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# Effect of an educational program on nurses' knowledge and practice regarding myocardial infarction management at Al-Thawra Hospital, Sana'a, Yemen

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## Abstract

# Background

Myocardial infarction (MI) remains a major cause of morbidity and mortality worldwide, particularly in low- and middle-income countries. Nurses in critical care settings play a key role in the early recognition and management of MI. This study evaluated effect of an educational program on nurses' knowledge and practice regarding MI management at Al-Thawra Hospital, Sana'a, Yemen.

# Methods

A pre-experimental, one-group pretest–posttest design was employed. Census sampling was used to invite all eligible nurses working in the Emergency Intensive Care Unit (ERICU) and Medical Coronary Care Unit (MCCU). Of 54 nurses initially identified, six participated in the pilot study and one did not meet the eligibility criteria; therefore, 47 nurses were included in the main study. Data were collected using a structured knowledge questionnaire and an observational clinical practice checklist. Pretest and posttest scores were compared using the Wilcoxon signed-rank test, while Bowker's test of symmetry assessed changes in categorical knowledge and clinical practice levels.

# Results

Significant improvements were observed in all assessed outcomes. The median general knowledge score increased from 39 to 48 ($Z = -5.674$, $p < 0.001$, $r = 0.83$), and the median specific MI knowledge score increased from 33 to 42 ($Z = -5.257$, $p < 0.001$, $r = 0.77$). Significant changes were observed in general and specific knowledge levels ($\chi^2 = 25.108$ and 20.063, respectively; both $p < 0.001$). At posttest, 39 nurses had high general knowledge and 33 had high specific knowledge. The median clinical practice score increased from 139 to 171 ($Z = -5.969$, $p < 0.001$, $r = 0.87$), with a significant change in clinical practice levels ($\chi^2 = 30.000$, $p < 0.001$).

# Conclusion

The educational program was associated with significant improvements in nurses' knowledge and clinical practice regarding MI management. Regular continuing education supported by standardized, evidence-based protocols may strengthen nurses' competencies in critical care. Further controlled or randomized studies with larger and more diverse samples are needed to assess the sustainability of these improvements.

## Introduction

Cardiovascular diseases (CVDs) are the leading cause of death globally. Estimated to be 17.9 million people died from CVDs in 2019, representing 32% of all global deaths. Of these deaths, 85% were due to heart attack and stroke [1]. MI is one of the life-threatening coronary events with sudden cardiac death. Also, it is one of the major causes of mortality and morbidity worldwide, with approximately 10% of patients admitted to emergency departments with chest pain each year receiving this diagnosis [2, 3]. According to the world health organization, acute coronary syndromes (ACS) are the leading cause of morbidity and mortality globally, accounting for over 7 million deaths every year [4]. MI is a type of ACS and is the most common coronary heart disease lesion, with prevalence approaching three million people worldwide and over one million deaths annually in the United States alone [5].

In low- and middle-income countries like Yemen, MI has been described as an invisible epidemic in the 21st century, occurring at a relatively younger age and often associated with a heavy burden of modifiable risk factors, including smoking, hypertension, diabetes, dyslipidemia, and local habits like khat chewing. A study conducted at Al-Thawra Hospital in Sana'a reported that 386 patients with confirmed acute myocardial infarction were admitted over three years; 90.2% were men with a mean age of 54 years, and the most prevalent risk factors were khat chewing 88%, smoking 81%, diabetes mellitus 25% and hypertension 18%. The in-hospital mortality rate reached 14.2% [6]. More recent Yemeni studies have confirmed that the burden of MI and ACS remained high. At Al-Thawra cardiac center in Sana'a, 39% of 637 patients with ACS developed acute heart failure, with a median age of 51 years and a very high prevalence of khat chewing 88%, hypertension 53%, diabetes 40%, and late presentation (> 12 hours from symptom onset) in more than half of patients; none of these patients received primary percutaneous coronary intervention [7].

