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Decade-long Trends in the Frequency of 90-day Rehospitalizations after Hospital Discharge for Acute Myocardial Infarction

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Abstract

There are limited data available describing relatively contemporary trends in 90-day rehospitalizations among patients who survive hospitalization after an acute myocardial infarction (AMI) in a community setting. We examined decade-long (2001–2011) trends in, and factors associated with, 90-day rehospitalizations in patients discharged from three central Massachusetts (MA) hospitals after AMI. Residents of the Worcester, MA, metropolitan area discharged after AMI from three central MA hospitals on a biennial basis between 2001 and 2011 comprised the study population (n=4,810). The average age of this population was 69 years, 42% were women, and 92% were white. Between 2001 and 2011, 30.0% of patients were rehospitalized within 90 days after hospital discharge, and 38% of 90-day rehospitalizations occurred after the first month post hospital discharge. Crude 90-day rehospitalization rates decreased from 31.5% in 2001/2003 to 27.3% in 2009/2011. After adjusting for several sociodemographic characteristics, comorbidities, and in-hospital factors, there was a reduced risk of being rehospitalized within 90 days after hospital discharge in 2009/2011 compared with 2001/2003 (risk ratio (RR)=0.87, 95% confidence interval (CI)=0.77 to 0.98); this trend was slightly attenuated (RR=0.90, 95% CI=0.79 to 1.02) after further adjustment for hospital treatment practices. Female sex, having several previously diagnosed comorbidities, an increased hospital stay, and the in-hospital development of

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atrial fibrillation, cardiogenic shock, and heart failure were significantly associated with an increased risk of being rehospitalized. In conclusion, the likelihood of subsequent 90-day rehospitalizations remained frequent, and we did not observe a significant decline in these rates during the years under study.

Keywords

Acute myocardial infarction; 90-day; hospital readmission

Introduction

Due to current hospital reimbursement policies that enforce penalties on excess 30-day readmissions,¹ several studies have reported 30-day rehospitalization rates and associated risk factors among patients surviving hospitalization for acute myocardial infarction (AMI).^{2–4} However, little is known about recent trends in 90-day rehospitalization rates, the reasons for rehospitalization, as well as risk factors that may affect 90-day rehospitalization rates among patients surviving an AMI. Our primary study objective was to describe decade-long (2001–2011) trends in the frequency of having a first rehospitalization within 90 days of discharge among patients surviving hospitalization for an AMI. Our secondary study objective was to describe the reasons for being rehospitalized, and factors associated with an increased risk of 90-day rehospitalizations, among residents of central Massachusetts (MA) discharged from the three principal medical centers in central MA after an AMI.

Methods

Described elsewhere in detail,^{5–8} the Worcester Heart Attack Study is a population-based investigation examining long-term trends in the descriptive epidemiology of AMI in residents of the Worcester, MA, metropolitan area (2010 census=518,000) hospitalized at all 16 medical centers in central MA on an approximate biennial basis between 1975 and 2011.^{5–8} Due to hospital closures, mergers, or conversion to long-term care facilities, fewer hospitals (n=11) have been providing care to greater Worcester residents since the 1990's.

Computerized printouts of patients discharged from all greater Worcester hospitals with possible AMI [International Classification of Disease (ICD) 9 codes: 410–414, 786.5] were identified and cases of possible AMI were independently validated using predefined criteria for AMI.^{5–8} These criteria included a suggestive clinical history, increases in several serum biomarkers, and serial electrocardiographic findings during hospitalization consistent with the presence of AMI. Patients who satisfied at least 2 of these 3 criteria, and were residents of the Worcester metropolitan area since this study is population-based, were included.

Because the focus of the current study was rehospitalization after hospital discharge for AMI, we included adult residents of the Worcester metropolitan area who survived their index hospitalization for AMI on a biennial basis between 2001 and 2011. We further restricted our study population to patients hospitalized at the three largest tertiary care and community medical centers in central MA. This was done since the majority (approximately

90%) of patients hospitalized for AMI in central MA were discharged from these facilities. The patient's index hospitalization and any subsequent readmission occurred in either of the three study hospitals. Patients who had their index hospitalization or their rehospitalization outside of these three major medical centers were not included. This study was approved by the Institutional Review Board at the University of Massachusetts Medical School.

