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J Am Heart Assoc. 2014;3:e001046; originally published September 18, 2014;

doi: 10.1161/JAHA.114.001046

The *Journal of the American Heart Association* is published by the American Heart Association, 7272 Greenville Avenue,
Dallas, TX 75231
Online ISSN: 2047-9980

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Characterizing Types of Readmission After Acute Coronary Syndrome Hospitalization: Implications for Quality Reporting

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Background—Thirty-day readmission rates have been tied to hospital reimbursement in the United States, but remain controversial as measures of healthcare quality. We profile the timing, main diagnoses, and survival outcomes of inpatient and emergency department readmissions after acute coronary syndrome (ACS), based on a large regional database.

Methods and Results—Patients enrolled in the Alberta Provincial Project for Outcomes Assessment in Coronary Heart Disease (APPROACH) registry with an ACS hospitalization between April 2008 and March 2010 (n=34 11) were included. Primary outcomes were inpatient and emergency department–only readmissions, at 30 days and 1 year. Predictors of 30-day readmission were identified, and the association between 30-day readmission status and mortality was evaluated. A total of 1170 (34.3%) patients had ≥ 1 hospital readmission within 30 days, reaching 2106 (61.7%) within 1 year of ACS discharge. Of first readmissions, 45% were emergency department only and 53% were for cardiovascular or possibly related diagnoses. Renal disease and diabetes predicted all-cause readmissions at 30 days and 1 year, but there were no robust predictors of cardiovascular readmissions. Thirty-day inpatient, but not emergency department, readmissions were associated with increased mortality.

Conclusions—Hospital readmissions within 30 days after discharge for ACS are common, and associated with increased mortality. However, our findings underline that readmissions are quite heterogeneous in nature, and that many readmissions are unrelated to index stay and thus not easily predicted with common clinical variables. All-cause 30-day readmission rates may be too simplistic, and perhaps even misleading, as a hospital performance metric. (*J Am Heart Assoc.* 2014;3:e001046 doi: 10.1161/JAHA.114.001046)

Key Words: acute care • acute coronary syndrome • hospitalizations • readmissions

Like other chronic illnesses, coronary artery disease is punctuated by episodes of acute exacerbation requiring hospitalization, most commonly for acute coronary syndromes (ACS). Despite improvements in acute care and survival after ACS hospitalization, early readmissions remain common, and have significant clinical and financial impact.¹ These readmissions are seen as undesirable events both for patients and healthcare systems. Because of the variability in readmission rates among different hospitals and regions, it has been argued that early readmissions are avoidable and furthermore are

related to suboptimal quality of care during the index hospitalization.² Therefore, 30-day readmission profiling is becoming a metric for institutional and regional performance, and beginning in 2012 in the United States, hospitals whose 30-day hospital readmission rates for certain conditions, including acute myocardial infarction (AMI), exceed the national average are financially penalized under the Patient Protection and Affordable Care Act.^{3–5} However, while some readmissions after AMI may be preventable with improved in-hospital and postdischarge processes, a substantial proportion may be unavoidable, unrelated to the index admission, or conversely reflect high-quality, responsible care.^{6–11} Therefore, considering early readmissions as a homogeneous phenomenon may obscure important variations in their impact and relevance.

While several investigators have sought to identify predictors of 30-day readmission following AMI^{12–14} or percutaneous coronary interventions,^{6,15} detailed contextual data about these encounters has been lacking. Furthermore, patients with an index admission for unstable angina have been excluded from most studies, and the relevance of admissions beyond the 30-day window has been poorly studied. We sought to profile the timing, main diagnoses, and survival outcomes of inpatient

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Received June 2, 2014; accepted July 14, 2014.

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and emergency department readmissions after acute coronary syndrome (ACS), based on a large inclusive regional database. Our findings shed light on the correlates of readmission episodes, with implications to the widespread reporting of readmission rates as an indicator of quality of care.

Methods

Study Population and Data Sources

This study included all subjects enrolled in the Alberta Provincial Project for Outcomes Assessment of Coronary Heart Disease (APPROACH)¹⁶ within the Alberta Health Services—Calgary and South Zones (population 1.5 million) who were discharged alive after an ACS hospitalization between April 1, 2008, and March 31, 2010. Patients are captured in the APPROACH database when they are admitted to a cardiac ward in any acute care hospital. APPROACH uses prospective data collection for patient characteristics, comorbidities, and details of management during the index hospitalization. The diagnosis of ACS and its subcategorization as unstable angina, non-ST elevation myocardial infarction (NSTEMI), and ST elevation myocardial infarction (STEMI), are entered at the time of discharge, and represent the physician's interpretation of all clinical data, including electrocardiography, biomarker elevation, and the results of cardiac testing. During the study period all participating centers used troponin T as the principal cardiac biomarker, with standardized cut-offs to define myocardial infarction.

