Heart & Lung - The Journal of Acute and Critical Care 70 (2025) 305–312

Contents lists available at ScienceDirect

Heart & Lung

journal homepage: www.heartandlung.com

Effectiveness of a nurse training intervention in the emergency department to improve the diagnosis and treatment of stemi patients: EDUCAMI study

Gemma Berga Congost, MsC, RN [a,b,c,*], Salvatore Brugaletta, PhD, MD [d,e,f], Paloma Garcimartin Cerezo, PhD, MsC, RN [g,h,i], Jonatan Valverde Bernal, MsC, RN [a,b], Mariona Berrocal Comalat, RN [a], Sonia Mena Mejías, RN [a], Lorena Muñoz Millán, RN [a], Selma Rodriguez Evangelista, RN [a], Judit Ruiz Gabalda, RN [a], Jordi Torralbas Ortega, PhD, RN, MsC [a,b], Joan Garcia-Picart, MD [a], Marcelo Jimenez-Kockar, MD [a], Dabit Arzamendi Aizpurua, PhD, MD [a,b], Mireia Puig Campmany, PhD, MD [a,b], María Antonia Martinez Momblan, PhD, MsC, RN [c,j]

[a] Hospital de la Santa Creu i Sant Pau, Barcelona, Spain
[b] Sant Pau Biomedical Research Institute, Barcelona, Spain
[c] University of Barcelona Faculty of Nursing, Barcelona, Spain
[d] Hospital Clínic, Cardiovascular Clinic Institute, Barcelona Spain
[e] August Pi i Sunyer Biomedical Research Institute (IDIBAPS), Barcelona, Spain
[f] University of Barcelona Faculty of Medicine and Health Sciences, Barcelona, Spain
[g] Nursing Department, Hospital del Mar, Parc de Salut Mar, Barcelona, Spain
[h] Research Group in Nursing Care, IMIM (Hospital del Mar Medical Research Institute), Barcelona, Spain
[i] Biomedical Network Research Centre for Cardiovascular Diseases, CIBERCV, Carlos III Health Institute, Madrid, Spain
[j] Research Networking Centre of Rare Diseases. CIBER-ER, Unit 747

ARTICLE INFO

Keywords:
STEMI
Electrocardiogram-to-balloon
Nurses
Triage
Training
Emergency department
Education

ABSTRACT

Background: Clinical practice guidelines for acute coronary syndrome recommend an interval between electrocardiogram (ECG) and balloon of <60 min in patients attending the emergency department (ED) of a hospital with primary angioplasty capacity. Compliance with this can be complex, especially in atypical presentations.
Objective: To assess the effectiveness of specific training for ED triage nurses in reducing ECG-balloon time in STEMI.
Methods: Quasi-experimental study with a pre-test-post-test design. In June 2021, a training intervention was implemented in the diagnosis of STEMI in the ED. The EDUCAMI program included complex presentations, emphasising disparities in women and elderly people. A historical sample was compared with a post-intervention sample.
All patients consecutively activated as code STEMI in the ED were included, excluding those activated out-of-hospital. The main variable was ECG-balloon time, which was compared according to sex and age.
Results: The final sample consisted of 447 patients distributed into historical sample (n = 327) and post-test groups (n = 120). A reduction from 88 (65–133) to 60 (50–116) minutes in ECG-balloon time was observed in the post-test group together with a shorter hospital stay of 5 (3-8) vs 4 (3–5.5) days (p = 0.013).
When comparing according to sex and age, a decrease in ECG-balloon time (p < 0.001) was observed in men and patients under 65 years of age (p < 0.001).

Abbreviation: CAD, Coronary Artery Disease; CRA, Cardiorespiratory Arrest; CRF, Case Report Form; DLP, Dyslipidaemia; DM, Diabetes Mellitus; ECG, Electrocardiogram; ED, Emergency Department; EMS, Emergency Medical Services; ESC, European Society of Cardiology; FMC, First Medical Contact; GPC, General Poor Condition.; HSCSP, Hospital de la Santa Creu i Sant Pau; AH, Arterial Hypertension; IC, Interventional Cardiology; Min, Minutes; MI, Myocardial Infarction; PCI, Percutaneous Coronary Intervention; SANC, Spanish Association of Nurses in Cardiology; STEMI, St-Segment Elevation Acute Myocardial Infarction; QI, Quality Indicators.

* Corresponding author at: Nursing Research Support Unit, Hospital de la Santa Creu i Sant Pau, 89 Sant Quintí St, Barcelona 08041, Spain.
E-mail address: gberga@santpau.cat (G. Berga Congost).

https://doi.org/10.1016/j.hrtlng.2025.01.006
Received 2 November 2024; Received in revised form 1 January 2025; Accepted 6 January 2025
Available online 14 January 2025

Conclusions: The training intervention proved effective, reducing the ECG-balloon time by 32 %. EDUCAMI reduces the time in men and young people, however, the bias persists in women and those over 65 years of age.

Introduction

Clinical practice guidelines for the management of ST-segment elevation acute coronary syndrome (STEMI) recommend an interval between diagnosis and reperfusion of <60 min when the patient directly attends the emergency department (ED) of a hospital with primary percutaneous coronary intervention (PCI) capability.[1] Compliance with these times significantly improves the quality of the process and clinical results, particularly in terms of morbidity and mortality.[2] Therefore, these intervals are considered optimal quality indicators (QI) in the management of code infarction (MI).[3,4]

Various studies show that there is room for improvement in compliance with response times in heart attacks,[5] especially in atypical clinical and electrocardiographic presentations, as well as in women and the elderly, who are frequently underdiagnosed and undertreated.[6,7] On the other hand, patients who contact the emergency medical services (EMS) directly have shorter times compared with those who attend the ED of a hospital equipped with primary PCI.[8,9]

Regular evaluations and ongoing training improve the identification and diagnosis of STEMI.[3,10] Training for emergency nurses is essential, given their crucial role in triage, which can impact response and treatment times.[11,12] In addition, some registries indicate that they do not always adequately recognise or prioritise STEMI, which underscores the need for specific training.[13-15]

Clinical simulation is an effective learning tool in clinical settings that enhances nurses' skills and competencies.[16,17] Some experience with its use has been reported in STEMI[18,19]; however, training programs with clinical simulation that simultaneously address atypical presentations and differences according to sex and age have not been described.

