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Temporal Trends in Acute Coronary Syndrome Presentations in Sri Lanka : A Seven-Year Retrospective Study

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Abstract

Background

To describe the temporal trends in acute coronary syndrome presentations at a Sri Lankan tertiary care centre and examine age- and sex-related differences in myocardial infarction presentation.

Methods

We retrospectively analysed 11,232 adult acute coronary syndrome admission episodes from 2019 to 2025. Temporal trends were assessed using chi-squared tests for trend. Multivariable logistic regression with patient-level cluster-robust standard errors examined factors associated with ST-elevation rather than non-ST-elevation myocardial infarction, with calendar year modelled categorically.

Results

Non-ST-elevation myocardial infarction accounted for 59.7% of all admissions and increased from 46.8% in 2019 to 62.1% in 2025 while unstable angina decreased from 36.2% to 12.0% (both $p < 0.001$). Patients aged ≥ 66 years accounted for 50.4% of admissions and their proportion increased over time ($p < 0.001$). Among 8,509 confirmed myocardial infarction admissions, 589 (6.9%, 95% confidence interval 6.4–7.5%) occurred in patients aged 18–45 years, with no significant linear temporal trend ($p = 0.303$). ST-elevation myocardial infarction occurred in 34.0% of patients aged 18–45 years versus 20.3% of those aged > 45 years. After adjustment for sex and calendar year, age 18–45 years (adjusted odds ratio 1.75, 95% confidence interval 1.45–2.12, $p < 0.001$) and male sex (adjusted odds ratio 1.84, 95% confidence interval 1.63–2.08, $p < 0.001$) were independently associated with ST-elevation myocardial infarction.

Conclusion

Acute coronary syndrome presentations shifted towards greater non-ST-elevation myocardial infarction predominance and older age distribution. No significant linear temporal trend in the proportion of young-onset myocardial infarction was detected, but younger age was associated with a greater relative likelihood of ST-elevation presentation compared with older myocardial infarction.

1. Introduction

Cardiovascular disease (CVD) accounts for approximately 19.8 million deaths annually, with 85% attributable to heart attack and stroke, and over three-quarters occurring in low- and middle-income countries (LMICs).[1] ACS encompassing STEMI, NSTEMI, and unstable angina, arises from acute

reduction in coronary blood flow and represents a major cause of morbidity and premature mortality globally.[2]

South Asian populations carry a disproportionately high ACS burden, particularly premature coronary disease, with MI occurring at younger ages than in many other populations.[3, 4] Urbanisation, dietary transition, and rising prevalence of risk factors including diabetes, hypertension, and dyslipidaemia contribute to the growing burden of ACS incidence across LMICs.[5, 6] Sri Lanka, as a middle-income South Asian country undergoing rapid demographic and epidemiological transition, is particularly vulnerable to this trajectory.[7, 8]

Young-onset MI (MI at age ≤ 45 years) carries unique long-term consequences, including loss of productive years and high recurrence risk.[9] Furthermore, South Asians experience their first MI at a younger age than individuals from other regions, with INTERHEART reporting a mean difference of approximately six years.[3]

Sex is an important modifier of ACS epidemiology. Women present at an older age, more frequently with atypical symptoms and NSTEMI, and experience worse outcomes compared with men.[10] Across Sri Lankan and regional registries, male predominance in ACS cohorts has been consistently reported [4, 7, 8, 11] Despite this burden, longitudinal ACS data from Sri Lanka remain limited. Existing Sri Lankan studies are largely cross-sectional or shorter term and do not examine temporal trends in subtype distribution, sex patterns, age-stratified STEMI/NSTEMI patterns, or young-onset MI over time.[7, 8, 11, 12] This study addresses these gaps by analysing seven-year trends in ACS presentations at Sri Jayewardenepura General (Teaching) Hospital (SJGH) and examining whether STEMI versus NSTEMI presentation differs according to age and sex, with particular emphasis on young-onset MI.

2. Methodology

2.1 Design and Setting

A retrospective, observational, single-centre study was conducted at SJGH, Sri Lanka, covering all ACS admissions from 1 January 2019 to 31 December 2025. The unit of analysis was the hospital admission episode. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

2.2 Inclusion and Exclusion Criteria

All hospital admission episodes in patients aged ≥ 18 years with an ACS-related final diagnosis (STEMI, NSTEMI, unstable angina or unspecified MI) recorded in the SJGH Electronic Inpatient Morbidity and Mortality Record (EIMMR) system per ICD-10 coding were included. Individual level risk factors, laboratory reports, treatments, coronary imaging and clinical outcomes were not available in the source

dataset and therefore not analysed. Eligible records were identified using ICD-10 codes I20, I20.0,I20.1,I20.8,I20.9,I21,I21.0,I21.1,I21.2,I21.3,I21.31,I21.36,I21.4 and I21.9.

The initial dataset contained 11,775 source records. Duplicate source rows within each annual dataset sharing the same BHT and admission date and representing the same hospital admission episode were identified and collapsed. This removed 521 repeated records, leaving 11,254 unique admission episodes. Recurrent admissions occurring on different admission dates were retained as separate clinical episodes. The BHT number served as the persistent patient identifier across admissions, allowing recurrent admissions from the same patient to be identified. Five episodes in patients aged < 18 years and 17 adult episodes with admission dates before 1 January 2019 were excluded, yielding a final analytic cohort of 11,232 adult ACS admissions between 1 January 2019 and 31 December 2025. Calendar year was assigned according to the recorded admission date.

Discharge mode was not analysed as a mortality outcome because the field was substantially incomplete and did not provide sufficiently reliable classification of in-hospital death, transfer, or discharge against medical advice.

2.3 Variables and Definitions

ACS subtype was retained exactly as recorded in the hospital-provided EIMMR extract and was not retrospectively classified by the study team. The recorded diagnostic categories were STEMI,NSTEMI, unstable angina and unspecified MI. Young-onset MI was defined as STEMI or NSTEMI in patients aged 18–45 years, consistent with South Asian definitions.[4, 12] Older MI was defined as STEMI or NSTEMI in patients aged > 45 years. For all analyses specifically comparing STEMI with NSTEMI, unstable angina and unspecified MI were excluded, yielding a confirmed adult MI cohort of 8,509 admissions.

