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Readmissions After Acute Myocardial Infarction: How Often Do Patients Return to the Discharging Hospital?

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Background**—**When patients require readmission after a recent myocardial infarction (MI), returning to the discharging (index) hospital may be associated with better outcomes as a result of greater continuity in care. However, little evidence exists to answer this frequent patient question.

Methods and Results**—**Among Medicare patients aged ≥65 years discharged home alive post-MI from 491 US hospitals in the ACTION (Acute Coronary Treatment Intervention Outcomes Network) Registry, we compared reason for readmission, duration of rehospitalization, and 30-day mortality between patients readmitted to the index versus nonindex hospital within 30 days of index MI discharge. Among 53 471 MI patients, 7715 (14%) were readmitted within 30 days, and most readmitted patients (73%) returned to the discharging hospital. Reason for readmission was not significantly associated with location of readmission. In multivariable modeling, the strongest factors associated with readmission to a nonindex hospital were distance from the discharging hospital, transfer-in during the index MI hospitalization, and frequency of nonindex hospital admissions in the year preceding to the index MI. Duration of rehospitalization did not differ significantly between patients readmitted to the index versus nonindex hospital (median, 4 versus 3 days; P=0.17). Mortality risk was also not significantly different between patients readmitted to the index versus nonindex hospital overall (7.4 versus 7.7%; adjusted odds ratio, 0.89; 95% CI, 0.73–1.10) and when stratified by reason for readmission (P for interaction=0.61).

Conclusions**—**Post-MI readmissions did not differ in reason for readmission, duration of rehospitalization, or associated mortality when compared between patients who returned to the discharging hospital and those who sought care elsewhere. **(*J Am Heart Assoc*. 2019;8:e012059. DOI: 10.1161/JAHA.119.012059.)**

Key Words: length of stay • mortality • myocardial infarction • readmission

In the United States, 10% and 20% of patients are readmitted to the hospital within 30 days after an acute myocardial infarction (MI).[1–3] Readmitted patients may return to the discharging (index) hospital or may instead seek care at a nonindex hospital for a variety of reasons, including travel distance and reason for readmission. The continuity of care that results from readmission to the index hospital may lead to better outcomes. In patients recently discharged after a heart failure hospitalization, those returning to the index hospital had shorter rehospitalization stays and lower mortality that those readmitted to a nonindex hospital.[4] In postoperative patients, patients returning to the index hospital had lower mortality as well as lower risk of further readmission when compared with patients readmitted to a nonindex hospital.[4–6] Whether returning to the index hospital is associated with better outcomes for patients readmitted post-MI is unknown. The most common readmission diagnoses for post-MI patients include further ischemic heart symptoms, respiratory symptoms, and heart failure.[7–9] Should patients re-presenting with cardiovascular symptoms be advised differently on where to seek care when compared with patients seeking care for reasons unrelated to their previous MI?

Using data from the NCDR (National Cardiovascular Data Registry) ACTION (Acute Coronary Treatment Intervention Outcomes Network) Registry linked to Center for Medicare and Medicaid Services claims data, we examined national patterns of post-MI readmissions stratified by admission to the index versus nonindex hospital within 30 days

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Accompanying Tables S1 and S2 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.119.012059

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Clinical Perspective

What Is New?

- Using a large national registry of myocardial infarction patients, the reason for readmission, length of stay during the rehospitalization, and mortality risk after an myocardial infarction were not significantly different between patients who returned to the index hospital versus those patients who were admitted to a nonindex hospital.

What Are the Clinical Implications?

- Though there has been an increased focus on trying to maintain continuity of care, the results of this analysis would suggest that for post–myocardial infarction readmissions, the location of readmission is not associated with an increased length of stay or an increased mortality risk.

postdischarge. Our study objectives were to: (1) describe the frequency of patients returning to the index hospital when rehospitalized; (2) compare patient characteristics and reasons for readmission between patients returning to the index hospital and those readmitted to a nonindex hospital; and (3) compare outcomes between patients returning to the index hospital and those readmitted to a nonindex hospital overall then stratified by reason for readmission.

Methods

Data Source

The ACTION Registry is the largest quality improvement registry of MI patients in the United States. Participating hospitals collect detailed inpatient data, including demographics, clinical characteristics, and in-hospital treatments and outcomes, through medical record review using a standardized set of data elements and definitions.[10] The institutional review boards of each reporting hospital approved participation in the ACTION Registry. The data, analytical methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure. Given that all data were abstracted retrospectively and anonymously without unique patient identifiers, institutional review boards waived the need for patient informed consent. Patients aged ≥65 years were previously linked to Center for Medicare and Medicaid Services claims records using 5 indirect identifiers (date of birth, sex, hospital identifier, date of admission, and date of discharge), as previously described.[11] From Center for Medicare and Medicaid Services data, we were able to ascertain readmissions to either the discharging hospital or to a nonindex hospital, the duration of rehospitalization, and all-cause mortality.