The main objective of our study was to demonstrate how a training intervention that incorporates clinical simulation aimed at ED triage nurses in a hospital equipped with a PCI service can reduce diagnosis and treatment times in STEMI. As a secondary objective, we analysed whether there were differences according to sex and age.

Methods

Study design and setting

A quasi-experimental study with a pre-test-post-test design after the implementation of a STEMI training intervention in an ED. A historical sample (January 2013-January 2017) was compared with a post-intervention sample (June 2021-December 2023).

The study was carried out in the ED of the Hospital de la Santa Creu i Sant Pau (HSCSP) in Barcelona, Spain. The HSCSP has formed part of the *Codi IAM* network of the Catalan Healthcare System. Around 450 MI codes per year are attended, 20 % of which are activated from the centre's own ED and the rest by the EMS that transfers the patient directly to the interventional cardiology (IC) room.

The study population consisted of consecutive patients with suspected STEMI activated as code STEMI by the ED of our hospital. Inclusion criteria were patients ≥ 18 years old, admitted to the ED of the hospital, and patients who had a first medical contact (FMC) outside the ED without a clear STEMI diagnosis and were then admitted to the ED for a final diagnosis. Exclusion criteria were patients identified and activated as code STEMI out-of-hospital as they bypassed the ED, patients who did not undergo coronary angiography, and pregnant women.

The study and its subsequent amendment were approved by the Clinical Research Ethics Committee (CEIC) of the HSCSP (IIBSP-IAM-2015, IIBSP-IAM-2015–84v2) and informed consent was requested from all participants of the training intervention.

This study is registered in the clinical trials registry NCT04333381 and obtained funding from the Department of Health of the Generalitat of Catalonia within the strategic plan for research and innovation in health (PERIS) granted to GBC, with the code SLT008/18/00,052.

Data collection and handling

Upon identifying a suspected STEMI case, the ED nurse quickly follows the recommendations of the 'Code STEMI' protocol, which includes a rapid assessment, a 12-lead ECG within 10 min, and communication of the findings to the ED physician and to the cardiology team. Early interventions are initiated, such as dual antiplatelet therapy, unfractionated heparin, nitrates, oxygen therapy (if SpO_2 < 90 %) and intravenous access. Patients are continuously monitored, and an urgent transfer to interventional cardiology is coordinated.

The baseline clinical characteristics of all patients were collected by the researchers through an anonymised *ad-hoc* data collection notebook (CRF) using the *Clinapsis* program. The response time variables in STEMI were collected prospectively by the primary angioplasty on-call staff throughout the study period using an *ad-hoc* form that responds to the centre's *codi IAM* registry, which is evaluated and mandatory. Other variables were also collected from the records of the medical history—where there is access to documentation from the study hospital—emergency medical services, primary care centres, and other centres belonging to the Catalan public hospital network.

Intervention

EDUCAMI was developed and implemented, an online and face-to-face theoretical and practical training activity with methodology based on clinical simulation and gamification, from May to June 2021. It was mainly aimed at ED triage nurses since, at the HSCSP, the ED triage is led by nurses who are experts in the diagnosis and early treatment of urgent situations and they play a prominent role in the identification and prioritisation of patients with STEMI in the ED.

The evidence clearly establishes advanced nursing competencies in triage,[20] which complement and optimise the work of the emergency medical team and the cardiologist. This comprehensive approach allows for STEMI diagnosis, where different professionals collaborate, although the final diagnostic confirmation rests with the ED physician or cardiologist in complex cases.

The EDUCAMI program was designed to strengthen essential competencies in STEMI care, such as early and accurate identification of STEMI in <10 min after the patient's arrival. It also focused on optimising effective communication among the multidisciplinary team to speed up care, promote evidence-based clinical decisions, suitably prioritise interventions, ensure the activation of diagnosis-balloon in under 60 min, and reduce disparities in care, paying special attention to differences according to gender and age.

Due to the nature of the clinical simulation training, a total of 20 ED nurses and clinicians were included. For recruitment, two information sessions were held and participant recruitment was through the head of the service and the ED supervisor.

The training program was developed and validated by members of the research team, endorsed by the Spanish Association of Nurses in Cardiology (SANC), and approved as the centre's annual training plan. (Annexe 1)

A 12-hour (h) training module was carried out with an online theoretical part (8 h) with gamification resources, with the discussion of four clinical cases focused on the diagnosis of typical and atypical ECGs suggestive of acute coronary occlusion and differences according to sex and age. In the face-to-face module (4 h), there was a session on QIs in STEMI and feedback from previous data, a workshop on the identification of ECGs with suspected STEMI, and two cases of clinical simulation based on an atypical clinical and electrocardiographic presentation that emphasised possible complications derived from delays in STEMI.

In addition, an infographic and a diptych on the identification and early diagnosis of STEMI as an additional tool for ED triage were provided. (Annex 2)

After completing the training program, all participants, both nurses and clinicians, demonstrated a significant improvement in their knowledge, with an average increase exceeding 50 %. Additionally, the program received excellent feedback, with a satisfaction score of 9.7 out of 10. Currently, the training program has been institutionalised with an annual implementation under the updated format "EDUCAMI II," designed to train newly incorporated professionals and reaccredit those who wish to refresh their competencies. Furthermore, an annual update session is conducted, focusing on the latest evidence-based practices and providing feedback on quality indicators related to STEMI management in the ED. This continuous education strategy ensures that the knowledge and skills acquired through the program remain up to date and directly applicable to clinical practice.

Target variables of the study

The primary outcome was the time between diagnosis and opening of the artery or balloon. Diagnostic time was established as the time to perform the electrocardiogram (ECG), and balloon time as the time in which the angioplasty guide traverses the lesion of the culprit artery. An ECG-balloon time ≤60 min is considered optimal, which is the time recommended in the STEMI clinical guidelines of the European Society of Cardiology (ESC) for patients who attend the ED of a centre equipped with primary PCI.[1]

Other response time variables and their intervals (pain, FMC, ED, ECG, activation, IC, and balloon time), which were measured in minutes (min), were also considered. (Fig. 1)

Statistical analysis

All patients consecutively activated as code STEMI from the ED were distributed into two groups: a historical sample of the centre from 2013 to January 2017 ($n = 327$) and the post-test group from June 2021 to December 2023, after the implementation of EDUCAMI ($n = 120$).