2.4 Age Classification

The adult cohort was examined using decade-based age groups : 18–29, 30–39, 40–49, 50–59, 60–69 and ≥ 70 years. These groups were used to describe the overall age and sex distribution of ACS admissions. For temporal assessment of the overall age distribution, patients were additionally grouped as 18–45, 46–55, 56–65, and ≥ 66 years.

For STEMI/NSTEMI analysis, four age categories (18–35, 36–45, 46–60 and > 60 years) were used to examine age-related patterns in presentation. The prespecified young-versus-older MI comparisons used 18–45 years versus > 45 years.

2.5 Statistical Analysis

Continuous age data were expressed as median and interquartile range (IQR) and categorical variables as frequencies and percentages. Pearson’s chi-squared test with Cramér’s V was used to assess associations between categorical variables, while temporal trends were assessed using chi-squared tests for linear trends. Young-versus-older (18–45 vs > 45 years) STEMI/NSTEMI comparisons were expressed as odds ratios (ORs) with 95% confidence intervals and assessed using Fisher’s exact test.

Wilson 95% confidence intervals were used for proportions, while exact conditional confidence intervals were used for crude odds ratios derived from Fisher's exact tests. Tests for trend across the four ordered age categories used ordinal scores of 1–4. The young-versus-older multivariable model was considered the primary inferential analysis; other subgroup and interaction analyses were secondary or exploratory, and no adjustment for multiple comparisons was applied. Admission-level descriptive tests did not account for within-patient correlation, which was addressed in the multivariable analyses using patient-level cluster-robust standard errors.

The association of young age with STEMI rather than NSTEMI after adjustment for sex and calendar year was assessed using multivariable logistic regression. Calendar year was modelled as a categorical variable in the primary model to account for year-to-year variation without assuming a linear temporal effect. Since recurrent admissions from the same patient were identifiable using the persistent BHT number, patient-level cluster-robust standard errors were used to account for within-patient correlation. A joint Wald test assessed the overall contribution of categorical calendar year.

A secondary model examined the predefined age categories (18–35, 36–45, 46–60, and > 60 years), with > 60 years as the reference group. A joint Wald test assessed the age-group-by-sex interaction.

A sensitivity analysis restricted the dataset to each patient's first observed eligible MI admission to assess whether recurrent admissions influenced the primary association. As this analysis contained one observation per patient, heteroskedasticity-robust HC1 standard errors were used. A further sensitivity analysis modelled calendar year as a continuous variable to assess the robustness of the primary association to an alternative temporal specification.

All tests were two-sided, with $P < 0.05$ considered statistically significant. Statistical analyses were performed using R version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria). No imputation was required because the principal analytic variables were complete.

2.6 Ethics

Ethical approval

was obtained from the Ethical Review Committee of Sri Jayewardenepura General Hospital prior to data collection (SJGH/26/ERC/013). Patient confidentiality was maintained at all times; all data were de-identified before analysis. As this was a retrospective study utilising routinely collected administrative data, individual patient consent was not required.

2.7 Data Quality and Bias

All eligible ACS admissions during the predefined study period were included to minimise selection bias. Annual source datasets were extracted directly from the hospital EIMMR database. Repeated rows representing the same admission episode were collapsed while recurrent admissions on different admission dates were retained as separate clinical episodes and linked using the persistent BHT

identifier. Diagnostic categories were retained as recorded in the EIMMR system without retrospective reclassification or independent clinical adjudication.

3. Results

3.1 Study Population

The final cohort comprised 11,232 ACS admissions. Overall median age was 66 years (IQR: 57–75); male patients were younger (median 64, IQR 55–73) than female patients (median 69, IQR 59–77). Males comprised 57.8% (n = 6,491) and females 42.2% (n = 4,741).

NSTEMI was the predominant ACS subtype (59.7%, n = 6,700), followed by unstable angina (18.9%, n = 2,118), STEMI (16.1%, n = 1,809), and unspecified MI (5.4%, n = 605). ACS subtype distribution differed significantly by sex (χ^2=244.11, df = 3, $P < 0.001$, Cramér's V = 0.147). Males had a higher percentage of STEMI than females (20.1% vs 10.7%), whereas unstable angina was more frequent among females (23.4% vs 15.5%).

Among the 8,509 confirmed STEMI or NSTEMI admissions, young-onset MI (18–45 years) accounted for 589 (6.9%, 95% CI 6.4–7.5%), of whom 486 (82.5%) were male and 103 (17.5%) were female. Baseline characteristics are presented in Table 1.

Table 1
Baseline characteristics and ACS subtype distribution by sex.

Characteristic	Total	Male (n = 6,491)	Female (n = 4,741)
Age, median (IQR), years	66 (57–75)	64 (55–73)	69 (59–77)
NSTEMI	6,700 (59.7%)	3,846 (59.3%)	2,854 (60.2%)
STEMI	1,809 (16.1%)	1,304 (20.1%)	505 (10.7%)
Unstable angina	2,118 (18.9%)	1,008 (15.5%)	1,110 (23.4%)
Unspecified MI	605 (5.4%)	333 (5.1%)	272 (5.7%)
Young-onset MI among MI admissions, 18–45 years	589/8,509 (6.9%)	486/5,150 (9.4%)	103/3,359 (3.1%)

Values are n(%) unless otherwise indicated. Percentages for young-onset MI use confirmed STEMI/NSTEMI admissions as denominators. ACS, acute coronary syndrome, IQR, Interquartile range, MI, myocardial infarction, NSTEMI, non-ST-elevation myocardial infarction, STEMI, ST-elevation myocardial infarction

3.2 Annual ACS Admissions and Subtype Trends

Admissions peaked in 2019 (n = 2164) and subsequently declined, with partial recovery during 2023–2024, before reaching the lowest annual total in 2025 (n = 1,047). The overall distribution of ACS subtypes changed significantly across the study period (χ^2=1077.2, df = 18, $P < 0.001$; Cramér's V = 0.179).

