

# Early Readmissions After Acute Myocardial Infarction



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**This study aims to evaluate the rate, predictors, and causes of 30-day readmissions in a single tertiary hospital in the United Kingdom. We conducted a retrospective study of all patients admitted between 2012 and 2014 with a diagnosis of acute myocardial infarction, who were in the Myocardial Infarction National Audit Project register. Data on patient demographics, comorbidities, care received, and in-hospital mortality were collected. Rates of 30-day readmission and causes of readmission were evaluated. Univariate and multiple logistic regressions were used to identify predictors of all-cause, cardiac, and noncardiac readmission. A total of 1,869 patients were included in the analysis and 171 had an unplanned readmission with 30 days (9%). Noncardiac problems represented half of all readmissions with the dominant cause noncardiac chest pain (50%). A variety of other noncardiac causes for readmission were identified and the most common were lower respiratory tract infection (4.3%), gastrointestinal problems (4.9%), bleeding (3.7%), dizziness, syncope, or fall (3.0%), and pulmonary embolus (2.4%). For cardiac causes of readmissions, common causes included acute coronary syndrome (17.1%), stable angina (11.6%), and heart failure (9.8%). Readmitted patients were more likely to be older, anemic, and less likely to receive coronary angiogram and percutaneous coronary intervention. After adjustment, the only predictor of all-cause readmission was older age. For noncardiac readmission, previous myocardial infarction was associated with significantly fewer readmissions. Our results suggest that early readmission after discharge with diagnosis of acute myocardial infarction is common. Chest pain is the most frequent cause of readmission, and interventions to reduce noncardiac chest pain admissions are needed. © 2017 Elsevier Inc. All rights reserved. (Am J Cardiol 2017;120:723–728)**

Improved care for patients with acute myocardial infarction (AMI) has resulted in a growing population that is at risk of readmission to hospital. Early readmissions are important because they may be related to the treatment of AMI. Major bleeding is a recognized complication, and a Danish nationwide registry reported that 4.6% of patients were admitted to hospital with bleeding after AMI.<sup>1</sup> Furthermore, heart failure is a recognized complication or sequelae of AMI, which is another important cause of readmission.<sup>2</sup> Second, the admission may be related to inadequate management of other comorbidities during their inpatient stay. It has been reported that more than 1/3 of patients have a diagnosed cardiovascular comorbidity when hospitalized with AMI and

5% have 4 or more comorbidities.<sup>3</sup> Finally, readmission within 30 days is a recognized quality of care indicator, and some healthcare systems have financial penalties associated with these admissions. Most of the literature on early readmissions have been based on older American registries and insurance databases that may not be relevant to contemporary practice, and such healthcare models are very different from healthcare systems in Europe. We therefore conducted a retrospective study of all patients admitted with AMI and those who are readmitted within 30 days of discharge at a tertiary center in the United Kingdom (UK). This study aims to determine the incidence of readmissions, the predictors of readmissions, and the causes of readmission in a large contemporary cohort of patients admitted with an AMI in the UK.

## Methods

Royal Stoke University Hospital is a large tertiary hospital in the West Midlands of the UK. We conducted a retrospective audit of participants who were admitted between 2012 and 2014 with a diagnosis of AMI. Potential participants were identified from our local Myocardial Infarction National Audit Project (MINAP) register, which captures all admissions with AMI. Anonymized data on patient demographics, comorbidities, care received, and in-hospital mortality were collected from the MINAP register. To identify participants with 30-day readmissions, we cross-checked the hospital numbers from the MINAP registry with hospital

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CSK conceptualized the study. CSK, CWW, HS, LB, TF, and AS collected the data. CSK performed the analyses. CSK and MAM drafted the study and all authors contributed in the writing of the study.

See page 727 for disclosure information.

