Review

Statistical Models and Patient Predictors of Readmission for Acute Myocardial Infarction

A Systematic Review

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Background—Readmission after acute myocardial infarction (AMI) has been targeted for public reporting because it is a common, costly, and often preventable outcome. To assist in ongoing efforts to risk-stratify patients and profile hospitals through public reporting of performance measures, we conducted a systematic review to identify models designed to compare hospital rates of readmission or predict patients' risk of readmission after AMI and to identify studies evaluating patient characteristics associated with AMI readmission.

Methods and Results—We identified relevant English-language studies published between 1950 and 2007 by searching MEDLINE, Scopus, PsycINFO, and all 4 Ovid Evidence-Based Medicine Reviews. Eligible publications reported on readmission up to 1 year after AMI hospitalization among adults. From 751 potentially relevant articles, 35 met our predefined inclusion/exclusion criteria. Overall, none developed models to compare readmission rates among hospitals or models to predict patients' risk of readmission. All 35 examined patient characteristics associated with AMI readmission. However, studies varied in methods for case and outcome identification, used multiple types of data sources, examined differing outcomes (often either readmission alone or a composite outcome of readmission or death) over varying follow-up periods (from 30 days to 1 year), and found few patient characteristics consistently associated with readmission.

Conclusions—Patient characteristics may be important predictors of AMI readmission; however, few variables were consistently identified. Thus, clinically, patient risk stratification is challenging. From a policy perspective, a validated risk-standardized model to profile hospitals using AMI readmission rates is currently unavailable in the literature. **(*Circ Cardiovasc Qual Outcomes*. 2009;2:500-507.)**

Key Words: myocardial infarction ■ patient readmission ■ review, systematic

The Centers for Medicare & Medicaid Services (CMS) is actively engaged in an ongoing program to profile health care institutions through public reporting of performance measures, as a means to both assist consumers in making health care decisions and drive quality improvement efforts nationally.[1] Readmission after hospital discharge is increasingly being viewed by payers and policymakers as an indicator of hospital-level quality and efficiency of care.[2,3] Thus, CMS is now working toward publicly reporting hospital readmission rates after discharge for selected leading causes of admission in the elderly, including acute myocardial infarction (AMI).

AMI is among the most common principal hospital discharge diagnoses among Medicare beneficiaries, and in 2005, it was the fourth most expensive condition billed to Medicare.[4] Readmission after AMI has been targeted for public reporting because this is a common, costly, and often preventable outcome. Based on 2005 Medicare data,[3] the Medicare Payment Advisory Commission estimates that ≈13.4% of Medicare AMI admissions were followed by a readmission within 15 days, accounting for nearly 21 000 admissions at a cost of $136 million. In addition, studies point to the success of various quality improvement interventions, such as pairing patients with peer advisors after discharge,[5] disease management programs administered by home health nurses,[6] and enrollment in cardiac rehabilitation programs,[7,8] to reduce the risk of readmission and improve outcomes for patients with AMI. These examples suggest that readmission rates can be

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reduced after hospitalization for AMI, in many cases by having index hospitals connect patients with appropriate services after discharge.

Implementing interventions to reduce readmission after AMI will require an understanding of the patient characteristics associated with readmission, as knowledge of relevant patient characteristics will help physicians stratify AMI patients according to risk of readmission and assist with tailoring discharge plans. In addition, any attempt to meaningfully compare rates of readmission across hospitals will require the ability to adequately and appropriately risk-adjust for differences in patient characteristics. Risk adjustment will help to ensure that measures designed to identify outlier hospitals with respect to readmission rates are doing so based on differences in the quality of AMI-related care rather than differences in the sociodemographic and clinical characteristics of the patient population. We know of no prior attempts to summarize the literature on models comparing AMI readmission rates for hospitals or the patient characteristics associated with readmission after AMI. Thus, the specific aims of this systematic review were to (1) identify and evaluate any existing statistical models to compare hospital-specific rates of readmission for patients initially admitted for AMI; (2) identify and evaluate any existing statistical models or risk scores to predict an individual's risk of readmission after discharge for AMI; and (3) identify and evaluate the consistency of published patient-level predictors of hospital readmission for patients with AMI.