NSTEMI remained the predominant subtype throughout, rising significantly from 46.8% in 2019 to 62.1% in 2025, with a significant positive linear trend (χ^2= 248.35, $P < 0.001$). Conversely, a sharp reduction was seen in unstable angina from 36.2% to 12.0% (χ^2=655.60, $P < 0.001$). STEMI demonstrated greater year-to-year variation, ranging from 11.0% in 2024 to 21.0% in 2025, although a significant overall linear trend was observed (χ^2=17.96, $P < 0.001$). Unspecified MI also showed a significant, although less distinct temporal trend (χ^2=10.36, $P = 0.001$). Annual distributions are shown in Fig. 1.

Annual proportions of ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), unstable angina, and unspecified myocardial infarction among 11,232 adult acute coronary syndrome admission episodes. The distribution of acute coronary syndrome subtypes differed significantly across calendar years (χ^2=1077.2, df = 18, $P < 0.001$). NSTEMI increased over the study period, while unstable angina declined substantially; STEMI showed greater year-to-year variation. Temporal trends in individual subtype proportions were assessed using chi-squared tests for linear trend.

3.3 Sex-Specific Trends

The proportion of male ACS admissions increased from 54.0% in 2019 to 60.3% in 2025, with the highest proportion observed in 2021 (61.7%). A modest but statistically significant temporal increase in the proportion of male admissions was noted (χ^2=5.27, $P = 0.022$). Annual distribution of ACS subtype and sex are presented in Supplementary Table S1.

Across the seven-year period, males were more likely to present with STEMI, while unstable angina was observed more commonly among females, consistent with the significant overall association between sex and ACS subtype described above (Table 1).

3.4 Age Group Distribution

Patients aged ≥ 66 years comprised 50.4% (5,656/11,232) of all ACS admissions and formed the largest predefined age group. Their proportion increased from 46.3% in 2019 to 54.6% in 2025 (χ^2=54.55, $P < 0.001$) (Table 2). In contrast, patients aged 18–45 years accounted for 7.4% (833/11,232) of all ACS admissions and declined from 8.4% in 2019 to 5.9% in 2025 (χ^2=12.84, $P < 0.001$). The overall age-group distribution also differed across calendar years (χ^2=79.96, df = 18, $P < 0.001$), although effect size was small (Cramér's V = 0.049) (Table 2).

In the decade-based analysis, patients aged ≥ 70 years represented the largest age group (39.8%), followed by 60–69 years (27.4%) and 50–59 years (20.5%). Male predominance was most pronounced among younger patients, accounting for 79.2% of those aged 18–29 years and 77.7% of those aged 30–

39 years, and declined progressively with advancing age. Among patients aged ≥ 70 years, the sex distribution was approximately equal (49.5% male and 50.5% female). The temporal age-group distribution is presented in Table 2.

Table 2
Annual distribution of ACS admissions by age group, 2019–2025.

Year	Total	18–45	46–55	56–65	≥ 66
2019	2,164	181 (8.4%)	349 (16.1%)	633 (29.3%)	1001 (46.3%)
2020	1,804	146 (8.1%)	320 (17.7%)	528 (29.3%)	810 (44.9%)
2021	1,579	123 (7.8%)	261 (16.5%)	391 (24.8%)	804 (50.9%)
2022	1,421	109 (7.7%)	212 (14.9%)	363 (25.5%)	737 (51.9%)
2023	1,647	128 (7.8%)	234 (14.2%)	421 (25.6%)	864 (52.5%)
2024	1,570	84 (5.4%)	216 (13.8%)	402 (25.6%)	868 (55.3%)
2025	1,047	62 (5.9%)	133 (12.7%)	280 (26.7%)	572 (54.6%)

Values are n(%) within each calendar year. ACS, acute coronary syndrome.

3.5 STEMI vs NSTEMI by Age Group

Restricting the analysis to confirmed STEMI and NSTEMI admissions (n = 8,509), STEMI prevalence differed significantly across the four predefined age groups (χ^2=147.64, df = 3, $P < 0.001$; Cramér's V = 0.132) and showed a significant overall inverse trend across ordered age categories (χ^2 for trend = 140.26, $P < 0.001$).

STEMI accounted for 32.4% (95% CI 24.2–41.8%) of MI admissions among patients aged 18–35 years and 34.3% (95% CI 30.2–38.6%) among those aged 36–45 years. This declined to 26.8% (95% CI 25.1–28.6%) among patients aged 46–60 years and 17.5% (95% CI 16.5–18.5%) among those aged > 60 years. These findings are shown in Table 3 **and** Fig. 2. farction

Table 3
STEMI versus NSTEMI presentation by age group.

Age group, years	Total MI	STEMI	NSTEMI	STEMI 95% CI	Adjusted OR (95% CI)	p-value
18–35	105	34 (32.4%)	71 (67.6%)	24.2–41.8	1.96 (1.27–3.00)	0.002
36–45	484	166 (34.3%)	318 (65.7%)	30.2–38.6	2.12 (1.71–2.62)	< 0.001
46–60	2,399	643 (26.8%)	1,756 (73.2%)	25.1–28.6	1.61 (1.43–1.82)	< 0.001
> 60	5,521	966 (17.5%)	4,555 (82.5%)	16.5–18.5	1.00 (reference)	—

STEMI proportions are presented with 95% Wilson confidence intervals. Adjusted odds ratios were derived from logistic regression adjusted for sex and categorical calendar year using patient-level cluster-robust standard errors; age > 60 years was the reference group. CI, confidence interval; MI, myocardial infarction, NSTEMI, non-ST-elevation myocardial infarction, STEMI, ST-elevation myocardial infarction, OR, odds ratio.

Proportion of STEMI among 8,509 confirmed myocardial infarction admission episodes, stratified by age group. Points represent observed proportions and error bars represent 95% Wilson confidence intervals. A significant overall inverse trend was observed across ordered age categories (χ^2 for trend = 140.26, $P < 0.001$).

After adjustment for sex and categorical calendar year, the odds of STEMI were higher among patients aged 18–35 years (aOR 1.96, 95% CI 1.27-3.00, $P = 0.002$), 36–45 years (aOR 2.12, 95% CI 1.71–2.62, $P < 0.001$) and 46–60 (aOR 1.61, 95% CI 1.43–1.82,$P < 0.001$) compared to those > 60 years. Male sex was independently associated with STEMI presentation (aOR 1.74, 95% CI 1.54–1.97, $P < 0.001$). (Table 3).