Study Population

Starting with the 79 701 MI patients aged ≥65 years who were enrolled in Medicare Part A and B fee-for-service plans before discharge at 504 US hospitals in the ACTION Registry between January 2007 and December 2010, we excluded patients who died during the index admission (n=5813), were transferred out of the ACTION hospital (n=3693), or were discharged to a skilled nursing facility (n=11 652). We additionally excluded patients whose residence was >100 miles driving distance (by map distance[12]) away from the discharging hospital (n=2821) given that these patients would be highly unlikely to present themselves immediately to the discharging hospital for acute medical concerns. For linked patients with multiple MI hospitalization records in the ACTION Registry during the study period, we excluded 2251 subsequent ACTION Registry records so that follow-up began at the start of the first admission. The final analysis population included 53 471 MI patients discharged alive after an MI from 491 US hospitals.

Data Definitions

We examined in- and outpatient claims for all readmissions involving at least 1 overnight stay that occurred within 30 days of index discharge. Transfers from the index MI discharging hospital to another acute care hospital and admissions for rehabilitation were not considered readmissions. Readmissions for percutaneous coronary intervention or coronary artery bypass graft that occurred within 30 days of discharge were counted if associated with any of the following principal diagnoses: acute MI (410.x1); unstable angina (411.1); heart failure (428.xx, 425.x, 415.0, 398.91, 402.x1, 404.x1, and 404.x3); arrhythmia (426.xx, 427.xx, 785.0, 785.1, 99.61, 99.62, and 99.69); and cardiac arrest (427.5, V12.53, and 99.60). These diagnoses were selected to avoid counting rehospitalizations that were planned for electively staged coronary revascularizations.

Location of readmission was defined as the location the patient first sought care and was determined by the hospital identifier of the first inpatient readmission or emergency room visit leading to at least an overnight stay. For example, if a patient had an emergency department visit at hospital A before being transferred to an inpatient admission at hospital B, the patient was classified as being readmitted to hospital A. If this hospital identifier was also the identifier of the ACTION hospital that discharged the patient after his or her index MI, the patient was defined as returning to the index hospital.

All-cause mortality was ascertained using the Medicare denominator file. Mortality was assessed from the time of index discharge. Reasons for readmission were classified into 3 groups based on the primary diagnosis code (Table S1): (1) diagnoses similar to the index MI (recurrent MI, unstable angina, ischemic heart disease, and chest pain); (2) potential sequelae of the index MI (heart failure, arrhythmia, myocarditis or pericarditis, procedural complications, gastrointestinal bleeding, stroke, and cardiac arrest); and (3) all other diagnoses.

Statistical Analysis

Cumulative incidence of all-cause readmission within 30 days after index MI discharge accounting for the competing risk of death was calculated using the Gray's method.[13] Readmitted patients were categorized into those readmitted to the discharging (index) hospital or those readmitted to a nonindex hospital. Patient characteristics, including demographics, socioeconomic status, past medical history, presenting features, in-hospital clinical events, discharge medications, and index hospital characteristics, were compared between patients readmitted to the index versus a nonindex hospital. The ZIP code of the patient was taken from the ACTION Registry data collection form, and Area Resource Files (2006–2010) were used to obtain information on socioeconomic status, including median household income and the percentage of patients aged ≥25 years with at least a high school diploma of the population living in the same ZIP code.[14] Hospital characteristics included teaching hospital status, total hospital beds, and hospital capability (coronary artery bypass graft or not). To examine the characteristics of the index MI hospital, we used a direct hospital identifier to search for information on the hospital's teaching status, annual MI volume, and total hospital beds from the American Hospital Association survey.[15] To estimate the distance between the patient's residence to the index hospital, we used the ZIP codes of the patient's residence and the index hospital. The other clinical variables described in Table 1 were extracted directly from the ACTION Registry data collection form.

Categorical variables were reported as frequencies (percentages), and continuous variables were reported as medians with 25th and 75th percentiles. Standardized differences were calculated as the difference in means or proportions divided by a pooled estimated of the SD.[16] An absolute standardized difference >10% (or 0.10) is considered a meaningful difference, whereas a smaller value supports the balance assumption between groups.[17] Furthermore, chi-square and Wilcoxon rank-sum tests were used to compare categorical and continuous variables, respectively.