Methods

Relevant studies were identified by searching the following databases: (1) Ovid MEDLINE (1950 to October 2007); (2) PubMed (1950 to October 2007); (3) Scopus, an Elsevier abstract and citation database (1996 to October 2007); (4) Ovid PsycINFO (1967 to October 2007); and (5) all Evidence-Based Medicine Reviews on Ovid, including ACP Journal Club (1991 to October 2007) and the Cochrane Database of Systematic Reviews, Database of Abstracts and Reviews of Effects, and Cochrane Central Register of Controlled Trials (4th Quarter 2007). We searched these databases using the following strategy. First, we performed a search that included the Medical Subject Heading (MeSH) term "patient readmission" (exploded) and the keywords "readmi$" and "rehosp$" (using "$" for truncation), identifying 16 208 publications using our readmission terms. Second, we performed a search that included the MeSH term "risk" (exploded) and the keywords "model$," "predict$," "use$," "util$," and "risk$," identifying 5 386 725 publications using our risk/model/prediction terms. Third, we performed a search that included the MeSH term "myocardial infarction" (exploded), identifying 115 306 publications using our AMI term. Finally, we combined our readmission, risk/model/prediction, and AMI terms. This search identified 751 articles.

We applied several inclusion and exclusion criteria that were defined a priori to these 751 articles. Publications eligible for inclusion reported on readmission within 1 year as a primary, secondary, or part of a composite outcome (generally, the combined outcome of readmission or death, whichever came first during the follow-up period). We excluded publications without primary data (reviews, letters, and editorials), abstracts, pediatric studies, and non-English language studies. We also excluded studies that reported results from a case series or case report and studies with no quantitative outcomes. In addition, we excluded studies whose primary focus was hospital- or physician-level characteristics, because the focus of our review is on identifying patient characteristics associated with readmission. Finally, we excluded experimental studies that examined the effect of an intervention on AMI readmission (eg, discharge planning, case management programs, or pharmaceutical treatment). However, we included publications that used data collected from a randomized clinical trial to examine the effect of participants' characteristics on readmission (independent of the effect of the intervention).

Two of the authors (M.M.D., B.D.S.) independently reviewed the titles and abstracts of retrieved publications and selected relevant articles for possible inclusion in our review. Based on this review, we excluded 660 publications either that did not report on readmission for patients hospitalized at baseline for AMI or that met at least 1 of our exclusion criteria.

The remaining 91 potentially eligible publications were retrieved. On detailed review of the full-text publication, we excluded 56 additional articles that met our predefined exclusion criteria.

We developed a standardized instrument to perform a detailed abstraction of the remaining 35 publications that form the basis of our review. The following variables were extracted: study purpose, design, and period; data sources used to ascertain both baseline characteristics and follow-up readmissions; analytic strategy, including methods used to handle deaths and transfers; readmission type, period, and location (index hospital versus any hospital); sample size (both hospitals and patients); and candidate variables examined as predictors of hospital readmission. All extractions were performed by 2 of the authors, and disagreements in assessment and data extraction were resolved by consensus.

Results

Among the 35 publications[9–43] included in our review, no models were identified that were developed for the purpose of comparing readmission rates among hospitals (aim 1), and no studies were done for the purpose of developing either models or risk scores to predict hospital readmission for individual patients (aim 2). All 35 of the studies were done for the purpose of determining patient-level predictors of hospital readmission for patients with AMI (aim 3). Characteristics of the 35 reviewed studies are summarized in Table 1. The majority of the studies used a prospective cohort design (n=23); 10 were retrospective cohort studies; and 2 used a cohort of patients drawn from a randomized controlled trial. More than one-third of the studies were conducted at a single hospital (n=13); only 1 study used data derived from a national sample of Medicare beneficiaries hospitalized for AMI. The sample size of the studies varied widely from 30 to 122 003, with 8 studies having a sample size of <100 patients.

A variety of data sources were used to determine baseline patient-level characteristics: only 4 studies solely used an administrative database, whereas the rest relied heavily on medical record review or patient interview. Choice of outcome measure varied considerably across studies as well. Almost half the studies used all-cause readmission as an outcome (n=16), whereas 11 used cardiac-related readmission, and 8 used the composite outcome of cardiac-related readmission or death. In terms of follow-up period examined, the most frequent was 1 year (n=20), followed by 6 months (n=7), 30 days (n=7), and 60 days (n=1). Across the studies, we found high reported rates of readmission after discharge for AMI. For example, rates of all-cause readmission at 30 days ranged from 11.3% to 28.1%. Readmissions were identified using Medicare data (n=4), chart abstraction (n=5), hospital administrative data (n=6), patient survey (n=11), or a combination of patient survey, hospital administrative data, and chart abstraction (n=9).