Trained nurses and physicians abstracted data on patient's sociodemographic characteristics, medical history, clinical data, and treatment practices through the review of hospital medical records. These factors included patient's age, sex, race, marital status, year of hospitalization, hospital length of stay, history of several previously diagnosed comorbidities (e.g., stroke, hypertension, diabetes mellitus), AMI order (initial vs. prior) and AMI type [ST-segment elevation myocardial infarction (STEMI) vs. non-STEMI (NSTEMI)].^{9,10} Information on the development of important in-hospital complications (e.g., atrial fibrillation,¹¹ cardiogenic shock,¹² heart failure,¹³ and stroke¹⁴) was also collected.

Data on the receipt of thrombolytic therapy and three coronary diagnostic and interventional procedures [cardiac catheterization, percutaneous coronary intervention (PCI), and coronary artery bypass grafting (CABG)] during hospitalization, and medications prescribed at the time of hospital discharge, including four effective cardiac medications [angiotensin converting inhibitors (ACE-I)/angiotensin receptor blockers (ARBs), aspirin, beta blockers, and lipid lowering agents], were obtained.

A rehospitalization was defined as the patient's first readmission to a study hospital within 90 days of hospital discharge after AMI. Two independent investigators adjudicated whether the principal reason for readmission was either cardiovascular disease (CVD) or non-CVD related based on information contained in hospital medical records. Indications for CVD related hospitalizations included an acute coronary syndrome (ACS), heart failure, type II diabetes mellitus, and chronic ischemic heart disease. Examples of non-CVD related hospitalizations included urinary tract infections, hemorrhage, osteoarthritis, and bone fractures.

For ease of analysis and interpretation, we aggregated the 6 individual study years into 3 two-year strata (2001/2003, earliest; 2005/2007, middle; and 2009/2011, most recent) for purposes of examining trends in our principal study outcome. Differences in the distribution of patient sociodemographic and clinical characteristics between patients hospitalized during the three aggregated time periods were examined using the ANOVA or Kruskal-Wallis tests for continuous variables and the chi-square test for categorical variables. The Cochran-Armitage tests and linear or quantile regression models were used to assess for linear trends over time among categorical and continuous variables, respectively.

Post-discharge rehospitalization rates were examined by calculating the frequency of having a first rehospitalization within 90 days among patients discharged from the hospital after their index AMI. We examined average weekly rates of being rehospitalized during the first 90 days after hospital discharge. We also examined the reasons for being rehospitalized during this period and calculated the cause-specific 90-day rehospitalization rates.

Multivariable adjusted Poisson regression models with robust error variance¹⁵ were used to examine the association between time period of hospitalization and the outcome of whether or not the patient was rehospitalized during the following 90 days while adjusting for several potentially confounding variables of prognostic importance.

Several covariates associated with rehospitalization after AMI in prior studies^{2,16} were examined including age, sex, race, marital status, AMI order and type, previously diagnosed comorbid conditions, hospital clinical complications, and hospital length of stay. We further adjusted for hospital treatment practices (i.e., thrombolytic therapy, cardiac catheterization, PCI, and CABG surgery, and the prescribing of ACE-I/ARBs, aspirin, beta blockers, and lipid lowering agents at the time of hospital discharge) during the patient's index hospitalization to examine their potential effects on 90-day rehospitalization trends. We repeated the same analyses after excluding patients (n=246) who were not rehospitalized but died during the 90-day post-discharge period, or by treating patients who were not rehospitalized but died within the 90-day post-discharge period as those who had a 90-day readmission. The results were presented as multivariable adjusted risk ratios (RR) and accompanying 95% confidence intervals (CI).

Results

The study population consisted of 4,810 adult residents of the Worcester metropolitan area who survived their hospitalization for AMI at the three major central MA medical centers between 2001 and 2011 (Table 1). Overall, the average age of this population was 68.9 years, 41.8% were women, 92.4 % were white, and 54.6% were married.