In addition, a quarter 25% of patients with ST-segment elevation myocardial infarction (STEMI) experienced MI with non-obstructive coronary arteries (MINOCA), and there was a significant occurrence of khat chewing among these patients [8]. A separate study emphasized a significant increase in the mortality rate for ACS during hospitalization, which subsequently increased over an extended period of time [9]. According to the gulf registry of acute coronary events, Yemen has a high in-hospital mortality rate of 10% for STEMI, which is much higher than other Gulf countries [10]. Despite the substantial burden of ACS in Yemen, evidence regarding nurses' knowledge and clinical practice in MI management remains limited.

Nurses working in ERICU and MCCU require adequate knowledge and practical competencies to recognize clinical deterioration, initiate timely interventions, and prevent complications. Structured continuing education may provide an effective approach to strengthening these competencies, particularly in settings where access to ongoing professional development and standardized clinical protocols is limited. Therefore, this study aimed to evaluate the effect of an educational program on nurses' knowledge and practice regarding MI management at Al-Thawra Hospital, Sana'a, Yemen.

# Materials and Methods

# Study design

A pre-experimental, one-group pretest–posttest design was employed. Nurses' knowledge and clinical practice regarding MI management were assessed immediately before the educational intervention and reassessed two weeks after completion of the program. Because the study did not include a control group or random allocation, observed pretest–posttest changes were interpreted as associations with exposure to the educational intervention rather than definitive evidence of causality.

## Study setting

The study was conducted in the ERICU and MCCU of Al-Thawra Hospital, Sana'a, Yemen. Data collection was conducted from July to September 2025.

## Sample size and sampling method

No formal sample size or power calculation was performed because census sampling was used to recruit all eligible nurses available in the accessible study population. The number of nurses working in the two target units (ERICU and MCCU) was relatively small (54 nurses); therefore, a census sampling approach was adopted. All nurses who met the eligibility criteria were invited to participate in the study. Of the 54 nurses employed in the two units, 6 participated in the pilot study and were excluded from the main study. Of the remaining 48 nurses, 1 was found to be ineligible. Consequently, 47 nurses were eligible for the main study and agreed to participate, including 30 nurses from the ERICU and 17 from the MCCU. Thus, the study included all nurses who were eligible for the main study and available in the accessible population during the study period.

## Study population and eligibility criteria

The study population comprised nurses working in the ERICU and MCCU at Al-Thawra Hospital, Sana'a, Yemen. The inclusion criteria were as follows: nurses working in the ERICU or MCCU, nurses holding a nursing diploma, bachelor's degree, or higher nursing qualification, nurses with at least one year of clinical work experience and nurses who agreed to participate in the study and provided informed consent. Nurses who did not meet the above eligibility criteria were excluded from the study.

## Variables and outcomes

The primary outcomes were nurses' knowledge and clinical practice regarding MI management. Knowledge was assessed in two domains: general knowledge regarding MI and specific knowledge regarding MI management. Clinical practice was assessed using an observational checklist covering key nursing procedures related to MI care. The primary comparison was the change in knowledge and

clinical practice scores from immediately before the educational intervention to two weeks after its completion. Secondary outcomes included changes in the categorical levels of general knowledge, specific knowledge, and clinical practice.

# Validity and reliability

The nurses' knowledge questionnaire was developed by the researcher following a review of relevant previous studies and current national and international clinical guidelines concerning the management of MI [11, 12]. The nurses clinical practice checklist was developed based on standardized clinical nursing skill checklists and evidence-based procedures for fundamental nursing clinical practice [13–15]. To establish content validity, the instruments were reviewed by a panel of three nursing experts. The experts assessed the clarity, relevance, comprehensiveness, and appropriateness of the items in relation to the study objectives and the local clinical context.

A pilot study involving approximately 10% of the intended sample was conducted before the main data collection to assess the clarity, applicability, feasibility, and acceptability of the instruments and to identify any items requiring modification. Nurses who participated in the pilot study were not included in the final study sample or analysis.

The instruments were initially developed in English, translated into Arabic, and subsequently back-translated into English to assess conceptual and linguistic equivalence between the two versions. The internal consistency of the instruments was assessed using Cronbach's alpha coefficient. The knowledge questionnaire demonstrated a Cronbach's alpha of 0.921, while the clinical practice checklist demonstrated a Cronbach's alpha of 0.911, indicating excellent internal consistency for both instruments.

