Recurrent myocardial infarction and emergency department visits: a retrospective study on the Stockholm Area Chest Pain Cohort

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ABSTRACT

Background Patients who experience acute myocardial infarction (AMI) are at risk of recurrent AMI. Contemporary data on recurrent AMI and its association with return emergency department (ED) visits for chest pain are needed.

Methods This Swedish retrospective cohort study linked patient-level data from six participating hospitals to four national registers to construct the Stockholm Area Chest Pain Cohort (SACPC). The AMI cohort included SACPC participants visiting the ED for chest pain diagnosed with AMI and discharged alive (first primary diagnosis of AMI during the study period not necessarily the patient’s first AMI). The rate and timing of recurrent AMI events, return ED visits for chest pain and all-cause mortality were determined during the year following index AMI discharge.

Results Among 1,377,061 patients presenting to the ED with chest pain as principal complaint from 2011 to 2016, 5.5% (75,791/1,377,061) were hospitalised with AMI. In total, 98.5% (74,671/75,791) of patients were discharged alive. In the year following index AMI discharge, 5.8% (432/7467) of AMI patients experienced ≥1 recurrent AMI event. Return ED visits for chest pain occurred in 27.0% (2017/7467) of index AMI survivors. During a return ED visit, recurrent AMI was diagnosed in 13.6% (274/2017) of patients. One-year all-cause mortality was 3.1% in the AMI cohort and 11.6% in the recurrent AMI cohort.

Conclusions In this AMI population, 3 in 10 AMI survivors returned to the ED for chest pain in the year following AMI discharge. Furthermore, over 10% of patients with return ED visits were diagnosed with recurrent AMI during that visit. This study confirms the high residual ischaemic risk and associated mortality among AMI survivors.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The incidence of acute myocardial infarction (AMI) in the undifferentiated emergency department (ED) patient with a chief report of chest pain is low. Existing population-based data on patients returning to the ED for chest pain following AMI discharge are sparse, and the association between ED visits for chest pain and recurrent AMI is currently unknown.

WHAT THIS STUDY ADDS

⇒ More than one in four survivors of an AMI will visit an ED for chest pain in the following year. Among patients presenting to the ED with chest pain, a history of prior AMI increases the incidence of recurrent AMI by a factor of 2.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study confirms the high residual ischaemic risk and associated mortality among AMI survivors and underscores the need for primary interventions and management strategies to improve outcomes in AMI survivors.

INTRODUCTION

Chest pain is the most common symptom of acute myocardial infarction (AMI) and is generally considered the second most common reason for emergency department (ED) visits. Over 8% of all ED visits between 2012 and 2016 in the Stockholm region were due to chest pain and the USA recorded over 7 million chest pain ED visits in 2018.1–3 AMI is ruled out in most patients presenting to the ED with chest pain—AMI is confirmed in 10%–23% of patients for whom chest pain is suggestive of acute coronary syndrome (ACS) and in about 5% of the overall population visiting the ED for chest pain.3–6 However, existing population-based data on patients returning to the ED for chest pain following AMI discharge are sparse. Most published reports provide the number of ED visits for chest pain rather than the number of patients visiting the ED for chest pain.7–9 Furthermore, the association between ED visits for chest pain and recurrent AMI is currently unknown.

The risk of cardiovascular events after ACS is high, with one in four patients experiencing recurrent events, including AMI, stroke or cardiovascular death within 5 years of discharge.10 Specifically, rates of recurrent AMI among patients with ACS vary from 3% to 25%, depending on the follow-up period.
and study population. Despite declining recurrent AMI rates in recent years, the absolute number of patients experiencing recurrent AMI has increased and remains a serious complication among AMI survivors. One-year recurrent AMI rates range from 2.5% to 10%, depending on the study period and study population. However, no population-based study has reported patient-level incidence rates for subsequent second and third recurrent AMI in the year following index AMI discharge.

Contemporary, patient-level data on recurrent AMI and its association with return ED visits for chest pain are needed to measure the incidence of recurrent AMI among AMI survivors as well as the in-hospital and 1-year mortality among AMI survivors and recurrent AMI survivors. Furthermore, these data can inform key components of clinical trials investigating new therapies in patients at risk of recurrent AMI. In this Swedish study, we retrospectively followed a real-world cohort of patients who presented to the ED with a principal complaint of chest pain, who were admitted to the hospital with AMI and were discharged alive. We measured the rate and timing of first, second and third recurrent AMI, return ED visits for chest pain and all-cause mortality in the year after AMI discharge.