We compared the frequency of each readmission diagnosis group between patients readmitted to the index hospital versus patients readmitted to a nonindex hospital. Additionally, frequency of each readmission diagnosis group was stratified by distance (≤25 versus >25 miles). We set the cutoff point for distance at 25 miles given that nearly 75% of readmitted patients lived within 25 miles of the hospital.

We modeled independent factors associated with patients being readmitted to the index hospital versus to a nonindex hospital within 30 days of discharge from the index hospitalization using generalized estimating equations logistic regression with an exchangeable working correlation matrix to account for within-hospital clustering. This approach produced estimates that were similar to those from logistic regression with variances that are adjusted for the correlation of outcomes within each hospital.[18] We identified covariates based on clinical judgment and are listed in Table S2 and included in the model even if they did not reach statistical significance in univariable comparisons. We examined linearity for log odds of continuous covariates and designated cutoff points where the relationship between the covariate and likelihood of being readmitted to the index hospital became flat or nonlinear. We assessed whether there was collinearity in the candidate covariates using Pearson correlation coefficients, and found that the maximum correlation coefficient between any 2 variables was 0.59, well below the threshold of 0.80 that would suggest collinearity. Adjusted odds ratios, 95% CIs, and χ^2 are reported for the covariates in the model. A c-statistic was calculated for the model.

We compared the duration of hospitalization between patients who were readmitted to the index hospital versus a nonindex hospital. Among patients who were transferred in to the ACTION hospital for their index MI, similar methods were applied to compare the duration of rehospitalization between those who were readmitted to the index hospital versus those who were readmitted to another hospital. We compared 30-day and 6-month mortality between patients readmitted to the index versus a nonindex hospital overall and then stratified by the reason for readmission group using logistic generalized estimating equation regression with covariates adapted from previous risk models (Table S2).[19] We adjusted for the covariates listed in Table S2. We repeated theses analyses subset on distance between patient residence and the discharging hospital (≤25 and >25 miles).

Percentage of missing data was low, <2% for most covariates. For modeling, missing values of continuous covariates were imputed to the MI type and sex-specific median of the nonmissing values. For categorical variables, missing values were imputed to the most frequent group. All statistical analyses were performed at the Duke Clinical Research Institute using SAS software (version 9.4; SAS Institute, Cary, NC).

Table 1. Baseline Patient and Hospital Descriptive Characteristics by Patients Not Readmitted, Readmitted to the Index Hospital, or Readmitted to a Nonindex Hospital

Variable*	Not Readmitted (n=45 756)	Readmitted[†]		
		Readmitted to Index Hospital (n=5595)	Readmitted to a Nonindex Hospital (n=2120)	ASD[‡]
Demographics				
Age, y	75.0 (69.0, 82.0)	77.0 (71.0, 84.0)	76.0 (70.0, 82.0)	0.12
White	40 677 (88.9)	4860 (86.9)	1842 (86.9)	<0.01
Female	19 293 (42.2)	2777 (49.6)	1014 (47.8)	0.04
BMI, kg/m^2	27.2 (24.1, 30.9)	26.6 (23.3, 30.5)	26.8 (23.3, 30.8)	0.03
Household income estimate, $	45 768 (40 603, 52 595)	46 566 (41 407, 54 328)	42 871 (38 186, 51 038)	0.36
% of people 25+ y with HS diploma	86.8 (83.0, 89.8)	87.0 (83.2, 90.0)	85.5 (79.9, 88.6)	0.30
Past medical history				
Previous MI	11 934 (26.1)	1736 (31.0)	677 (31.9)	0.02
Previous PCI	11 158 (24.4)	1473 (26.3)	574 (27.1)	0.02
Previous CABG	9230 (20.2)	1323 (23.6)	537 (25.3)	0.04
Previous HF	6573 (14.4)	1414 (25.3)	521 (24.6)	0.02
Previous stroke	4327 (9.5)	703 (12.6)	273 (12.9)	0.01
Diabetes mellitus	14 469 (31.6)	2220 (39.7)	844 (39.8)	<0.01
PAD	5790 (12.7)	1048 (18.7)	377 (17.8)	0.03
Hypertension	35 898 (78.5)	4721 (84.4)	1775 (83.7)	0.02
Dyslipidemia	28 893 (63.1)	3619 (64.7)	1383 (65.2)	0.01
Any admissions to index MI hospital in previous year	8640 (18.9)	1973 (35.3)	413 (19.5)	0.36
Any admissions to nonindex hospital in prior year	6502 (14.2)	775 (13.9)	819 (38.6)	0.59
Index MI hospitalization characteristics and treatment				
STEMI	14,767 (32.3)	1510 (27.0)	705 (33.3)	0.14
Cardiogenic shock	1006 (2.2)	139 (2.5)	79 (3.7)	0.07
HF	2910 (6.4)	604 (10.8)	221 (10.4)	0.01
Major bleeding	4255 (9.3)	839 (15.0)	306 (14.4)	0.01
PCI	26,352 (57.6)	2527 (45.2)	1017 (48.0)	0.06
CABG	3553 (7.8)	457 (8.2)	165 (7.8)	0.01
Index MI hospital characteristics				
Transfer-in	7900 (17.3)	388 (6.9)	872 (41.1)	0.87
Teaching hospital[§]	11 936 (26.1)	1375 (24.6)	711 (33.5)	0.20
Annual MI volume (patients per year)	123.1 (76.3, 185.6)	118.0 (74.0, 175.0)	134.0 (81.0, 196.0)	0.17
Total hospital beds	405.0 (276.0, 614.0)	397.0 (261.0, 604.0)	442.0 (286.0, 639.0)	0.14
Distance from residence to index hospital (miles)	9.8 (4.0, 27.4)	6.5 (3.0, 15.2)	29.0 (12.3, 48.4)	1.10
Residence to index hospital >25 miles	14 575 (27.3)	769 (13.7)	1210 (57.1)	1.01

