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Background—There are limited data available describing relatively contemporary trends in 30-day rehospitalizations among patients who survive hospitalization after an acute myocardial infarction (AMI) in the community setting. We examined decade-long (2001–2011) trends in, and factors associated with, 30-day rehospitalizations in patients discharged from 3 central Massachusetts hospitals after AMI.

Methods and Results—Residents of the Worcester, MA, metropolitan area discharged after AMI from 3 central Massachusetts hospitals on a biennial basis between 2001 and 2011 comprised the study population (N=4810). Logistic regression analyses were used to examine the association between selected factors and 30-day rehospitalizations. The average age of this population was 69 years, 42% were women, and 92% were white. During the years under study, 18.5% of patients were rehospitalized within 30 days after hospital discharge. Crude 30-day rehospitalization rates decreased from 20.5% in 2001–2003 to 15.8% in 2009–2011. After adjusting for several patient characteristics, there was a reduced odds of being rehospitalized in 2009–2011 (odds ratio 0.74, 95% CI 0.61–0.91) compared with 2001–2003; this trend was slightly attenuated after further adjustment for hospital treatment practices. Female sex, having previously diagnosed heart failure and chronic kidney disease, and the development of in-hospital cardiogenic shock and heart failure were associated with an increased odds of being rehospitalized.

Conclusions—While the likelihood of subsequent short-term rehospitalizations remained frequent, we observed an encouraging decline during the most recent years under study. Several high-risk groups were identified for purposes of heightened surveillance and intervention efforts to reduce the likelihood of being readmitted. **(*J Am Heart Assoc.* 2015;4:e002291 doi: 10.1161/JAHA.115.002291)**

Key Words: acute myocardial infarction • readmission • rehospitalization

Acute myocardial infarction (AMI) is a common manifestation of coronary heart disease that affected >800 000 adults in the United States in 2010.[1] Concomitant with advances in prehospital and hospital treatment, in-hospital survival after AMI has dramatically improved.[2] Many patients are being discharged from the hospital into the community who are at risk for being readmitted to the hospital due to a variety of contributory factors and reasons.[3,4] Although not all hospital readmissions can be prevented, excess readmissions within a short time frame can be a marker of poor quality of care and efficiency. Since the Centers for Medicare and Medicaid Services (CMS) began publicly reporting 30-day risk-standardized readmission rates for heart failure, AMI, and pneumonia as performance measures,[5] 30-day hospital readmission rates have become a quality performance measure for patients hospitalized with AMI.[5,6]

There has been considerable interest from hospitals and clinicians to better understand and improve modifiable factors associated with 30-day hospital readmissions, which are increasingly being linked to hospital reimbursement.[7] Although several studies have reported 30-day rehospitalization rates among patients surviving hospitalization for AMI,[4,8,9] few have examined risk factors for being readmitted to the hospital during the following month by using multivariable regression analyses. Moreover, there are little contemporary data that describe long-term trends in 30-day rehospitalization rates, the reasons for rehospitalization, as

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well as sociodemographic, clinical, and treatment-related factors that may affect 30-day rehospitalization rates among patients surviving an AMI.

Our primary study objective was to describe relatively contemporary decade long (2001–2011) trends in the frequency of 30-day rehospitalizations among patients surviving hospitalization for an AMI. Our secondary study objective was to describe patient characteristics, clinical factors, and treatment practices associated with an increased risk of 30-day rehospitalizations among residents of central Massachusetts discharged from the 3 principal medical centers in central Massachusetts after an AMI. Data from the Worcester Heart Attack Study were used in this study.[10–13]

Methods

Described elsewhere in detail,[10–13] the Worcester Heart Attack Study is an ongoing 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 Massachusetts on an approximate biennial basis between 1975 and 2011.[10–13] Due to hospital closures, mergers, or conversion to long-term care or rehabilitation facilities, fewer hospitals (n=11) have been providing care to greater Worcester residents during recent years.