Considering an alpha error of 0.05 and a statistical power of 80 %, a final sample of 120 patients consecutively activated as code MI in the post-test group, who met the selection criteria, was estimated to demonstrate a 40 % reduction in care time compared with the historical sample. This reduction, equivalent to 63 min, assumes a standard deviation of 160 min and an anticipated 10 % loss of patients.

First, a descriptive analysis was performed providing the percentage and number of cases for categorical variables, the mean value ± standard deviation for quantitative variables with a normal distribution, and the median with its interquartile interval for quantitative variables that did not follow a normal distribution.

The variables of the two groups—historical sample and post-test—were compared using the chi-square or Fisher's exact test in the case of categorical variables, or with the *t*-test or Mann-Whitney test in the case of quantitative variables.

A Mann-Whitney test was used to compare the different time intervals until reperfusion between these groups, given the high dispersion of the temporal variables.

The level of significance considered was 5 % ($\alpha = 0.05$), with a bilateral hypothesis. All analyses were conducted using the IBM-SPSS statistical package (V27.0).

Results

Patients included

During the study period, a total of 2747 code STEMI were activated in the study centre, 1687 in the pre-test period (from January 2013 to January 2017) and 1060 in the post-test period (from June 2021 to December 2023). The final sample consisted of 447 patients distributed into the historical sample ($n = 327$) and the post-test group ($n = 120$). (Fig. 2)

Of the total number of patients included, 75.2 % were men with a mean age of 64±14 years and 76 % ($n = 338$) received treatment with primary angioplasty. An overall all-cause mortality of 9.8 % ($n = 44$) was observed, with cardiorespiratory arrest (CRA) being the first event in 9.6 % of cases ($n = 43$).

Regarding the clinical profile, no significant differences were observed between the two groups, except in the electrocardiographic presentation of STEMI in the post-test group, with more frequent atypical presentations suggestive of acute coronary occlusion ($p < 0.001$). (Table 1)

Response times: diagnosis and treatment in STEMI and intervention

A 32 % reduction was observed in the ECG-balloon time, from 88 (65–133) to 60 (50–116) minutes in the post-test period ($p < 0.001$). Additionally, the post-test group presented a significant reduction in activation-interventional cardiology and interventional cardiology-balloon times ($p = 0.008$ and $p < 0.001$); however, higher pain-FMC and ED-ECG times were observed ($p < 0.001$ and $p = 0.043$, respectively). (Table 2)

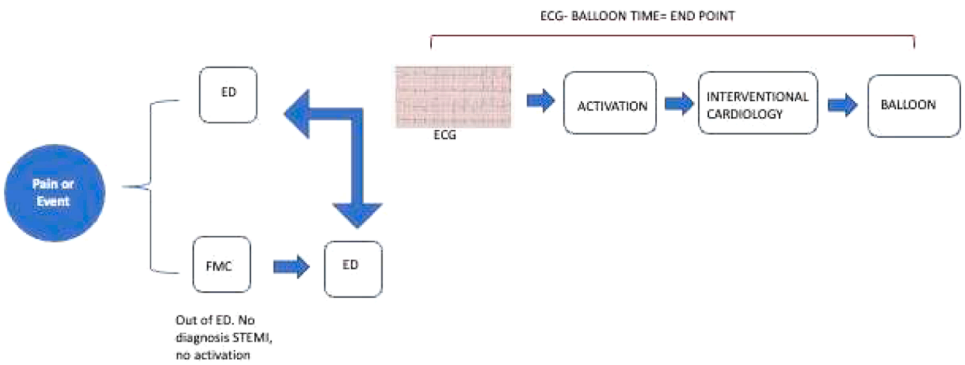

Fig. 1. Response times in STEMI patients admitted to the emergency department
ECG: Electrocardiogram. ED: Emergency Department. FMC: first medical contact.

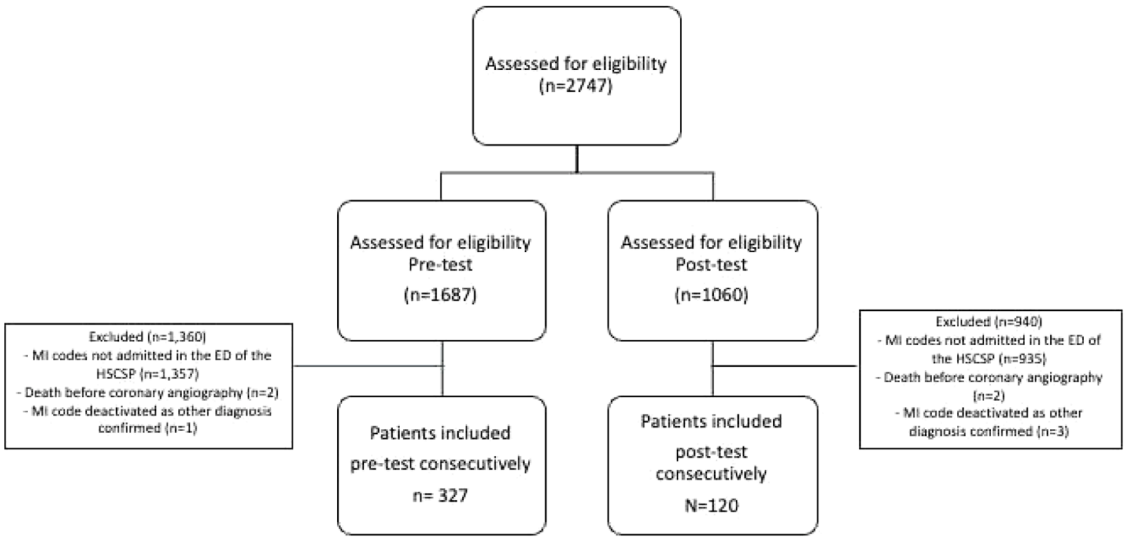

Fig. 2. Flow chart. Population included in the study
ED: Emergency Department. MI: myocardial infarction. HSCSP: Hospital Santa Creu i Sant Pau.