Using the prespecified young-versus-older comparison, STEMI occurred in 34.0% (200/589) of young MI admissions compared with 20.3% (1,609/7,920) among those aged > 45 years. Young patients therefore had approximately twice the unadjusted odds of STEMI (OR 2.02, 95% CI 1.68–2.42, $P < 0.001$).

In the primary multivariable model, young age remained independently associated with STEMI (aOR 1.75, 95% CI 1.45–2.12, $P < 0.001$). Likewise, male sex was independently associated with STEMI (aOR 1.84, 95% CI 1.63–2.08, $P < 0.001$) (Table 4). Calendar year showed significant overall variation when modelled categorically (joint χ^2=66.26, df = 6, $P < 0.001$).

Table 4
Multivariable analysis of factors associated with STEMI presentation.

Variable	Primary aOR (95% CI)	p-value	First-observed admission aOR (95% CI)	Sensitivity p-value
Young age, 18–45 vs > 45 years	1.75 (1.45–2.12)	< 0.001	1.78 (1.47–2.15)	< 0.001
Male vs female	1.84 (1.63–2.08)	< 0.001	1.87 (1.66–2.12)	< 0.001

The primary model included all eligible MI admission episodes and used patient-level cluster-robust standard error. the first observed admissions sensitivity model included one eligible MI admission per patient and used HC1 robust standard error. Both models adjusted for young age, sex and categorical calendar year. MI, myocardial infarction, STEMI, ST-elevation myocardial infarction, OR, odds ratio, aOR, adjusted odds ratio.

Among young patients, males had higher unadjusted STEMI odds than females (OR 2.44, 95% CI 1.42–4.34, $P = 0.001$). Young males also had higher STEMI odds than older males (OR 1.85, 95% CI 1.51–2.26, $P < 0.001$), whereas the corresponding young-versus-older comparison among females was not statistically significant (OR 1.38, 95% CI 0.79–2.29, $P = 0.208$). However, the formal age-group-by-sex interaction was not significant after adjustment for categorical calendar year (joint Wald $\chi^2=2.89$, df = 3, $P = 0.409$).

Since recurrent admissions were present, the main multivariable models used BHT-clustered robust standard errors. Among the 8,509 MI admission episodes, 7,266 unique patients were identified; 1,017 patients had more than one eligible MI admission. Restricting the analysis to each patient's first observed eligible MI admission produced similar results: with young age remaining independently associated with STEMI after adjustment for sex and categorical calendar year (aOR 1.78, 95% CI 1.47–2.15, $P < 0.001$). The association persisted after calendar year was modelled as a continuous variable in the full episode-level cohort (aOR 1.77, 95% CI 1.47–2.14, $P < 0.001$).

3.6 Young-Onset MI

Of 8,509 confirmed MI admissions, 589 (6.9%, 95% CI 6.4–7.5%) occurred in patients aged 18–45 years. The annual proportion of young-onset MI among MI admissions ranged from 5.55% in 2024 to 8.21% in 2021. No statistically significant linear temporal trend was observed ($\chi^2= 1.06$, $P = 0.303$) (Fig. 3).

Annual proportion of young-onset myocardial infarction among STEMI and NSTEMI admission episodes. Young-onset MI was defined as myocardial infarction occurring at age 18–45 years. Points represent annual proportions and error bars represent 95% Wilson confidence intervals. No significant linear temporal trend was observed ($\chi^2=1.06$, $P = 0.303$).

4. Discussion

This seven-year analysis demonstrates several changes in the ACS case mix in a Sri Lankan tertiary centre. NSTEMI remained the predominant presentation subtype and increased over time as unstable angina declined substantially. The proportion of older patients increased, while young-onset MI accounted for 6.9% of confirmed MI admissions and showed no statistically significant linear temporal trend. Importantly, younger age was independently associated with STEMI rather than NSTEMI presentation, an association which persisted after adjustment for sex and categorical calendar year and remained similar when the analysis was restricted to each patient's first observed eligible MI admission and when calendar year was modelled as a continuous variable.

4.1 NSTEMI Dominance and Subtype Shift

One of the most evident temporal changes in this cohort is the sharp increase in the proportion of NSTEMI from 46.8% in 2019 to 62.1% in 2025, with a concurrent fall in unstable angina from 36.2% to 12.0%. The overall distribution of ACS varied significantly over the seven-year period (χ^2=1077.2, P < 0.001; Cramér's V = 0.179). This pattern is in line with the changing diagnostic landscape of ACS. Wider use of high-sensitivity cardiac troponin assays can increase the detection of myocardial injury and reduce diagnoses of unstable angina by reclassifying some presentations as NSTEMI.[13] The observed pattern may therefore partly reflect changes in diagnostic practice, although information on assay use over the study period was not available in the present dataset. This also contrasts with earlier Sri Lankan cohorts in which STEMI constituted a larger proportion of ACS presentations.[7, 8]

Annual ACS admissions also declined from 2,164 in 2019 to 1,421 in 2022, with partial recovery in 2023–2024. Internationally, similar reductions in ACS admissions have been reported during the COVID-19 pandemic, including substantial declines in Italy and England, attributed to delayed care-seeking, reduced hospital attendance, and disruption of usual cardiovascular services.[14, 15]

The 2022 decline at SJGH coincided with Sri Lanka's severe economic crisis, with shortages of medications and medical supplies and wider disruption to the healthcare system.[16] Pandemic-related change in the healthcare-seeking behaviour and subsequent health-system disruption may therefore have contributed to the observed decline in hospital admissions. However, hospital admission counts cannot be interpreted as population-level ACS incidence and the continued year-to-year variation suggests that changes in referral patterns, healthcare utilisation and hospital case mix may also have contributed.

STEMI proportions varied more, from 11.0% in 2024 to 21.0% in 2025, nevertheless, a significant overall linear temporal trend was observed in the descriptive analysis (χ^2=17.96, P < 0.001**).** When calendar year was modelled categorically in the multivariable analysis, significant overall year-to-year variation remained (joint Wald χ^2=66.26, df = 6, P < 0.001). Importantly, the association between young age and STEMI presentation remained materially unchanged when calendar year was modelled either categorically or as a continuous variable.