ASD indicates, absolute standardized difference; BMI, body mass index; CABG, coronary artery bypass graft; HF, heart failure; HS, high school; MI, myocardial infarction; PAD, peripheral arterial disease; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction.
*Median (25th, 75th percentiles) or frequency (%).
[†]Among readmitted patients (n=7715).
[‡]Comparison between readmitted to the index hospital and readmitted to a nonindex hospital.
[§]Teaching hospital is defined as membership in the Council of Teaching Hospitals.

Table 2. Frequency (%) of Readmission Diagnoses by Readmission Location (Readmission to the Index Hospital Versus a Nonindex Hospital)

	Readmitted to Index Hospital (n=5595)	Readmission to a Nonindex Hospital (n=2120)	ASD
Overall			
Diagnosis similar to index hospitalization	1281 (22.9%)	465 (21.9%)	0.02
MI or unstable angina	700 (12.5%)	262 (12.4%)	0.01
Chest pain	259 (4.6%)	100 (4.7%)	<0.01
Ischemic heart disease	322 (5.8%)	103 (4.9%)	0.04
Potential sequelae of index MI	1803 (32.2%)	677 (31.9%)	0.01
Heart failure	1050 (18.8%)	401 (18.9%)	<0.01
Arrhythmia	344 (6.1%)	121 (5.7%)	0.02
Myocarditis or pericarditis	32 (0.6)	9 (0.4)	0.02
Procedural complication or bleeding	227 (4.1%)	83 (3.9%)	0.01
Stroke	144 (2.6%)	62 (2.9%)	0.02
Cardiac arrest	6 (0.1%)	1 (0.05%)	0.02
Other	2511 (44.9%)	978 (46.1%)	0.03
Residence ≤25 miles from index hospital			
Diagnosis similar to index hospitalization	1092 (22.6)	199 (21.9)	0.02
Potential sequelae of index MI	1544 (32.0)	284 (31.2)	0.02
Other	2190 (45.4)	427 (46.9)	0.03
Residence >25 miles from index hospital			
Diagnosis similar to index hospitalization	189 (24.6)	266 (22.0)	0.06
Potential sequelae of index MI	259 (33.7)	393 (32.5)	0.03
Other	321 (41.7)	551 (45.5)	0.08

ASD indicates absolute standardized difference; MI, myocardial infarction.