APPROACH data were linked with the Discharge Abstract Database (DAD) and the Ambulatory Care Classification System administrative databases to obtain the timing and diagnosis for hospital readmissions after discharge. In addition, this linkage reduces missing data comorbidities data.¹⁷ Comorbid illness is defined within the Discharge Abstract Database using the Charlson score,¹⁸ based on International Classification of Disease (ICD-10-CA) discharge codes.¹⁹ Comorbid illnesses were defined at time of index hospitalization. Data on all-cause mortality is provided by linkage with Alberta Vital Statistics. All data sources were updated through March 31, 2011. The University of Calgary Research Ethics Board has approved APPROACH registry data collection and linkages with secondary sources, and waived the requirement for individual consent for inclusion.

Hospital Readmission Definitions

We categorized the first hospital-based readmission after ACS discharge as follows. The reference group was patients who had no emergency department visit or inpatient readmission during the follow-up period. Readmitted patients were categorized as inpatient if they were hospitalized under the care of

an admitting service, either with or without being assessed in the emergency department first, and as emergency department if the first hospital readmission consisted of an assessment in the emergency department only. All readmissions were also categorized in terms of their relationship to the index admission based on the main discharge diagnosis codes, and were coded as cardiac-related, possibly related, and unrelated. In Canada, the "main discharge diagnosis" is defined as the diagnosis requiring the most resources during a hospital stay. Cardiovascular-related readmissions were those whose main diagnoses related to coronary artery disease, chest pain, congestive heart failure, arrhythmias, valvular heart disease, pericardial disease, or stroke. Readmissions were classified as possibly related when the main diagnosis may have been due to complications of a procedure (eg, wound infection, pleural effusion) or a medical therapy (eg, bleeding, acute renal failure, hypotension, electrolyte disturbance) provided during the initial hospitalization.

Cardiac-related readmissions were further subcategorized as either planned or unplanned. Planned readmissions were those involving elective coronary angiography, percutaneous coronary intervention, or cardiac surgery, using urgency codes in APPROACH. All other readmissions were considered to be unplanned.

Statistical Analysis

Demographic and clinical characteristics were compared by readmission status using χ^2 tests for categorical variables, overall ANOVA for continuous variables, and nonparametric *t* tests for non-normally distributed variables. Multivariable logistic regression models were created to predict readmissions. Initial predictors were selected for known or suspected associations with readmissions, and included age ≥ 75 years, female sex, index length of stay ≥ 7 days, STEMI/NSTEMI diagnosis, catheterization during index admission, congestive heart failure, pulmonary disease, renal disease, diabetes (uncomplicated and complicated), peripheral vascular disease, mild liver disease, and dementia. Stepwise backwards elimination was used to select variables²⁰ for the final logistic regression models to predict readmissions within 30 days and within 1 year. Separate models were created for all-cause readmissions and for the emergency department and inpatient subtypes, to determine whether similar variables were predictive across readmissions types. Only variables with a *P*-value < 0.05 were retained in the models. We report C-statistic values for model discrimination, as a measure of the extent to which readmission end points are related to the baseline clinical predictor variables that were modeled. A priori, we anticipated that these C-statistic values could be quite low for readmission endpoints, especially if a number of nonclinical factors influence whether a patient is readmitted or not.

We compared all-cause mortality in follow-up among patients who survived at least 30 days after the initial admission, according to both 30-day readmission status and readmission type, using Kaplan–Meier plots and the log-rank test, and used Cox proportional hazards models to adjust mortality estimates for known prognostic variables. All statistical analyses were performed with SAS version 9.2 (SAS Institute, Cary, NC). A 2-sided $P < 0.05$ identified statistical significance.

Results

Of 3609 patients discharged with a diagnosis of ACS between April 1, 2008 and March 31, 2010, 3411 (94.5%) survived to discharge and were included. The ACS diagnosis subcategories were 1128 (33.1%) unstable angina; 1517 (44.5%) NSTEMI; and 766 (22.5%) STEMI. The mean age was 65.6 ± 13.2 , and 1055 (30.9%) patients were female. Figure 1 summarizes these data and Table 1 summarizes key characteristics of the patients and their index ACS admissions.