To ensure consistency of the intervention, all subgroups received the same educational content, session duration, teaching materials, and sequence of theoretical and practical sessions. All sessions were delivered by the researcher using the same structured teaching plan and educational materials across all subgroups. No modifications were made to the educational intervention, session content, duration, or teaching methods after implementation commenced. No additional formal training or educational intervention related to MI management was provided to participants during the study period outside the educational program described above. No adverse events or unintended effects related to the educational intervention were reported.

## Data collection

Data were collected over a three-month period from July to September 2025. Throughout the data collection period, appropriate professional rapport was maintained with the participating nurses. Two methods of data collection were used. Nurses' knowledge was assessed using a self-administered questionnaire. The questionnaires were distributed to eligible nurses during their work shifts and

collected after completion. Nurses observed clinical practices were assessed through direct observation. The researcher observed nurses while they performed clinical procedures related to the care and management of patients with MI and documented their performance using the structured clinical practice checklist. Data were collected using two main instruments.

## Instrument I: Nurses' knowledge assessment questionnaire:

The knowledge questionnaire was developed by the researcher following a review of relevant previous studies and current national and international clinical guidelines related to MI management [11, 12]. The questionnaire consisted of closed-ended questions and was divided into three parts.

Part I: Demographic characteristics: This section collected information regarding the nurses' age, gender, marital status, educational level, years of clinical experience, unit of employment, previous training related to MI, and availability of a formal policy or protocol for MI management.

Part II: General knowledge regarding MI: This section consisted of 15 questions assessing nurses' knowledge of fundamental concepts related to MI, including the definition and types of MI, risk factors, signs and symptoms, diagnostic tests and investigations, complications, and prevention. Some questions included multiple correct response options, requiring participants to select all applicable answers. The maximum possible score for this section was 60 points.

Part III: Specific knowledge regarding the management of MI: This section consisted of 12 questions assessing nurses' knowledge of the medical and nursing management of MI. The items addressed immediate management, pharmacological and invasive/surgical interventions, and nursing interventions for patients with MI. Some questions included multiple correct response options. The maximum possible score for this section was 51 points.

# Instrument II: Nurses observed clinical practice checklist:

The nurses observed clinical practice checklist was developed and tested by the researcher based on standardized clinical nursing skill checklists and evidence-based procedures for fundamental nursing clinical practice [13–15]. The observational checklist was used to assess nurses' clinical performance in caring for patients with MI before and after the educational intervention.

The clinical practice assessment was conducted at two time points: immediately before the educational program to establish baseline clinical practice and two weeks after completion of the program to assess changes in the nurses' performance following the intervention. The observational checklist consisted of 116 procedural steps covering eight key areas of MI nursing care: cardiovascular system assessment is 10 steps, measurement of oxygen saturation using pulse oximetry is 16 steps, administration of oxygen therapy: 11 steps, cardiac monitoring is 15 steps, acquisition of a 12-lead electrocardiogram (ECG) is 21 steps, chest pain management is 21 steps, maintenance of cardiac tissue perfusion: 5 steps and prevention of bleeding during thrombolytic therapy is 17 steps.

# Educational intervention program

### Objectives

The educational intervention aimed to improve nurses' knowledge and practical competencies in the assessment and management of patients with MI, with particular emphasis on early recognition, cardiovascular assessment, ECG acquisition and monitoring, oxygen therapy, chest-pain management, maintenance of tissue perfusion, and prevention of complications. The educational intervention program was developed based on a review of relevant literature, clinical guidelines, and evidence-based principles concerning the knowledge and practical nursing skills required for MI management. The program was reviewed by three nursing experts with experience in critical care, medical-surgical nursing, and nursing education, who assessed the content for relevance, clarity, comprehensiveness, and appropriateness.

