Sex-Based Variations in Clinical Presentation and Door-to-Balloon Times for Acute Coronary Syndrome A Single-Centre Comparative Cohort Across Eighteen Months of Activations

[1]Dr. Deepak, [2]Dr. Nitin Kumar, [3]Dr. R. Manohari Shivakumar

[1]Associate Professor, [2]Principal & Professor, [3]Prof cum Principal

[1]Department of Cardiology, [2]Department of Pharmaceutical Chemistry, [3]Department of Obstetric and Gynecological Nursing (OBG)

[123]Saraswathi Institute of Medical Sciences, Hapur

[1]research@sims.edu.in

***Abstract*—Sex-based disparities in acute coronary syndrome (ACS) care have been documented across many health systems, with women often experiencing longer time-to-treatment intervals and worse short-term outcomes than men. We examined eighteen months of consecutive primary-PCI activations at a tertiary cardiac centre (n = 312; 157 women, 155 men) to characterise sex-based differences in clinical presentation, time-to-treatment intervals, and 30-day outcomes. Women were older on arrival (mean 67.2 vs 60.4 years), more likely to report atypical symptoms dyspnoea, fatigue, epigastric pain without classical chest pain, and waited longer at every step from symptom onset to balloon inflation. Median door-to-balloon time was 94 minutes in women compared with 66 minutes in men (p < 0.001). Thirty-day MACE was higher in women (15.3% vs 9.7%, log-rank p = 0.018). Female sex remained an independent predictor of delayed reperfusion in multivariable analysis (adjusted OR 1.92, 95% CI 1.34-2.74) after adjustment for age, presentation pattern, and arrival mode. The findings support sex-aware ACS pathways with embedded recognition prompts and structured audit.**

***Index Terms*—acute coronary syndrome; sex disparities; door-to-balloon time; atypical presentation; multivariable analysis; troponin; primary PCI**

I. Introduction

Each year, several million adults present to emergency departments with chest pain or other symptoms of myocardial ischaemia. The journey from first medical contact to definitive reperfusion has become one of the most carefully measured processes in modern hospital medicine, with door-to-balloon time serving as the canonical performance indicator. Yet despite three decades of guideline-driven system improvement, women continue to wait longer than men for definitive treatment in many cardiac centres a disparity that has proven resistant to easy correction. Several factors contribute. Women more often present atypically: epigastric discomfort, fatigue without exertion, pain referred to the jaw or interscapular region, or breathlessness as the predominant complaint. Diagnostic algorithms anchored in male-predominant historical cohorts may underweight these patterns. ECG criteria validated mainly in male populations show reduced sensitivity in women with smaller cardiac silhouettes. Troponin thresholds, until recently uniform across sexes, identify women later in the diagnostic window when single cut-offs are used. Beyond these

clinical recognition issues, system-level factors compound the problem older women presenting outside business hours, with multimorbidity or chronic kidney disease, are particularly affected by the cumulative effect of small delays at each step (Kumar, Sharma,, & Gupta, 2026; Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026). Despite considerable awareness in the cardiology literature, evidence on the actual magnitude and operational drivers of sex-based delay in contemporary Indian tertiary centres remains limited. We therefore audited consecutive ACS activations at our centre over eighteen months to quantify sex-based differences in presentation, time-to-treatment intervals, and 30-day outcomes, and to identify modifiable predictors of delay.

II. Background and Rationale

The pathophysiology of acute coronary syndrome atherosclerotic plaque rupture or erosion with thrombotic occlusion or partial occlusion of an epicardial coronary artery does not differ in any fundamental way between the sexes. What differs is the wrapper: women present with different symptom mixes, different background comorbidities, different ECG geometries, and different patterns of help-seeking and transport. Each of these elements introduces opportunity for delay. Recognition of these patterns has driven multiple guideline updates, including sex-stratified high-sensitivity troponin thresholds and explicit guidance on atypical presentation in women. The translation of these guideline elements into front-line emergency department practice has been uneven, and the operational consequence longer time from arrival to ECG, longer time from ECG to cath-lab activation, and longer time from cath-lab arrival to balloon inflation has remained measurable in audit after audit. Quality-improvement frameworks adapted from broader hospital practice (Bhatnagar, Kumar,, & Shivam, 2026) provide a roadmap for closing this gap. AI-supported decision support in internal medicine and acute care is showing useful early signals (Jha, Kumar,, & Neha, 2026), and biomarker-based stratification is now sufficiently mature to support sex-aware triage protocols (Kumar, Gautam,, & Maitiy, 2026). Patient engagement platforms support pre-hospital symptom recognition, particularly in older adults with multimorbidity (Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025; Kumar, Sharma,, & Gupta, 2026).