Computerized printouts of patients discharged from all greater Worcester hospitals with possible AMI (*International Classification of Disease, Ninth Revision* [ICD] codes: 410 to 414, 786.5) were identified, and cases of possible AMI were independently validated by using predefined criteria for AMI.[10–13] These criteria included a suggestive clinical history, increases in several serum biomarkers (eg, creatine kinase [CK], CK-MB, and troponin values), 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, because 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 in 2001, 2003, 2005, 2007, 2009, and 2011. This period was selected due to its contemporary nature and data availability. We further restricted our study population to patients hospitalized at the 3 largest tertiary care and community medical centers in central Massachusetts (UMass-Memorial Health Care and St. Vincent/Worcester Medical Center). This was done since the majority (≈90%) of patients hospitalized for AMI in central Massachusetts were discharged from these facilities, which also have excellent electronic medical records. The patient's index hospitalization occurred in any of the 3 study hospitals, as did any subsequent rehospitalization. Patients who had their index hospitalization or their rehospitalization outside of these major medical centers were not included in this study. This study was approved by the Institutional Review Board at the University of Massachusetts Medical School and that informed consent was waived.

Data Collection

Trained nurses and physicians abstracted information on patient demographic characteristics, medical history, clinical data, and treatment practices through the review of hospital medical records. These factors included patient's sociodemographic characteristics (eg, age, sex, race, marital status), year of hospitalization, hospital length of stay, history of previously diagnosed comorbidities (eg, stroke, diabetes, heart failure), AMI order (initial versus prior) and AMI type (ST-segment elevation myocardial infarction [STEMI] versus non-STEMI [NSTEMI]).[14,15] Information on the development of important in-hospital complications including atrial fibrillation,[16] cardiogenic shock,[17] heart failure,[18] and stroke[19] was also collected.

Data on the receipt of thrombolytic therapy and 3 coronary diagnostic and interventional procedures (cardiac catheterization, percutaneous coronary intervention [PCI], and coronary artery bypass grafting [CABG]) during hospitalization, and pharmacotherapies at the time of hospital discharge, including the prescribing of 4 effective cardiac medications (angiotensin converting inhibitors [ACEIs]/angiotensin type II receptor blockers [ARBs], aspirin, β-blockers, and lipid-lowering agents), were obtained.

A rehospitalization was defined as the patient's first admission to a study hospital within 30 days of discharge after their index hospitalization for AMI during the years under study. Two of the study investigators adjudicated whether the principal reason for readmission was due to either an AMI, cardiovascular disease (CVD) (excluding AMI)-related, or non–CVD-related readmission based on the review of information contained in hospital medical records. Indications for CVD-related hospitalizations included unstable angina, 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.

Data Analysis

For ease of analysis and interpretation, we aggregated the 6 individual study years into 2-year strata of 2001–2003 (earliest), 2005–2007 (middle), and 2009–2011 (most recent) for purposes of examining trends in our principal study outcomes. Differences in the distribution of various patient demographic and clinical characteristics between patients hospitalized during the 3 aggregated periods were examined using the ANOVA test for continuous variables and the χ^2 test for categorical variables. The Cochran-Armitage tests and linear regression models were used to assess for linear trends over time among categorical and continuous variables, respectively.

Short-term rehospitalization rates were examined by calculating the frequency of having a first rehospitalization within 30 days among patients discharged from the hospital after their index AMI during the years under study. We examined the reasons for being rehospitalized during this period and calculated the cause-specific 30-day rehospitalization rates. Multivariable-adjusted logistic regression analyses were performed to examine the association between the main explanatory variable of period of hospitalization (2001–2003, earliest; 2005–2007, middle; and 2009–2011, most recent) and the outcome of whether the patient was rehospitalized during the following 30 days while adjusting for several potentially confounding variables of prognostic importance. We dummy coded the variable of time period of hospitalization with the earliest period (2001–2003) serving as the reference group.

Several covariates associated with rehospitalization after AMI in prior studies[3,4] were examined including age, sex, race (white versus nonwhite), marital status (married versus not married), AMI order (initial versus prior), AMI type (STEMI versus NSTEMI), previously diagnosed comorbid conditions (angina, atrial fibrillation, heart failure, hypertension, peripheral vascular disease, stroke, diabetes, chronic obstructive pulmonary disease, depression, and chronic kidney disease), hospital clinical complications (atrial fibrillation, heart failure, cardiogenic shock, and stroke), and hospital length of stay. We further adjusted for hospital treatment practices, including the receipt of thrombolytic therapy and 3 coronary diagnostic and interventional procedures (cardiac catheterization, PCI, and CABG), and the prescribing of 4 guideline recommended cardiac medications (ACEIS/ARBs, aspirin, β-blockers, and lipid-lowering agents) at the time of hospital discharge during the patient's index hospitalization in our regression analyses to examine the potential effects of hospital treatment practices on 30-day rehospitalization trends. We repeated the same analyses after excluding patients (n=165) who were not rehospitalized but died within the 30-day postdischarge period. In addition, we repeated the same analyses by treating patients who were not rehospitalized but died within the 30-day postdischarge period as those who had a 30-day readmission.

