

Medication Adherence and Readmission After Myocardial Infarction in the Medicare Population

Yuting Zhang, PhD; Cameron M. Kaplan, PhD; Seo Hyon Baik, PhD; Chung-Chou H. Chang, PhD; and Judith R. Lave, PhD

According to the American Heart Association, 7.9 million Americans have a history of myocardial infarction (MI) and 450,000 deaths occur each year in the United States because of new and recurrent MIs.¹ Readmissions after MIs are common and costly. For example, the rates for 30-day all-cause readmission after an MI from 2006 to 2008 in the Medicare population were 22.5%, 24.8%, and 23% among white, black, and Hispanic patients, respectively.^{2,3} Previous research on readmissions focused primarily on 30-day all-cause readmission and examined the association between readmissions and hospital-level factors. This focus on 30-day readmissions was stimulated in part due to the Affordable Care Act (ACA), with Congress directing CMS to reduce payments to hospitals with higher than expected 30-day readmission rates. However, as a recent article notes,⁴ the policy makers' emphasis on 30-day readmission may be misguided since the majority of readmissions take place outside the 30-day window. Additionally, patient-level factors outside of the hospital's control may drive a considerable part of hospital readmission rates, especially for longer-term readmission.

One key factor affecting readmission rates is believed to be patients' compliance with essential medications, including beta-blockers, lipid-lowering agents (statins), aspirin, and (depending on the patient) angiotensin-converting enzyme (ACE) inhibitors or angiotensin II receptor blockers (ARBs). Because extensive clinical trials have shown these drugs to be very effective, they have become important components of lifelong medical therapy for these patients.⁵ As a result, clinical guidelines now recommend that patients who survive an acute MI receive these medications.⁶

Previous studies have shown that better medication adherence could reduce medical spending,⁷⁻¹¹ in part due to reduced hospitalization and emergency department use. Both adherence and the likelihood of readmission are time-dependent variables, and we expected that the likelihood of readmissions was influenced more by drug adherence closer in time to the reference point than adherence further in the past.

ABSTRACT

Objectives

To examine the relationship between 6-month medication adherence and 1-year downstream heart disease–related readmission among patients who survived a myocardial infarction (MI).

Study Design

Retrospective, nested case-control analysis of Medicare fee-for-service beneficiaries who were discharged alive post MI in 2008 (n = 168,882).

Methods

Patients in the case group had their first heart-disease–related readmission post MI discharge during the 6-to-9-month period or the 9-to-12-month period. We then used propensity score matching to identify patients in the control group who had similar characteristics, but did not have a readmission in the same time window. Adherence was defined as the average 6-month medication possession ratio (MPR) prior to the first date of the time-window defining readmission.

Results

After controlling for demographics, insurance coverage, and clinical characteristics, patients who had a heart-disease–related readmission had worse adherence, with MPRs of 0.70 and 0.74 in the case and control groups, respectively. Odds ratio of MPR ≥ 0.75 was 0.79 (95% CI, 0.75-0.83) among those with a readmission relative to those without.

Conclusions

Our study shows that better 6-month medication adherence may reduce heart-disease–related readmissions within a year after an MI.

Am J Manag Care. 2014;20(11):e498-e505

To resolve the issue of time-dependent variables, we used a retrospective, nested case-control study design to examine the relationship between 6-month adherence following a hospitalization for MI and a subsequent readmission that occurs between 6 and 12 months post MI. This method is commonly used in medicine and health service research, but it has not been used to study adherence and readmission. We hypothesize that patients with better 6-month adherence to essential medications used to treat MI are less likely to have readmissions related to heart disease.

METHODS

Study Design

The key challenge to studying how adherence affects readmission is that both adherence and the likelihood of readmission are time-dependent variables. For example, to study the effect of 6-month adherence on the readmission rates within 1 year of discharge, we could not have simply compared the 1-year readmission rates among individuals with good or bad 6-month adherence. We needed to ensure that the interval used to measure adherence occurred within a reasonably short period prior to the time we measure readmission, so we could more confidently infer that the adherence affects readmission.

We attempted to address time dependency using a nested case-control design because it allowed us to measure adherence before potential readmission. Specifically, we identified the case group as beneficiaries who had their first heart disease–related readmission during 2 time windows post MI: 6 to 9 months and 9 to 12 months. We chose the follow-up period to be a minimum of 6 months for 2 reasons: first, short-term readmissions (eg, 30-day readmission) are more likely due to hospital factors than to patient medication adherence.¹² Second, 6 months is the shortest period to meaningfully measure adherence because prescriptions with a 90-day supply are now common.

We then used propensity score matching to identify the control group: Medicare beneficiaries who had similar characteristics to those in the case group, as measured by observed covariates, but who did not have a readmission in the same time window. For both groups, the main exposure variable (adherence) was defined as the average 6-month medication possession ratio (MPR) prior to the first date of the time window defining readmission.