4.2 Sex-Specific Trends

Males accounted for 57.8% of ACS admissions, rising from 54.0% in 2019 to 60.3% in 2025 (p for trend = 0.022), consistent with male predominance reported previously in Sri Lankan and South Asian ACS cohorts(4,7,8,11). Furthermore, sex was associated with ACS phenotype (χ^2=244.11, $P < 0.001$; Cramér's V = 0.147). STEMI accounted for 20.1% of male ACS admissions compared with 10.7% in females, and unstable angina was more common among women (23.4% vs 15.5%).

This difference is clinically relevant as sex disparities in ACS extend beyond admission frequency. Differences between young women and men with AMI have been shown in symptom perception, cardiovascular and psychosocial risk profiles, pre-hospital delay, and treatment. In VIRGO, young women presented with longer delays and were less likely to receive timely reperfusion when presenting with STEMI.[17]

In the present study, male sex was independently associated with STEMI presentation (aOR 1.84, 95% CI 1.63–2.08; $P < 0.001$). Young males also had higher crude odds of STEMI compared to young females (OR 2.44, 95% CI 1.42–4.34). However, there was no significant formal interaction between age group and sex (joint Wald χ^2=2.89, df = 3, $P = 0.409$). The findings therefore support separate associations of younger age and male sex with STEMI presentation, without evidence that the age-related association differed significantly by sex. This distinction is of clinical relevance. The lower proportion of STEMI in women should not be interpreted as lower coronary risk, particularly where differences in symptom recognition, referral and treatment may influence the phenotype recorded at hospital presentation.[17]

4.3 Age Distribution

Patients aged ≥ 66 years constituted 50.4% of all ACS admissions, rising from 46.3% in 2019 to 54.6% in 2025 (χ^2 for trend = 54.55, $P < 0.001$). However, the overall age distribution also changed significantly over the study period (χ^2=79.96, $P < 0.001$), but the effect size was small (Cramér's V = 0.049), indicating a gradual demographic shift in the ACS population.

This is in keeping with Sri Lanka's demographic transition. The proportion of adults aged > 60 years is projected to increase from approximately 14% to 22% by 2037 [18], providing an important population-level context for the increasing contribution of older adults to the ACS case mix.

Premature coronary disease remains clinically significant. Male preponderance was especially noticeable in the younger decades, reaching 79.2% among those aged 18–29 years and 77.7% among those aged 30–39. Patients between the ages of 18 and 45 made up 7.4% of all ACS admissions. Compared to other population groups, South Asians tend to experience their first MI at an earlier age. According to INTERHEART, the first MI occurred approximately six years earlier in South Asian countries, and this was largely attributed to increased exposure to adverse cardiovascular risk factors at younger ages.[3]

Therefore, the findings illustrate a dual epidemiological burden: an ageing ACS population that may require increasingly complex cardiovascular care, as well as a persistent burden of premature coronary

disease among younger patients, predominantly men.

4.4 STEMI vs NSTEMI Across Age Groups

One of the main findings of this study was the inverse relationship between age and STEMI presentation. STEMI accounted for 32.4% of MI presentations in the 18–35 year group and 34.3% in the 36–45 year group, compared with 26.8% in the 46–60 year group and 17.5% in the > 60 year age group. The overall age-group association was significant (χ^2=147.64, $P < 0.001$; Cramér's V = 0.132) with similar higher STEMI in the two younger groups and substantially lower proportions in the older groups (**χ^2** for trend = 140.26, $P < 0.001$**).**

The gradient remained evident after multivariable adjustment. Adjusted STEMI odds were higher among patients aged 18–35 years (aOR 1.96, 95% CI 1.27–3.00), 36–45 years (aOR 2.12, 95% CI 1.71–2.62) and 46–60 years (aOR 1.61, 95% CI 1.43–1.82) compared with patients aged > 60 years. The estimates in the two youngest groups were similar, suggesting that the higher relative likelihood of STEMI presentation was not confined to the young subgroup.

This finding is further supported by current regional data. Despite lower prevalence of several conventional risk factors, patients under 45 years were more likely than older patients to present with STEMI in the South Asian cohort of 23,560 ACS patients reported by Peerwani et al. Smoking and family history of premature coronary disease were more common.[4] This is similar to the long-standing INTERHEART observation that earlier risk factor exposure is highly linked to earlier MI in South Asians.[3]

The mechanism underlying this age-related difference in presentation cannot be determined from the present dataset. Young STEMI patients have been reported in intracoronary imaging studies to show different plaque characteristics, such as higher frequency of erosion, reduced calcification and less severe atherosclerotic disease than older patients according to modern intracoronary imaging.[19] Additionally, single vessel disease is more common in younger South Asian STEMI populations, according to regional angiographic data. However, the present study did not include coronary imaging or individual risk factor data and therefore these mechanisms remain speculative in relation to the observed age gradient.

4.5 Young-Onset MI

Young-onset MI accounted for 589 of 8,509 confirmed MI admissions (6.9%, 95% CI 6.4–7.5%), annual prevalence ranging from 5.55% to 8.21%, with no significant temporal trend over the seven-year period ($\chi^2 = 1.06$, $p = 0.303$). This differs from the modest global increase in age-standardised early-onset ischemic heart disease incidence reported in recent analyses, while South Asia continues to carry a high absolute burden.[20] In a South Asian registry of 23,560 ACS patients, young patients (≤ 45 years) comprised 12.2% of presentations [4] higher than observed here. Differences between the two cohorts may reflect differences in study setting, referral patterns, case selection, and population structure, and direct comparison should therefore be interpreted cautiously.

In our cohort, 34.0% of MI admissions among patients aged 18–45 years were STEMI compared with 20.3% among those aged > 45 years. Young patients had approximately twice the unadjusted odds of STEMI (OR 2.02, 95% CI 1.68–2.42, $P < 0.001$), and this association remained significant after adjustment for sex and categorical calendar year (aOR 1.75, 95% CI 1.45–2.12, $P < 0.001$). These findings indicate that, although STEMI was not the predominant MI subtype among younger patients, younger age was associated with a substantially greater relative likelihood of STEMI presentation compared with older age.