Table 2 describes the timing and main diagnoses for hospital readmissions. During 1 year of follow-up, 2106 (61.7%) had at least 1 hospital readmission, and 1170 (34.3%) were readmitted within 30 days. In total, there were 695 (20.3%) inpatient readmissions within 30 days. The median time from index discharge to readmission was 0.8 months (Q1 to Q3 0.2, 1.4). The first hospital readmission was an assessment in the emergency department only in 942 (44.7%) and was an inpatient admission in 1164 (55.3%). The readmissions were categorized as cardiovascular

in 984 (46.7%), as possibly related to the index admission in 135 (6.4%), and as unrelated in the remaining 987 (46.9%) cases. Considering only 30-day readmissions, 594 (50.8%) were cardiovascular and another 90 (7.7%) were possibly related to the index admission. Cardiac catheterization and/or revascularization procedures were performed in 291 inpatient readmissions (24.8%). Of these, 213 (73.2%) occurred in the first 30 days, including 24 (8.2%) planned procedures. No sex-based differences were present for any of the outcomes listed in Table 2.

Predictors of Readmission

Table 3 summarizes the results of multivariable predictive logistic regression modeling for all-cause and cardiac readmission types. There was considerable variability in the predictor variables between all-cause versus cardiovascular readmission types, and between 30-day versus 1-year time points. Considering all-cause readmissions, both renal disease and diabetes mellitus predicted an increased risk at both time points, while having undergone a cardiac catheterization during the index ACS hospitalization predicted a reduced risk. However, neither renal disease nor cardiac catheterization status predicted cardiovascular readmissions, and diabetes mellitus predicted only inpatient cardiovascular readmission types. Other variables had divergent associations with different readmission types. For instance, age ≥ 75 was associated with significantly lower odds of either all-cause or cardiac readmission within 30 days, but with significantly increased odds of all-cause inpatient hospitalization by 1 year. Furthermore, length of stay at the index hospitalization > 7 days was associated with significantly increased odds of all-cause hospitalizations, but with a similar-magnitude reduced odds of readmission for a cardiovascular cause. The fully adjusted models had only modest discriminatory capacity for predicting readmissions, with C-statistics between 0.526 and 0.580 for cardiovascular readmissions, and between 0.553 and 0.658 for all-cause readmissions.

Mortality

Among 3386 patients who survived at least 30 days after the index admission, having a readmission within 30 days was associated with a higher risk of all-cause mortality (adjusted hazard ratio [HR], 95% CI=1.43, 1.15 to 1.79, compared to those without a readmission within 30 days) over a median follow-up of 0.8 years (Figure 2A, $P < 0.0001$). However, this excess mortality was not observed in patients in the emergency department–only readmission group (Figure 2B). Patients with an emergency department readmission were at significantly lower risk of death (HR 0.58, 95% CI 0.36 to 0.95,

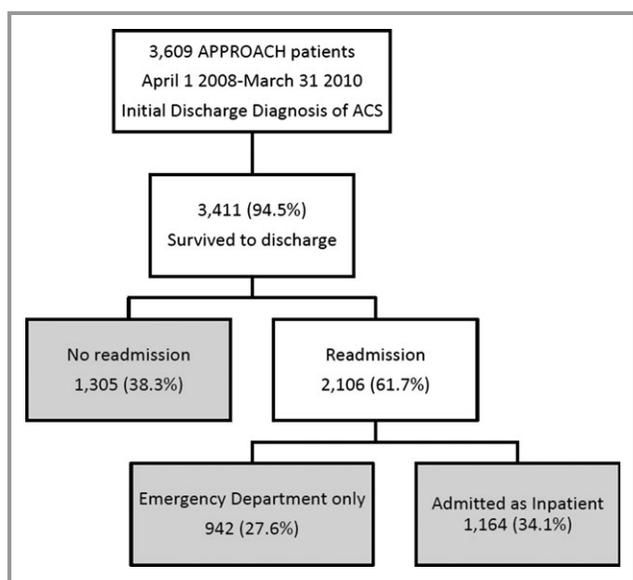


Figure 1. Flow chart of patient cohort. ACS indicates acute coronary syndrome; APPROACH, Alberta Provincial Project for Outcomes Assessment in Coronary Heart Disease.