The results of our logistic regression analyses were presented as multivariable-adjusted odds ratios (OR) and accompanying 95% CIs, which were calculated based on standard errors clustered at the hospital level to account for potential within-hospital correlation with variance adjustment through the use of Morel's small sample bias correction.[20] All statistical analyses were conducted by using SAS version 9.3 (SAS Institute, Inc).

Results

Study Population Characteristics

The study population consisted of 4810 adult residents of the Worcester metropolitan area who survived their hospitalization for AMI at the 3 major central Massachusetts 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 their AMI were more likely to be younger and have a history of hypertension, peripheral vascular disease, diabetes, or chronic kidney disease than were patients who were hospitalized during earlier study periods (Table 1). Between 2001 and 2011, 32.6% of our study sample was diagnosed with a STEMI, which declined from 34.0% in 2001–2003 to 31.1% in 2009–2011. The average hospital length of stay in this study population was 5.5 days, which declined from 6.4 days in 2001–2003 to 4.7 days in 2009–2011 (Table 1). In addition, the likelihood of developing cardiogenic shock and stroke during hospitalization remained relatively low (3.5% and 1.4% overall, respectively), whereas the incidence rates of in-hospital heart failure and atrial fibrillation were considerably higher (34.4% and 18.8% overall, respectively) during the years under study (Table 1).

Thirty-Day Rehospitalization Rates

The overall 30-day rehospitalization rate for patients who survived their index AMI was 18.5%. The average postdischarge 30-day rehospitalization rates decreased from 2001–2003 (20.5%) to 2009–2011 (15.8%) (P for trend=0.001) (Table 2). The proportion of patients who were rehospitalized was the highest (6.6%) during the first week (0 to 7 days) after hospital discharge and continued to decrease as the length of postdischarge time increased (Figure 1). Rehospitalizations that occurred during the first week after hospital discharge accounted for 35.6% of all 30-day rehospitalizations; this proportion decreased from 39.2% in 2001–2003 to 27.2% in 2009–2011.

In examining the specific causes of 30-day rehospitalizations, 53.9% were CVD related (excluding AMI), 38.1% were non–CVD related, and 8.0% were due to a recurrent AMI during the years under study. The overall cause-specific 30-day rehospitalization rates due to CVD, non-CVD, and AMI were 10.0%, 7.0%, and 1.5%, respectively, during the years

Table 1. Characteristics of Patients Who Survived an AMI: Worcester Heart Attack Study, 2001–2011

	2001–2003 (n=1923)	2005–2007 (n=1517)	2009–2011 (n=1370)	*P* Value*	*P* for Trend†
Age, mean (y)	70.8	69.2	65.7	<0.001	<0.001
Age, %					
<55 y	15.2	18.1	23.1	<0.001	
55 to 64 y	17.5	19.3	23.0		
65 to 74 y	21.6	20.0	24.5		
75 to 84 y	28.0	28.0	21.5		
85+ y	17.7	14.6	7.9		
Female, %	42.8	41.9	40.3	0.35	0.16
White, %	94.0	91.7	91.1	0.005	0.002
Married, %	53.7	54.4	56.1	0.40	0.19
Hospital length of stay, mean (d)	6.4	5.2	4.7	<0.001	<0.001
Medical history, %					
Angina	22.5	12.9	4.6	<0.001	<0.001
Atrial fibrillation	14.1	12.9	13.0	0.50	0.33
Heart failure	22.6	24.3	19.6	0.011	0.08
Hypertension	71.0	75.4	75.4	0.003	0.003
Peripheral vascular disease	14.9	20.4	19.9	<0.001	<0.001
Stroke	11.5	10.8	9.8	0.28	0.11
Diabetes	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	<0.001	<0.001
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
In-hospital clinical complications, %					
Atrial fibrillation	20.9	19.9	14.5	<0.001	<0.001
Cardiogenic shock	3.4	4.1	3.0	0.26	0.66
Stroke	1.8	0.5	1.8	0.001	0.83
Heart failure	37.9	36.4	27.5	<0.001	<0.001
Physiological factors on hospital admission					
Initial heart rate, mean (beats/min)	86.5	84.7	83.8	0.002	0.001
Systolic blood pressure, mean (mm Hg)	144.1	143.6	140.3	0.001	<0.001
Diastolic blood pressure, mean (mm Hg)	77.6	77.8	78.1	0.78	0.48
Serum glucose, mean (mg/dL)	171.5	165.8	169.5	0.10	0.48
Estimated glomerular filtration rate, mean (mL/min per 1.73 m^2)	58.5	61.3	53.0	<0.001	<0.001
Medications at hospital discharge, %					
Angiotensin-converting enzyme inhibitors/angiotensin type II receptor blockers	59.3	68.6	64.8	<0.001	<0.001
Aspirin	83.2	92.4	93.2	<0.001	<0.001
Blockers	83.1	91.0	89.7	<0.001	<0.001
Lipid-lowering agents	65.6	79.1	88.8	<0.001	<0.001