Regarding QIs, there was a significant improvement in the ECG-balloon, FMC-balloon, and ED-balloon indicators ($p < 0.001$, $p < 0.001$, and $p < 0.001$, respectively), except for pain-balloon ($p < 0.001$). In addition, the post-test group had a shorter hospital stay of five ([3–8]) vs four (3–5.5) days ($p = 0.013$). (Table 1)

Analysis according to sex and age

In the post-test group, a decrease in ECG-balloon ($p < 0.001$), activation-interventional cardiology ($p = 0.040$), interventional cardiology-balloon ($p = 0.002$), and FMC-balloon intervals ($p = 0.014$) was observed in men. On the other hand, in women, a positive effect was only observed in interventional cardiology-balloon time ($p = 0.020$). Furthermore, sex differences in the post-test stage persist in women for the FMC-ECG ($p < 0.001$), ED-ECG ($p = 0.003$), and ECG-activation intervals ($p = 0.030$). (Table 3)

In the post-test group, those under 65 years of age exhibited a reduction in ECG-balloon ($p < 0.001$), ECG-activation ($p = 0.037$), activation-interventional cardiology ($p = 0.015$), interventional cardiology-balloon ($p < 0.001$), ED-balloon ($p = 0.021$), and FMC-balloon intervals ($p = 0.004$); those over 65 years of age had a greater delay in pain-FMC ($p < 0.001$) and FMC-ECG ($p = 0.006$). In addition, the age bias was maintained in the post-test stage in the case of the elderly for practically all intervals. (Table 4)

Additionally, to try to isolate external effects during the study period, an analysis was conducted, eliminating the year 2021, which was considered the year with the greatest impact of the COVID-19 epidemic. This did not cause any notable changes to the findings. This showed a reduction in the ECG-balloon time in the post-test period ($p = 0.05$). The post-test group presented a significant reduction in interventional cardiology-balloon times ($p < 0.006$); however, higher pain-FMC and FMC-ECG times were observed ($p = 0.005$ and $p = 0.043$, respectively).

Discussion

Our study shows that a nurse-oriented training intervention, which highlighted atypical STEMI presentations and age- and sex-related biases, can significantly reduce the ECG-balloon time interval, with an average decrease of 32 %. This intervention was particularly effective in men and people under 65 years of age. In the study by McLaren et al., [10] a training intervention on atypical ECGs for ED physicians was conducted, resulting in a significant reduction in diagnosis and activation times. However, unlike our study, it focused on the ECG-activation interval, without considering treatment delays.

It should be noted that EDUCAMI obtained a higher percentage reduction in ECG-balloon time than other reports,[21] however, the reduction was less than the 40 % estimated in our hypothesis. Additionally, it is important to note that, in the pre-intervention period, the ECG-balloon time recommended by the ESC clinical guidelines for patients attending the ED of a hospital with primary PCI was not met; only 19 % of cases complied with this indicator. In contrast, in the post-test period, the guideline-recommended 60 min were reached and 48 % of cases fulfilled this indicator.[1]

After the implementation of EDUCAMI, a considerable reduction was observed not only in the ECG-balloon time but also in the intervals between activation and reaching haemodynamics. This indicates a better organisation of the circuits and a greater awareness of professionals, allowing a more efficient management of transfers.

Concerning the pain-FMC time, a significant increase was recorded in the post-test group. This increase appears to be associated with the period during which the intervention was carried out, given that, although the most critical phase of the COVID-19 pandemic had subsided, there were still recurring waves of the epidemic. Various studies have reported that the population delayed seeking urgent medical attention due to fear of infection, which could explain the longer times observed.[22,23]

The ED-ECG time experienced a slight increase in the post-test stage (5 vs 7 min) without clinical repercussions, as it remained within the limits recommended by the clinical guidelines (<10 min).[1]

Unlike other registers, our series features some discretely superior response times,[24] this is attributed to a higher percentage of patients included with an initial diagnosis of CRA that were activated as code STEMI, which has been described as a predictor of delay.[25] Our registry also includes patients with atypical presentations suggestive of acute coronary occlusion, without a clear ST-segment elevation, who more frequently present with delayed diagnosis.[7] Indeed, 37 % of cases in the post-test group presented atypical ECGs and 20.8 % of the entire sample reported equivalent or non-specific symptoms.

Regarding the results according to sex, we observed that, after EDUCAMI, the response time in patients with STEMI decreased significantly in men who attended the ED. However, in women, the reduction of these times was limited to the coronary intervention phase, after diagnosis. This evidences, as several studies have pointed out, that there is still a bias in STEMI diagnosis according to sex[26,27] despite the age and

Table 1
Baseline clinical characteristics of study participants' variables.

Variables	STEMI Code n = 447 (100 %)	Before STEMI training n = 327 (100 %)	After STEMI training n = 120 (76.1 %)	p-value
Male gender	336 (75.2)	249 (76.1)	87 (72.5)	0.459
Age	64±14	64±14.1	66±13.6	0.175
AH	271 (60.6)	198 (60.6)	73 (60.8)	0.957
DLP	244 (54.8)	177 (54.1)	67 (56.8)	0.667
DM	118 (26.5)	84 (25.7)	34 (28.6)	0.546
Tobacco use	268 (60)	197 (60.2)	71 (59.2)	0.913
Obesity	83 (18.6)	63 (19.3)	20 (16.7)	0.585
CAD	109 (24.4)	80 (24.5)	29 (24.2)	0.948
Killip III/IV	77 (17.6)	58 (18.1)	19 (16.1)	0.673
FMC ED	254 (56.8)	184 (56.3)	70 (58.3)	0.747
Working hours	172 (38.5)	120 (36.7)	52 (43.3)	0.228
PCI	338 (76)	248 (75.8)	90 (76.3)	0.925
ECG ST elevation	341 (76.3)	267 (81.7)	75 (63)	< 0.001
Chest pain	354 (79.2)	254 (77.4)	99 (83.2)	0.224
CRA	43 (9.6)	36 (11)	7 (5.9)	0.101
In-hospital mortality	44 (9.8)	38 (11.6)	6 (5)	0.039
Hospital stay	4 (3–8)	5 (3–8)	4 (3–5.5)	0.013
False positive	59 (13.2)	42 (12.8)	17 (14.3)	0.752
QI ECG-Balloon < 60	92 (26.9)	47 (19)	45 (47.9)	< 0.001
QI PCI < 720	311 (85.2)	217 (87.5)	94 (80.3)	0.083
QI FMC-ECG < 10	220 (49.4)	167 (51.1)	53 (44.9)	0.283
QI ED-ECG > 10	297 (66.7)	222 (67.9)	75 (63.6)	0.425
QI IC-Balloon < 30	257 (75.1)	185 (74.6)	72 (76.6)	0.780
QI FMC-Balloon < 60	60 (17.5)	32 (12.9)	28 (29.5)	< 0.001
QI ED-Balloon < 60	84 (24.5)	47 (19)	37 (38.9)	< 0.001
QI Pain-Balloon < 180	253 (74.2)	217 (87.5)	36 (38.7)	< 0.001

The table shows n (%). Mean ± standard deviation. CAD: coronary artery disease; CRA: cardiorespiratory arrest; DLP: dyslipidaemia; DM: diabetes mellitus; ECG: electrocardiogram; ED: Emergency Department; FMC: first medical contact; GPC: general poor condition; AH: arterial hypertension; PCI: percutaneous coronary intervention; QI: quality indicator.