Take-Away Points

This study demonstrates that patients' good adherence to essential myocardial infarction (MI) medications is a key factor in preventing readmission occurring 6 months to 1 year after discharge, and suggests that clinicians need to pay attention to outpatient medication adherence after inpatient discharge.

- The probability of having a preventable readmission 6 to 12 months post MI discharge was much lower for beneficiaries with good adherence to all MI drugs compared with those with poor adherence.
- Outpatient physicians should pay more attention to medication adherence among MI survivors to prevent readmission in the first year after discharge.

The first heart disease–related readmission day for each beneficiary in the case group was selected as the index date in order to focus the following 2 dates: the start date from which we counted back 6 months to define adherence, and the anchor date for the matched individuals in the control group to define adherence.

Data Source and Case/Control Groups

We used 2008 and 2009 pharmacy and medical claims data for all fee-for-service Medicare beneficiaries with Parts A, B, and D coverage who had an MI in 2008. MI was defined as having at least 1 inpatient claim with a primary or secondary diagnosis code as 410.X1 in *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*.

We first identified beneficiaries who a) had an MI in 2008 and were discharged alive (the discharge date was defined as discharge index date); b) were enrolled in a stand-alone Part D plan continuously for 6 months after the discharge index date; and c) had a heart disease–related readmission (primary and secondary ICD-9-CM diagnosis codes 390-459). We excluded patients who were readmitted within the first 6 months after discharge or who died.

Propensity Score Matching Adjustment Variables

To ensure that the case and control groups were comparable, we used propensity score matching. In calculating propensity scores, we first conducted a logistic model with the response variable as having a heart disease–related readmission between 6 and 9 months post discharge; that was the index date (ie, an indicator for case/control groups). In the model, we accounted for individual-level characteristics for demographic, insurance coverage, and health status. The demographic variables included gender, age (by group: aged ≤ 34 years, 35-50 years, 51-64 years, 65-74 years, 75-84 years, and ≥ 85 years), and race or ethnic group (non-Hispanic white, non-Hispanic black, Hispanic, Asian, and others/unknown, all relative to white).

Table 1. Beneficiaries With First Readmission 6 to 9 Months Post Discharge Compared With Their Matched Controls: Summary of Characteristics, Before and After Propensity Score Matching

		Before Matching			After Matching		
		Readmission		P	Readmission		P
		No	Yes		No	Yes	
N		68,074	7150		33,381	6864	
Female, %		45.2	43.1	<.001	42.4	42.7	.60
Race, %	White	81.4	77.1	<.001	78.0	77.5	.44
	Black	9.0	12.5	<.001	12.0	12.5	.23
	Hispanic	6.2	6.9	.02	6.5	6.6	.90
	Asian	2.0	2.1	.83	2.1	2.0	.74
	Native	0.6	0.7	.18	0.7	0.7	.84
	Others	0.7	0.7	.75	0.7	0.7	.70
Age, %	<35 y	0.2	0.1	.22	0.1	0.1	.93
	35-50 y	3.4	3.2	.31	3.0	3.1	.51
	51-64 y	10.6	12.4	<.001	12.1	12.3	.62
	65-74 y	31.8	26.6	<.001	25.4	26.6	.02
	75-84 y	32.7	33.2	.41	33.8	33.1	.26
	≥85 y	21.3	24.4	<.001	25.7	24.8	.10
Dual-eligible (Medicare/Medicaid), %		40.7	48.2	<.001	48.4	48.0	.49
Non-dual LIS, ≤150% FPL, %	7.4	7.0	0.32	7.7	7.0	0.06	
Disabled, %		14.1	15.7	<.001	15.1	15.5	.44
Previous MI, %		8.4	13.9	<.001	12.8	13.7	.02
More than 90 days in SNF, %	0.1	0.1	0.10	.1	0.1	0.39	
Risk scores	RxHCC	1.1	1.2	<.001	1.2	1.2	.005
	CMS-HCC	2.0	2.4	<.001	2.3	2.4	<.001
Zip code level	High school (some or grad), %	57.6	57.4	.24	57.4	57.4	.97
	College (some or grad), %	21.2	20.6	.001	20.6	20.6	.99
	Log of median household income	10.6	10.6	<.001	10.6	10.6	.84

CMS-HCC indicates Centers for Medicare & Medicaid Services—Hierarchical condition category risk scores; FPL, federal poverty line; LIS, low-income subsidy; log, logarithm; MI, myocardial infarction; LIS, low-income subsidy; RxHCC, prescription drug hierarchical condition category risk scores; SNF, skilled nursing facility.