**METHODS**

**Study design and approval**

This retrospective, descriptive cohort study used a large real-world population database to investigate AMI incidence in patients presenting to the ED with chest pain in Stockholm County and the rate of recurrent AMI among AMI survivors. Patients presenting to hospital with chest pain other than via the ED were not included. Patients were followed for 1 year (365 days) after discharge from index AMI.

Following the inclusion of the Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies Registry (SWEDEHEART) and the National Diabetes Registry, the study received a second approval in 2018 (2018/1089–31). SWEDEHEART is a nationwide register supported by the Swedish Society of Cardiology and the Swedish Heart Association covering approximately 90% of all patients with an index diagnosis or procedure included in a national registry. Patient data were anonymised and the link to the unique personal identification number (PIN) was kept by National Board of Health and Welfare. The anonymised linked database was managed by Theme of Acute and Reparative Medicine, Karolinska University Hospital, and Karolinska Institutet, Stockholm, Sweden.

**Settings**

Six hospitals in Stockholm County, Sweden provided patient-level data to the Stockholm Area Chest Pain Cohort (SACPC): Norrtälje Hospital, Danderyd Hospital, Karolinska University Hospital (in Solna and in Huddinge), St. Görans Hospital, Södersjukhuset and Södertälje Hospital.

**Participants**

The SACPC includes all patients presenting to the ED with a principal complaint of chest pain at any of the six participating hospitals from 1 January 2011 to 31 December 2016. Index AMI designates the first primary diagnosis of AMI during the study period and is not necessarily the patient’s first AMI. The AMI cohort includes all SACPC patients aged 18-80 years admitted to the hospital from the ED with confirmed AMI and discharged alive. The recurrent AMI cohort includes patients with recurrent AMI during the year following index AMI discharge, irrespective of admitting department.

**Variables**

The primary discharge diagnosis for index and recurrent AMI was retrieved from the Swedish National Patient Register and defined using the International Classification of Disease version 10 codes I21 or I22. The positive predictive value for the diagnosis of AMI in the Patient Register has been found to be 98%–100%. Common conditions and procedure codes for percutaneous coronary intervention and coronary artery bypass grafting were retrieved from the Swedish National Patient Register. The date and the underlying causes of death were retrieved from the Cause of Death Register. Completeness of the Cause of Death Register has been found to be 98%–100%. The primary discharge diagnosis for index and recurrent AMI was retrieved from the Swedish National Patient Register and defined using the International Classification of Disease version 10 codes I21 or I22. The positive predictive value for the diagnosis of AMI in the Patient Register has been found to be 98%–100%.

**Data sources**

Patient-level data for every ED visit including date, time, principal complaint and PIN were extracted from the electronic healthcare records systems of the six participating hospitals. The ED visit data set was sent to the Swedish National Board of Health and Welfare for linking through the PIN to the National Patient Register, the Cause of Death Register, the Prescribed Drug Register and SWEDEHEART. Following linkage, the PIN was replaced by a study identification number prior to returning the ED visit data set to the researchers. The SACPC was derived from the linked ED visit data set by identifying unique patients with at least one visit to the ED with a principal complaint of chest pain from 2011 to 2016.

**Study size**

The sample size was determined by the number of patients presenting to the ED for chest pain and diagnosed with an AMI in the six participating hospitals in Stockholm County during the study period.
Coronary artery disease

Statistical methods
Patient characteristics were analysed descriptively at the time of the index AMI. The frequency and proportion of patients were compared using the $\chi^2$ test for categorical variables and the Median test for continuous variables.

RESULTS
The SACPC included 137,706 unique adults aged 18–80 years who had at least one ED visit for chest pain during 2011–2016 (figure 1). In total, 7,579 of 137,706 (5.5%) ED patients with chest pain were diagnosed with AMI and hospitalised. Among ED patients with chest pain and AMI, there were 112 in-hospital deaths. Overall, 7,467 of 7,579 (98.5%) ED patients with chest pain and AMI were discharged alive and comprised the AMI cohort (online supplemental figure S1).