Table 2
Primary and secondary endpoints. Time of STEMI activation in acute myocardial infarction.

Time Variables	Total STEMI	Before STEMI education n = 327 (100 %)	After STEMI education n = 120 (100 %)	p-value
No. of patients	447 (100)	327 (100)	120 (100)	
ECG-Balloon time	**83 (58–122)**	**88 (65–133)**	**60 (50–116)**	**< 0.001**
Pain-FMC time	90 (30–240)	80 (25–181)	126.5 (56–541)	< 0.001
FMC-ECG time	11 (5–30)	10 (5–26)	14 (5–49)	0.095
ED-ECG time	6 (0–14)	5 (0–14)	7 (3–13)	0.043
ECG-Activation time	26 (12–70)	30 (12–75)	20 (10–54)	0.082
Activation-IC time	29 (17–35)	30 (20–35)	25 (15–33)	0.008
IC-Balloon time	25 (19–30)	25 (20–31)	20 (16–28)	< 0.001
ED-Balloon time	85 (60–127)	88 (64–122)	71 (57–141)	0.141
FMC-Balloon time	105 (73–165)	109 (77–160)	91 (59–204)	0.089
Pain-Balloon time	215 (135–466)	207 (135–405)	223 (135–608)	0.321

The table shows n (%) Median (interquartile range). Time intervals: minutes (min); ECG: electrocardiogram; ED: Emergency Department; FMC: first medical contact; IC: interventional cardiology.

sex criteria that were included in the training intervention.

EDUCAMI sought to foster awareness of this bias in our context[7] and contained measures aimed at emphasising differences in clinical and electrocardiographic presentations of STEMI in women and the elderly, along with simulation scenarios designed to address these disparities; however, improvements in response times were not achieved equitably.

Similarly, previous studies that have employed machine learning techniques to improve the training of professionals in the management of STEMI have reported less favourable results in underrepresented populations, such as women and the elderly. This phenomenon can be attributed to the predominance of young males in the dataset used, as they represent the population most studied in previous research.[28]

As pointed out by other authors, the biases associated with health professionals towards these groups of patients may contribute to the delay in door-to-balloon time, due to an underestimation of symptoms in women and the elderly, especially in those cases where clinical presentations are more atypical.[29]

Similarly, the Pain-FMC time in the post-intervention stage increased by 177 % in women and 44 % in men. This increase is mainly attributed to the COVID-19 epidemic and, on the other hand, to the fact that, as reported by other authors, women tend to have a greater delay in seeking medical assistance because they have greater difficulty in recognising symptoms and different educational needs.[30] Also, because the reduced access to healthcare that many women experience is often exacerbated during pandemics.[31]

Aligning with reports from other authors, our series confirms that chest pain is the predominant symptom in men and women, however, women more frequently present accompanying symptoms and prodromes that can interfere with the diagnosis.[28,32,33]

Regarding differences according to age after the implementation of EDUCAMI, a significant decrease in all response times for STEMI in young people was observed. However, patients over 65 years of age had longer delays in the pain-FMC, FMC-ECG, and pain-balloon intervals and did not show any benefits in the other intervals, indicating that an age bias persists in the elderly despite the training intervention.[34]

As indicated by other reports, multidisciplinary, continuous, and regular training interventions on STEMI are required[34,35] that emphasise the differences in diagnosis and treatment according to sex and age, thus raising awareness among health professionals.[36] In addition, they underline the need for specific validated training in the management of STEMI in women and the elderly. In this sense, the type of intervention has been modified and adapted to diverse populations, giving rise to EDUCAMI II, which is expected to be able to validate its effectiveness in these groups in the near future and demonstrate that the disparities in the management of STEMI in our centre have been mitigated.

It should be noted that the training conducted is easily reproducible, and once organised, it can be readily repeated in different emergency services.

It is essential to apply protocols and clinical guidelines developed and implemented by multidisciplinary teams that include specific guidelines for women and the elderly, as well as the continuous evaluation of response times in both groups.[3,37] In addition, digital tools to support clinical decision-making should be implemented to warn about the possibility of bias. In this sense, developing and validating algorithms using artificial intelligence could contribute to improving the identification and early diagnosis of STEMI in women and the elderly.[38,39] Also, gender- and age-disaggregated audits, awareness

Table 3
Time of STEMI activation in acute myocardial infarction by sex.

Time Variables	Total Males n = 336 (75.2)	Males Before EDUCAMI 249 (76.1)	Males After EDUCAMI 167 (51.07)	p-value	Total Females n = 111 (24.8)	Females Before EDUCAMI 78 (23.9)	Females After EDUCAMI 160 (48.93)	p-value	p-value by sex
ECG-Balloon time	80 (57–117)	85 (65–120)	57 (49.7–100)	< 0.001	92 (64.2–155.7)	93 (70–165)	90 (52–130.5)	0.142	0.141
Pain-FMC time	92 (30–227)	83 (25.2–175)	120 (58–525)	0.003	84 (25–360)	62.5 (19.8–241.5)	172 (53–664)	0.020	0.681
FMC-ECG time	10 (5–26)	10 (5–25)	7 (4.2–31.5)	0.570	15 (8–49)	12 (5–32.5)	39 (16.5–101)	< 0.001	< 0.001
ED-ECG time	5 (0–13)	5 (0–14)	6 (2.5–12.5)	0.242	8 (0–15)	5 (0–14,25)	9 (5−20)	0.089	0.003
ECG-Activation time	25 (10.7–63.2)	26 (11–70)	17 (9.5–48)	0.069	34 (14–89)	33 (15–98.5)	39 (11.5–69)	0.594	0.030
Activation-IC time	29 (16–35)	30 (17–37)	25 (15–33)	0.040	30 (20–35)	30 (23.8–35)	27 (15–33.5)	0.069	0.865
IC-Balloon time	25 (19–29)	25 (20–30)	20 (16–26)	0.002	26 (20–35)	29 (20–35)	20 (15.5–31)	0.020	0.899
ED-Balloon time	81 (57–117)	85 (62–117.5)	64 (56–130)	0.057	101 (70.2−178.2)	94 (74–173)	112 (60–203.5)	0.979	0.141
FMC-Balloon time	101 (66–157)	106 (75.5–155.5)	77 (56–171.5)	0.014	120 (85–213.7)	120 (85–190)	129 (82–274.5)	0.678	0.141
Pain-Balloon time	202 (130.7–386.2)	203 (133–339.5)	200 (128–596)[a]	0.948	267 (155.7–608.5)	240 (152–535)	380 (180.5–898)	0.142	0.061