Table 1. Characteristics of the Patients and Index Hospitalizations

	All Patients N=3411	No Readmission N=1305	Emergency Department Only N=942	Inpatient Admission N=1164	P Value
Male	2356 (69.1%)	917 (70.3%)	668 (70.9%)	771 (66.2%)	0.034
Mean age (SD)	65.6 (13.2)	65.2 (13.4)	63.1 (12.9)	68.2 (12.8)	<0.0001*
Median Index LOS (Q1 to Q3)	5.0 (3.75, 6.25)	5.0 (4.0, 6.0)	5.0 (4.0, 6.0)	5.0 (3.5, 6.5)	0.857†
Median days to readmission (Q1 to Q3)	23.0 (5.25, 40.75)	—	30.0 (12.25, 47.75)	18.0 (3.25, 32.75)	<0.0001†
Index discharge diagnosis					0.018
NSTEMI	1517 (44.5%)	555 (42.5%)	425 (45.1%)	537 (46.1%)	
STEMI	766 (22.5%)	296 (22.7%)	236 (25.1%)	234 (20.1%)	
Unstable angina	1128 (33.1%)	454 (34.8%)	281 (29.8%)	393 (33.8%)	
Cardiac catheterization and/or revascularization‡	2376 (69.7%)	942 (72.2%)	737 (78.2%)	697 (59.9%)	<0.0001
Patient residence					<0.0001
Calgary and surrounding areas	1774 (52.0%)	661 (50.7%)	487 (51.7%)	626 (53.8%)	
Nonmetropolitan	1196 (35.1%)	420 (32.2%)	360 (38.2%)	416 (35.7%)	
Unknown	441 (12.9%)	224 (17.2%)	95 (10.1%)	122 (10.5%)	
Comorbidities					
Heart failure	322 (9.7%)	104 (8.0%)	63 (6.7%)	165 (14.2%)	<0.0001
Diabetes	884 (25.9%)	295 (22.6%)	216 (22.9%)	373 (32.0%)	<0.0001
Cancer	162 (4.8%)	45 (3.5%)	44 (4.7%)	73 (6.3%)	0.004
Mild liver disease	20 (0.6%)	6 (0.5%)	4 (0.4%)	10 (0.9%)	0.322
Moderate/severe liver disease	16 (0.5%)	5 (0.4%)	3 (0.3%)	8 (0.7%)	0.396
Renal disease	305 (8.9%)	87 (6.7%)	59 (6.3%)	159 (13.7%)	<0.0001
Pulmonary disease	523 (15.3%)	163 (12.5%)	117 (12.4%)	243 (20.9%)	<0.0001
Peripheral vascular disease	160 (4.7%)	54 (4.1%)	25 (2.7%)	81 (7.0%)	<0.0001
Dementia	22 (0.6%)	10 (0.8%)	5 (0.5%)	7 (0.6%)	0.769
Metastatic cancer	2 (0.1%)	0	0	2 (0.2%)	0.145
Cerebrovascular disease	266 (7.8%)	87 (6.7%)	65 (6.9%)	114 (9.8%)	0.007
Peptic ulcer disease	353 (10.4%)	118 (9.0%)	97 (10.3%)	138 (11.9%)	0.072
Rheumatic disease	17 (0.5%)	4 (0.3%)	5 (0.5%)	8 (0.7%)	0.401
Paraplegia	5 (0.2%)	2 (0.2%)	2 (0.2%)	1 (0.1%)	0.754
HIV	0	0	0	0	—
Charlson score					<0.0001
0	599 (17.6%)	272 (20.9%)	142 (15.1%)	185 (15.9%)	
1	1526 (44.7%)	612 (46.9%)	476 (50.5%)	438 (37.6%)	
2	536 (15.7%)	185 (14.2%)	135 (14.3%)	216 (18.6%)	
3	374 (11.0%)	133 (10.2%)	96 (10.2%)	145 (12.5%)	
4+	376 (11.0%)	103 (7.9%)	93 (9.9%)	180 (15.5%)	

LOS indicates length of stay; NSTEMI, non-ST elevation myocardial infarction; STEMI, ST elevation myocardial infarction.

*F-test; †Kruskal–Wallis test; ‡revascularization = percutaneous coronary intervention and/or coronary artery bypass graft.

compared to patients without readmission), while those with an inpatient readmission were at higher risk HR (1.83, 95% CI 1.45 to 2.31, compared to patients without readmission).

Finally, among patients with a readmission within 30 days, the Kaplan–Meier risk of death was not statistically different in those with cardiac and noncardiac causes of readmission,

Table 2. Characteristics of Hospital Readmissions

	All Readmissions N=2106	Emergency Department Only N=942	Inpatient Admission N=1164
Readmission within 7 days, %	597 (28.3%)	213 (22.6%)	384 (32.0%)
Readmission within 30 days, %	1170 (55.6%)	475 (50.4%)	695 (59.7%)
Mean LOS days, SD	2.94 (12.2)	0.06 (0.26)	5.3 (16.1)
Median LOS days (Q1 to Q3)	0* (−0.5, 0.5)	0* (0)	1 (0.25, 2.25)
Cardiac readmission, %	984 (46.7%)	388 (41.2%)	596 (51.2%)
Possibly related readmission, %	135 (6.4%)	54 (5.7%)	81 (7.0%)
Unrelated readmission, %	987 (46.9%)	500 (53.1%)	487 (41.8%)
Cardiac catheterization and/or revascularization†, %	291 (13.8%)	0	291 (25.2%)
Within first 30 days, %	213 (73.2%)	—	213 (73.2%)
Planned, %	24 (8.2%)	—	24 (8.2%)
Unplanned, %	267 (91.8%)	—	267 (91.8%)

LOS indicates length of stay.