AMI indicates acute myocardial infarction.
**P*-values derived from ANOVA tests for continuous variables and χ^2 tests for categorical variables.
†*P* values derived from Cochran-Armitage tests for categorical variables and linear regression models for continuous variables.

Table 2. Association Between Time Period of Hospitalization and 30-Day All-Cause Rehospitalizations Among Patients Who Survived an AMI: Worcester Heart Attack Study, 2001–2011 (N=4810)

Study Period	Frequency of 30-Day Rehospitalizations % (n)	Adjusted for Sociodemographics and Comorbidities*	Further Adjusted for in-Hospital Factors†	Further Adjusted for Hospital Treatment Practices‡
		Adjusted OR (95% CI)		
2001–2003	20.5 (395)	1.00	1.00	1.00
2005–2007	18.4 (279)	0.86 (0.73–1.01)	0.88 (0.74–1.04)	0.92 (0.77–1.08)
2009–2011	15.8 (217)	0.70 (0.58–0.84)	0.74 (0.61–0.91)	0.78 (0.65–0.93)

ACEI indicates angiotensin-converting inhibitors; AMI, acute myocardial infarction; ARBs, angiotensin type II receptor blockers; CABG, coronary artery bypass grafting; OR, odds ratio; PCI, percutaneous coronary intervention.
*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 (ACEIs/ARBs, lipid-lowering agents, β-blockers, and aspirin) at the time of hospital discharge.

under study (Figure 2). The average postdischarge 30-day rehospitalization rates due to non–CVD-related reasons decreased (*P* for trend <0.001) during the years under study, while no significant changing trends in 30-day rehospitalization rates due to CVD (excluding AMI) or AMI were observed (Figure 2).

In examining changing trends in 30-day rehospitalizations after adjusting for several demographic characteristics, comorbidities, and in-hospital clinical factors, there was no significant difference in the odds of having a 30-day rehospitalization in 2005–2007 (OR 0.88, 95% CI 0.74 to 1.04), but there was a reduced odds of being rehospitalized during the subsequent 30 days (OR 0.74, 95% CI 0.61 to 0.91) among patients who survived an AMI in 2009–2011, in comparison with those discharged in 2001–2003 (Table 2). After further adjustment for medical procedures and treatments received during hospitalization, there was a significantly reduced odds of being rehospitalized during the subsequent 30 days (OR 0.78, 95% CI 0.65 to 0.93) in 2009–2011 compared with those discharged from the hospital in 2001–2003 (Table 2). We observed similar results after excluding patients who were not rehospitalized but died during the 30-day postdischarge period. We also observed similar results when we analyzed these patients as those who had a 30-day hospital readmission.

Factors Associated With All-Cause 30-Day Rehospitalizations

Using multivariable-adjusted regression analyses, we examined the role of various prognostic factors associated with 30-day rehospitalizations in all study patients (Table 3). Female sex, having previously diagnosed heart failure and chronic kidney disease, and the development of in-hospital cardiogenic shock and heart failure were significantly

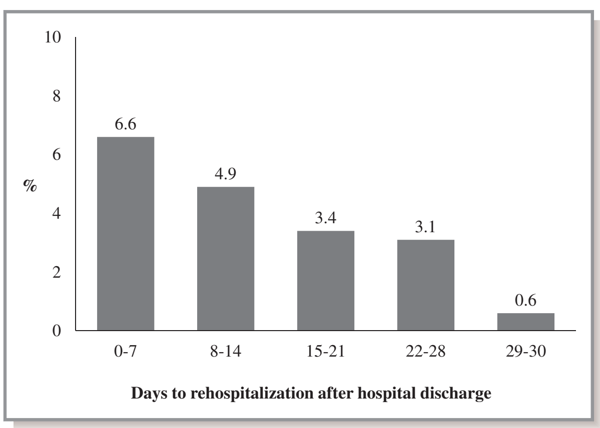

Figure 1. Rates of rehospitalizations within 30 days after hospital discharge among patients who survived an acute myocardial infarction: Worcester Heart Attack Study, 2001–2011 (n=4810).