The program consisted of three phases: preparation, implementation, and evaluation. During the preparation phase, administrative approval was obtained from the relevant authorities at Al-Thawra Hospital, including the training affairs department, cardiac center, and emergency department. The purpose and procedures of the study were explained to eligible nurses, and written informed consent was obtained. Participation was voluntary, and confidentiality and anonymity were maintained throughout the study. The intervention was standardized and was not individually tailored to participants. All nurses received the same educational content and sequence, regardless of baseline knowledge or professional characteristics. To minimize disruption to clinical services and accommodate nurses' work schedules, the 47 participants were divided into nine subgroups: five subgroups from the ERICU (n = 30 and four from the MCCU (n = 17). During the implementation phase, each subgroup received four 45-minute sessions during official working hours in designated nursing rooms. The program comprised two theoretical and two practical sessions. Teaching methods included interactive lectures, group discussions, demonstrations, and return demonstrations, supported by audiovisual materials, including PowerPoint presentations, instructional videos, and educational booklets. The content and teaching methods for each session are presented in Table 1. During the evaluation phase, nurses' knowledge and clinical practical skills were assessed immediately before the intervention (pretest) and two weeks after completion of the program (posttest). The same knowledge questionnaire and observed- clinical practice checklist was used at both time points to assess changes following the intervention.

Table 1
Structure and content of the educational intervention program

| Component | Session | Duration | Content | Teaching methods |
|---|---|---|---|---|
| Theoretical | 1 | 45 min | Coronary anatomy and physiology; MI definition and classification; risk factors; pathophysiology; clinical manifestations. | Interactive lecture; discussion |
| Theoretical | 2 | 45 min | ECG interpretation; cardiac biomarkers; medical treatment; complications; patient education. | Lecture; discussion; audiovisual material |
| Practical | 3 | 45 min | Cardiovascular assessment; oxygen saturation; oxygen therapy; cardiac monitoring | Demonstration; return demonstration |
| Practical | 4 | 45 min | 12-lead ECG acquisition; chest-pain management; tissue perfusion; prevention and monitoring of bleeding during thrombolytic therapy. | Demonstration; return demonstration |

# Data analysis

Data were coded and analyzed using SPSS version 27. Descriptive statistics, including frequencies, percentages, and medians were used to summarize participant characteristics and study variables. Because knowledge and clinical practice scores were measured repeatedly in the same participants, pretest–posttest differences in scores were assessed using the Wilcoxon signed-rank test. This non-parametric test was selected because the assumptions required for a parametric paired-samples test were not adequately met. Changes in the categorical levels of nurses' knowledge and clinical practices between the pretest and posttest assessments were examined using the Bowker's test of symmetry. This test was appropriate for evaluating changes in paired categorical variables with more than two categories, such as low, moderate, and high levels. A two-sided p-value $< 0.05$ was considered statistically significant. Effect sizes were reported for the Wilcoxon signed-rank tests.

*Scoring system for nurses' knowledge*: The knowledge questionnaire consisted of multiple-response items, with some questions containing more than one correct answer. For each item, one point was awarded for each correct response that was selected and for each incorrect response that was correctly not selected. No points were awarded for incorrect responses that were selected or correct responses that were not selected. Thus, the scoring system assessed both the recognition of correct information and the identification and avoidance of incorrect information. The general knowledge section had a maximum possible score of 60 points, whereas the specific knowledge section had a maximum possible score of 51 points. The total scores for both knowledge components were computed by summing individual item scores. These raw scores were then converted into percentage scores of the maximum possible score and categorized as follows: low knowledge: ≤50% of total percentage scores, moderate knowledge: 51–74% of total percentage scores and high knowledge: ≥75% of total percentage scores.

These categories were used to assess changes in nurses' knowledge regarding MI and its management following the educational intervention.

*Scoring system for nurses' clinical practices*: The clinical practice checklist consisted of 116 procedural steps, with a maximum possible score of 232 points. Each procedural step performed correctly according to the established standard was assigned 2 points. A step performed incorrectly or incompletely was assigned 1 point, whereas a step that was not performed was assigned 0 points. The researcher directly observed each nurse while performing the specified clinical procedures and documented the observed performance using the structured clinical practice checklist. For each nurse, the total clinical practice score was calculated, with a maximum possible score of 232 points. The total scores were then converted into percentages of the maximum possible score and categorized as follows: low clinical practice: ≤50% of total percentage scores, moderate clinical practice: 51–74% of total percentage scores and high clinical practice: ≥75% of total percentage scores. These categories were used to assess changes in nurses' clinical practices regarding the management of MI following the intervention.