Results

Among 53 471 older post-MI patients discharged to home, 7715 (14.4%) were readmitted within 30 days, and of these, 5595 (73%) returned to the discharging hospital. Table 1 describes the characteristics of these patients. Patients readmitted to a nonindex hospital were slightly younger in age (median, 76 versus 77) and resided in areas of lower household income and lower educational levels than those readmitted back to the hospital from which they were discharged. Although previous cardiovascular history and risk factors were not significantly different between groups, patients readmitted to a nonindex hospital were more likely to have presented with ST-elevation myocardial infarction, to undergo percutaneous coronary intervention or experience cardiogenic shock during the index MI hospitalization than patients readmitted to the index hospital. Patients residing in the South were more likely to be readmitted to a nonindex hospital, whereas patients residing in the West, Northeast, or Midwest were more likely to be readmitted to the index hospital (data not shown). Furthermore, patients readmitted to a nonindex hospital were more likely to be transferred into the ACTION hospital during the index MI admission, lived further away from the index MI hospital, and more likely to have sought care at an outside hospital before their index MI than patients readmitted to the index hospital (Table 1).

Among patients readmitted within 30 days after the index discharge, 1746 (22.6%) were readmitted for conditions similar to the index admission diagnosis, 2480 (32.1%) were readmitted for potential sequelae of the index MI, and 3489 (45.2%) were readmitted for other diagnoses. As shown in Table 2, frequency of these readmission diagnoses did not differ significantly between patients readmitted to the index versus nonindex hospital, regardless of the distance between patient residence and the index hospital.

In multivariable modeling, geographical distance from patient residence to the discharging hospital was the strongest factor associated with patients being readmitted to a nonindex hospital; nonindex readmissions were more likely to be transferred in during the index MI hospitalization and had higher frequency of admissions to nonindex hospitals in the year preceding the index MI (Figure). The c-statistic of the full model was 0.83; the c-statistic of the model including only these top covariates was 0.82. Patients with non–ST-elevation myocardial infarction and those who underwent coronary revascularization during the index MI hospitalization were more likely to return to the discharging hospital. Of note, reason for readmission was not significantly associated with location of readmission, nor were patient comorbidities or index hospitalization length of stay.

Median duration of readmission did not differ significantly between patients readmitted to the index versus nonindex hospital (4 [2, 6] versus 3 days [2, 6]; P=0.17). Of patients who presented to the nonindex hospital, 422 (19.9%) transferred to another hospital and most of these transfers (88.4%) returned to the index hospital. When stratified by readmission reason, median duration of readmission did not differ significantly between patients readmitted to the index versus nonindex hospital, respectively: 3 (2, 5) versus 3 days (2, 5) for readmission reasons similar to the index hospitalization diagnosis (P=0.25); 4 (2, 6) versus 4 days (2, 6) for potential sequelae of the index hospitalization diagnosis (P=0.70); and 4 (2, 6) versus 4 days (2, 6) for other readmission reasons (0.08).