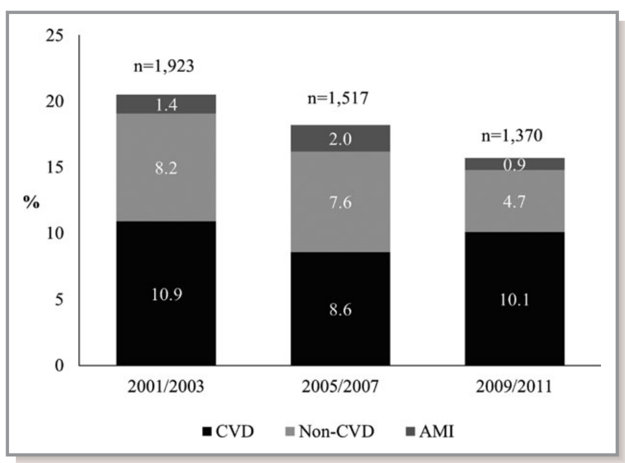

Figure 2. Cause-specific 30-day rehospitalization rates after hospital discharge among patients who survived an AMI: Worcester Heart Attack Study, 2001–2011 (n=4810). AMI indicates acute myocardial infarction; CVD, cardiovascular diseases exclude AMI.

associated with an increased odds of being rehospitalized for any reason within 30 days after hospital discharge. On the other hand, patients who received various coronary diagnostic and interventional procedures (cardiac catheterization and PCI and/or CABG) had a reduced odds for being rehospitalized within 30 days after hospital discharge compared with those who did not undergo these procedures (Table 3). We observed similar factors that were significantly associated with 30-day rehospitalizations after excluding patients who were not rehospitalized but died during the 30-day postdischarge period. We also observed similar factors associated with hospital readmission when we analyzed these patients as having had a 30-day hospital readmission.

Discussion

The results of this large observational study suggest that, among greater Worcester residents who survived their hospitalization for an AMI at the major medical centers in central Massachusetts between 2001 and 2011, nearly 1 in 5 patients remained at risk for being rehospitalized within 30 days and 36% of all 30-day rehospitalizations occurred during the first week after hospital discharge during the years under study. Our findings suggest a decline in the odds of being rehospitalized during the first 30 days after hospital discharge in the most recent years under study, though this odds was slightly attenuated after further adjustment for hospital treatment practices. In addition, we identified several demographic and clinical factors associated with an increased odds for being rehospitalized during the first month after hospital discharge for AMI.

Trends in and Magnitude of 30-Day Rehospitalization Rates

Reducing hospital readmissions is a national priority to improve the quality of patient care and lower health care spending.[5,7,21] This is because excess hospital readmissions indicate potentially poor health care quality or inadequate coordination of postdischarge care, represent a significant burden to both patients and the health care system, and are costly.[5,7,21]

Several prior studies have examined the frequency of 30-day rehospitalizations after AMI.[4,8,9] Between 2007 and 2009, nearly 1 in every 5 Medicare fee-for-service patients discharged from all acute care hospitals in the United States after an AMI was readmitted within 30 days after hospital discharge.[8] In a recent study that used an all-payer administrative data set from California, which consisted of 107 256 hospitalizations for AMI among adults younger than 65 years between 2007 and 2009, the 30-day rehospitalization rate was 15%.[9] A retrospective cohort study conducted in 3 hospitals in Olmsted County, MN, during 1987–2010 found that the 30-day readmission rates among adult patients who survived their hospitalization for a first AMI were ≈23% during 1987–1992, 22% during 1993–2004, and 19% during the most recent period under study (2005–2010).[4] In our study, we found similar results in that nearly one-fifth of adult greater Worcester residents who survived their hospitalization for an AMI on a biennial basis between 2001 and 2011 were readmitted to the hospital within 30 days after hospital discharge. In addition, our study observed an encouraging decline in the odds of having a 30-day rehospitalization during the most recent years (2009–2011) under study after adjustment for several potentially confounding variables of prognostic importance.

