

# Usefulness of the ACTION ICU score to predict complications requiring critical care in Mexican patients with non-ST-segment elevation myocardial infarction

## Utilidad de la puntuación ACTION ICU como predictor de complicaciones en pacientes mexicanos con infarto agudo al miocardio sin elevación del segmento ST

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### Abstract

**Objective:** The Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit (ACTION ICU) score is a tool for assessing the risk of complications associated with non-ST-segment elevation myocardial infarction (NSTEMI) requiring intensive care unit (ICU) admission. The study aimed to describe the usefulness of the ACTION ICU score in Mexican patients with NSTEMI. **Methods:** A single-center, retrospective, observational, and comparative study of patients with NSTEMI admitted between January 2017 and December 2023; patients with respiratory failure, cardiac arrest, shock, and arrhythmias requiring a pacemaker on admission were excluded from the study. Based on the collected data, the ACTION ICU score was applied to all patients. The cutoff score for ICU admission is 5, with a 9.3% risk of complications. During hospitalization, the composite primary outcome included cardiac arrest, shock, heart block requiring a pacemaker, respiratory failure, stroke, or death. The score's performance was determined by calculating the area under the curve (AUC). **Results:** A total of 345 NSTEMI patients were included; 41 (14.2%) developed the primary outcome. The most common complications were shock (12.5%) and respiratory failure (8.1%). A score of 0 to 5 points was present in 187 patients (54.2%), 10 of whom (5.3%) developed the primary outcome. The score had an AUC of 0.77 [CI 0.64-0.97, p value 0.01]. **Conclusions:** The ACTION ICU score showed acceptable discriminative ability for identifying patients with NSTEMI who need ICU care, providing a valuable tool to predict complications and implement best practices in medical units with limited resources.

**Keywords:** Non-ST-segment elevation myocardial infarction. ACTION ICU. Acute coronary syndrome. Coronary care unit. Intensive care unit. Complications.

### Resumen

**Objetivo:** La puntuación ACTION ICU evalúa el riesgo de complicaciones asociadas con el infarto agudo del miocardio sin elevación del segmento ST (IAMSEST) que requieren ingreso a unidad de cuidados intensivos (UCI). El objetivo del estudio fue describir la utilidad de la puntuación ACTION ICU en pacientes mexicanos con IAMSEST. **Métodos:** Estudio retrospectivo,

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observacional y comparativo que incluye pacientes con IAMSEST admitidos entre enero de 2017 y diciembre de 2023; se excluyeron del estudio los pacientes con insuficiencia respiratoria, paro cardíaco, shock y arritmias que requirieron marcapaso al ingreso. La puntuación ACTION ICU se calculó en función de los datos recopilados. El punto de corte para el ingreso a UCI es 5, con un riesgo de complicaciones del 9.3%. Durante la hospitalización, el desenlace primario compuesto fue paro cardíaco, shock, bloqueo cardíaco que requirió marcapasos, insuficiencia respiratoria, evento cerebrovascular o muerte. El desempeño de la puntuación para predecir complicaciones se determinó mediante el cálculo del área bajo la curva (ABC). **Resultados:** Se estudió un total de 345 pacientes con IAMSEST; 41 (14.2%) desarrollaron el desenlace primario. Las complicaciones más frecuentes fueron shock (12.5%) e insuficiencia respiratoria (8.1%). Una puntuación de 0 a 5 puntos estuvo presente en 187 pacientes (54.2%), diez de los cuales (5.3%) desarrollaron el desenlace primario. La puntuación tuvo un ABC de 0.77 [IC 0.64-0.97, valor de  $p$  0.01]. **Conclusiones:** La puntuación ACTION ICU mostró una capacidad discriminativa aceptable para identificar pacientes con IAMSEST que ameritan manejo en la UCI.

**Palabras claves:** Infarto agudo de miocardio sin elevación del segmento ST. Puntaje ACTION ICU. Síndrome coronario agudo. Unidad de cuidados coronarios. Unidad de cuidados intensivos. Complicaciones.

## Introduction

Acute coronary syndrome (ACS) is often the first clinical manifestation of cardiovascular disease, a leading cause of mortality and morbidity worldwide, especially in low- and middle-income countries<sup>1</sup>. About 70% of all ACS do not exhibit significant ST-segment elevation on electrocardiography. A partial or intermittent occlusion of the coronary artery leads to ST-segment depressions (approximately 31%), T-wave inversions (approximately 12%), combined ST-segment depression and T-wave inversion (16%), or neither (approximately 41%)<sup>2</sup>.