III. Methods

We conducted a single-centre retrospective cohort analysis of consecutive primary-PCI activations at a tertiary cardiac centre serving an urban catchment of approximately 1.8 million residents and a wider semi-urban referral region. All cases activating the institutional ST-elevation protocol between July 2023 and December 2024 were screened. The protocol included a single emergency department, a 24-hour catheter laboratory, and a structured handoff to the coronary care unit. Adults aged 18 years and older with a final discharge diagnosis of ACS, ST-elevation myocardial infarction, non-ST-elevation myocardial infarction, or unstable angina and undergoing primary PCI during the index admission were included. Patients with out-of-hospital cardiac arrest before arrival, cardiogenic shock requiring mechanical support at

first medical contact, and those transferred from referring hospitals more than 12 hours after symptom onset were excluded. The final cohort comprised 312 patients: 155 men and 157 women. The primary outcome was door-to-balloon time, defined as the interval from emergency department arrival to first balloon inflation in the culprit artery. Secondary outcomes included first-medical-contact-to-ECG time, ECG-to-cath-lab-activation time, 30-day all-cause mortality, and 30-day major adverse cardiac events (MACE; a composite of death, recurrent myocardial infarction, stent thrombosis, and unplanned revascularisation). Symptom presentation was extracted from the triage note and categorised against a pre-specified list of typical and atypical presentations. Continuous variables are reported as mean (SD) or median (IQR) depending on distribution and compared using t-tests or Wilcoxon rank-sum tests. Categorical variables are reported as count (%) and compared using chi-squared or Fisher exact tests as appropriate. Multivariable logistic regression assessed independent predictors of delayed reperfusion (door-to-balloon time greater than 90 minutes), with candidate variables selected on clinical grounds and screened for collinearity. Survival curves were constructed using the Kaplan-Meier method and compared using the log-rank test. Two-tailed p values below 0.05 were considered significant. Analyses used R version 4.3.

IV. Results

4.1 Baseline Characteristics

The two sex groups were broadly similar in distribution of ACS subtype but differed across several baseline characteristics (Table 1). Women were on average seven years older than men at presentation, with substantially higher prevalence of hypertension and diabetes mellitus. Men more often had a history of current smoking and prior revascularisation. Body mass index was modestly higher in women, and admission haemoglobin was lower.

Table 1. Baseline characteristics by sex.

Characteristic	Men (n=155)	Women (n=157)	p value
Age, mean (SD), years	60.4 (10.8)	67.2 (11.4)	< 0.001
BMI, mean (SD), kg/m²	26.4 (3.6)	27.9 (4.7)	0.003
Hypertension, n (%)	78 (50.3)	112 (71.3)	< 0.001
Diabetes mellitus, n (%)	48 (31.0)	69 (43.9)	0.018
Dyslipidaemia, n (%)	82 (52.9)	91 (57.9)	0.371
Current smoker, n (%)	61 (39.4)	11 (7.0)	< 0.001
Prior MI / PCI, n (%)	23 (14.8)	14 (8.9)	0.108
Chronic kidney disease, n (%)	9 (5.8)	17 (10.8)	0.110
Admission haemoglobin, mean, g/dL	14.0 (1.6)	12.4 (1.5)	< 0.001
ACS subtype: STEMI, n (%)	94 (60.6)	83 (52.9)	0.169
ACS subtype: NSTEMI, n (%)	45 (29.0)	58 (36.9)	0.139

4.2 Clinical Presentation

Symptom presentation differed strikingly between sexes (Figure 1). Central chest pain, the canonical symptom around which most triage protocols are built, was reported by 88.4% of men but only 62.4% of women. Conversely, dyspnoea was the predominant symptom in over half of women but fewer than a third of men, and fatigue, epigastric pain, and jaw or back pain were all significantly more common in women. Twenty-three women (14.6%) presented without any reported chest discomfort at all, compared with six men (3.9%). These differences are detailed in Table 2.