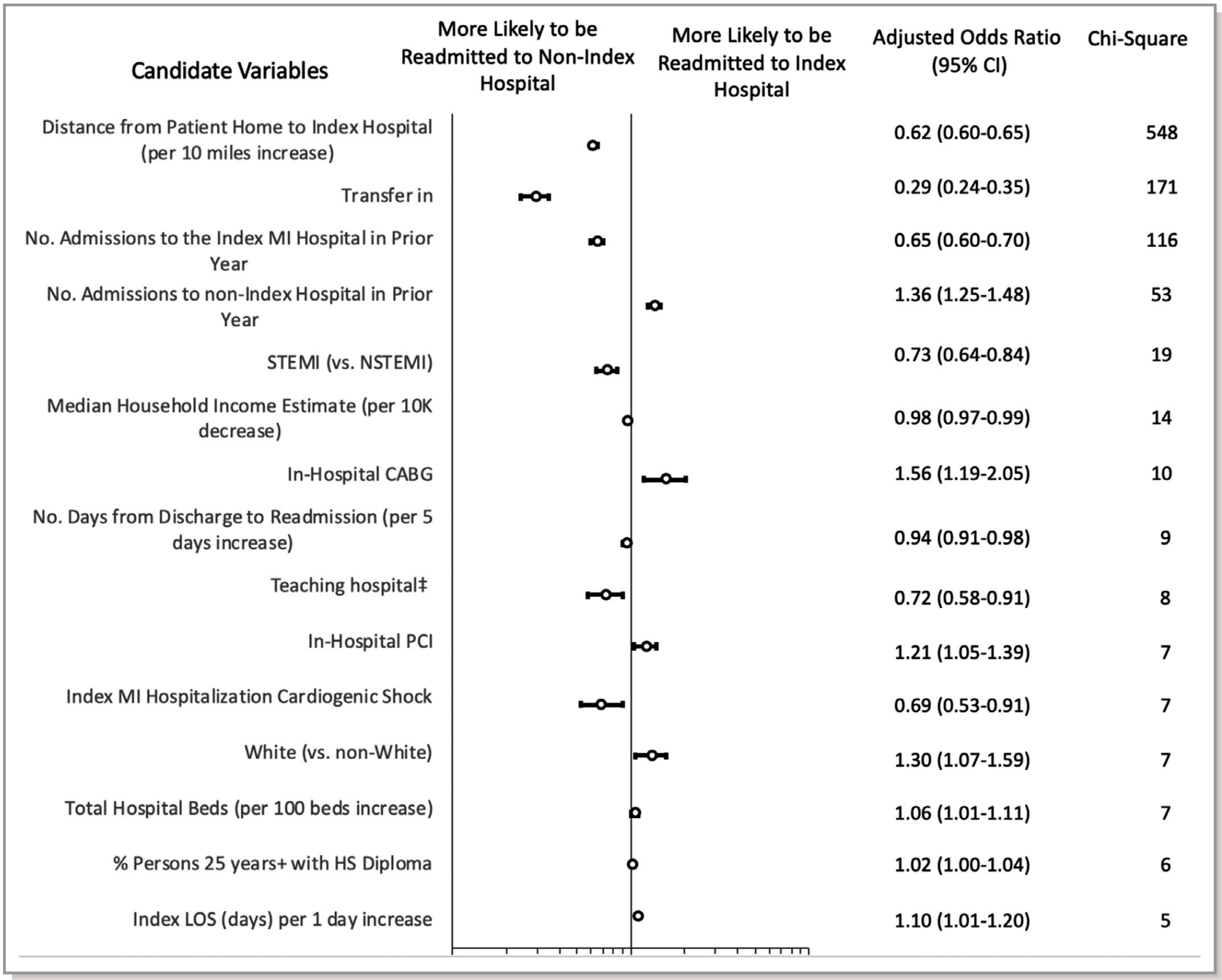

Figure. Factors associated with location of readmission. The following covariates were included in the model, but were not the strongest factors associated with location of readmission: age (years), female, BMI (kg/m^2), previous MI, previous PCI, previous CABG, previous HF, previous stroke, diabetes mellitus, previous PAD, Charlson comorbidity index >3, index MI hospitalization HF, nadir hemoglobin (g/dL), index MI hospitalization stroke, index MI hospitalization major bleed, ejection fraction (%), initial serum creatinine (mg/dL), hospital capability (CABG or not), readmission primary diagnosis similar to index MI diagnosis, readmission primary diagnosis potential sequelae of index MI, and weekday vs weekend readmission date. ‡Teaching hospital is defined as membership in the Council of Teaching Hospitals. BMI indicates body mass index; CABG, coronary artery bypass graft; HS, high school; LOS, length of stay; MI, myocardial infarction; NSTEMI, non–ST-segment–elevation myocardial infarction; PAD, peripheral arterial disease; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction.

Among readmitted patients, 579 (7.5%) died within 30 days and 1655 (21.5%) died within 6 months of index discharge. Mortality did not differ significantly between patients readmitted to the index versus nonindex hospital at 30 days (7.4 versus 7.7%; adjusted odds ratio, 0.89; 95% CI, 0.73–1.10) or at 6 months (21.8 versus 20.5%; adjusted odds ratio, 0.96; 95% CI, 0.83–1.11). There remained no significant difference in mortality between patients readmitted to the index versus a nonindex hospital when stratified by readmission diagnosis or distance from the hospital (Table 3).

Discussion

In this nation-wide study, 73% of patients who were readmitted after a recent MI returned to the index hospital. The factors most strongly associated with location of readmission included distance from home to the discharging hospital, transfer-in during the index MI hospitalization, and number of admissions to a nonindex hospital within the year preceding the index MI hospitalization. Reason for readmission did not differ significantly between patients readmitted to the discharging hospital versus a nonindex hospital. Finally,

Table 3. Observed* and Adjusted Mortality Among Patients Readmitted to the Index Versus a Nonindex Hospital by Reason for Readmission