Despite the advent of biomarkers, such as high-sensitivity troponin testing, which have increased the diagnosis of non-ST-segment elevation acute myocardial infarction (NSTEMI)<sup>3</sup>, in-hospital mortality has been on a downward trend, estimated at 3.4%, with a 1.6% risk of cardiogenic shock<sup>4</sup>.

In most hospitals, NSTEMI patients are treated in intensive care units (ICUs) or coronary care units (CCUs) as a routine procedure<sup>5</sup>. About 43% of initially stable patients with NSTEMI that are treated in an ICU, only 14% of these patients ultimately develop complications requiring critical care during their hospital stay<sup>6</sup>.

Most patients with ACS (54%) admitted for monitoring alone without any other indication for admission to an ICU/CCU had a short stay and low rates of complications and mortality, highlighting the need for studies to refine triage strategies for lower-risk patients with ACS, which represent a significant volume of admissions ICUs/CCUs<sup>7</sup>.

The Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit (ACTION ICU) score is a 9-variable predictive model applied at

hospital admission to determine the probability of developing complications requiring ICU/CCU care in patients with NSTEMI. The original study yielded an area under the curve (AUC) of 0.72, with better performance than the TIMI, GRACE, and CRUSADE scores<sup>6</sup>.

The nine variables included in the score are (Table 1): signs or symptoms of heart failure on admission, heart rate, systolic blood pressure, initial troponin level, serum creatinine, previous coronary revascularization, chronic lung disease, ST-segment depression on the ECG, and age<sup>6</sup>. Values from 0 to 1 correspond to a low risk of complications (< 3.4%), while scores  $\geq 14$  represent a high risk of complications (39.3%). The cutoff score for ICU/CCU admission is 5, with a 9.3% risk of complications<sup>6</sup>.

Despite the original research findings, few studies have evaluated the accuracy of this score, with discrepancy results among different populations<sup>5,8</sup>. At present, no validation studies have been conducted on the ACTION ICU score in Mexican patients. A well-judged selection of high-risk patients with NSTEMI into critical care units is essential for efficient resource use, and reducing surveillance in the ICU/CCU could significantly reduce disease costs. The purpose of this study was to describe the usefulness of the ACTION ICU score in predicting complications that require critical care in Mexican patients with NSTEMI.

## Material and methods

A retrospective, observational, and comparative study included patients admitted to the CCU diagnosed with NSTEMI, defined according to guidelines criteria<sup>1</sup>. The study was performed from January 2017 to December 2023 in a secondary care hospital in Mexico City, which serves as a cardiovascular center;

**Table 1.** ACTION ICU score

Variable	Points
Age, years	
< 70	0
≥ 70	1
Serum creatinine, mg/dL	
< 1.1	0
≥ 1.1	1
Heart rate, bpm	
< 85	0
85-100	1
≥ 100	3
Systolic blood pressure, mmHg	
< 125	3
125-145	1
≥ 145	0
Initial troponin, × upper limit of normal	
< 12	0
≥ 12	2
Signs or symptoms of heart failure	
No	0
Yes	5
ST depression	
No	0
Yes	1
Prior revascularization	
No	1
Yes	0
Chronic lung disease	
No	0
Yes	2

ACTION ICU: Acute Coronary Treatment and Intervention Outcomes Network intensive care unit.  
Adapted from Fanaroff *et al.*<sup>6</sup>.

coronary angiography, and laboratory tests were performed during the index hospitalization.

Medical records of patients hospitalized for NSTEMI were examined. Patients with respiratory failure, cardiac arrest, shock, and arrhythmias requiring a pacemaker on admission were excluded from the study. Patients who were transferred to other units or departments other than cardiology or lacked any necessary data required to calculate the ACTION ICU score were eliminated from the study.

The following information was collected from medical records: age, gender, comorbidities, weight, height, body mass index (BMI), signs/symptoms of heart failure, vital signs at admission, electrocardiogram findings, days of hospitalization, coronary angiography findings, presence of outcomes, as well as laboratory

results on admission (high-sensitivity cardiac troponin I, serum creatinine, and hemoglobin values). ACTION ICU score was applied to all patients.

The primary outcome was the dependent variable, defined as the presence of any complications during the index hospitalization consisting of cardiac arrest, shock (sustained systolic blood pressure < 90 mmHg or mean arterial pressure < 60 mmHg), high-grade atrioventricular block requiring a pacemaker, respiratory failure, stroke, or death.

The protocol received approval from the research and ethics committee (Record No. 130.129.2023/444.2024) and complied with the Declaration of Helsinki principles. Since the research was without risk, informed consent was not needed. The authors collected all data and added them to a secure database free of patients' personal information and guaranteed privacy.