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administrative records with admission episodes. A retrospective review of computerized patient records was performed for patients who were readmitted to understand why they were readmitted and the care they had received before readmission. We included patients from addresses that are in the catchment areas for Royal Stoke University Hospital. These addresses begin with the postcodes ST1-ST13, ST15-ST18, and ST21. For patients with multiple admissions with acute coronary syndrome (ACS), we only considered their first admission with AMI.

From the local MINAP registry, we collected data on patient demographics, comorbidities, measurements, and test results on admission, medication, and management. Diagnosis at 30-day readmission, team that managed the patient on readmission, and length of stay of initial admission were captured from a review of electronic records.

Data analysis was performed on STATA 14 (StataCorp., College Station, TX, USA). Raw data were initially cleaned, where each variable was reviewed in detail and outlier values were removed. We excluded patients with death in-hospital ( $n = 78$ ) and those with planned readmission ( $n = 23$ ). Descriptive statistics were presented for all included variables according to whether the patients were or were not readmitted within 30 days.  $p$  Values were determined using analysis of variance for continuous variables, and chi-square test was used for categorical variables. We assumed the missing values for data were random and used multiple imputations to account for missing data. Multiple imputations with chained equations using the function *mi impute chained* was used to account for the missing data

using 10 imputed dataset. Multiple logistic regression was performed with the function *mi estimate* to identify univariate predictors of patients who were readmitted within 30 days. Predictors with  $p$  value  $< 0.05$  were included in a multivariate model to determine independent predictors of readmission, cardiac readmission, and noncardiac readmission. Graphical illustration was used to present causes of readmission, and exact causes of readmission are shown in table form.

## Results

Between 2012 and 2014, 2,052 patients with a diagnosis of ACS, AMI, or unstable angina were admitted to the Royal Stoke Hospital from its local catchment areas. After exclusion of 78 patients that died in-hospital, 23 planned readmissions for staged procedures, and 82 patients with a diagnosis of unstable angina, there were a total of 171 of 1,868 patients (9.1%) who were readmitted within 30 days. The flow diagram of participants is shown in [Figure 1](#).

The extent of missing data for collected variables is shown in [Supplementary Table 1](#). All variables had less than 10% missing data and the highest extent of missing data were smoking status (9%) and receipt of coronary artery bypass graft (9%).

[Table 1](#) lists the baseline characteristics of participants according to readmission status within 30 days. Patients who were readmitted were older ( $p < 0.001$ ), had lower hemoglobin ( $p = 0.008$ ), and were less likely to receive coronary angiogram ( $p = 0.001$ ) and percutaneous coronary intervention (PCI) ( $p = 0.031$ ).