[a] The table shows n (%) Median (interquartile range). Time intervals: minutes (min); ECG: electrocardiogram; ED: Emergency Department; FMC: First Medical Contact; IC: interventional cardiology

Table 4
Time of STEMI activation in acute myocardial infarction by age.

Time Variables	Total < 65 years STEMI 223 (49.9)	<65 years Before STEMI training 167 (51.01)	<65 years After STEMI training 56 (46.7)	*P*-value	Total ≥65 years STEMI 224 (50.1)	≥65 years Before STEMI training 160 (48.9)	≥65 years After STEMI training 64 (53.3)	*P*-value	*P*-value by age
ECG-Balloon time	**73 (54–103)**	**77 (62.3–115)**	**54 (47–83)**	**<0.001**	**93 (66–148)**	**94 (72.3–147.5)**	**91.5 (53.5–149)**	**0.262**	**0.005**
Pain-FMC time	84 (30–180)	73 (30–165)	94 (40.5–437.7)	0.082	101 (26–320)	88 (20–230)	176 (63–600)	<0.001	0.197
FMC-ECG time	10 (5–20)	10 (5–20)	7 (3–30)	0.483	14 (6–43)	12 (5–35)	19 (8–95.2)	0.006	0.033
ED-ECG time	5 (0–10)	5 (0–11)	5 (2–10)	0.333	6 (0–15)	6 (0–15)	8 (4–15)	0.104	0.019
ECG-Activation time	25 (10–57)	25 (10–64)	17 (9–35)	0.037	32 (13–87)	31.5 (14.3–90)	33 (12–71)	0.579	0.094
Activation-IC time	27 (16–35)	29 (16–35)	24 (12–31.7)	0.015	30 (20–35)	30 (20–35.8)	27 (17–33)	0.125	0.163
IC-Balloon time	24 (19–28)	25 (20–30)	20 (15–24)	<0.001	25 (20–33)	26 (20–33)	23.5 (18–31)	0.133	0.036
ED-Balloon time	74 (57–105)	76.5 (60–105.8)	59 (52–96)	0.021	102 (69–148)	102.5 (74.3–140.5)	99 (60.3–169)	0.845	0.015
FMC-Balloon time	89 (61–137)	95 (70.5–145.8)	66 (56.25–115.7)	0.004	120 (90–200)	120 (93.3–183.8)	148 (71–255)	0.749	0.002
Pain-Balloon time	185 (124–330)	188.5 (125–329.5)	153.5 (105–385)	0.502	242 (156–512)	236.5 (154–466.3)	335 (174–671.7)	0.049	0.022

The table shows n (%) Median (interquartile range). Time intervals: minutes (min); ECG: electrocardiogram; ED: Emergency Department; FMC: first medical contact; IC: interventional cardiology.

campaigns, and equitable inclusion in STEMI records can generate solid evidence.

Future studies should evaluate the effectiveness of these measures to guarantee equity in STEMI care.

The training intervention not only enhanced knowledge and reduced response times but also led to sustainable modifications in the ED workflow. Protocols such as the systematic use of right-sided and posterior leads have significantly improved diagnostic accuracy, particularly in complex STEMI presentations, while the implementation of serial ECGs has ensured continuous monitoring of dynamic changes. These workflow adjustments have contributed to improved adherence to quality indicators in STEMI management and reflect a shift toward a more evidence-based, standardised, and patient-centred approach to care. Furthermore, this training has been institutionalised into the annual education plan for ED nurses and clinicians, providing reaccreditation and updates for current staff while also preparing newly incorporated professionals. This highlights the critical role of ongoing education in driving long-term improvements in clinical practice and optimising patient outcomes.

Limitations

A limitation of this study could be the possible information bias related to the lack of blinding. To foresee this possible bias, we included all variables that could act as confounders and performed an initial analysis that helped us determine the possible biases and a final multivariate analysis.

Another limitation is the single-centre nature of this study and that

patients activated as STEMI cases out-of-hospital were excluded, which could limit the generalisability of the findings to other clinical settings. However, since the variables and interventions used are based on established clinical guidelines, in practice, it was possible to reduce variability, which minimises this limitation.

Other factors may have conditioned response times in STEMI. This training intervention had been scheduled for March 2020; the COVID-19 epidemic forced it to be delayed until June 2021. The participating ED professionals rated the course as excellent, however, it was a period in which there was a significant care and emotional burden and this could have conditioned the results. Nevertheless, the recovery of normality in terms of continuous training and performing the first training intervention on STEMI through clinical simulation, was referred to as a positive stimulus for all participants.

In addition, during the post-intervention period, multiple waves of COVID-19 impacted healthcare-seeking behavior and response times. Many patients with suspected STEMI experienced delays in seeking medical care due to fear of infection or perceived inadequacies in healthcare availability. Moreover, initial response times in the ED may also have been affected by the logistical challenges posed by the implementation of infection control measures, such as donning personal protective equipment (PPE), which added an unavoidable layer of complexity to emergency care workflows.

Conclusion

The EDUCAMI training intervention, aimed mainly at ED triage nurses, has proven to be effective, reducing the time between ECG and balloon by 32 %, aligning with clinical guideline recommendations. Furthermore, there were significant improvements in intrahospital transfer times and interventionism. However, the marked increase in the pain-to-FMC interval during the COVID-19 pandemic underscores the need to address external factors, to ensure consistent improvements across the entire STEMI care pathway.