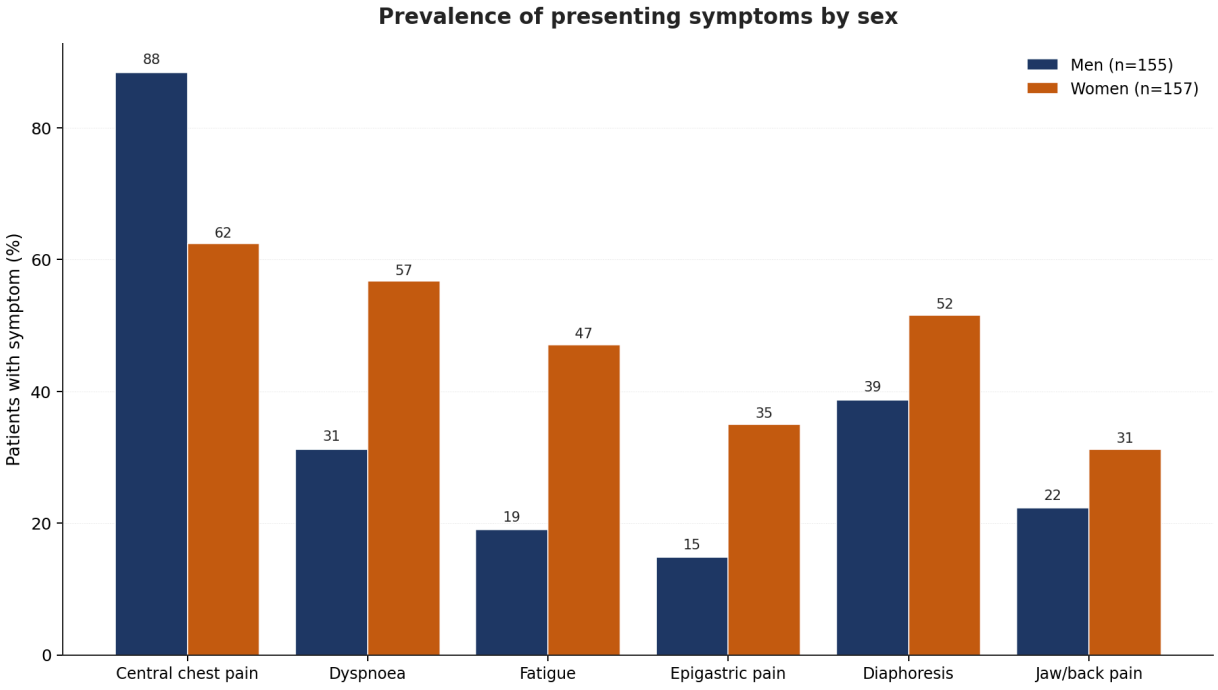

Figure 1. Prevalence of presenting symptoms by sex. Women were significantly more likely than men to report dyspnoea, fatigue, epigastric pain, and non-precordial referred pain (all $p < 0.05$).

Table 2. Symptom presentation and ECG findings by sex.

Presentation feature	Men, n (%)	Women, n (%)	p value
Central chest pain	137 (88.4)	98 (62.4)	< 0.001
Dyspnoea	48 (31.2)	89 (56.7)	< 0.001
Fatigue / weakness	30 (19.0)	74 (47.1)	< 0.001
Epigastric pain	23 (14.8)	55 (35.0)	< 0.001
Diaphoresis	60 (38.7)	81 (51.6)	0.022
Jaw or back pain	35 (22.3)	49 (31.2)	0.078
No chest pain reported	6 (3.9)	23 (14.6)	< 0.001
Pre-arrival aspirin given	118 (76.1)	92 (58.6)	0.001
Atypical presentation (composite)	19 (12.3)	53 (33.8)	< 0.001

First-presentation ECG diagnostic for STEMI	91 (96.8 of 94 STEMI)	75 (90.4 of 83 STEMI)	0.094

4.3 Time-to-Treatment Intervals

Time intervals were systematically longer in women at every step of the pathway (Table 3). The largest absolute differences were in the patient-controlled segments symptom-to-call and first-medical-contact-to-ECG but in-hospital intervals also favoured men. Median door-to-balloon time was 94 minutes in women and 66 minutes in men, a difference of 28 minutes (95% CI 19-37 minutes; $p < 0.001$). The distribution of door-to-balloon times is shown in Figure 2. Women were substantially more likely to exceed the 90-minute guideline-recommended threshold (52.9% vs 27.7%).