*0 represents 1 day (<24 hour).

†Revascularization=percutaneous coronary intervention and/or coronary artery bypass graft.

though the small number of patients with possibly related readmissions appeared to be at increased risk of death (Figure 2C). Adjusted HRs (95% CI) for cardiac-related and possibly related readmissions were 1.16 (0.91, 1.48) and 1.74 (1.10, 2.74), respectively. All HR were adjusted for age, sex, diabetes, heart failure, pulmonary disease, peripheral vascular disease, renal failure, and index length of stay >7 days.

Discussion

These data provide several important insights into the phenomenon of repeat hospital visits after ACS discharge. First, as has been previously reported, these readmissions are common: 20% of our cohort had an inpatient readmission and an additional 14% had an emergency department visit within 30 days. Overall, 62% had a hospital visit within 1 year. Second, 30-day inpatient readmissions are associated with an increased risk of mortality within 1 year, but patients whose first readmission is an emergency department assessment only do not share this elevated risk. Third, only about half of these readmissions are potentially related to the index stay. In fact, only 11.2% of our cohort had a cardiovascular inpatient readmission within 30 days. As has been reported in other series, a minority (8%) of these cardiac readmissions were for elective procedures such as staged percutaneous coronary intervention or coronary artery bypass grafting surgery.⁶ Fourth, while some features are reliably associated with an increased (renal disease, diabetes) or decreased (cardiac catheterization during the index stay) risk of all cause readmissions, the overall discriminatory performance of our

multivariable logistic models was modest, indicating that many readmissions were not predictable even with the detailed demographic and clinical data available. In particular, we found few robust predictors of cardiovascular readmissions, which are those most likely to be preventable by improved care at the index ACS admission.

Toward a Broader and Deeper Characterization of Readmissions After ACS

Absolute readmission rates reported in this study are higher than in some prior publications.^{6,21} However, it is difficult to directly compare rates, due to several factors. First, because all Alberta hospitals participate in mandatory province-wide reporting of readmissions, the rates reported here are inclusive. Second, since we studied hospital readmissions following all ACS events, this study captured patients with a discharge diagnosis of unstable angina, whereas most prior studies limited their evaluation to only those patients with NSTEMI and/or STEMI.^{6,13–15,21} Sangu et al. did include patients with unstable angina in their cohort, and found that they had a similar risk of 30-day readmission compared with NSTEMI patients, but a lower risk than STEMI patients. In our study, 30-day inpatient and cardiovascular readmission rates were similar regardless of ACS subtype, indicating while patients with unstable angina may be at lower acute risk than those with NSTEMI or STEMI, they should be included in interventions aimed at reducing readmission rates after ACS. Finally, most studies examining 30-day readmission rates have not addressed the prevalence and impact of emergency

Table 3. Multivariable Adjusted Predictors of Readmission After ACS Discharge

	All Readmissions 30 Days	Inpatient Readmissions 30 Days	All Readmissions 1 Year	Inpatient Readmissions 1 Year
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
All-cause readmissions after ACS admission				
Age >75 year	0.69 (0.58, 0.82)	—	—	1.33 (1.13, 1.57)
Female sex	—	—	—	—
Index LOS > 7 days	1.22 (1.04, 1.46)	1.33 (1.09, 1.62)	—	1.40 (1.18, 1.66)
NSTEMI*	1.25 (1.06, 1.48)	—	—	—
STEMI*	1.31 (1.07, 1.64)	—	—	—
Cardiac catheterization during index admission	0.52 (0.44, 0.61)	0.41 (0.34, 0.49)	—	0.56 (0.48, 0.66)
Peripheral vascular disease	—	—	—	1.42 (1.02, 1.99)
Diabetes	1.33 (1.13, 1.57)	1.49 (1.24, 1.80)	1.36 (1.11, 1.66)	1.39 (1.18, 1.64)
Pulmonary disease	—	1.36 (1.09, 1.69)	1.26 (1.07, 1.49)	1.57 (1.29, 1.91)
Cancer	—	—	1.54 (1.08, 2.19)	—
Renal disease	1.51 (1.17, 1.95)	1.66 (1.22, 2.11)	1.42 (1.10, 1.86)	1.48 (1.15, 1.91)
Rural/unknown residence [†]	1.26 (1.09, 1.46)	—	—	—
Area under ROC curve	0.613	0.658	0.553	0.645
Cardiac readmissions after ACS admission				
Age >75 year	0.79 (0.64, 0.98)	—	—	—
Female sex	—	—	—	—
Index LOS >7 days	0.63 (0.50, 0.80)	0.65 (0.51, 0.86)	0.75 (0.63, 0.89)	—
Heart failure	1.48 (1.09, 2.00)	1.61 (1.11, 2.24)	—	—
Diabetes	—	1.30 (1.03, 1.64)	—	1.26 (1.04, 1.54)
Pulmonary disease	—	—	—	1.37 (1.09, 1.72)
Rural/unknown residence [†]	1.51 (1.26, 1.80)	1.33 (1.07, 1.64)	—	—
Area under ROC curve	0.578	0.580	0.526	0.536

ACS indicates acute coronary syndrome; LOS, length of stay; NSTEMI, non-ST elevation myocardial infarction; OR, odds ratio; ROC, receiver operating characteristic curve; STEMI, ST elevation myocardial infarction.