### Statistical analysis

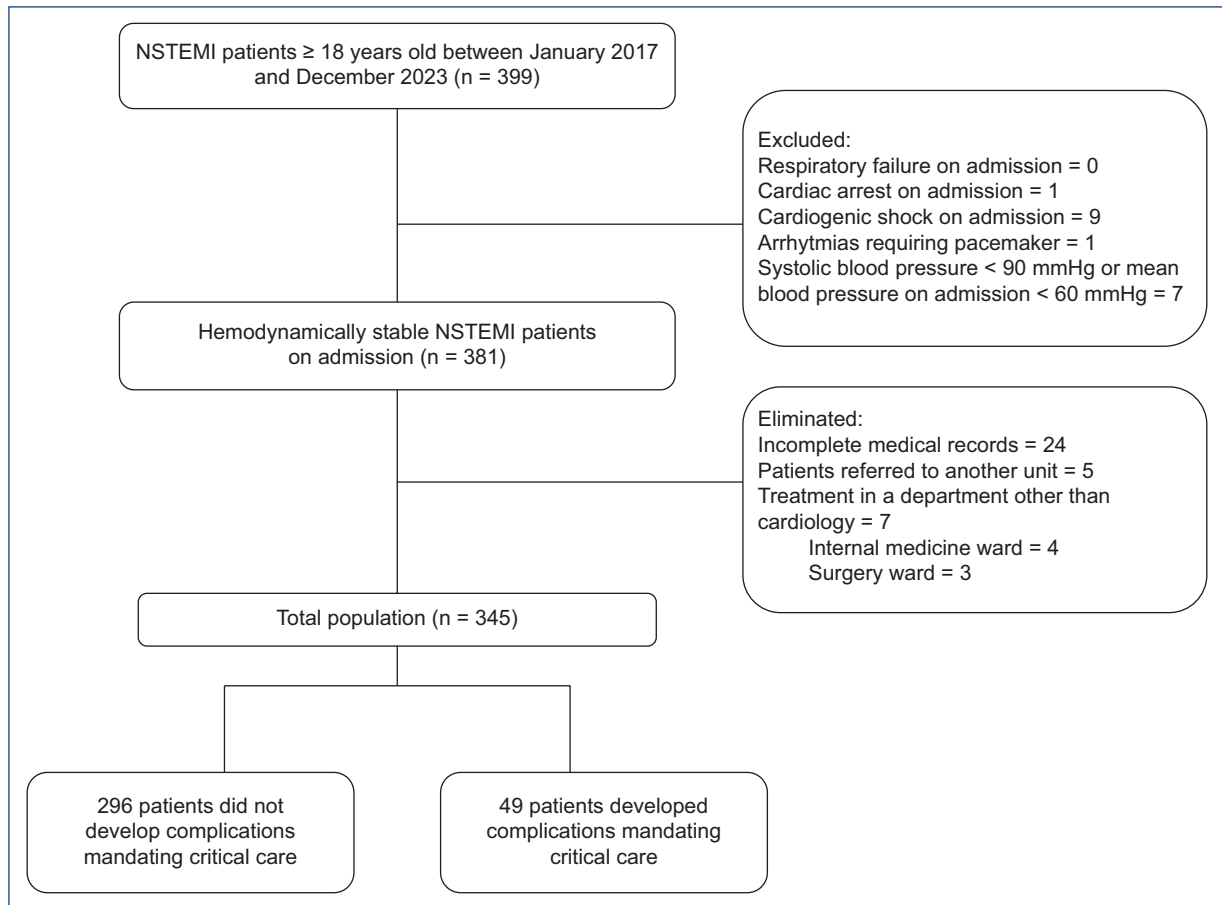
According to data distribution, descriptive analysis was carried out with the report of means and their deviations or medians and interquartile ranges. Qualitative variables were expressed as frequencies and proportions. To look for differences between groups, the Chi-square test and Fisher's exact test were used for categorical variables, Student's t-test was used to compare means, and Mann-Whitney's U-test was used to compare medians.

The area under the receiver operating characteristic curve (AUC) was calculated to determine ACTION ICU's discriminative ability to predict complications requiring critical care. In addition, sensitivity, specificity, positive predictive value, and negative predictive value were calculated. Data were analyzed with STATA SE 14.

### Results

During the study period, a total of 399 patients with the diagnosis of NSTEMI were evaluated. Of this group, 18 patients (4.5%) were excluded due to the following criteria: cardiac arrest, 1; cardiogenic shock, 9; arrhythmias, 1; and patients with shock at admission, 7. Of these 381 patients, 24 patients (6.3%) were eliminated due to incomplete medical records, 5 patients (1.3%) due to being transferred to another unit, and another 7 (1.8%) were transferred to another department other than cardiology, obtaining a total population of 345 patients (Fig. 1).