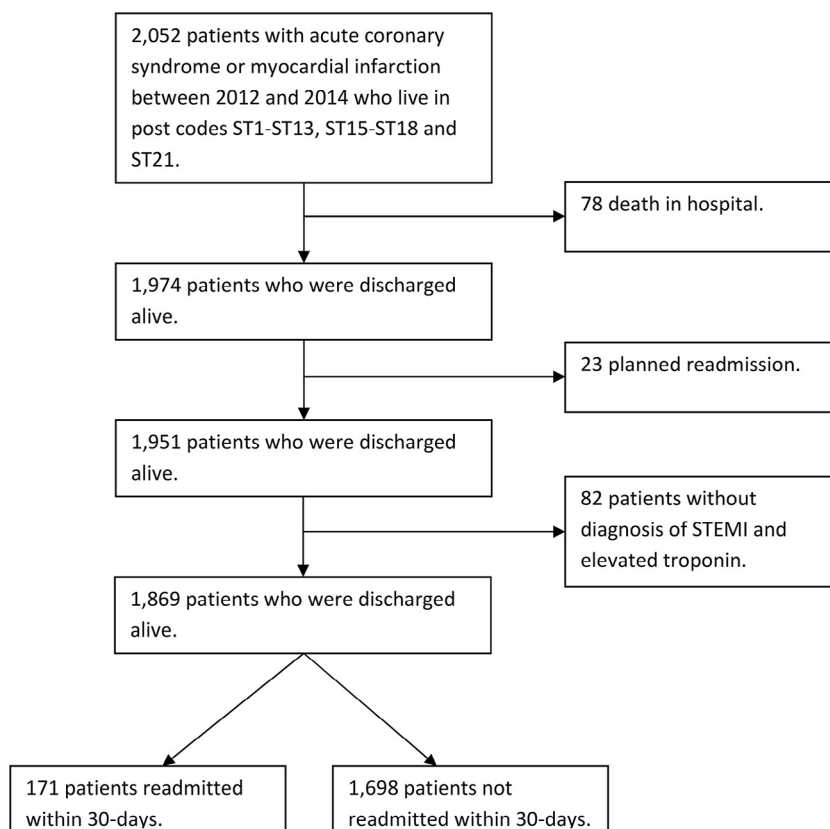


Figure 1. Flow diagram of participant inclusion.

Table 1  
Patient characteristics according to outcome status

Variable	Alive and not readmitted (n = 1,698)	Readmitted within 30 days (n = 171)	p Value
Age (y)	66 ± 13	71 ± 13	<0.001
Men	1,186 (70%)	110 (64%)	0.14
Smoker			0.002
Never smoker	459 (29%)	54 (35%)	
Ex-smoker	560 (35%)	68 (44%)	
Current smoker	563 (36%)	34 (22%)	
Hypertension	860 (51%)	88 (51%)	0.84
Hypercholesterolemia	593 (35%)	52 (30%)	0.24
Diabetes mellitus	341 (20%)	44 (27%)	0.058
Angina pectoris	156 (9%)	21 (12%)	0.19
Previous myocardial infarction	325 (19%)	29 (17%)	0.49
Previous stroke	102 (6%)	14 (8%)	0.26
Asthma or long-term obstructive pulmonary disease	233 (14%)	24 (14%)	0.91
Renal disease	65 (76%)	11 (6%)	0.10
Previous percutaneous coronary intervention	123 (7%)	14 (8%)	0.65
Previous coronary artery bypass graft	106 (6%)	9 (5%)	0.61
Systolic blood pressure	142 ± 29	142 ± 29	0.93
Hemoglobin	141 ± 20	136 ± 21	0.008
Creatinine	89 ± 56	97 ± 85	0.12
Cardiac arrest	119 (7%)	9 (5%)	0.38
Angiotensin-converting enzyme inhibitor or angiotensin receptor blocker	1,519 (94%)	152 (94%)	1.00
Beta blocker	1,498 (90%)	154 (93%)	0.29
Statin	1,580 (95%)	162 (96%)	0.77
Antiplatelet	1,564 (94%)	159 (95%)	0.92
Coronary angiogram	1,431 (87%)	130 (77%)	0.001
Percutaneous coronary intervention	1,179 (69%)	105 (61%)	0.031
Coronary artery bypass graft	53 (3%)	6 (4%)	0.87

The highest cause of readmission was noncardiac causes of readmission, which accounted for 50% of admission, whereas 46% were cardiac causes and 4% were unknown.

The causes of readmissions are shown in Table 2. The most common causes of readmission were noncardiac chest pain (20.1%) and acute coronary syndrome (17.1%). Other common reasons for admission were stable angina (11.6%), heart failure or pulmonary edema (9.8%), arrhythmia (4.9%), and pericarditis (2.4%). For noncardiac causes, other prevalent causes for readmission include lower respiratory tract infection or exacerbation of chronic obstructive pulmonary disease (4.3%), gastrointestinal problem (4.9%), bleeding (3.7%), dizziness, presyncope, syncope and fall (3.0%), and pulmonary embolus (2.4%). The remaining causes had 3 or fewer readmissions.