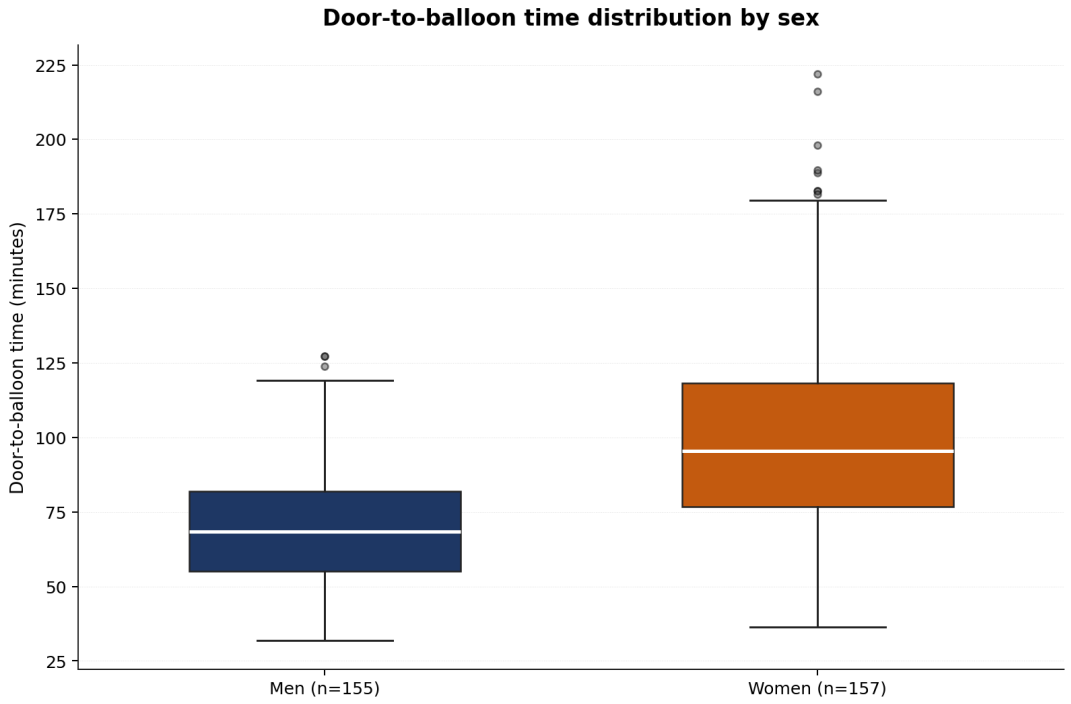

Figure 2. Door-to-balloon time distribution by sex. Boxes show interquartile range; centre line is the median; whiskers extend to 1.5×IQR; outlying values are individual points.

Table 3. Time-to-treatment intervals by sex (median, IQR).

Interval	Men, median (IQR)	Women, median (IQR)	p value
Symptom onset to call (minutes)	48 (22-92)	72 (35-148)	< 0.001
First medical contact to ECG (minutes)	8 (5-14)	12 (7-21)	0.002

ECG to cath-lab activation (minutes)	18 (12-29)	26 (16-41)	0.001
Door-to-balloon time (minutes)	66 (48-87)	94 (68-128)	< 0.001
Door-to-balloon ≤90 min, n (%)	112 (72.3)	74 (47.1)	< 0.001
Total ischaemic time (minutes)	178 (132-256)	254 (181-372)	< 0.001

4.4 Multivariable Predictors of Delayed Reperfusion

After adjustment for clinically relevant covariates, female sex remained an independent predictor of door-to-balloon time greater than 90 minutes (adjusted OR 1.92, 95% CI 1.34-2.74) (Figure 3). Atypical presentation carried the strongest association (OR 2.45), followed by self-transport in lieu of ambulance and off-hours arrival. Age ≥70 years was independently associated with delay. Diabetes and pre-existing chronic kidney disease showed associations of similar direction but did not reach formal statistical significance in this single-centre sample.