## Results

# Demographic and professional characteristics of nurses

All 47 nurses who participated in the main study completed the educational intervention and both the pretest and posttest assessments and were included in the final analysis. Table 2 presents the demographic and professional characteristics of the participating nurses. Of the 47 nurses, 21 (44.7%) were aged 27–32 years, and 30 (63.8%) were male. Most participants were married (63.8%) and held a diploma-level qualification (66.0%). Regarding clinical experience, 32 nurses (68.1%) had 1–5 years of experience. Thirty nurses (63.8%) worked in the ERICU, while 17 (36.2%) worked in the MCCU. Only 14 nurses (29.8%) reported having previously received training in MI management, whereas 33 (70.2%) had not. Similarly, 15 nurses (31.9%) reported the presence of a formal MI management policy at the hospital, while 32 (68.1%) reported that no such policy was present.

Table 2
Demographic and professional characteristics of nurses (n = 47)

| Variables | n | % |
|---|---|---|
| **Age (Years)** | | |
| 21–26 | 17 | 36.2 |
| 27–32 | 21 | 44.7 |
| ≥ 33 | 9 | 19.1 |
| **Sex** | | |
| Male | 30 | 63.8 |
| Female | 17 | 36.2 |
| **Marital status** | | |
| Unmarried | 17 | 36.1 |
| Married | 30 | 63.8 |
| **Educational level** | | |
| Diploma | 31 | 66.0 |
| Bachelor and above | 16 | 34.0 |
| **Clinical experience (Years)** | | |
| 1–5 | 32 | 68.1 |
| 6–10 | 11 | 23.4 |
| ≥ 11 | 4 | 8.6 |
| **Unit of employment** | | |
| ERICU | 30 | 63.8 |
| MCCU | 17 | 36.2 |
| **Previous training in MI management** | | |
| Yes | 14 | 29.8 |
| No | 33 | 70.2 |
| **Presence of a formal MI management policy at the hospital** | | |
| Yes | 15 | 31.9 |
| No | 32 | 68.1 |

*MI= myocardial infarction; ERICU= Emergency Intensive Care Unit; MCCU= Medical Coronary Care Unit.*

# Total general knowledge scores of nurses regarding MI

Table 3 presents the comparison of nurses' total general knowledge scores regarding MI before and after the educational intervention. Forty-one nurses demonstrated higher knowledge scores at posttest, five had lower scores, and one showed no change. The median general knowledge score increased from 39 pre-intervention to 48 post-intervention. The Wilcoxon signed-rank test demonstrated a statistically significant improvement in nurses' general knowledge regarding MI following the educational intervention (Wilcoxon signed-rank test, Z = − 5.674, p < 0.001, r = 0.83).

Table 3
Comparison of nurses' total general knowledge scores before and after the educational intervention (n = 47)

| Measure | Pretest Median | Posttest Median | Wilcoxon Z | *p*-value |
|---|---|---|---|---|
| Total general knowledge score | 39 | 48 | −5.674 | < 0.001 |

*Wilcoxon signed-rank test: Negative ranks = 5; positive ranks = 41; ties = 1.*

# Total specific knowledge scores of nurses regarding MI

Table 4 presents the comparison of nurses' total specific knowledge scores regarding MI before and after the educational intervention. Forty-one nurses demonstrated higher specific knowledge scores at posttest, five had lower scores, and one showed no change. The median specific knowledge score increased from 33 before the intervention to 42 after the intervention. The Wilcoxon signed-rank test demonstrated a statistically significant improvement in nurses' specific MI-related knowledge following the educational intervention (Z = − 5.257, *p* < 0.001, r = 0.77).