Since June 2009, the CMS began publicly reporting 30-day risk-standardized readmission rates for AMI as one of the major hospital performance measures.[5] Further, the Patient Protection Affordable Care Act of 2010, through the establishment of the Medicare Hospital Readmissions Reduction Program, has created new payment penalties (effective October 1, 2012) to reduce readmissions because hospitals with excess readmissions can lose up to 3% of their Medicare reimbursement by 2015.[7] Although some early evidence suggests that the Medicare Hospital Readmissions Reduction Program has had a positive impact on reducing the rates of 30-day rehospitalization among Medicare beneficiaries,[22] there remains no clear consensus on how many hospital readmissions may in all actuality be preventable. Moreover, there are also concerns about potential flaws in the methodology for determining excess readmissions and computation of the penalty to hospitals.[21] Thus, it remains of considerable public health and clinical importance to continue monitoring contemporary trends in 30-day rehospitalization rates after AMI given ongoing refinement of the methodological approach by the CMS to predict the risk of hospital readmissions according to various patient, provider, and health systems characteristics.

With regard to the timing of hospital readmissions, a recent study that analyzed Medicare fee-for-service claims data (2007–2009) on 30-day readmissions after hospitalization for AMI showed that ≈40% of all 30-day readmissions occurred during the first week after hospital discharge.[8] Another recent study using 2007–2009 administrative data from the state of California found that 19% of readmissions occurred within 0 to 3 days, and 21% occurred during 4 to 7 days, after hospital discharge for AMI.[9] Similar to these results, our study found that 36% of all 30-day rehospitalizations occurred during the first week after hospital discharge for AMI. These findings suggest that proper arrangement of transitional care and continuing follow-up with patients during the first several days to first week post hospital discharge can be beneficial in reducing hospital readmission rates within 30 days among these patients. Encouragingly, we also observed a decline in

Table 3. Association Between Various Prognostic Factors and 30-Day All-Cause Rehospitalizations Among Patients Who Survived an AMI: Worcester Heart Attack Study, 2001–2011 (N=4810)

Factors	Adjusted for Sociodemographics and Comorbidities*	Further Adjusted for in-Hospital Factors†	Further Adjusted for Hospital Treatment Practices‡
	Adjusted OR (95% CI)		
Age <55 y	1.00	1.00	1.00
Age 55 to 64 y	1.16 (0.75–1.78)	1.10 (0.73–1.67)	1.10 (0.75–1.63)
Age 65 to 74 y	1.32 (0.84–2.08)	1.19 (0.79–1.79)	1.19 (0.81–1.75)
Age 75 to 84 y	1.51 (1.00–2.27)	1.34 (0.91–1.95)	1.28 (0.88–1.85)
Age 85+ y	1.38 (0.79–2.41)	1.21 (0.76–1.92)	1.06 (0.66–1.72)
Female (vs male)	1.28 (1.09–1.50)	1.29 (1.10–1.52)	1.26 (1.09–1.46)
White (vs nonwhite)	0.74 (0.50–1.09)	0.73 (0.47–1.12)	0.74 (0.49–1.11)
Married (vs not married)	1.06 (0.87–1.30)	1.07 (0.88–1.31)	1.08 (0.90–1.31)
Comorbidity			
Angina	1.07 (0.88–1.31)	1.08 (0.89–1.32)	1.10 (0.90–1.36)
Atrial fibrillation	1.30 (0.96–1.74)	1.17 (0.85–1.62)	1.15 (0.85–1.56)
Heart failure	1.42 (1.17–1.73)	1.27 (1.02–1.58)	1.24 (1.02–1.50)
Hypertension	1.00 (0.81–1.23)	1.00 (0.81–1.22)	1.00 (0.82–1.22)
Peripheral vascular disease	1.23 (0.89–1.71)	1.19 (0.85–1.65)	1.20 (0.87–1.66)
Stroke	1.06 (0.76–1.46)	1.08 (0.77–1.50)	1.04 (0.75–1.43)
Diabetes	1.16 (1.00–1.33)	1.12 (0.97–1.29)	1.11 (0.97–1.27)
Chronic obstructive pulmonary disease	1.06 (0.84–1.35)	1.02 (0.79–1.33)	1.02 (0.79–1.30)
Depression	1.05 (0.85–1.30)	1.06 (0.86–1.30)	1.06 (0.87–1.29)
Chronic kidney disease	1.42 (1.09–1.86)	1.36 (1.04–1.77)	1.31 (1.03–1.67)
Initial AMI (vs prior AMI)		0.87 (0.73–1.03)	0.88 (0.75–1.03)
ST-segment myocardial infarction		1.10 (0.91–1.32)	1.13 (0.96–1.34)
Hospital length of stay (/d)		1.01 (0.99–1.03)	1.01 (1.00–1.03)
In-hospital clinical complication			
Atrial fibrillation		1.31 (1.00–1.72)	1.32 (0.99–1.75)
Cardiogenic shock		1.51 (1.10–2.07)	1.59 (1.18–2.14)
Stroke		0.86 (0.22–3.38)	0.87 (0.23–3.26)
Heart failure		1.35 (1.12–1.64)	1.32 (1.10–1.57)
Coronary diagnostic/interventional procedure			
No coronary procedure			1.00
Cardiac catheterization			0.77 (0.60–0.99)
Cardiac catheterization and PCI and/or CABG			0.70 (0.54–0.90)
Thrombolytic therapy			1.29 (0.79–2.10)
Medication at hospital discharge			
ACEIs/ARBs			1.05 (0.83–1.33)
Aspirins			1.24 (1.00–1.54)
Blockers			1.07 (0.85–1.34)
Lipid-lowering agents			0.97 (0.79–1.20)