During the most recent years under study, patients who survived an AMI were more likely to be younger and have a history of hypertension, peripheral vascular disease, diabetes, or chronic kidney disease than patients hospitalized during earlier study periods. Between 2001 and 2011, 32.6% of our study sample was diagnosed with a STEMI and the median hospital length of stay was 4 days. The overall risk of developing cardiogenic shock (3.5%) or stroke (1.4%) during hospitalization remained relatively low whereas the overall risk of developing in-hospital heart failure (34.4%) or atrial fibrillation (18.8%) was considerably higher. We also observed an increasing trend in the use of cardiac catheterization and PCI and in the prescribing of effective cardiac medications at the time of hospital discharge (Table 1).

The overall 90-day rehospitalization rate for patients who survived their index AMI was 30.0% (n=1,445), which decreased between 2001/2003 (31.5%) and 2009/2011 (27.3%) (p for trend=0.012) (Table 2). Of all 90-day rehospitalizations, 38.4% (n=554) occurred after the first 30 days. There was a significant decline in the rates of rehospitalization during the first 30 days between 2001/2003 (20.5%) and 2009/2011 (15.8%) (p for trend=0.001), but not in the following 31–60 days and 61–90 days (Figure 1).

When we examined average weekly rates of rehospitalizations during the first 90 days after hospital discharge, the proportion of rehospitalizations was the highest (6.6%) during the first week and continued to decrease as the length of post-discharge time increased (Figure 2-a). The largest decline in the rates of readmission occurred during the first week after

hospital discharge, which decreased from 8.1% (2001/2003) to 4.3% (2009/2011) (p for trend<.001) (Figure 2-b). We did not observe any other significant decrease over time in average weekly rates of rehospitalizations after the first week during the years under study.

In examining the specific causes of 90-day rehospitalizations, 60.3% of patients were rehospitalized due to CVD related causes across all years; the proportion of 90-day rehospitalizations due to CVD related reasons was 61.2% in 2001/2003, 55.5% in 2005/2007, and 64.8% in 2009/2011.

In examining changing trends in 90-day rehospitalizations after adjusting for several sociodemographic characteristics, comorbidities, and in-hospital factors, there was a significantly reduced risk of being rehospitalized during the subsequent 90 days ($RR=0.87$, 95% $CI=0.77-0.98$) among patients who survived an AMI in 2009/2011, compared with those discharged in 2001/2003; this trend was attenuated ($RR=0.90$, 95% $CI=0.79-1.02$) after further adjustment for medical procedures and treatments received during hospitalization (Table 2). We found similar results after excluding patients who were not rehospitalized but died during the 90-day post-discharge period and when we analyzed these patients as having had a 90-day rehospitalization.

Using multivariable adjusted regression analyses, we observed that female sex, having previously diagnosed AMI, heart failure, peripheral vascular disease, diabetes mellitus, and chronic kidney disease, an increased length of hospital stay, and in-hospital development of atrial fibrillation, cardiogenic shock, and heart failure were significantly associated with an increased risk of being rehospitalized during the first 90 days after hospital discharge than respective comparison groups. Patients who received various coronary diagnostic and interventional procedures had a reduced risk for being rehospitalized compared with those who did not undergo these procedures (Table 3). Similar factors were associated with being rehospitalized after excluding patients who were not rehospitalized but died during the 90-day post-discharge period and when we analyzed these patients as having had a 90-day hospital readmission.

Discussion

The results of this study suggest that, among greater Worcester residents who survived their hospitalization for an AMI at the three major medical centers in central MA between 2001 and 2011, nearly 1 in 3 patients were rehospitalized within 90 days and 38% of 90-day hospital readmissions occurred after the first month post hospital discharge. Three out of every five rehospitalizations within 90 days after hospital discharge were CVD related. We failed to note a significant decline in the multivariable adjusted risk of having a 90-day rehospitalization during the years under study and we identified several factors associated with an increased risk for being readmitted to the hospital.

Reducing hospital readmissions has become a national priority to improve the quality of patient care and lower healthcare spending.^{1,17,18} However, there have been little published data examining trends in the frequency of rehospitalizations within 90 days after patients are discharged from the hospital,¹⁹ particularly after an AMI. Our investigation found that

nearly one third of patients who survived their index AMI were rehospitalized over the next 3 months, with two thirds of these readmissions related to CVD.