Table 4
Comparison of nurses' total specific knowledge scores before and after the educational intervention (n = 47)

| Measure | Pretest Median | Posttest Median | Wilcoxon Z | *p*-value |
|---|---|---|---|---|
| Total specific knowledge score | 33 | 42 | −5.257 | < 0.001 |

*Wilcoxon signed-rank test: Negative ranks = 5; positive ranks = 41; ties = 1.*

# General knowledge level of nurses regarding MI

Table 5 presents the distribution of nurses according to their general knowledge levels regarding MI pre and post the educational intervention. Overall, the findings demonstrated a marked shift toward higher knowledge levels following the intervention. Among the 18 nurses who had a low level of general knowledge at pre-intervention, 14 improved to a high level and 4 improved to a moderate level. Of the 15 nurses with a moderate level of knowledge at pre-intervention, 12 progressed to a high level, 2 remained at the moderate level, and 1 declined to a low level. Among the 14 nurses who had a high level of

knowledge at pre-intervention, 13 maintained a high level, while 1 shifted to a moderate level. Bowker's test of symmetry indicated that the distribution of general knowledge levels differed significantly between the pre- and post-intervention assessments ($\chi^2 = 25.108$, $p < 0.001$), demonstrating a statistically significant change in nurses' general knowledge levels following the educational intervention.

Table 5
General knowledge levels of nurses regarding MI pre and post the educational intervention

| Pre-intervention | Post- intervention | | | Total |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Low | 0 | 4 | 14 | 18 |
| Moderate | 1 | 2 | 12 | 15 |
| High | 0 | 1 | 13 | 14 |
| Total | 1 | 7 | 39 | 47 |

# Specific knowledge level of nurses regarding MI

Table 6 presents the distribution of nurses according to their specific knowledge levels regarding MI pre and post the educational intervention. Overall, the findings demonstrated notable shifts toward higher levels of specific knowledge following the intervention. Among the 16 nurses who had a low level of specific knowledge at pre-intervention, 7 improved to a moderate level, 7 improved to a high level, and 2 remained at the low level. Of the 17 nurses with a moderate level of specific knowledge at pre-intervention, 13 progressed to a high level, 2 remained at the moderate level, and 2 declined to a low level. Among the 14 nurses who had a high level of specific knowledge at pre-intervention, 13 maintained a high level, while 1 shifted to a moderate level. Bowker's test of symmetry demonstrated a statistically significant difference in the distribution of specific knowledge levels between the pre- and post-intervention assessments ($\chi^2 = 20.063$, $p < 0.001$), indicating a statistically significant change in nurses' specific knowledge levels following the educational intervention.

Table 6
Specific knowledge levels of nurses regarding MI before and after the educational intervention

| Pre-intervention | Post- intervention | | | Total |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Low | 2 | 7 | 7 | 16 |
| Moderate | 2 | 2 | 13 | 17 |
| High | 0 | 1 | 13 | 14 |
| Total | 4 | 10 | 33 | 47 |

# Total observed clinical practice scores of nurses regarding MI

Table 7 presents the comparison of nurses' total observed clinical practice scores before and after the educational intervention. The median total clinical practice score increased from 139 before the intervention to 171 after the intervention. All 47 nurses demonstrated higher post-intervention clinical practice scores, with no negative ranks or ties. The Wilcoxon signed-rank test showed a statistically significant improvement in observed clinical practice scores following the educational intervention ($Z = -5.969$, $p < 0.001$, $r = 0.87$).

Table 7
Comparison of nurses' total observed clinical practice scores before and after the educational intervention (n = 47)

| Measure | Pretest Median | Posttest Median | Wilcoxon Z | *p*-value |
|---|---|---|---|---|
| Total observed practice score | 139 | 171 | −5.969 | < 0.001 |

*Wilcoxon signed-rank test: Negative ranks = No; positive ranks = 47; ties = No.*

# Clinical practice levels of nurses regarding MI

Table 8 presents the distribution of nurses according to their clinical practice levels regarding MI patients pre and post the educational intervention. Overall, substantial positive shifts in clinical practice levels were observed following the intervention. Among the 17 nurses who had a low clinical practice level at pre-intervention, 10 improved to a high level, 6 improved to a moderate level, and 1 remained at the low level. Of the 15 nurses with a moderate clinical practice level at pre-intervention, 14 progressed to a high level, while 1 remained at the moderate level. All 15 nurses who had a high clinical practice level at pre-intervention maintained a high clinical practice level after the intervention, with no decline to a lower clinical practice level observed among this group. Bowker's test of symmetry demonstrated a statistically significant difference in the distribution of clinical practice levels between the pre- and post-

intervention assessments ($\chi^2 = 30.000$, $p < 0.001$), indicating a statistically significant change in nurses clinical practice levels following the educational intervention.