ACEI indicates angiotensin-converting inhibitor; AMI, acute myocardial infarction; ARB, angiotensin type II receptor blocker; CABG, coronary artery bypass grafting; OR, odds ratios; PCI, percutaneous coronary intervention.

*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 (ACEIs/ARBs, lipid-lowering agents, β-blockers, and aspirin) at the time of hospital discharge.

the proportion of patients who were readmitted during this particularly high-risk period during the years under study, which may suggest that efforts at reducing hospital readmissions may be paying dividends in reducing short-term hospital readmissions.

While we did not have specific information available to more fully describe and characterize any efforts that were being carried out at participating study hospitals to reduce their hospital readmission rates for patients discharged after an AMI, more-aggressive systemwide efforts were being put in place in 2011 at UMass-Memorial Health Care to systematically measure and reduce the rates of hospital readmissions at these 2 medical centers.

Causes and Predictors for 30-Day Rehospitalizations

A retrospective cohort study of adult patients in Olmsted County, MN,[4] who were discharged from the hospital after a first AMI found that 43% of 30-day rehospitalizations after AMI were related to the incident AMI, 30% were unrelated, and 27% had an unclear relationship. The investigators also reported that about 8% of all 30-day rehospitalizations were due to a recurrent AMI.[4] A recent study of Medicare fee-for-service beneficiaries hospitalized for AMI at all acute care hospitals in the United States between 2007 and 2009 showed that 10% of patients were readmitted for the same condition after their index AMI hospitalization.[8] We observed similar results in that 8% of all 30-day rehospitalizations were due to AMI, and a significant proportion (38%) of all 30-day rehospitalizations were non–CVD related. As the prevalence of comorbid conditions and aging of the American population increase over time, and efforts continue to be focused on the enhanced use of effective secondary prevention strategies to improve the postdischarge outcomes of patients with AMI, 30-day rehospitalizations after AMI due to non-CVD causes require further attention. Indeed, declining lengths of hospital stay, number and complexities of evidence-based medications, older age of this patient population, increased use of observation units, and primary focus on the patient's underlying heart condition, but not on other important comorbidities these patients have been previously diagnosed with, may have in part contributed to the high rate of non–CVD-related readmissions in this patient population. Recent research has also suggested that patients discharged from the hospital may be vulnerable to "posthospitalization syndrome," which puts them at risk for rehospitalization for conditions unrelated to their initial hospitalization.[23] Further research is needed to confirm the association between this syndrome and other hospital and postdischarge factors that may place patients at risk for non–CVD-related hospital readmissions and identify effective strategies for reducing readmissions.

Although efforts remain ongoing to find strategies that hospitals can use to prevent many readmissions, there is an ongoing debate on whether the hospital is the appropriate entity to be held accountable for all short-term readmissions, particularly when many of the events and circumstances that are associated with readmission may take place outside of the hospital setting and after the administration of effective acute care. These factors include patients' lifestyle behaviors and practices; employment, marital, and financial status; adherence to discharge instructions and medications; and the availability and quality of postdischarge care. Thus, reducing the frequency of hospital readmissions requires considerable collaborations, not only from hospitals but also from patients and their caregivers and other community professionals and providers across the continuum of health.