Prior studies examining 30-day readmissions after AMI have shown that about 40% of these readmissions occurred during the first week after hospital discharge.^{3,4} Similarly, we found that approximately 1 in every 5 patients who were rehospitalized over the subsequent 90 days were readmitted to the hospital during the first week after hospital discharge, and this proportion has declined over time. These data suggest that efforts at reducing hospital readmissions may be paying dividends in reducing short-term hospital readmissions. Although our prior study reported an encouraging decline in 30-day rehospitalizations between 2001 and 2011,²⁰ our current investigation did not observe a significant decline in the risk of 90-day rehospitalizations during the same period. The fact that nearly 40% of rehospitalizations occurred after the first 30 days raises a concern that there may be insufficient efforts and resources dedicated to continued follow up with patients after the first month post hospital discharge for an AMI.

Little attention has been paid to the causes for 90-day readmissions for patients discharged from the hospital after AMI. As the prevalence of comorbid conditions and aging population increase over time, and efforts continue to be focused on the enhanced use of effective secondary prevention strategies to improve the post-discharge outcomes of patients with AMI, 90-day rehospitalizations after AMI due to non-CVD causes require further attention.

A prior study examined 5,219 patients hospitalized with an ACS in the Australian and New Zealand sites of the Global Registry of Acute Coronary Events (GRACE).²¹ Female gender, previously diagnosed hyperlipidemia, recurrent ischemia, having a STEMI, and an elevated GRACE risk score were associated with a higher risk of an early rehospitalization (30-days); a greater burden of cardiac disease and clinical evidence of heart failure were strongly associated with an increased risk of late rehospitalization (2–6 months).²¹ Our study observed that female sex, having several previously diagnosed comorbidities, an increased hospital stay, and the in-hospital development of complications were significantly associated with an increased risk of being rehospitalized within 90 days after hospital discharge for AMI. Healthcare providers should pay extra attention to these high risk groups of vulnerable patients to prevent potential early readmissions when planning hospital discharge and post discharge management.

The strengths of the present study include its large population of adult residents hospitalized with a confirmed AMI in central MA and examination of decade-long trends in 90-day rehospitalization rates among these patients. However, since our study population only included patients who had been hospitalized and discharged at three central MA medical centers, one needs to be careful in extrapolating our findings to those who reside in other geographic areas. If a rehospitalization occurred outside of the Worcester metropolitan area, it was not captured but it is expected that this number would be quite small. Since study patients were mainly white, the generalizability of our findings to other racial/ethnic groups is limited. There is also the potential for unmeasured confounding in our observed associations since we did not have data available on patient's income, education,

psychosocial factors, treatment preference, and adherence to various post discharge treatment regimens which may have affected the endpoints examined.

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Figure 1.

Rates of rehospitalizations within 90 days after hospital discharge among patients who survived an acute myocardial infarction (AMI): Worcester Heart Attack Study, 2001–2011

Figure 2.

Average weekly rates of rehospitalizations within 90 days after hospital discharge among patients who survived an acute myocardial infarction (AMI): Worcester Heart Attack Study, 2001–2011 (a) Overall (b) By 3 time periods

Characteristics of patients who survived an acute myocardial infarction (AMI): Worcester Heart Attack Study, 2001–2011

Table 1

Variable	2001/2003 (n=1,923)	2005/2007 (n=1,517)	2009/2011 (n=1,370)	P-value*	P for trend†
Age, mean (years)	70.8	69.2	65.7	<.001	<.001
Age <55 years	15.2%	18.1%	23.1%	<.001	
Age 55–64 years	17.5%	19.3%	23.0%		
Age 65–74 years	21.6%	20.0%	24.5%		
Age 75–84 years	28.0%	28.0%	21.5%		
Age 85 years	17.7%	14.6%	7.9%		
Female	42.8%	41.9%	40.3%	0.35	0.16
White	94.0%	91.7%	91.1%	<.005	0.002
Married	53.7%	54.4%	56.1%	0.40	0.19
Hospital length of stay, median (IQR) (days)	5 (3–8)	4 (3–6)	3 (2–5)	<.001	<.001
Angina pectoris	22.5%	12.9%	4.6%	<.001	<.001
Atrial fibrillation	14.1%	12.9%	13.0%	0.50	0.33
Heart failure	22.6%	24.3%	19.6%	0.01	0.08
Hypertension	71.0%	75.4%	75.4%	<.005	0.003
Peripheral vascular disease	14.9%	20.4%	19.9%	<.001	<.001
Stroke	11.5%	10.8%	9.8%	0.28	0.11
Diabetes mellitus	33.0%	34.4%	37.4%	0.028	0.009
Chronic obstructive pulmonary disease	18.3%	15.7%	15.8%	0.06	0.041
Depression	15.5%	16.7%	17.5%	0.29	0.12
Chronic kidney disease	15.8%	22.3%	22.3%	<.001	<.001
ST-segment myocardial infarction	34.0%	32.2%	31.1%	0.19	0.07
Initial myocardial infarction	65.0%	64.9%	64.8%	0.99	0.91
<u>In-hospital clinical complications</u>					
Atrial fibrillation	20.9%	19.9%	14.5%	<.001	<.001
Cardiogenic shock	3.4%	4.1%	3.0%	0.26	0.66
Stroke	1.8%	0.5%	1.8%	<.001	0.83
Heart failure	37.9%	36.4%	27.5%	<.001	<.001
<u>In-hospital management</u>					