*ACS type reference, unstable angina.

[†]Patient residence reference=metro/moderate metro influence.

department visits. In this study, 41% of readmissions within 30 days were emergency department assessments without inpatient admission, similar to the findings in a recent study by Vashi and colleagues examining readmissions after a range of index discharge diagnoses.²² Contrary to that report, we found that the majority of these emergency department-only visits were unrelated to the index ACS discharge. Interestingly, unlike those with an inpatient readmission, patients with emergency department-only readmissions within 30 days did not experience an increased risk of mortality. In fact, we found that patients with emergency department-only readmissions were associated with lower mortality by 1 year compared with nonreadmitted patients. Further research into the unmeasured reasons for this difference is warranted.

The existing literature related to readmissions after AMI^{3,6,13–15,22–25} focuses on early 30-day postdischarge

all-cause readmissions. The specific time period explored in these studies is based upon the commonly chosen 30-day readmission rates utilized as a hospital performance measure. However, several groups have raised concerns about the validity of utilizing 30-day readmission rates as a performance metric.^{9,10} Arguments include that only a small proportion of 30-day readmissions can be considered preventable and most importantly, that it is unclear that 30-day readmission rates represent poor quality of care. High rates can in fact represent low mortality or good access to care.⁹ A recent multicenter prospective study reported that <20% of 30-day readmissions were urgent, unplanned, and avoidable.⁶

Predictors of delayed hospital readmissions may be equally as valuable as the predictors of early readmissions in understanding the burden of chronic coronary artery disease and the resource implications in caring for patients with this

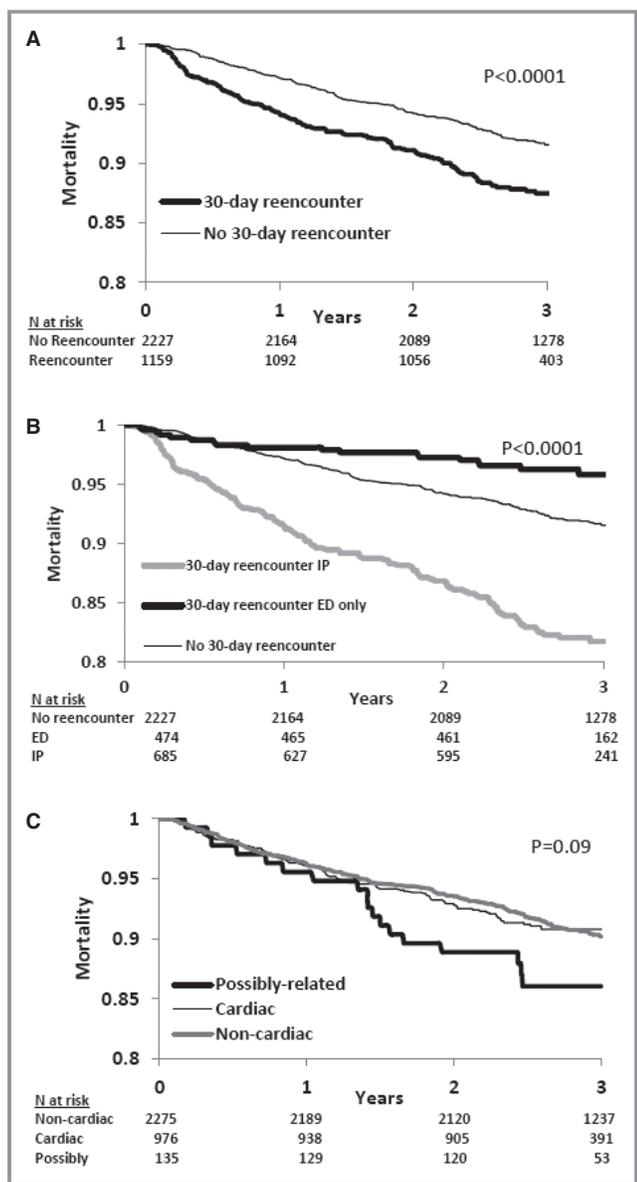


Figure 2. Kaplan–Meier plots for all-cause mortality for patients who survived at least 30 days after initial discharge (and who survived their initial hospitalization if they were admitted before 30 days and discharged after 30 days). Patients categorized by 30-day readmission status (A): (yes/no); (B): no/emergency department (ED)/inpatient (IP) groups; (C): cardiac/possibly-related/noncardiac groups.

condition. In our study, 61.9% of ACS patients had hospital readmissions within 1 year of discharge, and 53% of these delayed readmissions had a cardiovascular cause.