EDUCAMI managed to reduce diagnosis and treatment times for STEMI in men and patients under 65 years of age. However, bias in diagnosis and treatment persists in women and the elderly, even though training focused on these groups and their specific disparities.

Funding

The Government of Catalonia (Spain) provided funding for this research with a grant issued in 2019 within the framework of the Strategic Health Research and Innovation Plan (PERIS) 2016–2020 to GBC, with file code SLT008/18/00,052. The funders had no role in the design, execution, interpretation, or writing of this study.

CRediT authorship contribution statement

Gemma Berga Congost: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Salvatore Brugaletta:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Paloma Garcimartin Cerezo:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Conceptualization. **Jonatan Valverde Bernal:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Data curation. **Mariona Berrocal Comalat:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Investigation, Formal analysis, Data curation. **Sonia Mena Mejías:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Investigation, Data curation. **Lorena Muñoz Millán:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Investigation, Data curation. **Selma Rodriguez Evangelista:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Investigation, Data curation. **Judit Ruiz Gabalda:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Investigation, Data curation. **Jordi Torralbas Ortega:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis. **Joan Garcia-Picart:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Investigation, Formal analysis, Data curation. **Marcelo Jimenez-Kockar:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Formal analysis, Data curation. **Dabit Arzamendi Aizpurua:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Data curation. **Mireia Puig Campmany:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Investigation, Conceptualization. **María Antonia Martinez Momblan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank Roberto Lazzari, Maria Teresa Álvarez Albarran, Montserrat Vila Perales, and Núria Castelló Fosch, who contributed as teachers in the training intervention, to Ignasi Gich for his contribution to the data analysis and all participants, health centre staff, and the Government.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hrtlng.2025.01.006.

References

1. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al. 2023 ESC Guidelines for the management of acute coronary syndromes. *Eur Heart J*. 2023 12; 44(38):3720–3826.
2. Zuccarelli V, Andreaggi S, Walsh JL, Kotronias RA, Chu M, Vibhishanan J, et al. Treatment and care of patients with ST-segment elevation myocardial infarction—what challenges remain after three decades of primary percutaneous coronary intervention? *J Clin Med*. 2024 15;13(10):2923.
3. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et al. 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. *Eur Heart J*. 2018;39(2):119–177.
4. Ludman P, Zeymer U, Danchin N, Kala P, Laroche C, Sadeghi M, et al. Care of patients with ST-elevation myocardial infarction: an international analysis of quality indicators in the acute coronary syndrome STEMI Registry of the EURObservational research programme and ACVC and EAPCI associations of the European society of cardiology in 11 462 patients. *Eur Heart J Acute Cardiovasc Care*. 2023;12(1):22–37.
5. Bosmans S, Sluyts Y, Lysens De Oliveira E Silva-Van Acker J, Van Caenegem O, Sinnaeve PR, Dubois P, et al. Adherence to quality indicators for ST-elevation myocardial infarction and its relation to mortality: a hospital network analysis from the Belgian STEMI database. *Eur Heart J - Qual Care Clin Outcomes*. 2021;7(6): 601–607.
6. Shehab A, AlHabib KF, Bhagavathula AS, Hersi A, Alfaleh H, Alshamiri MQ, et al. Clinical presentation, quality of care, risk factors and outcomes in women with acute ST-Elevation Myocardial Infarction (STEMI): an observational report from six middle eastern countries. *Curr Vasc Pharmacol*. 2019;17(4):388–395.
7. Berga Congost G, Martinez Momblan MA, Valverde Bernal J, Márquez López A, Ruiz Gabalda J, Garcia-Picart J, et al. Association of sex and age and delay predictors on