Table 2 shows the demographic and clinical characteristics of the study population. Patients were



**Figure 1.** Flowchart patient selection. NSTEMI: non-ST-segment-elevation myocardial infarction.

subdivided according to the occurrence of the primary outcome. The mean age was  $66 \pm 11$  years, with a mean BMI of  $28.3 \pm 4.4$  kg/m<sup>2</sup>, and 71.6% were men. Regarding medical history, hypertension (71.6%), smoking (61.4%), and diabetes (53.9%) were the most common in this population. The majority of patients (89.3%) had obstructive coronary artery disease on coronary angiography, with 2-3 vessels affected in 54.5% of cases, with the left anterior descending artery (66.6%) followed by the right coronary artery (53%) being the most affected.

The primary outcome occurred in 49 patients (14.2%). Patients who presented complications were more likely to be older ( $69.5 \pm 11.9$  vs.  $65.7 \pm 10.8$ ,  $p = 0.02$ ), lower weight ( $71 \pm 12.4$  vs.  $77.2 \pm 14.3$ ,  $p < 0.01$ ), shorter in height ( $1.61 \pm 0.1$  vs.  $1.64 \pm 0.1$ ,  $p = 0.01$ ), diabetes (69.4% vs. 51.3%,  $p = 0.02$ ), signs or symptoms of acute heart failure (44.8% vs. 13.5%,  $p < 0.01$ ), higher heart rate ( $85.5 \pm 17.8$  vs.  $79 \pm 17.6$ ,  $p = 0.02$ ), lower systolic blood pressure ( $130 \pm 24.7$  vs.  $141 \pm$

$26.5$ ,  $p = 0.006$ ), ST-segment depression (49% vs. 30.4%,  $p = 0.01$ ), higher serum creatinine ( $1.8$  vs.  $1.2$ ,  $p = 0.003$ ), reduced hemoglobin levels ( $13.1 \pm 2.5$  vs.  $14.8 \pm 2.2$ ,  $p < 0.01$ ), triple-vessel disease (42.8% vs. 21.3%,  $p < 0.01$ ), right coronary artery lesion (69.4% vs. 50.7%,  $p = 0.01$ ), and lesion in the circumflex artery (69.4% vs. 44.6%,  $p < 0.01$ ) at admission.

The most common complication was shock in 43 patients (12.5%), followed by respiratory failure ( $n = 28$ , 8.1%) and cardiac arrest ( $n = 11$ , 3.2%). In-hospital mortality was 3.2% ( $n = 11$ ) (Table 3).

### Action ICU score

In this study, 187 patients (54.2%) had an ACTION ICU score between 0 and 5 points. Ten patients (5.3%) with an ACTION ICU score of 0 to 5 points developed any complication of the primary outcome. The proportion of patients with complications for each score category is described in table 4.