Are Readmissions After ACS Predictable or Preventable?

Several groups have studied factors predictive of readmissions after ACS²¹ or AMI hospitalizations,^{13,26} and a systematic review¹⁴ evaluating the consistency of patient-level predictors

has been published. Some predictors most commonly reported included older age, heart failure, a prior AMI event, hypertension, and diabetes. Factors associated with all-cause 30-day readmissions after STEMI^{13,14,26} and percutaneous coronary intervention¹⁵ (both elective and for AMI) reported that patients readmitted within 30 days had higher rates of conditions such as previously diagnosed coronary artery disease, hypertension, diabetes, chronic obstructive pulmonary disease, chronic inflammatory conditions, renal disease, peptic ulcer disease, and metastatic cancer. Our predictive models for all-cause readmissions and cardiovascular readmissions within both 30 days and 1 year were derived from multivariable logistic regression that included many of these same variables, but we found significant variation in predictors depending on the cause and timing of readmission. This emphasizes the difficulties in determining reliable and modifiable risk factors for readmission, as highlighted in a recent editorial accompanying a focus issue dedicated to readmissions in JAMA.²⁷

Limitations

Our study has limitations. First, we were unable to assess the relative impact of a number of potential indicators of quality of post-ACS care, such as prescription medications at the time of discharge, cardiac rehabilitation referral, or family physician follow-up. Second, our study was conducted in the context of a healthcare system with universal coverage. Accordingly, our findings on predictors of readmission may not apply to settings such as the US healthcare system, where insurance status may influence the likelihood of readmission episodes. Third, our data linkage for determining occurrence of readmissions does not allow us to capture readmissions occurring outside of Alberta; however, we expect that these would be relatively rare events for our analysis, given that the study was confined to Alberta residents.

Conclusions

This study demonstrates that hospital readmissions within 30 days after discharge for an ACS are common, and that these are associated with increased mortality. Importantly, our findings underline that readmissions are rather heterogeneous in nature, and that many readmissions are unrelated to the index stay and thus not easily predicted with common clinical variables. All-cause 30-day readmission rates may be too simplistic, and perhaps even misleading, as a hospital performance metric.

Acknowledgments

The authors thank the personnel at the tertiary care sites for their diligence in data entry that enabled this work to be completed.

The authors thank the members of the APPROACH research working group.

Role of the Sponsors: Alberta Health Services, Libin Cardiovascular Institute of Alberta, Mazankowski Alberta Heart Institute, Alberta Health and Wellness, Merck Frosst Canada Inc, Eli Lilly Canada Inc, and Servier Canada Inc had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; the preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Sources of Funding

APPROACH was initially funded with a grant from the W. Garfield Weston Foundation. The ongoing operation of the APPROACH project has been made possible by support from Alberta Health Services (Calgary Zone, Edmonton Zone), Libin Cardiovascular Institute of Alberta and Mazankowski Alberta Heart Institute. The APPROACH initiative has also received contributions from Alberta Health and Wellness, and the following industry sponsors: Merck Frosst Canada Inc, Eli Lilly Canada Inc, Servier Canada Inc, to support the basic infrastructure of this cardiac registry initiative.

Disclosures

None.