Variable	2001/2003 (n=1,923)	2005/2007 (n=1,517)	2009/2011 (n=1,370)	P-value*	P for trend [†]
Cardiac catheterization	62.1%	74.9%	76.1%	<.001	<.001
Percutaneous coronary intervention	41.4%	55.5%	60.0%	<.001	<.001
Coronary artery bypass grafting	8.3%	6.3%	7.2%	0.09	0.17
Thrombolytic therapy	6.3%	0.5%	0.2%	<.001	<.001
<u>Medication at hospital discharge</u>					
Angiotensin converting enzyme inhibitors/Angiotensin receptor blockers	59.3%	68.6%	64.8%	<.001	<.001
Aspirin	83.2%	92.4%	93.2%	<.001	<.001
Beta blockers	83.1%	91.0%	89.7%	<.001	<.001
Lipid-lowering agents	65.6%	79.1%	88.8%	<.001	<.001

IQR: interquartile range

* P-values derived from ANOVA or Kruskal-Wallis tests for continuous variables and chi-square tests for categorical variables.

[†] P-values derived from Cochran-Armitage tests for categorical variables and linear or quantile regression models for continuous variables.

Table 2

Association between time period of hospitalization and 90-day all-cause rehospitalizations among patients who survived an acute myocardial infarction (AMI): Worcester Heart Attack Study, 2001–2011

Frequency of 90-day rehospitalizations		Adjusted for sociodemographics and comorbidities [*]	Further adjusted for in-hospital factors [†]	Further adjusted for hospital treatment practices [‡]
Study Period	% (n)	Adjusted RR (95% CI)		
2001/2003	31.5 (395)	1.00	1.00	1.00
2005/2007	30.7 (279)	0.93 (0.84–1.04)	0.94 (0.85–1.05)	0.97 (0.87–1.08)
2009/2011	27.3 (217)	0.84 (0.75–0.94)	0.87 (0.77–0.98)	0.90 (0.79–1.02)

RR: risk ratios; CI: confidence intervals

^{*} Adjusted for age, sex, race, marital status, and previously diagnosed comorbid conditions.

[†] Adjusted for sociodemographic characteristics, comorbid conditions, AMI order, AMI type, in-hospital complications, and hospital length of stay.

[‡] Adjusted for sociodemographic characteristics, comorbid conditions, in-hospital factors, and in-hospital management as represented by thrombolytic therapy and receipt of 3 coronary interventional procedures (cardiac catheterization, PCI, and CABG), and prescribing of 4 guideline-recommended cardiac medications (ACE-I/ARBs, lipid lowering agents, beta blockers, and aspirin) at the time of hospital discharge.