This finding is further supported by the sensitivity analysis. Of the 8,509 MI admissions, 7,266 unique patients were identified and 1,017 of them having multiple eligible MI admissions. When the analysis was restricted to each patient's first observed eligible MI admission (aOR 1.78, 95% CI 1.47–2.15, $P < 0.001$) the association remained similar. The result was also materially unchanged when calendar year was modelled as a continuous variable (aOR 1.77, 95% CI 1.47–2.14, $P < 0.001$). Therefore, repeated admissions or the specification of calendar year were unlikely to account for the observed association between younger age and STEMI presentation.

Further clinical context is provided by the sex-stratified results. Young men were more likely to have STEMI than young women (OR 2.44, 95% CI 1.42–4.34), while young men were more likely to have STEMI than older men (OR 1.85, 95% CI 1.51–2.26). However, the corresponding young-versus-older comparison among females was not significant (OR 1.38, 95% CI 0.79–2.29, $P = 0.208$). The formal age-group-by-sex interaction was also not significant ($P = 0.409$), indicating that these sex-stratified differences should be interpreted cautiously rather than as evidence of a differential age effect between men and women. These findings are consistent with VIRGO, which found that young women had lower rates of prompt reperfusion, longer presentation delays and lower frequencies of ST elevation than men.[17]

The absence of a growing temporal trend does not diminish the clinical importance of premature MI. Premature MI increases the risk of cardiovascular disease for decades and reduces productive life years. Studies conducted in South Asia consistently find that smoking, adverse metabolic risk and family history are significant characteristics of early disease.[3, 4] South Asia has a significant burden of early-onset ischemic heart disease, according to recent global analyses.[20] The persistence of young-onset MI, together with its higher relative likelihood of STEMI presentation, supports continued attention to early cardiovascular risk identification and prevention in younger adults. These findings also illustrate the value of routinely collected hospital data for cardiovascular surveillance in settings where longitudinal population-level ACS registries remain limited.

4.6 Limitations

Several limitations must be acknowledged. These results may not be representative of community-based ACS incidence as this is a single-center tertiary study. Patients with acute chest pain may have been diverted to or self-presented to surrounding private hospitals or other government facilities in the Nugegoda and Colombo region, therefore admission counts at SJGH may not accurately reflect the true

ACS burden in the studied population, especially during periods of high hospital occupancy or healthcare disruption.[14–16]

This concern is particularly relevant during the 2020–2022 period, where the reductions in SJGH coincided with the COVID-19 pandemic and Sri Lanka's economic crisis. The observed reduction in admissions may therefore reflect altered utilization of healthcare, referral pattern, or access rather than a true reduction in ACS incidence. More broadly, temporal changes in hospital case mix may have contributed to year-to-year variation across the full study period.

Individual-level data on cardiovascular risk factors, symptom onset, pre-hospital delay, treatment, coronary anatomy, and clinical outcomes were unavailable, limiting mechanistic and causal inference. Data on residential location were also unavailable, precluding socioeconomic or regional stratification.

Since the diagnoses were based on routinely recorded EIMMR categories without independent clinical adjudication, misclassification cannot be excluded. In addition, information on temporal changes in cardiac biomarker assays or diagnostic practice was unavailable, and such changes may have contributed to the observed shift from unstable angina towards NSTEMI.[13]

Although recurrent admissions from the same patient were accounted for using patient-level cluster-robust standard errors and a first admission sensitivity analysis, the study remains based on hospital admission episodes rather than a population-based cohort.

Discharge mode was not analysed as a mortality outcome because the field was substantially incomplete and did not provide reliable classification of true in hospital deaths from transfer to another hospital or leaving against medical advice.

5. Conclusion

Over the seven years, the ACS case mix at SJGH shifted towards a greater NSTEMI predominance and an increasing proportion of older patients. Young-onset MI represented 6.9% of confirmed MI admissions and showed no significant linear temporal trend over time; however, younger patients had substantially higher odds of presenting with STEMI than older patients, independent of sex and calendar year. This association remained robust after accounting for recurrent admissions and alternative modelling of calendar year.

These findings highlight the dual cardiovascular challenge of an ageing ACS population alongside a persistent premature MI burden. Further multicentre studies incorporating cardiovascular risk factors, coronary anatomy, healthcare access, treatment and clinical outcomes are needed to determine the mechanisms and clinical consequences underlying these patterns.

Declarations

Ethics

Ethical approval was granted by the SJGH Ethical Review Committee- SJGH/26/ERC/013. The study was conducted in accordance with the declaration of Helsinki. Data were fully de-identified prior to analysis. Individual patient consent was not required as this was a retrospective administrative data study.

Data Availability Statement

The data underlying this article were derived from routinely collected hospital administrative records and are not publicly available because of patient confidentiality and institutional data-governance requirements. De-identified data may be made available on reasonable request to the corresponding author, subject to approval by Sri Jayewardenepura General Hospital and applicable ethical and data-governance requirements.

Conflict of Interest

The authors have no conflicts of interest to declare.

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Author Contributions

Dr. Solith Senanayake conceived the study, led the study design, and contributed to the literature review, data interpretation, statistical analysis and manuscript preparation and subsequent reviews.

Dr. Liyana Nithya contributed to the literature review, development and planning of the study design and proposal, was responsible for statistical analysis and data interpretation, visualization, drafting of the manuscript and subsequent revisions.

Dr. Senath Karunathilleke contributed to the literature review, as well as the development and planning of the study proposal and data collection.

Dr. Chatura Malavipathirana and Dr. Kasun Gunatilaka contributed to study proposal, statistical analysis and data interpretation.

Dr. Jagath Herath supervised the study and critically reviewed the manuscript for intellectual content.

All authors contributed to the results and discussion sections. All authors have read and approved the final draft.