References

- DH Cardiovascular Disease Team. Cardiovascular Disease Outcomes Strategy. Available at: <https://www.gov.uk/>. Accessed March 05, 2013. Department of Health. Accessed January 23, 2014. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/214895/9387-2900853-CVD-Outcomes_web1.pdf.
- Joynt KE, Orav EJ, Jha AK. The association between hospital volume and processes, outcomes, and costs of care for congestive heart failure. *Ann Intern Med*. 2011;154:94–102.
- Centers for Medicare & Medicaid Services. Readmissions Reduction Program. Available at: <http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html>. Accessed July 29, 2014.
- Epstein AM. Paying for performance in the United States and abroad. *N Engl J Med*. 2006;355:406–408.
- Office of the Auditor General of Ontario. 2010 Annual Report—Discharge Of Hospital Patients. Toronto (ON): Government of Ontario; 2010. p. 64–93. Available at: http://www.auditor.on.ca/en/reports_en/en10/302en10.pdf. Accessed February 22, 2012.
- Khawaja FJ, Shah ND, Lennon RJ, Slusser JP, Alkatib AA, Rihal CS, Gersh BJ, Montori VM, Holmes DR, Bell MR, Curtis JP, Krumholz HM, Ting HH. Factors associated with 30-day readmission rates after percutaneous coronary intervention. *Arch Intern Med*. 2012;172:112–117.
- van Walraven C, Jennings A, Taljaard M, Dhalla I, English S, Mulpuru S, Blecker S, Forster AJ. Incidence of potentially avoidable urgent readmissions and their relation to all-cause urgent readmissions. *CMAJ*. 2011;183:E1067–E1072.
- van Walraven C, Bennett C, Jennings A, Austin PC, Forster AJ. Proportion of hospital readmissions deemed avoidable: a systematic review. *CMAJ*. 2011;183:E391–E402.
- Joynt K, Jha A. Thirty-day readmissions—truth and consequences. *N Engl J Med*. 2012;366:1366–1369.
- Kangovi S, Grande D. Hospital readmissions—not just a measure of quality. *JAMA*. 2011;306:1796–1797.
- Berenson R, Paulus R, Kalman N. Medicare's readmissions-reduction program—a positive alternative. *N Engl J Med*. 2012;366:1364–1366. doi: 10.1056/NEJMp1201268 Epub March 28, 2012.
- Kocher RP, Adashi EY. Hospital readmissions and the Affordable Care Act: paying for coordinated quality care. *JAMA*. 2011;306:1794–1795.
- Kociol RD, Lopes RD, Clare R, Thomas L, Mehta RH, Kaul P, Pieper KS, Hochman JS, Weaver WD, Armstrong PW, Granger CB, Patel MR. International variation in and factors associated with hospital readmission after myocardial infarction. *JAMA*. 2012;307:66–74.
- Desai MM, Stauffer BD, Feringa HH, Schreiner GC. Statistical models and patient predictors of readmission for acute myocardial infarction: a systematic review. *Circ Cardiovasc Qual Outcomes*. 2009;2:500–507.
- Curtis JP, Schreiner G, Wang Y, Chen J, Spertus JA, Rumsfeld JS, Brindis RG, Krumholz HM. All-cause readmission and repeat revascularization after percutaneous coronary intervention in a cohort of medicare patients. *J Am Coll Cardiol*. 2009;54:903–907.
- Ghali WA, Knudtson ML. Overview of the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease. On behalf of the APPROACH investigators. *Can J Cardiol*. 2000;16:1225–1230.
- Southern DA, Norris CM, Quan H, Shrive FM, Galbraith PD, Humphries K, Gao M, Knudtson ML, Ghali WA. An administrative data merging solution for dealing with missing data in a clinical registry: adaptation from ICD-9 to ICD-10. *BMC Med Res Methodol*. 2008;8:1.
- Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373–383.
- Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care*. 2005;43:1130–1139.
- Sun GW, Shook TL, Kay GL. Inappropriate use of bivariable analysis to screen risk factors for use in multivariable analysis. *J Clin Epidemiol*. 1996;49:907–916.
- Sangu PV, Ranasinghe I, Aliprandi Costa B, Devlin G, Elliot J, Lefkowitz J, Brieger D. Trends and predictors of rehospitalization following an acute coronary syndrome: report from the Australian and New Zealand population of the Global Registry of Acute Coronary Events (GRACE). *Heart*. 2012;98:1728–1731.
- Vashi AA, Fox JP, Carr BG, D'Onofrio G, Pines JM, Ross JS, Gross CP. Use of hospital-based acute care among patients recently discharged from the hospital. *JAMA*. 2013;309:364.
- Canadian Institute for Health Information. Health Indicators 2011. Ottawa, ON: CIHI; 2011.
- Dharmarajan K, Hsieh AF, Lin Z, Bueno H, Ross JS, Horwitz LI, Barreto-Filho JA, Kim N, Bernheim SM, Suter LG, Drye EE, Krumholz HM. Diagnoses and timing of 30-day readmission after hospitalization for heart failure, acute myocardial infarction, or pneumonia. *JAMA*. 2013;309:355.
- Tu JV, Austin PC, Filate WA, Johansen HL, Brien SE, Pilote L, Alter DA. Outcomes of acute myocardial infarction in Canada. *Can J Cardiol*. 2003;19:893–901.
- Allen LA, Smoyer-Tomic KE, Smith DM, Wilson KL, Agodoa I. Rates and predictors of 30-day readmission among commercially insured and Medicaid-enrolled patients hospitalized with systolic heart failure. *Circ Heart Fail*. 2012;5:672–679.
- Fontanarosa PB, McNutt RA. Revisiting hospital readmissions. *JAMA*. 2013;309:398.