Table 1. Characteristics of Identified Studies Examining Patient-Level Predictors of Readmission After AMI Hospitalization

Study	Study Type	Data Source* (Study Period)	Study Location	No. of Hospitals/No. of Patients	Study Outcome	Follow-Up Period	Analytic Model
Akosah et al, 2001[9]	Retrospective cohort	Medical chart review (1998–1999)	United States (La Crosse, Wisc)	1/79	All-cause readmission	1 y	Unadjusted analysis
Anzai et al, 1995[10]	Prospective cohort	Medical chart review (1985–1994)	Japan	1/233	Cardiac-related readmission	1 y	Logistic regression
Baker et al, 2004[11]	Retrospective cohort	Medicare data and medical chart review (1991–1997)	United States (greater Cleveland, Ohio)	30/8612	All-cause readmission	30 d	Logistic regression
Barbagelata et al, 2000[12]	RCT cohort	Medical chart review (study period not specified)	United States and Canada	Multiple, No. not presented/1830	All-cause readmission	30 d	Unadjusted analysis
Barbagelata et al, 2004[13]	RCT cohort	Medical chart review (study period not specified)	United States and Canada	Multiple, No. not presented/1827	All-cause readmission	30 d	Unadjusted analysis
Berkman and Abrams, 1986[14]	Retrospective cohort	Hospital administrative data and patient interview (1982–1983)	United States (Boston, Mass)	1/30	All-cause readmission	6 mo	Unadjusted analysis
Bernheim et al, 2007[15]	Prospective cohort	Medical chart review and patient Interview (2003–2004)	United States	18/2018	All-cause readmission	1 y	Hierarchical proportional hazards
Chyun et al, 2002[16]	Retrospective cohort	Medicare data and medical chart review (1992–1993)	United States (Conn)	35/1698	Cardiac-related readmission	1 y	Cox proportional hazards
Davoodi et al, 2005[17]	Prospective cohort	Medical chart review (2004)	Iran	1/160	All-cause readmission	6 mo	Unadjusted analysis
Dokainish et al, 2005[18]	Prospective cohort	Medical chart review (study period not specified)	Not specified	1/50	Cardiac-related readmission or death	1 y	Cox proportional hazards
Frasure-Smith et al, 2000[19]	Prospective cohort	Hospital administrative data, medical chart review, and patient interview (1991–1994)	Canada	10/848	Cardiac-related readmission	1 y	Unadjusted analysis
Helgeson, 1991[20]	Prospective cohort	Medical chart review and patient interview (study period not specified)	United States (Long Island, NY, and Denver, Colo)	3/90	Cardiac-related readmission or death	1 y	Logistic regression
Heller et al, 2000[21]	Retrospective cohort	Hospital administrative data (1995–1997)	Australia	22/1218	Cardiac-related readmission	1 y	Logistic regression
Hung et al, 1997[22]	Prospective cohort	Medical chart review (1991–1992)	Australia	1/200	Cardiac-related readmission or death	6 mo	Logistic regression
Jonas et al, 1999[23]	Prospective cohort	Medical chart review (1996)	Israel	Multiple, No. not presented/2212	All-cause readmission	30 d	Unadjusted analysis
Kamalesh et al, 2005[24]	Retrospective cohort	Hospital administrative data (1990–1997)	United States	Multiple, No. not presented/67889	All-cause readmission	1 y	Logistic regression
Khan et al, 2007[25]	Prospective cohort	Medical chart review (study period not specified)	United Kingdom	1/129	Cardiac-related readmission or death	6 mo	Cox proportional hazards
Khan et al, 2007[26]	Prospective cohort	Medical chart review (study period not specified)	United Kingdom	1/980	Cardiac-related readmission or death	60 d	Logistic regression
Khan et al, 2007[27]	Prospective cohort	Medical chart review (study period not specified)	United Kingdom	1/983	Cardiac-related readmission or death	1 y	Unadjusted analysis
Kinova and Kozhuharov, 2004[28]	Prospective cohort	Medical chart review (study period not specified)	Bulgaria	1/91	Cardiac-related readmission	6 mo	Cox proportional hazards
Lauzon et al, 2003[29]	Prospective cohort	Medical chart review and patient interview (1996–1998)	Canada	10/550	All-cause readmission	1 y	Unadjusted analysis
Marrugat et al, 1998[30]	Prospective cohort	Medical chart review (1992–1994)	Spain	4/1460	Cardiac-related readmission	6 mo	Unadjusted analysis
Maynard et al, 1997[31]	Prospective cohort	Medical chart review (1988–1994)	United States (King County, Wash)	19/5051	Cardiac-related readmission	1 y	Unadjusted analysis