**Table 2.** Patients characteristics

Characteristics	Total (n = 345)	No complications (n = 296)	Complications (n = 49)	p
Female, n (%)	98 (28.4)	82 (27.7)	16 (32.6)	0.47
Age (years), mean (SD)	66 (11.1)	65.7 (10.8)	69.5 (11.9)	0.02
Patient < 65 years, n (%)	149 (43.2)	132 (44.6)	17 (34.7)	0.2
Weight (kg), mean (SD)	76.3 (14.2)	77.2 (14.3)	71 (12.4)	< 0.01
Height (m), mean (SD)	1.63 (0.1)	1.64 (0.1)	1.61 (0.1)	0.01
BMI (kg/m <sup>2</sup> ), mean (SD)	28.3 (4.4)	28.5 (4.5)	27.2 (4)	0.06
Medical history				
Diabetes, n (%)	186 (53.9)	152 (51.3)	34 (69.4)	0.02
Hypertension, n (%)	247 (71.6)	211 (71.3)	36 (73.5)	0.75
Prior MI, n (%)	105 (30.4)	87 (29.4)	18 (36.7)	0.3
Prior HF, n (%)	54 (15.6)	42 (14.2)	12 (24.5)	0.06
Prior PCI, n (%)	94 (27.2)	80 (27)	14 (28.6)	0.82
Prior CABG, n (%)	6 (1.7)	6 (2)	0	0.31
Prior stroke, n (%)	6 (1.7)	5 (1.7)	1 (2)	0.86
Current/Recent smoker, n (%)	212 (61.4)	186 (62.8)	26 (53.1)	0.19
Current dialysis, n (%)	8 (2.3)	7 (2.4)	1 (2)	0.88
Hypothyroidism, n (%)	19 (5.5)	17 (5.7)	2 (4.1)	0.63
Chronic lung disease, n (%)	9 (2.6)	8 (2.7)	1 (2)	0.78
Baseline clinical and laboratory findings				
HF, n (%)	62 (18)	40 (13.5)	22 (44.8)	< 0.01
Heart rate (beats/min), mean (SD)	79.9 (17.7)	79 (17.6)	85.5 (17.8)	0.02
Systolic blood pressure (mmHg), mean (SD)	140 (26.5)	141 (26.5)	130 (24.7)	0.006
New or presumed new ST-segment depression, n (%)	114 (33)	90 (30.4)	24 (49)	0.01
Troponin ratio ( $\times$ ULN), mean (SD)	289 (824)	307 (878)	182 (326)	0.33
Serum creatinine (mg/dl), mean (SD)	1.3 (1.4)	1.2 (1.2)	1.8 (2.2)	0.003
Hemoglobin (g/dL), mean (SD)	14.6 (2.3)	14.8 (2.2)	13.1 (2.5)	< 0.01
Clinical course and coronary artery disease				
Hospital length of stay (days), median (IQR)	4 (3-5)	4 (3-5)	7 (4-10)	< 0.01
ACTION ICU score, median (IQR)	5 (4-7)	5 (4-6.3)	8 (6-12)	<0.01
Obstructive CAD, n (%)	308 (89.3)	262 (88.5)	46 (94)	0.2
Single-vessel disease, n (%)	120 (34.8)	113 (38.2)	7 (14.3)	< 0.01
Double-vessel disease, n (%)	104 (30)	86 (29.1)	18 (36.7)	0.3
Triple-vessel disease, n (%)	84 (24.3)	63 (21.3)	21 (42.8)	<0.01
LFT+Triple vessel disease, n (%)	14 (4.1)	10 (3.4)	4 (8.2)	0.24
Right coronary artery, n (%)	184 (53)	150 (50.7)	34 (69.4)	0.01
LADA, n (%)	230 (66.6)	192 (65)	38 (77.6)	0.06
Circumflex artery, n (%)	166 (48)	132 (44.6)	34 (69.4)	< 0.01
Left main trunk, n (%)	24 (7)	16 (5.4)	8 (16.3)	0.05

BMI: body mass index; CAD: coronary artery disease; HF: heart failure; IQR: interquartile range; LADA: left anterior descending artery; LFT: left main trunk; MI: myocardial infarction; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft surgery; ULN: upper limit of normal.

The use of a cutoff score of 5 points for the ACTION ICU score (like the original study) showed a sensitivity of 87.7% for predicting complications, with a specificity of 42.6%; the positive predictive value and negative predictive value were 20.2 and 95.4%, respectively. A cutoff score of 4 points showed better performance for predicting complications in our population: sensitivity 93.8%, specificity 24%, positive predictive value 17%, and negative predictive value

96%. [Table 5](#) shows the performance of the ACTION ICU score.

In the multivariate analysis, the variable with the highest correlation for the risk of developing complications was the presence of heart failure (OR: 4.78; 95% CI 2.17-10.52,  $p < 0.01$ ) followed by elevated creatinine levels (OR: 2.24, 95% CI: 1.31-3.83,  $p = 0.003$ ) ([Table 6](#)). The area under the curve for the ACTION ICU score was 0.77 (95% CI: 0.64-0.97,  $p = 0.01$ ) ([Fig. 2](#)).

**Table 3.** Description of outcomes

Events	Total population (n = 345)
Shock, n (%)	43 (12.5)
Respiratory failure, n (%)	28 (8.1)
Cardiac arrest, n (%)	11 (3.2)
Death, n (%)	11 (3.2)
Heart block, n (%)	4 (1.1)
Stroke, n (%)	1 (0.3)

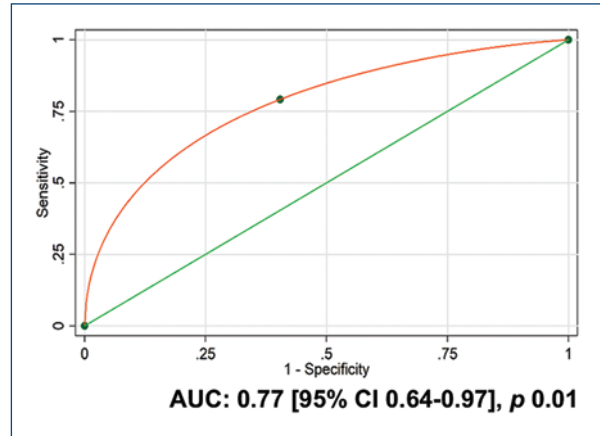
**Table 4.** Distribution of patients for each point in the ACTION ICU score

Score	Total population (n = 345)	Patients with primary outcome (n = 49)	Proportion of patients with primary outcome (%)
0	1	0	0
1	9	1	11.1
2	23	2	8.7
3	41	0	0
4	58	3	5.2
5	55	4	7.3
6	51	6	11.8
7	25	7	28
8	15	4	26.6
9	16	3	18.7
10	11	3	27.3
11	10	3	30
12	11	3	27.3
≥ 13	19	10	52.6

ACTION ICU: Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit.