Evaluation of potential factors associated with readmission at 30 days is shown in Table 3. Age, hemoglobin, receipt of angiogram, and receipt of PCI had univariate odds ratios with p values <0.05. When these variables were all placed in the same model, only increasing age was associated with a significant increase in 30-day readmission. For cardiac readmission, none of the variables were significant when all these variables are included in a model. For noncardiac readmission, previous myocardial infarction was associated with significantly fewer readmissions.

## Discussion

Our results suggest that early readmission after discharge with a diagnosis of AMI is common. Considering broad categories

of admission, noncardiac problems represent half of all reasons for readmission, and noncardiac chest pain represents the most frequent specific cause for readmission. Cardiac readmissions represent 45% of all readmissions and most of these cases are due to stable angina, acute coronary syndrome, or heart failure. The present study suggests that in a large tertiary hospital in the UK, the 30-day readmission rate is 9% and the older age is the only predictor of early readmission.

Rates of early readmission after AMI vary depending on the timing of follow-up and the cohort studied. Two American studies reported 30-day readmission rates of 11.3%<sup>4</sup> and 18.6%.<sup>5</sup> The median time to readmission, according to one study, was 10 days<sup>4</sup> and this is consistent with another study, which suggests that 67.6% of readmissions occur within 15 days of discharge.<sup>6</sup> The timing of the readmission within the 30-day time frame was studied in a cohort from Brazil where elderly patients with ACS were found to have 12.5% readmission within 7 days, 22.5% in 8 to 15 days, and 38% in 16 to 30 days.<sup>7</sup> Among a subpopulation who undergo PCI, a recent review suggests that among patients that undergo PCI, it has been reported that 30-day readmission rates are 4.7% to 15.6%.<sup>8</sup> Interestingly, analysis of the Australian and New Zealand population of GRACE cohort reported a decline over 9 years from about 24% to 15% readmission over 6 months but there was no major change in readmission within 30 days, which was approximately 7% in 1999 and 6% in 2007.<sup>9</sup> The present study reports a 30-day readmission rate of 9% and this readmission rate is similar to those reported in existing literature. In the present study, majority of patients were admitted within 7 days (51%) and this decreased to 22.6% in

Table 2

Causes of readmissions at 30 days

Cardiac causes of readmission (n = 79)	Patients	
Acute coronary syndrome	28	(17.1%)
Stable angina	19	(11.6%)
Heart failure/acute pulmonary edema	16	(9.8%)
Arrhythmia	8	(4.9%)
Pericarditis	4	(2.4%)
Cardiac arrest	2	(1.2%)
Cardiogenic shock	1	(0.6%)
Pericardial effusion	1	(0.6%)
Noncardiac causes of readmission (n = 85)	Patients	
Noncardiac chest pain (troponin negative)	33	(20.1%)
Lower respiratory tract infection or exacerbation of long-term obstructive pulmonary disease	7	(4.3%)
Gastrointestinal problem—abdominal pain, dyspepsia, biliary colic, cholecystitis, diverticulitis, gastroenteritis	8	(4.9%)
Bleeding—epistaxis, upper gastrointestinal bleed, hematuria	6	(3.7%)
Dizziness, presyncope, syncope, fall	5	(3.0%)
Pulmonary embolus	4	(2.4%)
Stroke	3	(1.8%)
Renal failure	3	(1.8%)
Sepsis	2	(1.2%)
Hypo/hyperkalemia	2	(1.2%)
Hypoglycemia	1	(0.6%)
Hypertension	1	(0.6%)
Iron deficiency anemia	1	(0.6%)
UTI	1	(0.6%)
Postural hypotension	1	(0.6%)
Headache	1	(0.6%)
Cough	1	(0.6%)
Rash	1	(0.6%)
Pressure sore	1	(0.6%)
Anxiety	1	(0.6%)
Social admission	1	(0.6%)
Generally unwell	1	(0.6%)
Total	164	(100%)

day 8 to day 14, to 14.0% in day 15 to day 21, and to 12.1% in day 22 to day 30 (Figure 2).