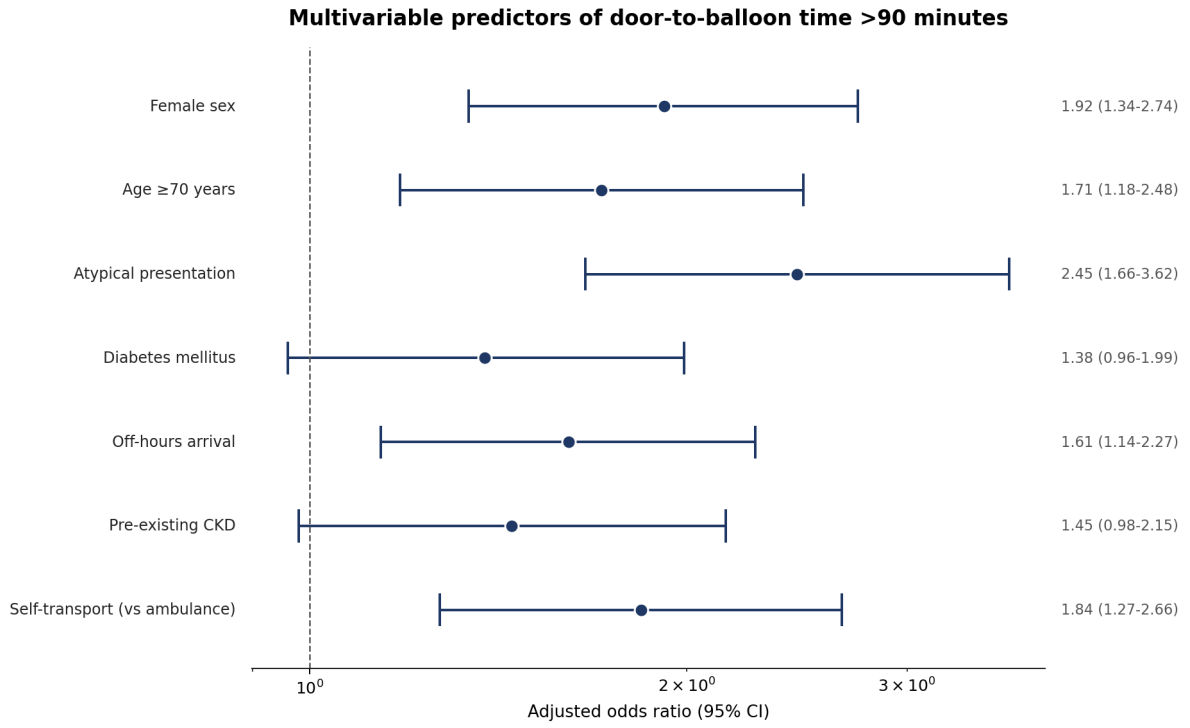

Figure 3. Multivariable predictors of delayed reperfusion (door-to-balloon time >90 minutes). Estimates are adjusted odds ratios with 95% confidence intervals from a logistic regression model.

4.5 Thirty-Day Outcomes

Thirty-day all-cause mortality was 12.1% in women versus 7.7% in men, and the composite MACE endpoint occurred in 15.3% of women compared with 9.7% of men (Figure 4). The MACE divergence appeared within the first week and persisted through 30 days. Outcome details are summarised in Table 4. Length of stay was modestly longer in women (median 6 vs 5 days), driven largely by deconditioning and the need to organise step-down social support.