Population	30-Day Mortality			6-Month Mortality		
	Readmitted to Index Hospital (n=5595)	Readmitted to Nonindex Hospital (n=2120)	Adjusted OR (95% CI)	Readmitted to Index Hospital (n=5595)	Readmitted to Nonindex Hospital (n=2120)	Adjusted OR (95% CI)
Overall (n=7715)	416 (7.4%)	163 (7.7%)	0.89 (0.73, 1.10)	1220 (21.8%)	435 (20.5%)	0.96 (0.83, 1.11)
Reason for readmission						
Similar to index hospitalization (n=1746)	95 (7.4%)	36 (7.7%)	0.84 (0.53, 1.34)	240 (18.7%)	82 (17.6%)	0.99 (0.70, 1.40)
Potential sequelae of the index MI (n=2480)	124 (6.9%)	42 (6.2%)	1.10 (0.70, 1.70)	381 (21.1%)	117 (17.3%)	1.17 (0.88, 1.56)
Other (n=3489)	197 (7.9%)	85 (8.7%)	0.82 (0.61, 1.10)	599 (23.9%)	236 (24.1%)	0.85 (0.70, 1.03)
Distance from hospital						
≤25 miles (n=5736)	368 (7.6%)	77 (8.5%)	0.83 (0.64, 1.08)	1094 (22.7%)	199 (21.9%)	0.95 (0.80, 1.14)
>25 miles (n=1979)	48 (6.2%)	86 (7.1%)	0.93 (0.60, 1.44)	126 (16.4%)	236 (19.5%)	0.86 (0.62, 1.19)

MI indicates myocardial infarction; OR, odds ratio.
*Frequency (%).

duration of rehospitalization and mortality rates did not differ significantly between patients readmitted to the index hospital versus a nonindex hospital.

Patients who develop new symptoms after a recent hospital discharge are often uncertain whether to return to the discharging hospital or to present to a local hospital. For a post-MI patient, the discharging hospital may provide more continuity of care, whereas a local hospital has the advantage of more-expedited care. Providers face uncertainty as well in advising patients on where to seek care, with decision making often dependent on the acuity of symptoms and potential reason for readmission. Patterns of readmission have not previously been described.

We hypothesized that patients with diagnoses similar to or related to the index MI would be more likely to return to the discharging hospital. Our study showed that more than half of readmitted patients presented for symptoms related to their MI or for potential complications of the index MI. Yet, surprisingly, the reason for readmission was not a significant factor associated with location of readmission. Clinical characteristics, such as comorbidity burden or in-hospital complications during the index hospitalization, were also not key drivers of location of readmission. Critics of programs such as the Hospital Readmissions Reduction Program have argued that variations in hospital readmissions are more accounted for by hospital location and patient population served than by the practices of that hospital.[20,21] Herrin et al demonstrated that the number of Medicare beneficiaries per capita, as well as the proportion of residents with lower educational status living near the hospital, were associated with higher readmission rates.[22] Our study also showed that patient socioeconomic status likely influences location of readmission; the strongest predictors of where patients presented were factors such as geographical distance and past care-seeking behavior.

We hypothesized that patients who were readmitted to the index hospital would have shorter duration of rehospitalization and potentially lower mortality than those readmitted to the nonindex hospital based on the advantages of continuity of medical care and easy access to medical records documenting past treatment. However, duration of rehospitalization did not significantly differ based on location of readmission, and fewer than 1 in 5 patients readmitted to a nonindex hospital required transfer for continuing care. This remained the case even among patients who initially required interhospital transfer for care for their index MI. With the increasing portability of electronic medical records, easier access to pertinent information about past hospitalizations likely makes returning to the index hospital less critical for continuity of care. We also observed no significant difference in mortality between patients readmitted to the discharging versus nonindex hospital. Given that half of readmissions were diagnoses that were not primarily related to the index admission, continuity of care may be relatively unimportant. Additionally, given that there was no significant difference in readmission diagnoses or mortality outcomes between readmitted patients living a shorter or a longer distance from the index hospital, it did not appear that patient decision to return to the index hospital or present to a nonindex hospital based on distance from their home had an impact on outcomes.

This study has several important implications for post-MI care and readmissions. These results allow us to provide some reassurance to patients of the safety of seeking medical care locally as needed and avoid delays in care that may be incurred by attempting to return to the discharging hospital, regardless of reason for readmission. Many hospitals have implemented strategies to prevent 30-day readmissions. Our results suggest that for patients who are not local to the index hospital, the strategy should include efforts to give anticipatory guidance to providers in the patient's local community, and build a shared electronic medical record infrastructure with area hospitals to provide continuity. Additionally, it is increasingly important for hospitals to work together as a regional network to prevent unnecessary readmissions both at their own institution as well as neighboring institutions. With improvements in health information technology, care continuity can be, in part, provided through seamless health records, and we will likely be seeing a shift away from the return of patients to the index hospital for readmission.