(*Continued*)

Table 1. Continued

Study	Study Type	Data Source* (Study Period)	Study Location	No. of Hospitals/No. of Patients	Study Outcome	Follow-Up Period	Analytic Model
Maynard et al, 1997[32]	Prospective cohort	Medical chart review (1988–1994)	United States (King County, Wash)	19/5051	Cardiac-related readmission	1 y	Logistic regression
McClellan et al, 2004[33]	Retrospective cohort	Medicare data and medical chart review (1998)	United States (Ga)	101/552	All-cause readmission	30 d	Logistic regression
Møller et al, 2001[34]	Prospective cohort	Medical chart review (study period not specified)	Not specified	No. not presented/67	Cardiac-related readmission or death	1 y	Unadjusted analysis
Perez, 2002[35]	Retrospective cohort	Hospital administrative data (1998–1999)	Canada	93/4183†	Cardiac-related readmission	30 d	Hierarchical logistic regression
Portnay et al, 2005[36]	Retrospective cohort	Medicare data and medical chart review (1994–1996)	United States	Multiple, No. not presented/ 78 975	All-cause readmission	30 d	Logistic regression
Poulsen et al, 1999[37]	Prospective cohort	Medical chart review (study period not specified)	Denmark	1/58	Cardiac-related readmission	1 y	Unadjusted analysis
Poulsen et al, 2001[38]	Prospective cohort	Medical chart review (study period not specified)	Denmark	1/183	Cardiac-related readmission or death	1 y	Unadjusted analysis
Rahimi et al, 2007[39]	Prospective cohort	Medical chart review and patient interview (2003–2004)	United States	19/2498	All-cause readmission	1 y	Hierarchical proportional hazards
Salisbury et al, 2007[40]	Prospective cohort	Medical chart review and patient interview (2003–2004)	United States	19/2481	All-cause readmission	1 y	Cox proportional hazards
Steg et al, 2004[41]	Prospective cohort	Medical chart review (1999–2001)	Multinational (14 countries, including United States)	94/sample size not specified	All-cause readmission	6 mo	Unadjusted analysis
Stern et al, 1977[42]	Prospective cohort	Medical chart review and patient interview (study period not specified)	United States (Washington, DC)	1/68	All-cause readmission	1 y	Unadjusted analysis
Tu et al, 2003[43]	Retrospective cohort	Hospital administrative data (1997–2000)	Canada	Multiple, No. not presented/ 122003	Cardiac-related readmission	1 y	Descriptive

RCT indicates randomized controlled trial.
*For baseline sample characteristics.
†No. of admissions as opposed to unique patients.

The studies also varied in methods for identifying and excluding patients hospitalized at baseline for AMI. Eight of the studies included patients who died during the follow-up period in their main outcome analyses (ie, death or readmission), 24 examined death during the follow-up period as a separate outcome, 1 excluded these patients from analyses, and 2 did not discuss their analytic plan for patients who died during follow-up. Only 11 of the studies discussed their analytic plan for patients who were transferred during their baseline hospitalization: 5 excluded these patients from analyses, 1 "assigned" the hospitalization to the transferring (index) hospital, and 5 "assigned" the hospitalization to the receiving hospital.

No consistent pattern emerged in the analytic approach of the 35 studies reviewed. Almost half of the studies used unadjusted (eg, χ^2) analysis to identify significant predictor variables. Of those studies using more sophisticated statistical techniques, most favored logistic regression over Cox proportional hazards modeling. Only 3 studies used hierarchical modeling techniques to account for clustering of patients within hospitals.

The majority of studies (n=30) were explicitly performed to examine the association between hospital readmission and a specific patient-level characteristic, including various sociodemographic variables, comorbid conditions, and index hospitalization clinical variables. The remaining 5 studies did not have a primary independent variable of interest; rather, they examined the association between hospital readmission and a list of potential predictors. None of the studies that included a multivariable analysis presented a C-statistic or other measure of model performance. In addition, no studies presented a power calculation, thus it is unclear whether many of the smaller studies were adequately powered to detect associations of interest.