It has been suggested that the period up to 30 days after AMI is a period where patients are at high risk of readmission due to a wide variety of illnesses,<sup>6</sup> and studies have identified many different causes for readmission after AMI. A study in Texas, United States (US), by Rodriguez et al reported that the principal causes of readmissions were 42% cardiac related, 15% respiratory, and 11% gastrointestinal.<sup>4</sup> Another study, which took place in Brazil, suggested that the most frequent causes of readmissions were acute coronary syndrome (41.6%) and readmissions for PCI procedures (25%).<sup>7</sup> Another large American study of Medicare beneficiaries, however, suggests that heart failure was the most common cause for readmission and this was followed by AMI, renal disorder, arrhythmias, and pneumonia.<sup>6</sup> In the present study, 45% of readmissions within 30 days are due to cardiac causes. We observed that half of all readmissions were because of noncardiac diagnoses. The most frequent noncardiac diagnosis was noncardiac chest pain, and other common but

Table 3

Factors associated with readmission at 30 days

(A) All-cause readmission		
Univariate association with 30-day readmission with p <0.05	Odds ratio (95% CI)	p Value
Age	1.03 (1.01–1.04)	<0.001
Hemoglobin	0.99 (0.98–1.00)	0.008
Angiogram	0.55 (0.37–0.80)	0.002
PCI	0.70 (0.51–0.97)	0.032
Multivariate association with 30-day readmission (all variables in the same model)	Odds ratio (95% CI)	p Value
Age	1.02 (1.00–1.03)	0.014
Hemoglobin	0.99 (0.99–1.00)	0.24
Angiogram	0.76 (0.43–1.35)	0.36
PCI	1.07 (0.67–1.70)	0.78
(B) Cardiac readmissions		
Univariate association with 30-day cardiac readmission with p <0.05	Odds ratio (95% CI)	p Value
Age	1.03 (1.01–1.05)	0.002
Hemoglobin	0.99 (0.98–1.00)	0.048
Angiogram	0.48 (0.29–0.81)	0.006
PCI	0.56 (0.35–0.88)	0.012
Multivariate association with 30-day cardiac readmission (all variables in the same model)	Odds ratio (95% CI)	p Value
Age	1.01 (1.00–1.04)	0.075
Hemoglobin	1.00 (0.98–1.01)	0.50
Angiogram	0.85 (0.40–1.79)	0.66
PCI	0.80 (0.43–1.49)	0.48
(C) Noncardiac readmissions		
Univariate association with 30-day noncardiac readmission with p <0.05	Odds ratio (95% CI)	p Value
Previous myocardial infarction	0.43 (0.21–0.90)	0.026
Multivariate association with 30-day cardiac readmission (all variables in the same model)	Odds ratio (95% CI)	p Value
Previous myocardial infarction	0.43 (0.21–0.90)	0.026

less frequent diagnoses were lower respiratory tract infection and gastrointestinal causes for admission.

Several studies have attempted to identify predictors of readmission, and the heterogeneity in independent predictors identified may reflect the differences in participant characteristics, comorbidities, and management factors evaluated in predictive models, and health care delivery in the health-care systems that the models were derived.<sup>5,9,10</sup> Another interesting factor associated with readmission was psychological stress, which was shown to be associated with a threefold increase in 30-day readmission.<sup>11</sup> Interestingly, one study suggests that the predictive value of the factors such as comorbidity which predict readmission change over time as 42.6% of 30-day readmission is related to incident myocardial infarction, but this proportion decreases over time.<sup>5</sup>



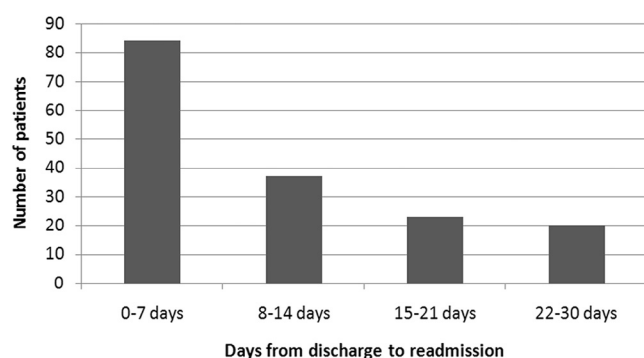


Figure 2. Timing of readmission.