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Clinical trial number : Not applicable

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Figures

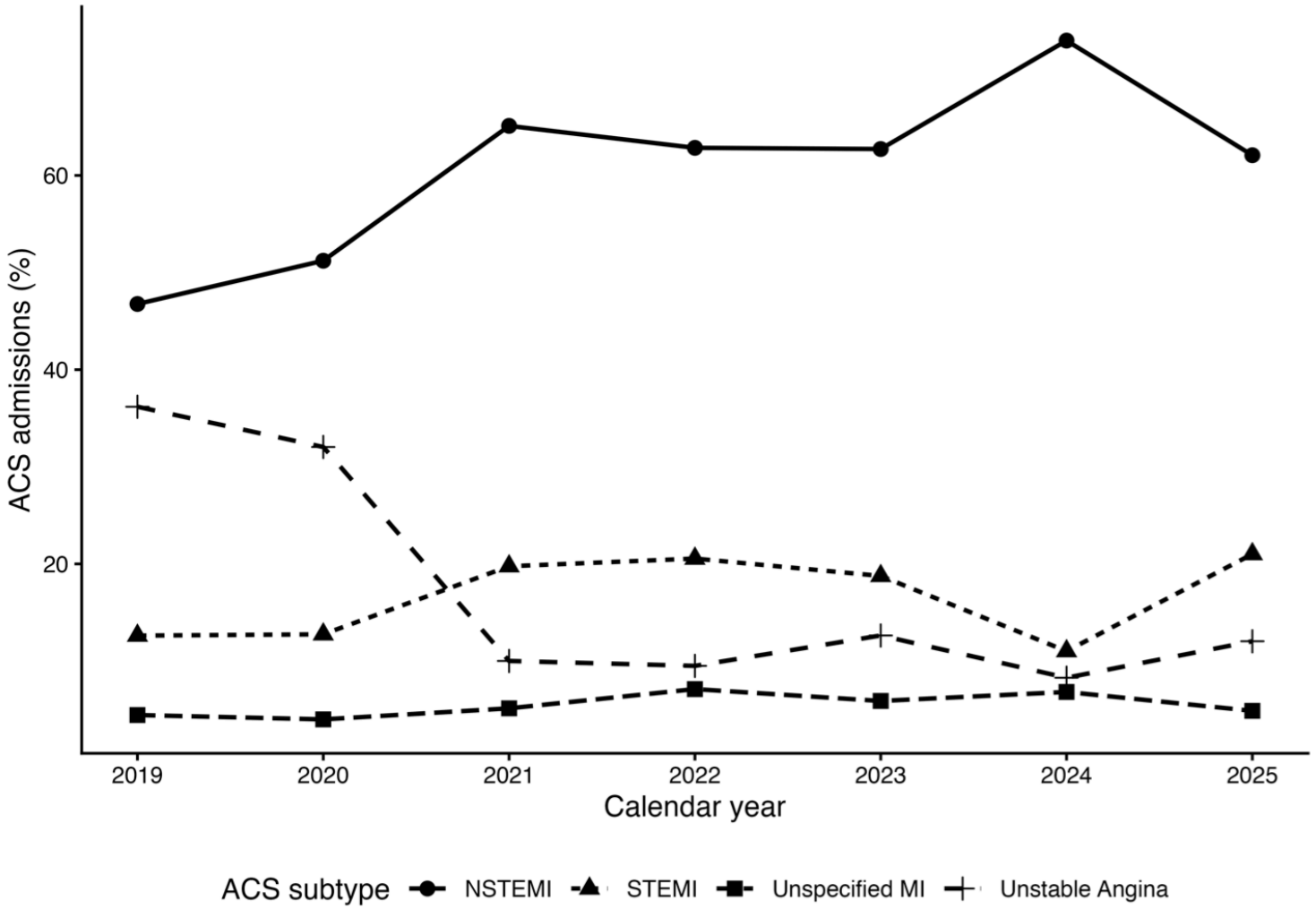


Figure 1

Annual distribution of acute coronary syndrome subtypes, 2019–2025.
Annual proportions of ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), unstable angina, and unspecified myocardial infarction among 11,232 adult acute coronary syndrome admission episodes. The distribution of acute coronary syndrome subtypes differed significantly across calendar years (χ^2=1077.2, df=18, *P*<0.001). NSTEMI increased over the study period, while unstable angina declined substantially; STEMI showed greater year-to-year variation. Temporal trends in individual subtype proportions were assessed using chi-squared tests for linear trend.