Part D data have an enhanced Research Triangle Institute Race Code verified by first and last name algorithms, which is much more accurate than the usual race variable found in claims data.¹³ We also included information on whether the beneficiary qualified for Medicare because of disability.

The data included 2 additional insurance variables: whether the beneficiary had Medicaid (was dual-eligible) and/or received a low-income subsidy (LIS). These 2 variables provide information on the beneficiary’s income as

well as the amount of co-payment and premium subsidies they receive. The income of the median dual-eligible is 75% of the federal poverty level (FPL), although there is some variation across states, while the incomes of the beneficiaries in the LIS group are below 150% of the FPL. Thus, the income in the non-LIS group is above 150% of the FPL. However, since the majority of beneficiaries in the LIS group also have some Medicaid coverage, we created 3 mutually exclusive income categories: duals, non-dual LIS, and non-LIS.

Table 2. Beneficiaries With First Readmission 9 to 12 Months Post Discharge Compared With Their Matched Controls: Summary of Characteristics, Before and After Propensity Score Matching

		Before Matching			After Matching		
		Readmission		P	Readmission		P
		No	Yes		No	Yes	
N		61,500	5377		25,081	5184	
Female, %		45.3	44.9	.54	42.4	44.6	.003
Race, %	White	81.7	78.7	<.001	79.5	79.0	.40
	Black	8.8	11.1	<.001	10.9	11.0	.75
	Hispanic	6.1	6.9	.04	6.5	6.7	.71
	Asian	2.1	2.0	.68	1.9	2.0	.64
	Native	0.5	0.7	.23	0.7	0.7	.92
	Others	0.8	0.7	.45	0.6	0.7	.37
Age, %	<35 y	0.1	0.3	.01	0.2	0.3	.30
	35-50 y	3.5	3.4	.81	3.2	3.3	.77
	51-64 y	10.6	10.9	.51	10.4	10.7	.49
	65-74 y	32.3	28.7	<.001	27.9	28.7	.21
	75-84 y	32.8	32.3	.43	32.4	32.3	.95
	≥85 y	20.7	24.5	<.001	25.9	24.6	.05
Dual-eligible (Medicare/Medicaid), %	40.0	45.7	<.001	46.3	45.7	0.42	
Non-dual LIS, ≤150% FPL, %	7.4	7.7	0.42	6.8	7.6	0.03	
Disabled, %		14.2	14.6	.45	13.9	14.3	.37
Previous MI, %		7.9	13.2	<.001	12.5	13.2	.07
More than 90 days in SNF, %	0.1	0.1	0.38	.1	0.1	0.88	
Risk scores	RxHCC	1.1	1.2	<.001	1.2	1.2	.57
	CMS-HCC	2.0	2.3	<.001	2.3	2.3	.07
Zip code level	High school (some or grad), %	57.6	57.4	.09	57.6	57.3	.07
	College (some or grad), %	21.2	20.7	.005	20.6	20.7	.71
	Log of median household income	10.6	10.6	.08	10.6	10.6	.28

CMS-HCC indicates Centers for Medicare & Medicaid Services—Hierarchical condition category risk scores; FPL, federal poverty line; LIS, low-income subsidy; log, logarithm; MI, myocardial infarction; RxHCC, prescription drug hierarchical condition category risk scores; SNF, skilled nursing facility.

The health status variables included 2 prospective risk scores: the CMS Hierarchical Condition Category score and the analogous score for prescription drugs. These risk scores were calculated using the diagnoses and spending in the year prior to the discharge index date. We calculated the prospective risk scores using prior year diagnoses, except for the 2.3% of the sample who were new enrollees, for whom we used concurrent risk scores based on age and gender.¹⁴ Risk scores represent a proxy for health sta-

tus, with higher scores indicating greater severity of illness and higher expected healthcare utilization. We included 2 additional health status indicators: one for a history of prior MI and the other for institutionalization, defined as 90 days of care in a nursing home. Our sample represents community-residing beneficiaries; less than 0.1% spent more than 90 days in nursing home facilities. Because Part D data include drugs used in nursing homes, we did not exclude these individuals.

Finally, the model accounted for zip code level income and education: logarithm of the median household income within the zip code in which the beneficiary lived, and educational level (percentages of residents in the zip code who had not completed high school, had completed high school only, and had attended or completed college).

Nearest Neighbor 1:5 Matching

We used nearest neighbor 1:5 matching with replacement, restricting the difference in propensity scores to be within .001. When using 6 to 9 months post MI as a window for readmission, we had 7264 cases and 68,074 potential controls. We were able to match 6864 cases. Our final sample included these 6864 cases and 33,726 controls. (We had 404 cases with fewer than 5 controls). When using 9 to 12 months post MI as the window for readmission, we had 5377 total cases and 61,500 potential controls. We were able to match 5184 cases and our final sample includes these 5184 cases and 25,843 controls.