Across the 35 studies, there was limited consistency as to which variables were included in analyses (Table 2). For instance, age (n=21) and sex (n=22) were frequently included as potential predictors or covariates. Among the 21 studies that included age, only 2 reported a significant effect of increasing age on risk of readmission. In the remaining 19 studies that included age, the effect was either nonsignificant (n=10) or unknown (eg, the multivariable model included age, but its significance was not reported; n=9). Among comorbid conditions, the most frequently included in analy-

Table 2. Candidate Variables Included in Identified Studies Examining Patient-Level Predictors of Readmission After AMI Hospitalization

Candidate Variable	Studies Examining Candidate Variable, n (%)	Studies Reporting Statistical Association Between Candidate Variable and Readmission, n (%)	Studies for Which the Statistical Association Between Candidate Variable and Readmission Was Significant, n (%)
Sociodemographic variables			
Age	21 (60)	12 (57)	2 (17)
Sex	22 (63)	14 (64)	5 (36)
Race	9 (26)	3 (33)	0 (0)
Income	3 (9)	3 (100)	2 (67)
Education	2 (6)	1 (50)	0 (0)
Living status	4 (11)	2 (50)	0 (0)
Insurance	2 (6)	0 (0)	0 (0)
Comorbid conditions			
Congestive heart failure	7 (20)	4 (57)	1 (25)
Prior AMI	7 (20)	5 (71)	1 (20)
Coronary artery disease	4 (11)	0 (0)	0 (0)
Hypertension	14 (40)	6 (43)	1 (17)
Diabetes	11 (31)	5 (45)	1 (20)
Chronic kidney disease	2 (6)	2 (100)	1 (50)
Chronic obstructive pulmonary disease	3 (9)	1 (33)	1 (100)
Cerebrovascular accident/stroke	3 (9)	1 (33)	0 (0)
Tobacco use	10 (29)	4 (40)	0 (0)
Hypercholesterolemia	7 (20)	4 (57)	0 (0)
Prior revascularization	4 (11)	3 (75)	2 (67)
Depression	4 (11)	4 (100)	2 (50)
Markers of AMI severity			
Peak creatine kinase/troponin	5 (14)	3 (60)	0 (0)
AMI location	7 (20)	4 (57)	0 (0)
Coronary angiographic findings	5 (14)	2 (40)	2 (100)
Initial physical exam variables	5 (14)	4 (80)	1 (25)
Length of stay	4 (11)	3 (75)	1 (33)
Revascularization	10 (29)	6 (60)	2 (33)
Serum markers			
Hematocrit or hemoglobin	1 (3)	0 (0)	0 (0)
Blood urea nitrogen or creatinine	4 (11)	3 (75)	0 (0)
Brain natriuretic peptide	3 (9)	2 (67)	2 (100)

ses were hypertension (n=14) and diabetes mellitus (n=11), but even these were included in less than half of the studies reviewed. History of revascularization was found to be significantly associated with increased risk of readmission in 2 of 3 studies that included the variable and reported its significance.

Largely nonsignificant or unknown results were also reported for many of the AMI severity and serum markers. Index hospitalization clinical variables examined and found to be significant included brain natriuretic peptide (BNP) and echocardiographic measurements.

Discussion

Our systematic review found remarkably few studies that provide information about predictors of readmission after AMI or allow for the stratification of risk at the patient level or profiling of performance at the hospital level. There are no existing statistical models to compare hospital-specific rates of readmission for patients initially admitted for AMI and no existing statistical models or risk scores to predict an individual's risk of readmission after discharge for AMI. All 35 studies explored 1 or more patient-level characteristics as possible predictors of readmission, but considerable variation existed among the studies in the characteristics considered as primary predictors, ranging from sociodemographic factors to markers of severity of the index AMI. There was also little consistency in the covariates used during analysis, with only age and sex appearing in a majority of the studies. While providing preliminary evidence in many cases for important predictors, further work is necessary to determine the required variables for appropriately risk-adjusting readmission rates.

