear of being exposed to the virus contributed to the decrease in hospital admission rates of STEMI patients.[12,13] In addition, the CODE STEMI program is intended for STEMI patients with a symptoms-to-hospital duration < 12 h; thus, this condition is difficult to achieve because the symptoms-to-hospital time in STEMI patients during the pandemic was reported to be prolonged.[14,15] As a result, patients with prolonged time are unable to enter the CODE STEMI program algorithm.

During the pandemic, PPCI remained the main recommendation for treating patients with STEMI. Primary percutaneous coronary intervention is associated with better outcomes in patients with STEMI compared with thrombolysis. Following World Health Organization guidelines, all health workers in catheterization labs are required to wear appropriate PPE.[16] The American Heart Association recommends a negative pressure lab specialized for patients with positive COVID-19 results.[17] However, as the informant stated, the availability of PPE was limited. In addition, providing a negative pressure catheterization lab was not possible because of hospital conditions. With these considerations, thrombolytics were prioritized as the initial drugs for STEMI patients without thrombolytic contraindications.[16] According to this study, there was an increase in the percentage of procedures administering thrombolytics during the COVID-19 pandemic (3% vs. 16%, $p = 0.002$).

We observed some variable components, which included response time (i.e., door-to-wire crossing time) and clinical outcomes (i.e., MACEs and mortality), that can be considered components of efficacy and effectiveness. According to our findings, there was an increased door-to-wire crossing time during the COVID-19 pandemic, but this was not statistically significant (161 vs. 173, $p = 0.065$). This condition may have occurred because of the influence of the addition of COVID-19 screening procedures as part of the CODE STEMI algorithm. The CODE STEMI algorithm during the pandemic recommends that STEMI patients with a symptoms-to-hospital duration < 12 h and a probability of being infected with COVID-19 be prioritized for fibrinolytic as long as there are no contraindications, while patients must be confirmed negative for COVID-19, preferably for PPCI. The screening system for COVID-19 status for the patients included medical history, physical examination, chest X-ray, PCR test, and laboratory tests. Especially at the beginning of the pandemic, the availability of PCR equipment was very limited, and the process took quite a long time. This resulted in delays in patient treatment. Delayed reperfusion, especially PPCI, was also experienced in various countries around the world, such as China, England, France, the Netherlands, and Pakistan.[14,18–21] This delay in response time may have affected MACEs and mortality. These rates were more likely to increase during the COVID-19 pandemic compared to the pre-COVID-19 CODE STEMI period. Thus, it may indicate that there was a reduction in the efficacy and effectiveness of the CODE STEMI program during the COVID-19 pandemic.

To evaluate efficiency, we can refer to the amount of healthcare service benefits and the costs of these healthcare services. The benefits of health care services can be observed by assessing MACEs, mortality, and length of stay. Our study found no statistically significant differences in clinical outcomes, such as in MACEs (13% vs. 11%, $p = 0.581$) and mortality (7% vs. 5%, $p = 0.706$). However, there was a significant prolonged duration of the length of stay, indicating a reduction in benefits. The inadequate laboratory capacity for PCR in Indonesia at the beginning of the pandemic led to delays in diagnosing COVID-19 and performing reperfusion therapy.[22] This delay also contributed to a greater incidence of MACEs and mortality, a longer length of stay, and greater costs. This increased length of stay during the COVID-19 pandemic was also experienced in various countries, such as China and India.[23,24] Therefore, based on the results of the data analysis, the efficiency of healthcare services in the CODE STEMI program was reduced during the COVID-19 pandemic.

The optimality component can be evaluated by comparing the obtained profit and the costs expended. A program can be said to be optimal

if it has achieved maximum effectiveness at a low cost. In this study, we found that during the COVID-19 pandemic, the CODE STEMI program experienced reduced effectiveness and increased costs. Therefore, it can be said that it was less than optimal at the time.

Physical distancing was implemented to prevent the transmission of COVID-19 infection. However, physical distancing had a negative impact on communication during the pandemic. As the informants stated, communication problems occurred not only between health care staff but also between health care staff and the patients/families themselves. Our results are similar to those of other studies in that the use of telehealth entailed several limitations, including the inability to effectively assess and treat patients.[25] Nevertheless, there was innovation in the use of EMRs. This research highlights the benefits of EMRs in helping prevent the transmission of COVID-19. The use of EMRs is known to have various benefits, such as facilitating easy access to patient health information that is considered accurate and reliable by health care providers.[26]

Acceptability is defined as conformity to the wishes, desires, and expectations of patients and their families, while equity is defined as conformity to a principle that determines what is just and fair in the distribution of health care and its benefits among members of the population.[6] Despite the inevitable delays in treatment because of mandatory infection control procedures and changes in reperfusion strategies during the outbreak, the patients believed that medical personnel handled their tasks properly and efficiently. The patients stated that there were no management issues as a result of the COVID-19 pandemic.

Legitimacy is defined as conformity to social preferences, as expressed in ethical principles, values, norms, mores, laws, and regulations.[6] Changes in the CODE STEMI program were made based on international recommendations and guidelines, which were adapted to local conditions.

Limitations

This was a single-center study, and the data were specific, as they were obtained from a single institution. The small number of samples included in the study may have affected the results. Thus, increasing the number of samples and extending the time covered in the sampling technique can be considered in future research to obtain better results.

CONCLUSION

The implementation of the CODE STEMI program during the COVID-19 pandemic revealed that modified pathways are required because of the COVID-19 screening process. According to Donabedian, during the pandemic, the CODE STEMI program's healthcare service quality decreased because of a reduction in efficacy, effectiveness, efficiency, and optimality. Despite these limitations brought about by the pandemic, the CODE STEMI program was able to provide good services for STEMI patients.

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