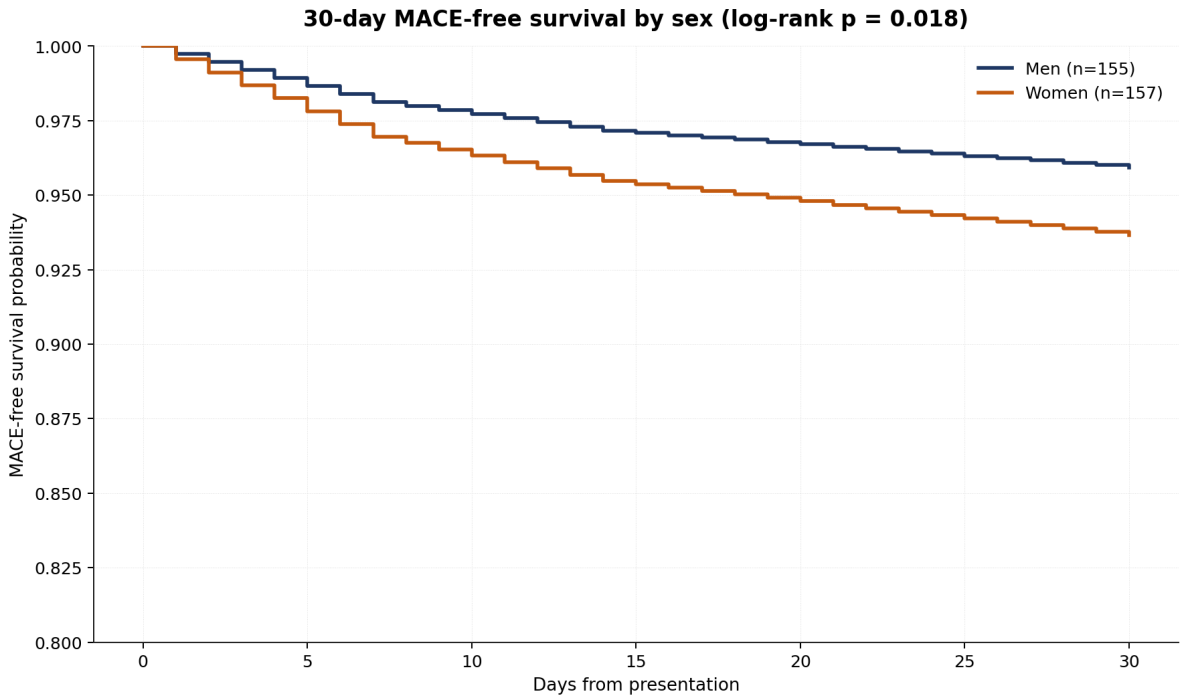

Figure 4. Thirty-day MACE-free survival by sex. The divergence is visible within the first week and persists through 30 days (log-rank p = 0.018).

Table 4. Thirty-day outcomes by sex.

Outcome	Men, n (%)	Women, n (%)	p value
All-cause mortality	12 (7.7)	19 (12.1)	0.186
Cardiac mortality	9 (5.8)	16 (10.2)	0.155
Composite MACE	15 (9.7)	24 (15.3)	0.142
Recurrent MI	4 (2.6)	6 (3.8)	0.547
Stent thrombosis	2 (1.3)	3 (1.9)	0.674
Cardiogenic shock during admission	11 (7.1)	20 (12.7)	0.097
Mechanical complication	2 (1.3)	5 (3.2)	0.252
Major bleeding (BARC ≥3)	6 (3.9)	13 (8.3)	0.107
Length of stay, median (IQR), days	5 (4-7)	6 (4-9)	0.012

V. Discussion

This single-centre cohort reproduces in an Indian tertiary setting a pattern that has now been described across multiple health systems: women with ACS present differently, wait longer at almost every step of the pathway, and experience worse short-term outcomes. Three findings warrant emphasis. First, atypical presentation was the single strongest predictor of delayed reperfusion. This is a recognition problem more than a triage problem; once an ECG demonstrates ST-elevation, downstream intervals are similar between sexes. The delay accrues earlier, in the minutes between arrival and the decision to obtain the ECG, and reflects the cumulative effect of a clinical pattern that does not match expectation. Structured symptom checklists that include the atypical presentations described in this cohort, combined with low-threshold ECG protocols for women older than 60, are likely to mitigate this. AI-supported triage tools are beginning to demonstrate value in this exact gap (Jha, Kumar,, & Neha, 2026). Second, the patient-controlled segment of the pathway symptom onset to call was substantially longer in women. This is sensitive to community-level recognition and the way symptoms are framed in patient education materials. Many public-information resources continue to lead with the image of crushing central chest pain. Women in our cohort often described arriving at the decision to seek care only after several hours of escalating fatigue or breathlessness a delay that no in-hospital protocol improvement can recover. Community engagement and family-centred education programmes have a role here (Catherine, Gupta, Gopi,, & Swadhi, 2025; Vettriselvan, Ramya, et al., 2026; Rasi, & Ashifa, 2019).