Limitations

Our results should be interpreted in the context of several limitations. The study involved patients treated at hospitals with an intrinsic interest in quality improvement as evidenced by their participation in ACTION Registry. Medicare claims data were used to ascertain readmissions, so our study could only characterize outcomes of patients aged ≥65 years. We also recognize that the decision of where the patient will be readmitted may be made by emergency medical services, rather than directly by the patient, especially in emergent situations. The decision of the location of readmission may also be influenced by hospital capacity or divert status. Additionally, whether the patient was readmitted for a diagnosis similar or different to the index admission depends on the accuracy of the readmission primary diagnosis coding, which may vary based on provider opinion and hospital billing practices. Furthermore, there may have been planned readmissions for reasons not related to the index MI that were not excluded in this analysis. Moreover, we were not able to access other granular components of the readmission, including complications of the readmission. Additionally, we are not able to capture data, including what proportion of nonindex hospitals share an electronic medical record with the index hospital. Although a broad range of patient-level clinical factors were used in multivariable modeling, the possibility of confounding by unmeasured covariates remains. Finally, these findings may not be generalizable to non-MI conditions.

Conclusions

More than 1 in 4 patients who required readmission after a recent MI sought care at a hospital other than the discharging hospital. Reasons for readmission did not differ significantly between patients readmitted to the index versus nonindex hospital. Readmission to a nonindex hospital was not associated with longer duration of rehospitalization or higher mortality compared with readmission to the index hospital. These patterns are reassuring with respect to continuity of care and patient outcomes.

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Disclosures

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Supplemental Material

Table S1. Reasons for readmission based on primary diagnosis code.

Readmission Diagnoses	ICD-9 Codes
Diagnosis Similar to Principal Index Hospitalization	
MI or unstable angina	410.x, 411.x, 413.x
Ischemic Heart Disease	414.x, V17.x, V81.x
Chest Pain	786.x
Potential sequelae of the index MI	
Heart Failure	428.X
Arrhythmia	426.x, 427.x, 785.0, 785.1, also procedure codes 99.61, 99.62, 99.69
Myocarditis or Pericarditis	420.x, 422.x, 423.x,
Procedural Complications	996.x, 997.x
Gastrointestinal bleeding	530.x, 535.x, 569.x
Stroke	430.x, 431.x, 432.x, 433.x, 434.x, 436.x
Cardiac Arrest	427.5, V12.53
Other	>600 diagnoses, diagnoses that occur in ≥3% of patients: Unspecified Septicemia (038.9), Pneumonia, Organism Unspecified (486), Chronic Obstructive Pulmonary Disease with Acute Exacerbation (491.21), Acute Respiratory Failure (518.81), Acute Renal Failure, unspecified (584.9), Urinary Tract Infection, site not specified (599.0)

Table S2. List of Covariates for Multivariable Models.

Characteristic Category	Characteristic
Patient Demographics	Age (years) Female White (vs. non-White) BMI (kg/m^2) % Persons 25+ years with HS Diploma or more* Median Household Income Estimate ($)*
Past Medical History	Prior MI Prior PCI Prior CABG Prior Heart Failure Prior Stroke Diabetes Prior PAD Charlson Comorbidity Index > 3
Index MI Hospitalization Presenting Features	STEMI (vs. NSTEMI) In-Hospital PCI In-Hospital CABG Transfer in Index LOS (days) Nadir Hemoglobin (g/dL) Initial Serum Creatinine (mg/dL) Ejection Fraction (%)
Index MI In-Hospital Complications	Heart Failure Cardiogenic Shock Stroke Major Bleeding
Readmission Primary Diagnosis	Similar to Index MI Diagnosis Potential Sequelae of Index MI Other Diagnoses
Index MI Hospital Characteristics	Teaching Hospital[‡] Total Hospital Beds[‡] Hospital Capability (CABG or not) [‡]
Other Characteristics	Distance from Patient Home to Index Hospital[α] No. Days from Discharge to Readmission Weekday vs. Weekend Readmission Date No. Admissions to Index MI Hospital in Prior Year No. Admissions to Hospital other than the Index MI Hospital in Prior Year

* Derived from census data based on patient residence zip code

‡ Teaching hospital is defined as membership in the Council of Teaching Hospitals. These variables were derived from the American Hospital Association Survey[1]

α Derived from map distance as previously defined[2]

β These were derived from CMS.

BMI = body mass index; CABG = coronary artery bypass grafting; LOS= length of stay; MI = myocardial infarction; NSTEMI= Non-ST-elevation myocardial infarction; PAD = peripheral artery disease; PCI = percutaneous coronary intervention; STEMI = ST-elevation myocardial infarction.

Supplemental References:

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