the time of primary angioplasty activation for myocardial infarction patients in an emergency department. *Heart Lung*. 2023;58:6–12.
8. Carol Ruiz A, Masip Utset J, Ariza Solé A. researchers of the Codi Infart registry of Catalonia. Predictors of late reperfusion in STEMI patients undergoing primary angioplasty. impact of the place of first medical contact. *Rev Espanola Cardiol Engl Ed*. 2017;70(3):162–169.
9. De Diego O, Rueda F, Carrillo X, Oliveras T, Andrea R, El Ouaddi N, et al. Performance analysis of a STEMI network: prognostic impact of the type of first medical contact facility. *Rev Esp Cardiol Engl Ed*. 2023;76(9):708–718.
10. McLaren JTT, Taher AK, Kapoor M, Yi SL, Chartier LB. Sharing and Teaching Electrocardiograms to Minimize Infarction (STEMI): reducing diagnostic time for acute coronary occlusion in the emergency department. *Am J Emerg Med*. 2021;48:18–32.
11. Cesar LAM, Mansur AP, Ramos RF, Magalhães C, Ferreira JFM, Oliveira NAD, et al. Treinamento de Não-Cardiologistas pode Melhorar os Resultados do Tratamento de Infarto Agudo do Miocárdio com Supra de ST. *Arq Bras Cardiol [Internet]*; 2021 [cited 2024 Jul 9]; Available from https://abccardiol.org/article/treinamento-de-nao-cardiologistas-pode-melhorar-os-resultados-do-tratamento-de-infarto-agudo-do-miocardio-com-supra-de-st/.
12. Berga Congost G, Brugaletta S, Valverde Bernal J, Márquez López A, Ruiz Gabalda J, Garcia-Picart J, et al. The importance of organizational variables in treatment time for patients with ST-elevation acute myocardial infarction improve delays in STEMI. *Australas Emerg Care*. 2021;24(2):141–146.
13. Week J, Johnson J. Are triage nurse knowledgeable about acute coronary syndromes recognition? *ABNF Journal*. 2017;28(3):69–75.
14. Saban M, Zaretsky L, Patito H, Salama R, Darawsha A. Round-off decision-making: why do triage nurses assign STEMI patients with an average priority? *Int Emerg Nurs*. 2019;43:34–39.
15. Alsharawneh A, Sawalha M, Tabar NA, Elshatarat RA, Almarwani AM, Saleh ZT, et al. Impact of triage nurses' recognition of acute coronary syndrome on patients' clinical outcomes: a retrospective study. *Heart Lung*. 2024;68:60–67.
16. O'Rourke LA, Morrison M, Grimsley A, Cotter VT. High-fidelity simulation and nurse clinical competence—An integrative review. *J Clin Nurs*. 2023;32(9–10):1549–1555.
17. Lee J, Lee H, Kim S, Choi M, Ko IS, Bae J, et al. Debriefing methods and learning outcomes in simulation nursing education: a systematic review and meta-analysis. *Nurse Educ Today*. 2020;87, 104345.
18. Habib H, Ginanjar E, Mansjoer A, Sulistio S, Albar IA, Mulyana RM. ST-elevation myocardial infarction: a simulation case for evaluation of interprofessional performance in a hospital. *Emerg Med Int*. 2019;2019:1–4.
19. Whalen D, Dunne C, Dubrowski A, Mohamed L, Parsons MH Diagnosis and management of an inferior ST-elevation myocardial infarction: a simulation scenario. Cureus [Internet]. 2019 [cited 2024 Sep 7]; Available from: https://www.cureus.com/articles/12025-diagnosis-and-management-of-an-inferior-st-elevation-myocardial-infarction-a-simulation-scenario.
20. Usui M, Yamauchi T. *Guiding Patients to Appropriate care : Developing Japanese outpatient Triage Nurse Competencies [Internet]*. Nagoya University Graduate School of Medicine, School of Medicine; 2019. https://doi.org/10.18999/nagjms.81.4.597 [cited 2024 Sep 24]. Available from.
21. Nelson BD, McLaughlin CJ, Rivera OE, Kaul K, Ferdock AJ, Matuzsan ZM, et al. Implementation of a novel prehospital clinical decision tool and ECG transmission for STEMI significantly reduces door-to-balloon time and sex-based disparities. *Prehosp Emerg Care*. 2024:1–7.
22. Chew NWS, Ow ZGW, Teo VXY, Heng RRY, Ng CH, Lee CH, et al. The global effect of the COVID-19 pandemic on STEMI care: a systematic review and meta-analysis. *Can J Cardiol*. 2021;37(9):1450–1459.
23. McLaren JTT, Taher AK, Chartier LB. Flattening the other curve: reducing emergency department STEMI delays during the COVID-19 pandemic. *Am J Emerg Med*. 2021;49:367–372.
24. Thanavaro J, Buchanan P, Stiffler M, Baum K, Bell C, Clark A, et al. Factors affecting STEMI performance in six hospitals within one healthcare system. *Heart Lung*. 2021;50(5):693–699.
25. Alrawashdeh A, Nehme Z, Williams B, Smith K, Brennan A, Dinh DT, et al. Impact of emergency medical service delays on time to reperfusion and mortality in STEMI. *Open Heart*. 2021;8(1), e001654.
26. Rossello X, Mas-Lladó C, Pocock S, Vicent L, Van De Werf F, Chin CT, et al. Sex differences in mortality after an acute coronary syndrome increase with lower country wealth and higher income inequality. *Rev Esp Cardiol Engl Ed*. 2022;75(5):392–400.
27. DeFilippis EM, Collins BL, Singh A, Biery DW, Fatima A, Qamar A, et al. Women who experience a myocardial infarction at a young age have worse outcomes compared with men: the Mass General Brigham YOUNG-MI registry. *Eur Heart J*. 2020;41(42):4127–4137.
28. Harding Bradley V. Impact of gender bias in training data for machine learning models predicting myocardial infarction. *J Stud Res [Internet]*. 2023;12(3) [cited 2024 Dec 24]Available from https://www.jsr.org/hs/index.php/path/article/view/4532.
29. Pacheco C, Boivin-Proulx LA, Bastiany A, Matteau A, Mansour S, Gobeil F, et al. Impact of STEMI diagnosis and catheterization laboratory activation systems on sex- and age-based differences in treatment delay. *CJC Open*. 2021;3(6):723–732.
30. Sederholm Lawesson S, Isaksson RM, Ericsson M, Ängerud K, Thylén I. Gender disparities in first medical contact and delay in ST-elevation myocardial infarction: a prospective multicentre Swedish survey study. *BMJ Open*. 2018;8(5), e020211.
31. Connor J, Madhavan S, Mokashi M, Amanuel H, Johnson NR, Pace LE, et al. Health risks and outcomes that disproportionately affect women during the Covid-19 pandemic: a review. *Soc Sci Med*. 2020;266, 113364.
32. Khan NA, Daskalopoulou SS, Karp I, Eisenberg MJ, Pelletier R, Tsadok MA, et al. Sex differences in prodromal symptoms in acute coronary syndrome in patients aged 55 years or younger. *Heart*. 2017;103(11):863–869.
33. Gulati M, Levy PD, Mukherjee D, Amsterdam E, Bhatt DL, Birtcher KK, et al. 2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR guideline for the evaluation and diagnosis of chest pain: a report of the american college of cardiology/American heart association joint committee on clinical practice guidelines. *Circulation [Internet]*. 2021;144(22) [cited 2024 Aug 4]Available from https://www.ahajournals.org/doi/10.1161/CIR.0000000000001029.
34. Wang YC, Huang YY, Lo PH, Chang KC, Chen CH, Chen MF. Age-dependent impact of new ESC-Guideline recommended door-to-balloon times on mid-term survival in acute ST-elevation myocardial infarction patients undergoing primary percutaneous coronary intervention. *Int J Cardiol*. 2016;222:242–246.
35. Hernandez JM, Glembocki MM, McCoy MA. Increasing nursing knowledge of ST-elevated myocardial infarction recognition on 12-lead electrocardiograms to improve patients outcomes. *J Contin Educ Nurs*. 2019;50(10):475–480.
36. Stehli J, Duffy SJ, Burgess S, Kuhn L, Gulati M, Chow C, et al. Sex disparities in myocardial infarction: biology or bias? *Heart Lung Circ*. 2021;30(1):18–26.
37. Burgess L, Kynoch K, Hines S. Implementing best practice into the emergency department triage process. *Int J Evid Based Healthc*. 2019;17(1):27–35.
38. Wang YC, Chen KW, Tsai BY, Wu MY, Hsieh PH, Wei JT, et al. Implementation of an All-Day artificial intelligence–based triage system to accelerate door-to-balloon times. *Mayo Clin Proc*. 2022;97(12):2291–2303.
39. Chang KC, Hsieh PH, Wu MY, Wang YC, Wei JT, Shih ESC, et al. Usefulness of multi-labelling artificial intelligence in detecting rhythm disorders and acute ST-elevation myocardial infarction on 12-lead electrocardiogram. *Eur Heart J - Digit Health*. 2021;2(2):299–310.