AMI cohort
The median age was 66 years and 75.4% of participants were men (table 1). The ≥65 years of age population was represented in 49.3% of men and 65.1% of women. Type of AMI and NSTEMI/STEMI classification of index AMI were available for 96.9% and 95.5% of patients, respectively. Most index AMI were type 1 and 72.5% were...
NSTEMI. About half of the patients arrived at the ED by ambulance. Overall, 74.9% of the AMI cohort underwent coronary reperfusion. The most prevalent comorbidity was diabetes (18.2%), followed by history of prior AMI (14.4%). Other comorbidities recorded in ≤5% of patients included history of prior stroke, chronic kidney disease (CKD), peripheral artery disease and heart failure. Most patients were prescribed the guideline-recommended drug treatment at discharge for at least 6 months: aspirin (94.0%), P2Y₁₂ inhibitors (91.1%), beta blockers (93.5%), angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers (81.2%) or statins (94.8%).

During the year following index AMI discharge, 432 of 7467 (5.8%) patients experienced at least one recurrent AMI (figure 1). Almost half of the first recurrent AMI events (192/432, 44.4%) occurred within 30 days of discharge.

Table 1  Baseline characteristics in the AMI cohort

<table>
<thead>
<tr>
<th>Variable, n (%)</th>
<th>AMI population N=7467</th>
<th>Men N=5630 (75.4%)</th>
<th>Women N=1837 (24.6%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (IQR)</td>
<td>66 (15)</td>
<td>65 (14)</td>
<td>69 (14)</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;35 years</td>
<td>32 (0.4)</td>
<td>29 (0.5)</td>
<td>3 (0.2)</td>
</tr>
<tr>
<td>35–49 years</td>
<td>676 (9.1)</td>
<td>566 (10.0)</td>
<td>110 (5.9)</td>
</tr>
<tr>
<td>50–64 years</td>
<td>2781 (37.2)</td>
<td>2254 (40.0)</td>
<td>527 (28.6)</td>
</tr>
<tr>
<td>65–80 years</td>
<td>3978 (53.3)</td>
<td>2781 (49.3)</td>
<td>1197 (65.1)</td>
</tr>
<tr>
<td>Type of AMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 1 AMI</td>
<td>6790 (90.9)</td>
<td>5216 (92.6)</td>
<td>1574 (85.7)</td>
</tr>
<tr>
<td>Type 2 AMI</td>
<td>226 (3.0)</td>
<td>123 (2.2)</td>
<td>103 (5.6)</td>
</tr>
<tr>
<td>Type 3–5 AMI</td>
<td>329 (4.4)</td>
<td>203 (3.6)</td>
<td>126 (6.9)</td>
</tr>
<tr>
<td>Data not available in SWEDHEART</td>
<td>122 (1.6)</td>
<td>88 (1.6)</td>
<td>34 (1.9)</td>
</tr>
<tr>
<td>NSTEMI/STEMI classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSTEMI</td>
<td>5410 (72.5)</td>
<td>4037 (71.7)</td>
<td>1373 (74.7)</td>
</tr>
<tr>
<td>STEMI</td>
<td>1725 (23.1)</td>
<td>1382 (24.5)</td>
<td>343 (18.7)</td>
</tr>
<tr>
<td>Data not available in SWEDHEART</td>
<td>332 (4.4)</td>
<td>211 (3.7)</td>
<td>121 (6.6)</td>
</tr>
<tr>
<td>Arrived at ED by ambulance</td>
<td>3595 (48.1)</td>
<td>2601 (46.2)</td>
<td>994 (54.1)</td>
</tr>
<tr>
<td>Index AMI coronary reperfusion (PCI or CABG)</td>
<td>5594 (74.9)</td>
<td>4474 (79.5)</td>
<td>1120 (61.0)</td>
</tr>
<tr>
<td>Comorbidities recorded at index AMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>1359 (18.2)</td>
<td>1020 (18.1)</td>
<td>339 (18.5)</td>
</tr>
<tr>
<td>History of prior AMI</td>
<td>1075 (14.4)</td>
<td>834 (14.8)</td>
<td>241 (13.1)</td>
</tr>
<tr>
<td>History of prior stroke</td>
<td>350 (4.7)</td>
<td>253 (4.5)</td>
<td>97 (5.3)</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>201 (2.7)</td>
<td>141 (2.5)</td>
<td>60 (3.3)</td>
</tr>
<tr>
<td>Heart failure</td>
<td>244 (3.3)</td>
<td>167 (3.0)</td>
<td>77 (4.2)</td>
</tr>
<tr>
<td>Peripheral artery disease</td>
<td>118 (1.6)</td>
<td>87 (1.5)</td>
<td>31 (1.7)</td>
</tr>
<tr>
<td>Medication prescribed at index AMI discharge and continued for ≥6 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>7018 (94.0)</td>
<td>5326 (94.6)</td>
<td>1692 (92.1)</td>
</tr>
<tr>
<td>P2Y₁₂ inhibitors*</td>
<td>6805 (91.1)</td>
<td>5212 (92.6)</td>
<td>1593 (86.7)</td>
</tr>
<tr>
<td>Clopidogrel</td>
<td>3555 (47.6)</td>
<td>2618 (46.5)</td>
<td>937 (51.0)</td>
</tr>
<tr>
<td>Prasugrel</td>
<td>105 (1.4)</td>
<td>80 (1.4)</td>
<td>25 (1.4)</td>
</tr>
<tr>
<td>Ticagrelor</td>
<td>3553 (47.6)</td>
<td>2825 (50.2)</td>
<td>728 (39.6)</td>
</tr>
<tr>
<td>Beta blockers</td>
<td>6980 (93.5)</td>
<td>5274 (93.7)</td>
<td>1706 (92.9)</td>
</tr>
<tr>
<td>ACE inhibitors/ARB</td>
<td>6064 (81.2)</td>
<td>4621 (82.1)</td>
<td>1443 (78.6)</td>
</tr>
<tr>
<td>Statins</td>
<td>7081 (94.8)</td>
<td>5397 (95.9)</td>
<td>1684 (91.7)</td>
</tr>
</tbody>
</table>