Table 8
Clinical practice levels of nurses regarding MI patients pre and post the educational intervention

| Pre-intervention | Post- intervention | | | Total |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Low | 1 | 6 | 10 | 17 |
| Moderate | 0 | 1 | 14 | 15 |
| High | 0 | 0 | 15 | 15 |
| Total | 1 | 7 | 39 | 47 |

# Discussion

The demographic characteristics of the participants indicate that the study sample was predominantly composed of relatively young nurses with limited professional experience. Nearly half of the participants were aged 27–32 years, and most nurses with clinical work experience from 1–5 years. The relatively young age and limited clinical experience of participants may reflect the workforce composition within the two participating units; however, the study was not designed to investigate factors influencing nurses' age or professional experience. Similar workforce patterns have been reported in previous studies [16–18], which identified early-career nurses as an important component of the workforce in intensive and cardiac care settings.

Male nurses constituted the majority of the study participants (63.8%). This distribution may be related to local cultural and workforce characteristics in Yemen and Iraq and is consistent with findings reported by [18] and [19]. In contrast, studies conducted in India and Egypt [1, 20] reported a predominance of female nurses. Such differences may reflect variations in cultural norms, nursing education, recruitment practices, and workforce composition across countries.

Regarding educational attainment, two-thirds of the participants (66.0%) held a nursing diploma. This finding is consistent with previous studies [18, 21, 22]. However, it differs from findings reported by [9] and [23], in which nurses with bachelor's degrees constituted the majority. This variation may be related to differences in national educational systems, professional licensing requirements, and staffing standards for critical care services.

An important finding at baseline was the limited exposure of nurses to previous MI-related training and the lack of standardized written hospital policies for MI care. More than two-thirds of the participants had not previously attended MI training, while a similar proportion reported the absence of written and standardized policies. The lack of structured institutional guidance may limit opportunities for nurses to

apply standardized, evidence-based approaches to the assessment and management of patients with MI. Previous studies [1, 18] have similarly identified inadequate continuing education and limited availability of standardized protocols as important challenges in the provision of emergency cardiac care. These findings highlight the need for institutional mechanisms that support continuing education and the implementation of standardized clinical guidelines.

The improvement in nurses' general knowledge following the educational intervention indicates that structured educational approaches can enhance understanding of MI-related concepts among nurses with different levels of baseline knowledge. The categorical findings further demonstrated movement from lower to higher knowledge categories, particularly among nurses who initially had limited knowledge. This pattern is consistent with previous studies [16, 18, 23, 24], which reported improvements in nurses' understanding of MI pathophysiology, risk factors, clinical manifestations, and related aspects following structured educational interventions.

Although clinical experience contributes to the development and consolidation of professional knowledge, the present findings suggest that formal educational interventions can provide an effective mechanism for addressing knowledge gaps within a relatively short period. This is particularly relevant in settings where nurses may have limited access to continuing professional education. The findings are therefore consistent with the view that workplace-based educational programs can complement clinical experience by providing nurses with structured and focused learning opportunities.

A similar pattern was observed in specific MI-related knowledge, including areas requiring more specialized clinical understanding, such as diagnostic assessment, 12-lead ECG interpretation, emergency pharmacology, and thrombolytic therapy. The improvement across knowledge categories suggests that targeted educational content can address specific competency gaps rather than only increasing general awareness of MI. This finding is in agreement with previous research [1, 9, 17, 25], which has demonstrated the value of tailored educational interventions in developing nurses specialized cardiac-care competencies.

The findings also have practical implications for continuing professional development. Specialized aspects of MI management require nurses to integrate theoretical knowledge with timely clinical decision-making. Educational programs that focus on clinically relevant content, case-based learning, and standardized approaches may therefore help strengthen nurses' preparedness to respond to patients with acute MI. However, knowledge acquisition alone does not necessarily ensure sustained competence; continued observed clinical practice, supervision, and periodic reinforcement are likely to be important for maintaining these competencies over time.