Due to ongoing and planned changes in national reimbursement policies,[7] there has been great interest from health care providers to better understand and improve modifiable factors associated with 30-day rehospitalizations. A recent study in Olmsted County, MN, examined factors associated with 30-day rehospitalizations after an incident AMI.[4] The investigators found that certain comorbid conditions, a longer hospital stay, and complications of coronary angiography and revascularization or reperfusion were associated with an increased risk of being rehospitalized.[4] Our study observed that patients with a history of previously diagnosed heart failure and chronic kidney disease and the development of in-hospital cardiogenic shock and heart failure were significantly associated with an increased odds of being rehospitalized during the first month after hospital discharge for AMI. Although most of these factors are not modifiable, these findings suggest that health care providers should pay extra attention to these high-risk groups of vulnerable patients to prevent potential early readmissions when planning hospital discharge and postdischarge management. Future studies examining the postdischarge transitions of care in higher-risk patients, including those with multiple comorbid conditions and hospital clinical complications, remain needed to achieve greater declines in 30-day rehospitalizations in this patient population.

Despite the potential for confounding by indication given the nonrandomized nature of the present investigation, our multivariable regression analyses adjusting for the use of various hospital treatment practices showed that the use of invasive coronary interventions was associated with a reduced odds of being rehospitalized among patients hospitalized with AMI during the decade-long period under study. Furthermore, encouraging declines in 30 day rehospitalizations during the years under study were slightly attenuated after adjustment for hospital treatment practices, suggesting the beneficial effects of various cardiac treatment practices on 30-day readmission rates. A recent study examining 30-day rehospitalizations after an acute coronary syndrome among 5219 patients enrolled in the Australian and New Zealand populations of the Global Registry of Acute Coronary Events (GRACE) between 1999 and 2007 also observed similar results in that coronary revascularization during the acute hospital stay was associated with a reduced odds of being rehospitalized during the next month.[24]

Study Strengths and Limitations

The strengths of the present study include its large population of residents of all ages and both sexes from a major central Massachusetts metropolitan area who were hospitalized with a confirmed AMI and examination of relatively contemporary decade-long trends in 30-day rehospitalization rates among hospital survivors of an AMI. Several limitations need to be acknowledged, however, in the interpretation of the present findings. Because our study population included only patients who had been hospitalized and discharged at 3 central Massachusetts 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 or at other medical centers in central Massachusetts, it was not captured, although it is expected that this number would be quite small and unlikely to have changed during the years under study. This is because most patients typically return to their hospital of admission and the large tertiary care and community hospitals included in the present investigation capture the vast majority of hospitalizations that occur among residents of the Worcester metropolitan area. Because study patients were predominantly white, the generalizability of our findings to other race/ethnicity groups may be limited. There is also the potential for unmeasured confounding in our observed associations because we did not have information available on several patient-associated characteristics, such as income, education, psychosocial factors, and treatment preference, that may have affected the end points examined. We were unable to collect information on other factors that have been shown to affect 30-day rehospitalization after AMI, including transitions of care and patients' adherence to various postdischarge treatment regimens. Finally, although our study observed an encouraging decline in 30-day rehospitalizations during the most recent years (2009–2011) under study, future studies remain warranted to continue monitoring changes in 30-day rehospitalization rates after the implementation of financial penalties to hospitals due to excess readmissions in 2012.[7]

Conclusions

The results of this large observational investigation provide insights into trends and causes of 30-day rehospitalizations, and factors associated with an increased risk of 30-day rehospitalizations, among patients who survived hospitalization for an AMI between 2001 and 2011. The likelihood of subsequent rehospitalizations during the following month remained frequent; however, we observed an encouraging decline in the 30-day rehospitalization rate during the most recent years under study. Although most of the identified risk factors were not readily modifiable, our findings can, we hope, lead to better development of innovative, patient-centered, intervention strategies that can improve in-hospital management and follow-up care that will further reduce the 30-day rehospitalization rates of patients discharged from the hospital after an AMI.

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Disclosures

All authors have approved the final article. There are no conflicts of interest to disclose.

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Decade–Long Trends in 30–Day Rehospitalization Rates After Acute Myocardial Infarction

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