In the present study, the only independent predictor of readmission was older age, which differs from the previous studies and is likely related to differences in our cohort and the way healthcare is delivered in the UK.

In view of the wide range of predictors identified, a few studies have attempted to determine if risk prediction tools could be used to determine readmissions.<sup>4,12</sup> Rana et al suggested that individual clinical and demographic risk factors for readmissions have low predictive power, but comorbidities when combined into indexes result in modest predictive power.<sup>12</sup> Studies have also been conducted to compare several scores such as LACE, CADILLAC, CRUSADE, and TIMI-NSTEMI for their predictive values in unplanned admission, and LACE score provided the best prediction.<sup>13</sup> The difficulty with risk prediction is that the utility of the score should be simple enough for clinicians to implement with variables that are easily obtained for clinical use, but for administrative purposes, complex scores could be used so that on a service provision perspective better understanding of the treated patients and readmission risk could be determined. The problem with many of the studies is the heterogeneity in the variables considered in the derivation of the score that yields differences in predictive factors so it is not unequivocal that the main drivers of readmission are demographic factors, comorbidities, or other factors.

In the UK, there is a free healthcare system that is socialized and needs-based, whereas in the US, there are some government-assisted programs but majority of healthcare is privatized. As a result, the patients who are admitted to UK hospitals are less likely selected based on socioeconomic status or ability to afford healthcare. As healthcare is free in the UK, patients may present at an earlier stage before progression of illness. In contrast, in the US, patients who cannot afford healthcare may present later with more severe symptoms. In addition, resources are more limited in the UK, which can result in delays in investigations and treatments, whereas in the US, access to tests and therapeutic procedures may happen more quickly because they are paid for. It is difficult to be certain exactly how the healthcare system-related factors affect the population, which present with AMI, and we also cannot exclude cultural differences in health-seeking behaviors of patient populations.

Our study has several strengths and limitations. Our study cohort is unique because the study is a contemporary cohort, which took place in the UK where there is a National Health

Service which delivers publicly funded care that is unlike many of the American studies where the healthcare is insurance based. In addition, this patient level analysis is less likely to be affected by reporting bias, which may affect studies that use medical codes. The main limitations are that this study has a small sample size and took place in a single hospital over 2 years and did not capture other potential variables that might influence or predict readmissions. Even though the study took place in the single center, there is limited literature from the UK about readmissions. Although there are other areas in the UK where there are a higher prevalence of ethnic minorities and people of higher social class, the current population studied has good generalizability to a typical working class Caucasian population in the UK. Another limitation is the possibility that patients could be readmitted within 30 days to another hospital. However, we did limit this possibility of readmissions to other hospitals by only including patients from residences from postcodes in the Royal Stoke University Hospital catchment area. Also, it is possible that missing data were not random, which would violate assumptions that are essential to ensure the robustness of multiple imputations. We included variables that were statistically significant in our model to adjust for confounding, but this has the risk of not adjusting for all the variables needed or overadjusting. It would therefore be useful for the current models to be evaluated at different times or populations. A further limitation is that we were unable to test previous risk scores that use the Charlson comorbidity index.

In conclusion, early readmission after ACS is common. We found that the only independent predictor of early readmission was older age. Similar to existing literature, cardiac causes represent the most common reason for readmission.

## Disclosures

The authors have no conflicts of interest to declare.

## Supplementary Data

Supplementary data associated with this article can be found, in the online version, <http://dx.doi.org/10.1016/j.amjcard.2017.05.049>.

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