Despite the heterogeneous approach to measuring readmission, the 35 studies support prior claims that readmission after AMI is common. Focusing attention on the problem of readmission and supporting interventions to reduce these events have the potential to improve the quality and outcomes of care for AMI patients and possibly reduce costs. Although beyond the scope of this review, unmeasured process or postdischarge variables may also account for hospital variations in readmission rates.

The studies varied considerably in the sources of data used to ascertain baseline patient characteristics. However, the majority of studies performed chart abstraction or patient survey. Variables requiring abstraction or patient survey have considerably higher data collection costs compared with those contained within administrative databases. The studies reviewed do not establish whether models constructed using administrative variables would be sufficiently improved by the addition of variables obtained via chart abstraction or patient survey to justify the cost.

Additionally, the studies used various approaches for identifying cases of AMI and for identifying readmissions. Ensuring that all cases of AMI at a facility are identified and considered for possible inclusion is required to profile hospitals on their readmission rates. More problematic is ensuring that all readmissions, particularly those to other facilities, can be easily captured. Given the fragmented nature of health care in the United States, only Medicare currently has a sufficiently robust data set to ensure essentially all readmissions are identified. It is important to recognize, however, that this applies (with few exceptions) only to individuals aged 65 years and older, yet large numbers of younger individuals are also hospitalized for AMI and subsequently readmitted. The Department of Veterans Affairs (VA) has an extensive database to track adults of all ages who are hospitalized in VA facilities for AMI. However, the data are limited to VA service users, and it is difficult for the system to identify readmissions that occur outside the VA health care system. Until electronic medical records become ubiquitous and abstraction can be automated, readmission measures will need to be constructed using administrative data for many of the reasons detailed above.

Varying techniques were also used for handling interhospital transfers and accounting for the competing risk of death during follow-up. The question of how to handle transfers, particularly those transferred in from other facilities, is a challenging one. Key information about the initial phase of diagnosis and treatment may be missing, which may affect patient-level risk stratification and prediction. For the purposes of hospital-level profiling, it will be important to consider relevant patient characteristics present on admission. A successful measure for profiling hospitals will have to be rigorously constructed and consistently applied. Consensus around the analytic approach that best captures readmission rates reflective of provider quality will be necessary to move forward with measure development.

The data selected for incorporation into a model will differ between a measure to predict an individual's risk of readmission and a measure to profile hospitals on their readmission rates. Development of a readmission prediction model for individual patients should include all relevant information, including in-hospital events and discharge disposition. However, in developing a profiling model to assess the performance of hospitals by readmission rates, patient-level characteristics must be carefully selected to focus on those present on admission and to prevent inclusion of factors such as in-hospital complications, length of stay, and discharge disposition. Accounting for such characteristics could inappropriately risk-standardize hospital performance for the very differences in quality and efficiency that profiling attempts to measure.[44] Poorly constructed models could therefore undermine the very goal of focusing on readmission (ie, promotion of high-quality efficient care).

This study is not without limitations. Although we did a comprehensive search of the peer-reviewed literature, we did not include unpublished results or studies from the gray literature, such as agency reports and doctoral dissertations. In addition, we did not include non-English language studies. Further, we reexamined the excluded articles and found only 7 studies whose primary focus was a hospital-level characteristic. Of these, 2 presented results for a limited number of patient factors (eg, age, sex, race, specific clinical characteristics) as part of their multivariable analysis. The findings and conclusions of this review were not substantively affected by their exclusion.

In conclusion, our work demonstrates that readmission after AMI is a significant problem, and currently no models exist for measuring readmission rates for hospitals or modeling the risk of readmission for an individual patient. The limited work to date suggests important patient predictors for readmission exist and warrant further study. In addition, consensus around study design and analytic issues, such as the length of the follow-up period, handling of transfers, and accounting for competing risk of death, is required to advance efforts to measure hospital readmission rates. Moreover, models must use robust data sets to ensure that all cases of AMI and all readmissions are captured and appropriately attributed to the index hospital. Identification of consistent and reliable predictors of readmission will be required to appropriately risk-standardize hospital performance in readmission after AMI. Although variable selection may in part be informed by the literature, empirical development and validation analyses using appropriate data sets and rigorous hierarchical statistical methods will be needed. From a policy perspective, a validated risk-standardized statistical model that adjusts for important patient-level predictors of readmission is necessary if hospitals are to be profiled on their readmission rates, with the caveat that patient characteristics are likely to account for only a small amount of the variation among hospitals.

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None.

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