*Some patients switched between different types of P2Y₁₂ inhibitors during the study period.

ACE/ARB, angiotensin-converting enzyme/angiotensin II receptor blockers; AMI, acute myocardial infarction; CABG, coronary artery bypass grafting; ED, emergency department; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; SWEDHEART, Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies Registry.
Coronary artery disease

index AMI discharge (figure 2A). The recurrent AMI rate was 6.7 per 100 person-years (6.3 and 8.0 per 100 person-years in men and women, respectively). Among the AMI cohort, 27.0% (2017/7467) returned to the ED with a principal complaint of chest pain within 1 year after index AMI discharge (figure 2B). The most common non-AMI diagnoses made during the ED visit included symptoms and signs involving the circulatory and respiratory systems and diseases of the circulatory system (angina pectoris, chronic ischaemic heart disease). One-third of ED return patients (737/2017, 36.5%) had more than one return visit and most return ED visits (1580/2017, 78.3%) occurred within 6 months of index AMI discharge (figure 2C). The 1-year all-cause mortality rate after index AMI discharge was 3.1% (figure 2D), or 3.4 per 100 person-years (3.4 and 3.5 for men and women, respectively).

Recurrent AMI cohort

The recurrent AMI cohort was older and had a higher proportion of women than patients who did not experience recurrent AMI in the year after index AMI discharge (median age: 69 years vs 66 years, p<0.0001 and women: 29.2% vs 24.3%, p<0.0232; table 2). Type of AMI and NSTEMI/STEMI classification were available for 92.5% and 94.4% of the recurrent AMI cohort, respectively. Type and class of index AMI differed in the recurrent AMI cohort compared with patients without recurrent AMI. In the recurrent AMI cohort, index AMI was more frequently type 2 and NSTEMI compared with patients without recurrent AMI (type 2 AMI: 5.3% vs 2.9%, p=0.0032 and NSTEMI: 77.5% vs 72.1%, p=0.0023). In the recurrent AMI cohort, patients arrived in the ED by ambulance for their index AMI more frequently compared with patients without recurrent AMI (57.6% vs 47.6%, p<0.0001). All comorbidities measured at index AMI were significantly more prevalent in the recurrent AMI cohort compared with patients without recurrent AMI (table 2)—for example, diabetes (35.2% vs 17.2%, p<0.0001) and history of AMI prior to the index AMI (29.9% vs 13.4%, p<0.0001). Significantly fewer recurrent AMI patients underwent coronary reperfusion for index AMI versus patients without recurrent AMI (44.4%...
While most patients were prescribed P2Y12 inhibitors at discharge, there were significant differences in the distribution of specific P2Y12 inhibitors. In the recurrent AMI cohort compared with patients without recurrent AMI, clopidogrel and prasugrel were more often prescribed at index AMI discharge (clopidogrel: 61.1% vs 46.8%, p<0.0001 and prasugrel: 3.7% vs 1.3%, p<0.0001), whereas ticagrelor was less often prescribed (38.4% vs 48.1%, p<0.0001). Statins were less often prescribed at index AMI discharge in the recurrent AMI cohort compared with patients without recurrent AMI, clopidogrel and prasugrel were more often prescribed at index AMI discharge (clopidogrel: 61.1% vs 46.8%, p<0.0001 and prasugrel: 3.7% vs 1.3%, p<0.0001), whereas ticagrelor was less often prescribed (38.4% vs 48.1%, p<0.0001). Statins were less often prescribed at index AMI discharge (clopidogrel: 61.1% vs 46.8%, p<0.0001 and prasugrel: 3.7% vs 1.3%, p<0.0001), whereas ticagrelor was less often prescribed (38.4% vs 48.1%, p<0.0001). Statins were less
AMI cohort compared with patients without recurrent AMI (91.9% vs 95.0%, p=0.0046).