## Discussion

Our study provided the following important findings: (1) NSTEMI complications requiring critical care (including mortality) were lower than those reported in previous national registries<sup>9</sup>; however, remained similar to or higher than those reported in international studies<sup>5,6,8</sup>, (2) several of the comorbidities found in our study are similar to those identified in national and international registries (hypertension, previous myocardial infarction,



**Figure 2.** ROC curve to predict complications that require critical care (ACTION ICU). ROC: receiver operating characteristic; ACTION ICU: Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit.

and coronary revascularization were all prevalent), but these did not influence the appearance of complications<sup>6,8,9</sup>, (3) a rising national trend in diabetes prevalence<sup>9,10</sup>, and also the highest compared to previous international studies<sup>5,6,8</sup>, which contributes to the appearance of complications<sup>6</sup>, as well as an increasing trend in coronary heart disease of ≥ two vessels<sup>8,9,10</sup>, and (4) the onset of acute heart failure continues nowadays to be the most important risk factor for complications that require critical care<sup>9</sup>.

From their inception in the early 1960s as a means of providing rapid resuscitation to patients with dysrhythmias complicating acute myocardial infarctions, CCUs now provide comprehensive critical care to patients with cardiovascular diseases<sup>11,12</sup>. In light of such changes, international societies have called for further research to assist in the direction of CCU redesigns<sup>12</sup>.

According to Critical Care Cardiology Trials Network registry data, respiratory failure (26.7%) and shock (21.1%) represented the most common causes of CCU admissions and were associated with poor prognosis. Furthermore, nearly one-third of all patients admitted for “observation or monitoring post-procedure,” around 40% did not require critical care and had a very low mortality rate in the CCU (0.2-0.4%). The results suggested a better alignment of hospital resources concerning patient care needs and safety, with a redesign of cardiac critical care, and the launch of trials to test new strategies<sup>12</sup>.

**Table 5.** Performance of the ACTION ICU score in predicting complications

Score	n	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
1	9	100.0	0.3	14.2	100.0
2	23	98.0	3.0	14.3	90.0
3	41	93.8	10.0	14.7	91.0
4	58	93.8	24.0	17.0	96.0
5	55	87.7	42.6	20.2	95.4
6	51	79.6	60.0	24.7	94.6
7	25	67.3	75.0	31.0	93.3
8	15	53.0	81.1	32.0	91.2
9	16	45.0	85.0	33.0	90.3
10	11	38.7	89.2	37.2	90.0
11	10	32.6	92.0	40.0	89.2
12	11	26.5	94.2	43.3	88.6
13	10	20.4	97.0	52.6	88.0
14	4	12.2	99.0	66.6	87.2
15	4	6.1	99.3	60.0	86.5
16	0	0.0	99.6	0.0	85.7
17	1	0.0	99.6	0.0	85.7

The gold standard is the development of complications requiring critical care.  
ACTION ICU: Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit.

**Table 6.** Multivariable model of variables associated with NSTEMI complications

Variable	Total			< 65 years-old			≥ 65 years-old		
	OR	CI 95%	p	OR	CI 95%	p	OR	CI 95%	p
Prior PCI	0.31	(0.07-1.35)	0.12	0.03	(0.002-1.61)	0.08	0.39	(0.06-2.35)	0.31
Chronic lung disease	0.11	(0.008-1.77)	0.12	1	-	-	0.06	(0.03-1.39)	0.08
Signs/symptoms of HF	4.78	(2.17-10.52)	< 0.01	5.39	(0.88-32.7)	0.06	6.13	(2.14-17.48)	0.001
Creatinine	2.24	(1.31-3.83)	0.003	1.68	(0.76-3.73)	0.2	2.21	(0.95-5.12)	0.06
ST-segment depression	1.26	(0.57-2.75)	0.56	2.98	(0.54-16.44)	0.21	0.75	(0.26-2.13)	0.59
Systolic blood pressure	0.98	(0.97-1.01)	0.09	0.97	(0.94-1.01)	0.24	0.98	(0.96-1.00)	0.102
Heart rate	1.01	(0.99-1.03)	0.31	1.03	(0.99-1.08)	0.16	0.99	(0.97-1.02)	0.937
Troponin	1	(0.99-1.00)	0.51	0.99	(0.99-1.01)	0.42	0.99	(0.99-1.00)	0.718
Hemoglobin	0.78	(0.64-0.94)	0.01	0.68	(0.44-1.05)	0.09	0.75	(0.57-0.98)	0.03

HF: heart failure; PCI: percutaneous coronary intervention; NSTEMI: non-ST-segment elevation myocardial infarction.