Table 3

Association between various prognostic factors and 90-day all-cause rehospitalizations among patients who survived an acute myocardial infarction (AMI): Worcester Heart Attack Study, 2001–2011

Factors	Adjusted for sociodemographics and comorbidities*	Further adjusted for in-hospital factors [†]	Further adjusted for hospital treatment practices [‡]
	1.00	1.00	1.00
Age <55 years			
Age 55–64 years	1.18 (0.99–1.40)	1.14 (0.96–1.36)	1.14 (0.96–1.36)
Age 65–74 years	1.26 (1.06–1.49)	1.17 (0.99–1.40)	1.17 (0.99–1.40)
Age 75–84 years	1.29 (1.09–1.52)	1.19 (1.00–1.42)	1.16 (0.98–1.38)
Age 85 years	1.34 (1.11–1.62)	1.24 (1.02–1.50)	1.13 (0.93–1.38)
Female (vs. Male)	1.13 (1.03–1.25)	1.14 (1.04–1.25)	1.11 (1.01–1.22)
White (vs. non-White)	0.84 (0.72–0.98)	0.84 (0.72–0.97)	0.87 (0.75–1.01)
Married (vs. not Married)	1.01 (0.92–1.11)	1.02 (0.92–1.12)	1.03 (0.94–1.13)
Angina pectoris	0.98 (0.87–1.11)	0.98 (0.87–1.10)	1.01 (0.90–1.14)
Atrial fibrillation	1.21 (1.08–1.36)	1.15 (1.01–1.30)	1.13 (1.00–1.27)
Heart failure	1.29 (1.16–1.44)	1.18 (1.05–1.33)	1.15 (1.03–1.29)
Hypertension	1.07 (0.95–1.21)	1.06 (0.94–1.19)	1.07 (0.95–1.21)
Peripheral vascular disease	1.18 (1.06–1.31)	1.14 (1.03–1.27)	1.16 (1.05–1.30)
Stroke	1.02 (0.89–1.16)	1.03 (0.90–1.17)	1.00 (0.88–1.14)
Diabetes mellitus	1.20 (1.08–1.32)	1.16 (1.05–1.28)	1.15 (1.04–1.27)
Chronic obstructive pulmonary disease	1.08 (0.97–1.21)	1.05 (0.94–1.17)	1.04 (0.93–1.16)
Depression	1.05 (0.94–1.18)	1.05 (0.93–1.18)	1.04 (0.93–1.17)
Chronic kidney disease	1.32 (1.18–1.46)	1.27 (1.15–1.41)	1.20 (1.08–1.34)
Initial AMI (vs. Prior AMI)		0.87 (0.79–0.95)	0.89 (0.81–0.98)
ST-segment myocardial infarction		0.96 (0.87–1.07)	1.00 (0.89–1.11)
Hospital Length of Stay (per day)		1.01 (1.00–1.01)	1.01 (1.00–1.02)
<u>In-hospital clinical complication</u>			
Atrial fibrillation		1.13 (1.01–1.27)	1.15 (1.02–1.28)
Cardiogenic shock		1.26 (1.04–1.53)	1.34 (1.10–1.64)
Stroke		0.77 (0.50–1.17)	0.75 (0.50–1.14)

Adjusted for sociodemographics and comorbidities ^{*,†}	Further adjusted for in-hospital factors [‡]	Further adjusted for hospital treatment practices [‡]
Factors	Adjusted RR (95% CI)	
Heart failure	1.17 (1.06–1.31)	1.16 (1.05–1.29)
<u>Coronary diagnostic/interventional procedure</u>		
No coronary procedure		1.00
Cardiac catheterization		0.86 (0.75–0.99)
Cardiac catheterization and PCI and/or CABG		0.74 (0.65–0.83)
Thrombolytic therapy		1.24 (0.92–1.65)
<u>Medication at hospital discharge</u>		
ACEI/ARBs		1.04 (0.94–1.14)
Aspirins		1.23 (1.05–1.43)
Beta blockers		1.04 (0.91–1.19)
Lipid-lowering agents		1.02 (0.92–1.14)

RR: Risk ratios; CI: confidence intervals; CABG: Coronary artery bypass grafting

^{*} Adjusted for study period, sociodemographic characteristics, and comorbidities.

[†] Adjusted for study period, sociodemographic characteristics, comorbid conditions, AMI order, AMI type, in-hospital clinical complications, and hospital length of stay.

[‡] Adjusted for study period, sociodemographic characteristics, comorbid conditions, in-hospital factors, and in-hospital management as represented by thrombolytic therapy and receipt of 3 coronary interventional procedures (cardiac catheterization, PCI, and CABG), and prescribing of 4 guideline-recommended cardiac medications (ACE-I/ARBs, lipid lowering agents, beta blockers, and aspirin) at the time of hospital discharge.