Of the 432 patients who experienced recurrent AMI in the year following index AMI discharge, 411 (95.1%) were discharged alive (figure 1). Following the first recurrent AMI, 51 of 411 (12.4%) patients experienced a second recurrent AMI within 1 year from index AMI discharge with 94.1% (48/51) of those patients discharged alive. Seven of 48 (14.6%) patients experienced a third recurrent AMI within 1 year from index AMI discharge with all patients discharged alive. The timing and rate for each recurrent AMI event in the year following index AMI discharge are shown in online supplemental figure S2. When measured from recurrent AMI event date instead of index AMI discharge date, 25.5% (105/411) of patients experienced a second recurrent AMI in the year following the first recurrent AMI (online supplemental table S1). Furthermore, 40.8% (40/98) of patients experienced a third recurrent AMI in the year following the second recurrent AMI.

Overall, 274 patients were diagnosed with recurrent AMI during a return ED visit for chest pain within 1 year from index AMI discharge (figure 3A)—representing 63.4% (274/432) of all recurrent AMI patients and 13.6% (274/2,017) of patients who returned to the ED with chest pain. The remainder of patients with recurrent AMI (158/432) went directly to the cardiac care unit, had principal complaints on presentation to the ED other than chest pain (primarily symptoms and signs involving the circulatory and respiratory systems, in particular dyspnoea) or went to an ED outside Stockholm County. Diagnosis of recurrent AMI during a return ED visit for chest pain occurred in 68.6% (35/51) of patients with a second recurrent AMI and in 85.7% (6/7) of patients with a third recurrent AMI.

The 1-year all-cause mortality rate following index AMI discharge among patients without recurrent AMI was 2.5% (table 2). Among the 7579 patients who presented to the ED with chest pain and were hospitalised with AMI during 2011–2016, all-cause mortality was 4.4% (data not shown). When measured from date of recurrent AMI event, the 1-year all-cause mortality rate in the recurrent AMI cohort was 13.7%–6.7% within 30 days and 10.6% within 180 days (online supplemental table S1).

**DISCUSSION**

Chest pain is considered a non-specific symptom suggestive of a cardiac event—only 5%–6% of patients visiting the ED for this symptom are diagnosed with AMI. Published literature on return ED visits for chest pain is limited, with reports citing the total number of return ED visits rather than the number of patients returning to the ED for chest pain.7–9 In this study, nearly one-third of AMI survivors (2017/7467) returned to the ED for chest pain in the year following index AMI discharge and 13.6% (274/2,017) of those patients were diagnosed with recurrent AMI during that visit. Over 60% of patients with recurrent AMI (274/432) were diagnosed during a return ED visit for chest pain in the year following index AMI discharge. This study is the first to report the number of AMI survivors revisiting the ED for chest pain with recurrent AMI.

Available incidence data on recurrent AMI events are reported as total event rates or are limited to the first recurrent AMI. In Sweden from July 2006 to June 2011, 9729 total recurrent AMI events were reported in the year after index AMI discharge, representing 10% of recurrent cardiovascular events in AMI survivors. In the US Medicare population (age >65 years) from 2012 to 2014, the 1-year first recurrent AMI rate was 4.6% with a median of 106 days from discharge to recurrent AMI. A total recurrent AMI rate of 5.1% in the US Medicare population in 2013 was reported with no specification on
multiple recurrent AMI events in single patients during the study. Among commercially insured US adults (age ≤65 years) and Medicare recipients, the 1-year rate of total recurrent AMI events was 5.75%. Among 30-day AMI survivors in England, the 1-year first recurrent AMI rate was 5.6% in men and 7.2% in women from 2004 to 2010. The China PEACE-Prospective AMI study reported a 1-year first recurrent AMI rate of 2.5% in AMI survivors with an age of 60.7 from December 2012 to May 2014. Thirty-seven percent of first recurrent AMI occurred in the first 30 days following discharge. In a recent analysis of early recurrent AMI patients in the Cleveland Clinic health system, the authors report that the majority of early recurrent AMI occurred within the first 2 weeks after hospital discharge. In the current study, 44% of first recurrent AMI occurred in the first 30 days after discharge, which is consistent with that in the China PEACE-Prospective AMI study (35.7%) and the Cleveland Clinic population.