Routine admission to the CCU/ICU of patients with NSTEMI is a common practice and may limit care and resources to genuinely critical patients<sup>8</sup>. Using risk

scores could enable hospitals to identify NSTEMI patients at the highest risk for clinical deterioration who need immediate admission to the ICU/CCU while

**Table 7.** ACTION ICU performance in previous studies\*

Author	Country	Age (mean)	Complications (%)	AUC	Sens (%)	Sp (%)	PPV (%)	NPV (%)
Fanaroff et al. <sup>6</sup>	United States	77	14.3	0.72	78.4	53.5	22.1	93.6
Guimarães et al. <sup>5</sup>	Brazil	62.3	4.9	0.55	38.7	70.9	8.3	72
Vasquez-Rodriguez et al. <sup>8</sup>	Colombia	66	7.1	0.78	84	48.4	11	97.6
Present study	Mexico	66	14.2	0.77	87.7	42.6	20.2	95.4

\*Results using cutoff score of 5 points.

AUC: area under the curve; Sens: Sensitivity; Sp: Specificity; PPV: positive predictive value; NPV: negative predictive value; ACTION ICU: Acute Coronary Treatment and Intervention Outcomes Network intensive care unit.

safely admitting lower-risk patients to a non-intensive care setting<sup>6</sup>.

At present, popular scores such as GRACE or TIMI are still used in decision-making. However, these predict cardiovascular mortality, recurrent ischemia, and the need for urgent coronary intervention in the first 14 days to 6 months, and they were never developed initially to predict in-hospital complications requiring critical care<sup>8</sup>.

The ACTION ICU score was the first to predict the need for critical care in patients with NSTEMI. The score can be calculated automatically with electronic devices at the point of care to guide the location of care decisions without needing providers to memorize it<sup>6</sup>.

The tool was developed based on data from the ACTION registry, which evaluated 29,973 admissions of Medicare patients over 65 years of age with NSTEMI between April 1, 2011, and December 31, 2012<sup>6</sup>; however, because white patients made up most of the sampled population (85.4%), a requirement arose to evaluate different patient groups<sup>5,8</sup>.

In this study, we evaluated the utility of the ACTION ICU scale for predicting, through its nine variables, the probability that an initially hemodynamically stable patient with NSTEMI will develop a complication requiring critical care. In this cohort of Mexican patients, the ACTION ICU score performed well compared to the original study<sup>6</sup> (Table 7).

The ACTION ICU score was initially developed in patients  $\geq 65$  years of age, and it was thought it could perform poorly in the younger population<sup>6</sup>. In our study, 43.2% of the patients were  $< 65$  years of age, a population younger than the original study but similar to the reported by Vasquez-Rodriguez et al., which demonstrated that there was no significant difference in the score performance between the patients under or over 65 years of age<sup>8</sup>. Unlike Guimarães et al., our population is older; however, the percentage of the

population  $< 65$  years older is not stated in this study, making it premature to attribute limitations in score performance to “young” patients<sup>5</sup>.

Fanaroff et al. suggested that each hospital should select the best cutoff score for CCU/ICU admission when validating the ACTION ICU score<sup>6</sup>. Vasquez-Rodriguez et al. reported a cutoff score of 3 points as the best for predicting complications with a sensitivity of 96%, specificity of 15.4%, PPV of 7.9%, and NPV of 98.1%<sup>8</sup>. In our study, a cutoff score of 4 points gave the best results for predicting complications: sensitivity 93.8%, specificity 24%, PPV 17%, and NPV 96%.

In many nationwide public cardiology hospitals, NSTEMI patients are considered “high-risk” or “very-high-risk” patients, regardless of their hemodynamic status or complications, and are admitted directly to the CCU. In addition, due to the distance between the CCU and the hospital ward, which requires the patient to be moved between floors or wards or to use an elevator in the event of clinical deterioration, many hospitals are reluctant to admit hemodynamically stable patients with NSTEMI in a general ward or room.

This research was conducted on NSTEMI patients who were admitted to a CCU since the circumstances described above suggest that evaluating the ACTION ICU score only in a hospital ward setting could be risky; further research should focus on NSTEMI patients classified as “low-risk” of complications when hospitalized in a general ward under cardiac monitoring.

The study’s limitations included its retrospective nature, performance in a single center, and smaller sample size than previous studies. Since this study was conducted on a cardiac disease-focused unit, the patients may have been selected highly, which could alter the outcomes. In addition, all patients underwent coronary intervention during the hospitalization, making it difficult to apply our findings to medical units

lacking cardiac catheterization laboratories, cardiology departments, and CCUs.