The improvement in clinical practice scores provides further evidence that the educational intervention was associated with changes not only in nurses' knowledge but also in their observed clinical practices. The shift toward higher clinical practice categories was particularly evident among nurses who had lower or moderate clinical practice levels before the intervention, whereas nurses who already demonstrated high clinical practice levels generally maintained their level. These findings are consistent

with previous studies [26–28], which reported improvements in nurses observed clinical practices following educational interventions addressing acute cardiac care.

The observed changes in clinical practice may be explained by the combination of theoretical instruction and practical application provided through the educational program. Improved knowledge of patient assessment, monitoring, emergency management, medication administration, and recognition of complications can provide nurses with a clearer framework for responding to patients with MI. Nevertheless, the sustainability of these changes should be considered. Continued supervision, access to standardized protocols, refresher training, and regular competency assessment may be necessary to maintain improvements in observed clinical practice and translate educational gains into consistent, evidence-based patient care.

# Strengths and limitations

This study has several strengths. First, the census approach included all eligible nurses working in the two participating units, reducing selection within the accessible study population. Second, the study assessed both knowledge and directly observed clinical practice, providing a broader evaluation of the educational intervention than knowledge assessment alone. Third, the measurement instruments underwent expert review, pilot testing, and internal consistency assessment. Finally, the intervention combined theoretical instruction with practical demonstration and return demonstration, allowing both cognitive and clinical competencies to be addressed.

Several limitations should be considered. First, the one-group pretest–posttest design did not include a control group or random allocation; therefore, maturation, testing effects, history, and other external factors cannot be excluded, and causal inference is limited. Second, the sample was small and drawn from two units within a single hospital, which limits the generalizability of the findings to other hospitals and healthcare settings. Third, the post-intervention assessment was conducted only two weeks after completion of the educational intervention program; therefore, the study evaluated short-term changes rather than sustained effects. Fourth, repeated administration of the same knowledge questionnaire may have introduced a testing effect. Finally, although clinical practice was assessed by direct observation, participants may have modified their behavior because they knew they were being observed (Hawthorne effect).

## Conclusion

The educational program was associated with significant short-term improvements in nurses' general and MI-specific knowledge and observed clinical practice. These findings support the potential value of structured continuing education for strengthening nurses' competencies in MI management. Regular educational programs, supported by standardized evidence-based protocols and clinical algorithms, may help reinforce these competencies in critical care settings. Further multicenter studies using controlled

or randomized designs, larger samples, and longer follow-up periods are needed to determine the effectiveness and sustainability of these improvements.

# Abbreviations

ACS: Acute Coronary Syndrome, CVDs: Cardiovascular Diseases, ECG: Electrocardiogram, ERICU: Emergency Intensive Care Unit, MCCU: Medical Coronary Care Unit, MI: Myocardial Infarction, MINOCA: Myocardial Infarction with Non-Obstructive Coronary Arteries, STEMI: ST-segment Elevation Myocardial Infarction.

# Declarations


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### Author contributions

S.M.A. conceived and designed the study, collected data, and drafted the main manuscript text. N.A.A. supervised the research process, performed the statistical analysis, provided critical guidance, and contributed to manuscript revision. A.S.A. collected data participating in conceived and designed the study All authors reviewed and approved the final manuscript.


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### Data availability and materials

The datasets generated and/or analyzed during the current study are not publicly available due to institutional restrictions but are available from the corresponding author on reasonable request.

### Ethics approval and consent to participate

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The study protocol was approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences, Al-Razi University, Sana'a, Yemen *[Approval No: RU/15/FMHS/2025]*. Also, ethical approval was obtained from the administration of Al-Thawra hospital. The objective of the study was clearly explained to all participants. Written informed consent was obtained from all participants prior to inclusion in the study. Participants had the right to refuse or withdraw participation at any time, and the confidentiality of

participants' information was strictly maintained and used solely for research purposes. All procedures were carried out in accordance with relevant guidelines and regulations.

**Consent for publication**

Not applicable. This study does not contain any person's data in any form (including individual details, images, or videos).

**Competing interests**

The authors have declared that no competing interests exist.

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