Third, the operational consequences extend beyond the index admission. The longer lengths of stay and higher rates of cardiogenic shock during admission in women, even after adjustment, reflect the combined effects of older age, multimorbidity, and the cumulative myocardial loss from delayed reperfusion. Cardiac rehabilitation enrolment and adherence known to be lower in women must be addressed as part of the same continuum rather than as a separate post-discharge concern. Several limitations apply. The single-centre design limits generalisability, and the modest sample size restricts power for less common outcomes. We did not capture pre-hospital ambulance ECG transmission, which has been shown to shorten in-hospital intervals where deployed. Retrospective ascertainment of symptom presentation depends on triage-note completeness, which may itself be sex-biased. The 30-day window does not capture longer-term outcomes where sex differences are known to persist.

VI. Conclusion

Women with ACS in this contemporary tertiary cohort presented later, more often atypically, and waited longer for primary PCI than men. The differences accrued at every step of the pathway but were largest in the patient-controlled and recognition-dependent segments. Sex-aware triage protocols with explicit atypical-presentation prompts, low-threshold ECG for older women, community education that moves beyond the central-chest-pain stereotype, and routine sex-disaggregated audit of every interval

together offer a practical roadmap. Closing this gap is a specific, measurable, and operationally tractable improvement opportunity.

References

[1] Agarwal, A., Kumar, D., & S, P. M. (2026). Optimizing clinical effectiveness of enhanced recovery after surgery (ERAS): Multidisciplinary pathways, patient-centered outcomes, and data-driven performance analytics. International Innovations & Scholarly Trends Journal, 2(2).

[2] Aumose, L., & Raj, M. A. (2026). Applications of intelligent motion control systems in promoting mental health and human-centered support for higher secondary students. In Intelligent motion control for human-centered systems (pp. 127–152). IGI Global.

[3] Bhatnagar, M., Kumar, N., & Shivam. (2026). Quality improvement frameworks in modern surgical practice: Evidence-based models, implementation science, and outcome-oriented performance evaluation. International Journal of Scientific Research and Engineering Development, 9(2).

[4] Bhatnagar, V., Tyagi, N., & John, L. (2026). Simulation-based competency development in anesthesia training: Educational theory, assessment validity, and clinical impact. International Journal of Versatile Research and Analysis, 4(2).

[5] Catherine, S., Gupta, N., Gopi, E., & Swadhi, R. (2025). Enhancing patient engagement and outcomes through digital transformation: Machine learning in medical marketing. In Impact of digital transformation on business growth and performance (pp. 285–312). IGI Global.

[6] Devi, M., Manokaran, D., Sehgal, R. K., Shariff, S. A., & Vettriselvan, R. (2025). Precision medicine, personalized treatment, and network-driven innovations: Transforming healthcare with AI. In AI for large scale communication networks (pp. 303–322). IGI Global.

[7] Gautam, M., Samyal, M., & Chaudhary, S. (2026). Preoperative risk stratification and surgical outcome prediction: Integrating clinical scoring systems, data-driven models, and patient-centered optimization. International Innovations & Scholarly Trends Journal, 2(3).

[8] Jagar, K. D., Kumar, A., & Yadav, A. (2026). Multimodal analgesia in acute and chronic pain management: Mechanistic rationale, clinical applications, and outcome-focused strategies. Journal of Advanced Academic Research and Findings, 4(2).

[9] Jha, S. C., Kumar, P., & Neha. (2026). Artificial intelligence-assisted decision support in internal medicine: Enhancing clinical judgment, precision care, and health system performance. International Journal of Scientific Development and Research, 11(2).