In this study, 5.8% (432/7,467) of AMI survivors experienced at least one recurrent AMI in the year following index AMI discharge. Consistent with previous reports, the recurrent AMI cohort was older, more likely to be women, had greater frequency of comorbid conditions and was less likely to undergo revascularisation compared with the non-recurrent AMI cohort. Among the first recurrent AMI survivors, 12.4% (51/411) experienced a second AMI and 14.6% (7/48) of second recurrent AMI survivors experienced a third AMI in the year following index AMI discharge. When measured during the year following each recurrent AMI event, one in three (145/431, 33.6%) recurrent AMI survivors experienced multiple recurrent AMI events after index AMI discharge.

Among the AMI cohort, the 1-year all-cause mortality was 3.1%. This study population is restricted to adult AMI patients ≤80 years with chest pain admitted from the ED and is not comparable to the general Stockholm or Swedish AMI population. The 1-year mortality rate in the SWEDHEART population ≤80 years a year after AMI discharge during the same time period was about 7%. However, SWEDHEART includes all hospitalised AMI patients irrespective of admission source and includes in-patients who experienced AMI during unrelated hospital admissions. In this study, the recurrent AMI cohort compared with patients without recurrent AMI experienced significantly higher in-hospital mortality (4.9% vs 1.5%, p<0.0001) and all-cause mortality in the year following discharge (11.6% vs 2.5%, p<0.0001). Mortality rates specific to first, second or third recurrent AMI in the year following index AMI are relatively unknown in the literature and, therefore, no comparisons can be made.

Limitations
The source population (SACPC) included all adult patients in Stockholm County presenting to the ED with chest pain as the principal complaint. The SACPC-derived AMI cohort does not include: (1) all patients diagnosed with AMI, (2) all patients presenting to the ED with other symptoms and diagnosed with AMI or (3) patients who bypassed the ED going directly to the cardiac intensive care unit. Therefore, this AMI cohort does not represent the entire Stockholm AMI population from 2011 to 2016. Subsequent analysis of the recurrent AMI cohort includes all patients readmitted to the hospital with recurrent AMI regardless of principle complaint or admitting department. Comorbid conditions and baseline characteristics known to increase the risk of recurrent AMI were associated with recurrent AMI in this study population as discussed above. However, because data such as number of diseased vessels and/or the completeness of revascularisation were not available as well as the small number of second (n=51) and third (n=7) recurrent AMI, we were unable to identify independent variables associated with a higher risk of recurrent AMI. The study population was restricted to adults aged 18–80 years to align with the SWEDHEART register.

CONCLUSION
This study retrospectively followed patients presenting to the ED with chest pain in Stockholm County and admitted to hospital with AMI between 2011 and 2016. This AMI population was mostly treated following guideline recommendations, and the incidence of recurrent AMI was high and increased with each subsequent AMI event. Furthermore, 3 in 10 AMI survivors revisited the ED for chest pain within 1 year and in 10 patients returning to the ED were diagnosed with recurrent AMI during that visit. These observations underscore the need for primary interventions and management strategies to improve outcomes in AMI survivors. The results from this study informed the feasibility of and sample size calculation for a phase 3 clinical trial in patients at risk of recurrent AMI.

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Contributors MJH led the study design and collection of the data. TA performed the statistical analyses. All authors contributed to data interpretation. MJH and MLD drafted the manuscript. TA, MLD and SR reviewed and approved the final manuscript. SR and MD are responsible for the overall content as guarantor. The authors wish to thank Anne Sayers for editorial support.

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Competing interests TA has received consulting fees from Idorsia Pharmaceuticals Ltd. for statistical processing, MLD is an employee of Idorsia Pharmaceuticals Ltd. and receives stock unrelated to this publication. SR is an employee of Idorsia Pharmaceuticals Ltd. and receives stock unrelated to this publication.

Patient consent for publication Not applicable.

Ethics approval This study was approved by the Regional Ethics Committee in Stockholm in 2014 (2014/1822-31/4).
Provenance and peer review  Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data underlying this article can be made available to researchers fulfilling Swedish legal requirements for access to personal sensitive data upon reasonable request to the corresponding author.

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