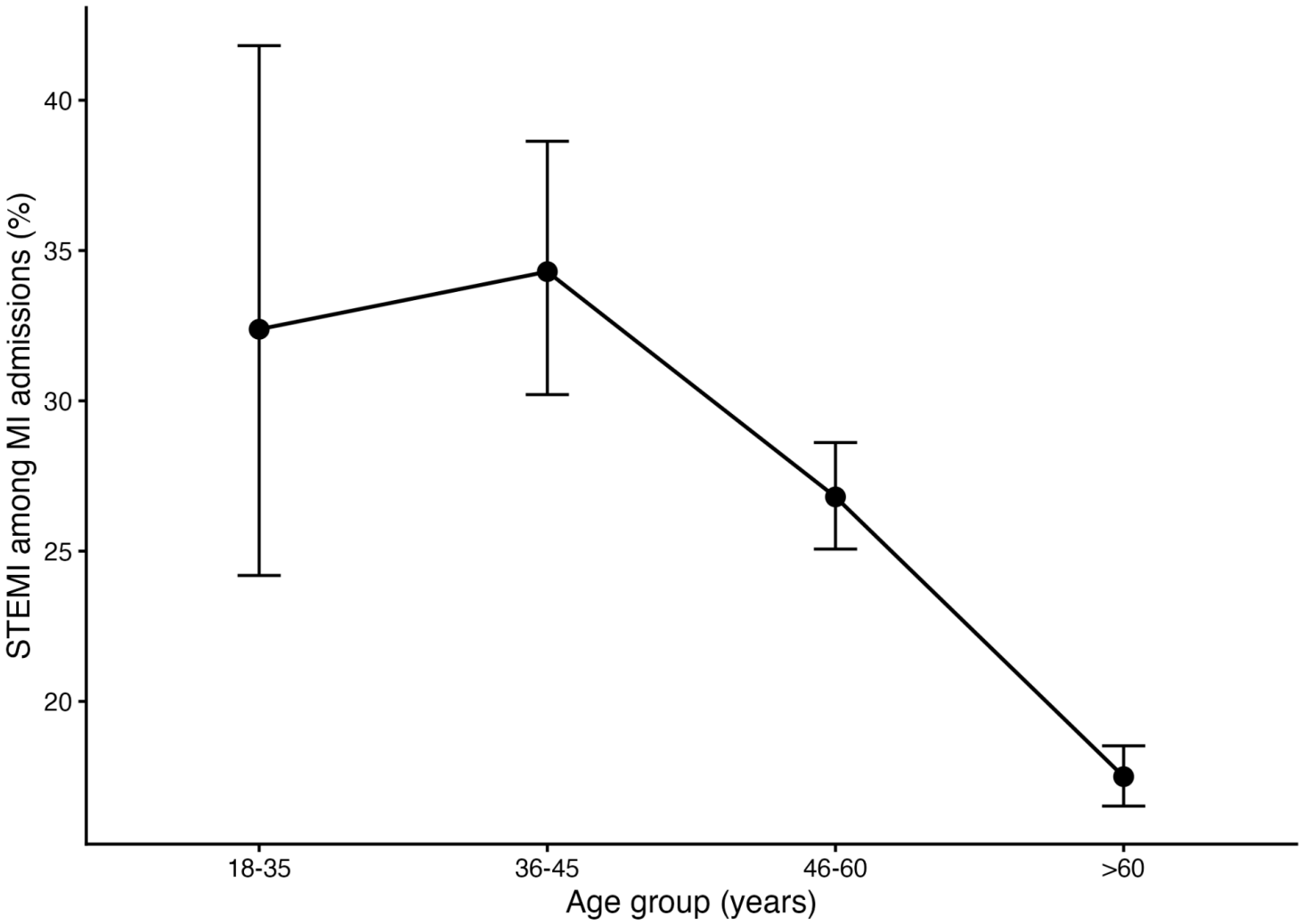


Figure 2

STEMI proportion across age groups among patients with myocardial infarction.
Proportion of STEMI among 8,509 confirmed myocardial infarction admission episodes, stratified by age group. Points represent observed proportions and error bars represent 95% Wilson confidence intervals. A significant overall inverse trend was observed across ordered age categories (χ^2 for trend=140.26, P<0.001).

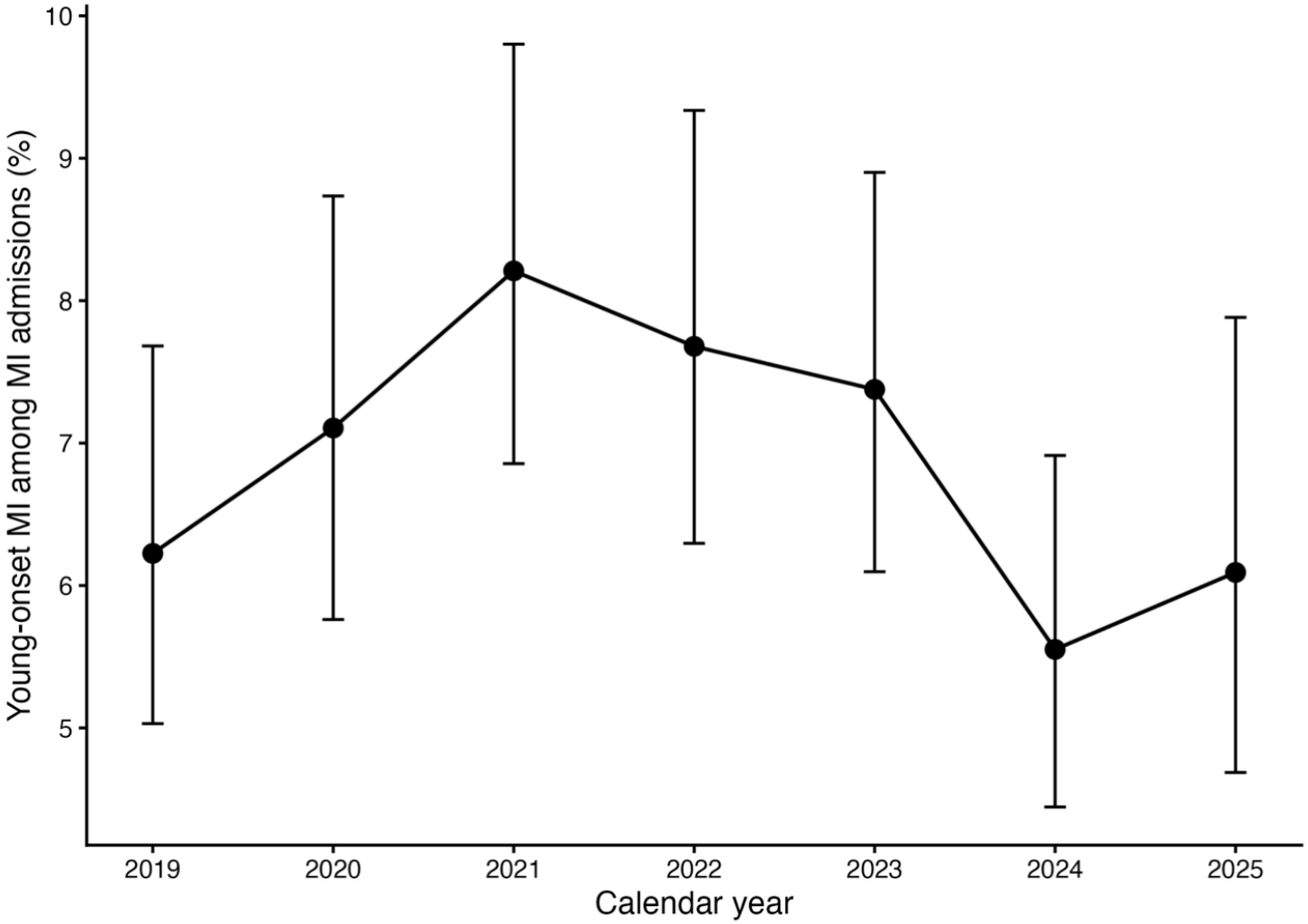


Figure 3

Annual prevalence of young-onset myocardial infarction, 2019–2025.
Annual proportion of young-onset myocardial infarction among STEMI and NSTEMI admission episodes. Young-onset MI was defined as myocardial infarction occurring at age 18–45 years. Points represent annual proportions and error bars represent 95% Wilson confidence intervals. No significant linear temporal trend was observed (χ^2=1.06, *P*=0.303).

Supplementary Files

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- Supplementarymaterials.docx