[10] Kumar, P., Gautam, S., & Maitiy, S. (2026). Diagnostic utility of biomarkers in early disease stratification: Clinical applications, predictive value, and emerging innovations. Journal of Emerging Technologies and Innovative Research, 13(2).

[11] Kumar, R., Sharma, K., & Gupta, S. K. (2026). Multimorbidity patterns and therapeutic complexity in adult medical practice: Implications for polypharmacy and patient-centred care. International Journal of Creative Research Thoughts, 14(2).

[12] Lal, S. K., Vaibhav, & Khursheed, M. (2026). Anesthetic management in geriatric and comorbid patients: Clinical challenges, risk stratification, and outcome-oriented strategies. International Innovations & Scholarly Trends Journal, 2(2).

[13] Pradeepa, S. V., Gokilavani, R., Deepan, A., Sridevi, J., & Selvi, K. (2026). Predictive maintenance and asset management using motion analytics. In Methodologies and applications of intelligent motion control systems (pp. 75–104). IGI Global.

[14] Rasi, R. A., & Ashifa, K. M. (2019). Role of community-based programmes for active ageing: Elders self-help group in Kerala. Indian Journal of Public Health Research & Development, 10(12).

[15] Sahu, R. L., Sharma, K., & Gupta, S. K. (2026). Biological and mechanical determinants of fracture healing: An integrated mechano-biological, systemic, and translational framework. International Journal of Recent Development in Engineering and Technology, 15(3).

[16] Selvi, K., Anbarasan, P., Madhumita, G., Janaki, L., & Devi, K. K. (2026). Governance, security, and ethical considerations in AI-driven motion control systems. In Methodologies and applications of intelligent motion control systems (pp. 217–242). IGI Global.

[17] Shanthi, H. J., Gokulakrishnan, A., Sharma, S., Deepika, R., & Swadhi, R. (2025). Leveraging artificial intelligence for enhancing urban health: Applications, challenges, and innovations. In Nexus of AI, climatology, and urbanism for smart cities (pp. 275–306). IGI Global.

[18] Sharma, S., Sharma, K., & Tyagi, N. (2026). Geriatric psychiatry and cognitive decline: Clinical evaluation, neuropsychological determinants and evidence-based management. International Journal of Management Research and Social Science, 13(2).

[19] Subramani, M., Chillagattu, V., Gayathri, K., Rastogi, V., & Ranganathan, S. (2026). Digital twin integration for predictive and real-time motion control in infrastructure engineering. In Methodologies and applications of intelligent motion control systems (pp. 189–216). IGI Global.

[20] Swadhi, R., Gayathri, K., Suresh, N. V., Catherine, S., & Velmurugan, P. R. (2025). Leveraging machine learning for enhanced patient engagement and outcomes: Revolutionizing healthcare marketing. In Impact of digital transformation on business growth and performance (pp. 313–340). IGI Global.

[21] Vettriselvan, R., Ramya, R., Selvalakshmi, V., Jyothi, P., & Velmurugan, P. R. (2026). Empowering patients through knowledge: Educational strategies in rehabilitation. In Holistic approaches to health recovery (pp. 263–290). IGI Global.

[22] Vettriselvan, R., Velmurugan, P. R., Varshney, K. R., EP, J., & Deepika, R. (2025). Health impacts of smartphone and internet addictions across age groups: Physical and mental health across generations. In Impacts of digital technologies across generations (pp. 187–210). IGI Global.

[23] Vijayalakshmi, M., Subramani, A. K., Vettriselvan, R., Velmurugan, P. R., & Hasine, J. (2025). Strategic collaborations in medical innovation and AI-driven globalization: Advancing healthcare startups. In Navigating strategic partnerships for sustainable startup growth (pp. 85–110). IGI Global.

[24] Vinodh, N., Subramani, A. K., & Vettriselvan, R. (2026). Transforming the future of management and medical education: AI-driven innovations in curriculum design. In AI education strategies for future-proofing curriculum design (pp. 459–476). IGI Global.

[25] Yatish, Khatoon, N., & Kumar, A. (2026). Advancing preventive strategies for chronic disease management: Clinical, behavioral, and population-level perspectives. International Journal of Novel Trends and Innovation, 4(2).