Despite the limitations mentioned above, this study demonstrated the applicability of ACTION ICU for assessing the risk of complications requiring critical care in patients with NSTEMI. According to our knowledge, the ACTION ICU score has never been evaluated in the Mexican population. Therefore, this study's results are valuable for properly stratifying NSTEMI patients in Mexico on hospital admission.

## Conclusions

The ACTION ICU score showed acceptable discriminative ability for identifying Mexican patients with NSTEMI at risk of complications that warrant critical care management. In our population, a cutoff score of 4 points performed best for predicting complications. The effectiveness of this risk score will need to be further investigated in medical units nationwide, especially those with limited resources.

## Clarifying note

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## Conflicts of interest

The authors declare no conflicts of interest.

## Ethical considerations

**Protection of humans and animals.** The authors declare that the procedures followed complied with the ethical standards of the responsible human

experimentation committee and adhered to the World Medical Association and the Declaration of Helsinki. The procedures were approved by the Institutional Ethics Committee.

**Confidentiality, informed consent, and ethical approval.** The authors have obtained approval from the Ethics Committee for the analysis of routinely obtained and anonymized clinical data, so informed consent was not necessary. Relevant guidelines were followed.

**Declaration on the use of artificial intelligence.** The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

## 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;44:3720-826.
2. Bhatt DL, Lopes RD, Harrington RA. Diagnosis and treatment of acute coronary syndromes: a review. *JAMA*. 2022;327:662-75.
3. Corcoran D, Grant P, Berry C. Risk stratification in non-ST elevation acute coronary syndromes: risk scores, biomarkers and clinical judgment. *Int J Cardiol Heart Vasc*. 2015;8:131-7.
4. Martin SS, Aday AW, Almarzooq ZI, Anderson CA, Arora P, Avery CL, et al. 2024 heart disease and stroke statistics: a report of US and global data from the American Heart Association. *Circulation*. 2024;149:e347-913.
5. Guimarães PO, Sampaio MC, Malafaia FL, Lopes RD, Fanaroff AC, de Barros E Silva PG, et al. Clinical outcomes and need for intensive care after non-ST-segment-elevation myocardial infarction. *Eur J Intern Med*. 2020;76:58-63.
6. Fanaroff AC, Chen AY, Thomas LE, Pieper KS, Garratt KN, Peterson ED, et al. Risk score to predict need for intensive care in initially hemodynamically stable adults with non-ST-segment-elevation myocardial infarction. *J Am Heart Assoc*. 2018;7:e008894.
7. Fagundes A Jr., Berg DD, Park JG, Baird-Zars VM, Newby LK, Barsness GW, et al. Patients with acute coronary syndromes admitted to contemporary cardiac intensive care units: insights from the CCCTN registry. *Circ Cardiovasc Qual Outcomes*. 2022;15:e008652.
8. Vasquez-Rodríguez JF, Idrovo-Turbay C, Perez-Fernandez OM, Cruz-Tapias P, Isaza N, Navarro A, et al. Risk of complications after a non-ST segment elevation acute myocardial infarction in a Latin-American cohort: an application of the ACTION ICU score. *Heart Lung*. 2023;57:124-9.
9. Martínez-Sánchez C, Borrayo G, Carrillo J, Juárez U, Quintanilla J, Jerjes-Sánchez C, et al. Clinical management and hospital outcomes of acute coronary syndrome patients in Mexico: the Third National Registry of Acute Coronary Syndromes (RENASICA III). *Arch Cardiol Mex*. 2016;86:221-32.
10. González-Pliego JA, Gutiérrez-Díaz GI, Celis A, Gudiño-Amezcu DA. Registro de síndromes coronarios agudos sin elevación del segmento ST en un centro hospitalario de tercer nivel de atención (estudio RES-CATA-SEST). *Arch Cardiol Mex*. 2014;84:92-9.
11. Morrow DA, Fang JC, Fintel DJ, Granger CB, Katz JN, Kushner FG, et al. Evolution of critical care cardiology: transformation of the cardiovascular intensive care unit and the emerging need for new medical staffing and training models: a scientific statement from the American Heart Association. *Circulation*. 2012;126:1408-28.
12. Bohula EA, Katz JN, van Diepen S, Alviar CL, Baird-Zars VM, Park JG, Barnett CF, et al. Demographics, care patterns, and outcomes of patients admitted to cardiac intensive care units: the critical care cardiology trials network prospective North American multicenter registry of cardiac critical illness. *JAMA Cardiol*. 2019;4:928-35.