Measurement of Adherence

We calculated 6-month adherence by tracing back from the readmission date for 6 months. Because the control group did not have a readmission date, we traced back from the anchor date, defined above, for 6 months to determine 6-month adherence. In addition, we constrained beneficiaries to be continuously enrolled in a stand-alone Part D plan during the 6-month MPR measurement periods. As a result, the total sample size dropped from 40,590 to 40,245 for the 6-to-9-month readmission window, and from 31,027 to 30,265 for the 9-to-12-month readmission window.

Two adherence measures were created: 1 for beta-blockers and the other for all 3 subclasses used to treat MI (beta-blockers, statins, and ACE inhibitors/ARBs). We measured adherence for only beta-blockers separately because the 6-month persistent use of beta-blockers post MI is a Healthcare Effectiveness Data and Information Set (HEDIS) quality measure. We did not measure adherence for aspirin because aspirin is usually purchased over the counter and is not included in Part D claims data.

Adherence was measured by MPR, defined as the ratio of days of supply of medication the patient had in possession (numerator) over the number of days in the measurement period multiplied by the number of medications

Table 3. Estimated Medication Possession Ratios Comparing Beneficiaries With and Without a Heart Disease–Related Readmission, Using Results From Rate Regressions

		6-9 Months Post MI	9-12 Months Post MI
All MI drugs	With readmission	0.70	0.70
	Without readmission	0.74	0.74
Beta-blockers	With readmission	0.75	0.77
	Without readmission	0.78	0.80

MI indicates myocardial infarction. The dependent variable is 6-month medication possession ratio ranging from 0 to 1. The covariates include individual-level characteristics for demographics, insurance coverage, and health status, as well as zip code level income and education (see "Propensity Score Matching Adjustment Variables" section in text). Figures in Table 3 are after adjustment for these covariates.

prescribed (denominator). Since we include several different medications into 1 MPR measurement, we only count medications in the denominator after the initial prescription following hospital discharge. For example, suppose a patient filled her first beta-blocker prescription on January 1, 2008, and her first ACE inhibitor prescription on February 1, 2008. Her MPR would be the number of beta-blocker pills in the first month divided by 30, while her MPR for the subsequent months would be her number of beta-blocker pills plus the number of ACE inhibitor pills divided by 60.

We then defined 2 indicators for good adherence with 2 commonly used thresholds.^{11,15} The first indicator: 1 = MPR \geq 0.80; 0 = otherwise. The second indicator: 1 = MPR \geq 0.75; 0 = otherwise. We excluded any days in the hospital, for any non–heart-related reason, from the denominator when calculating the MPR because medications used in the hospital cannot be observed in Part D event data (excluding or not excluding hospital days gives very similar results, because we were only measuring 6-month adherence). Prescriptions filled during any nursing home stay, however, can be observed in Part D data and so were included.

Statistical Analysis After Matching

We tested the distribution of MPR and found it was not normally distributed. Thus, after propensity score-matching, we performed 2 types of regressions: a rate logistic regression and a binary logistic regression. In the rate logistic regression, the dependent variable is 6-month MPR ranging from 0 to 1. In the binary logistic regression, the dependent variable is the indicator for good adherence—we tested separately for MPR \geq 0.8 and MPR \geq 0.75. Robust standard errors were used to adjust for the dependence within each matched group.

In both models, the key independent variable was the indicator for being in the case or control group—that is,

whether one had a heart disease–related readmission during the time window. We also controlled for all the covariates used in calculating propensity scores, and we then applied a doubly robust procedure in estimating covariate effects in the main outcome models (the 2 types of logistic regression models). The resulting estimators give unbiased estimates of covariate effects when either propensity score or main outcome model is correctly specified, thus allowing the analyst 2 opportunities for obtaining accurate results (doubly robust). The assumption of no unmeasured confounders is still required.¹⁶

Finally, with this study design, the regression results provide the probability of having good adherence conditional on whether one had a readmission. However, the probability of having a readmission conditional on whether one is a good adherent or not is the core policy-relevant variable. Thus, we used Bayesian probability theory to calculate the probabilities of having readmission given whether one was a good adherent or not. We calculated these separately for each time window and adherence measure.

RESULTS

The comparisons of characteristics between the case and control groups before and after propensity score-matching are summarized in **Table 1** (6-9 months post MI cohort) and **Table 2** (9-12 months post MI cohort). Most characteristics are comparable between case and control groups after matching. For the characteristics that have statistically significant differences between the cases and the controls, the magnitude of the differences is small. In the 6 to 9 months cohort, about 15% of our sample were younger than 65 years; 43% were female; and 14% had a history of MI prior to 2008.

Effects of 6-month adherence on downstream readmission. Both rate (**Table 3**) and logistic (**Table 4**) regressions

■ **Table 4.** Odds Ratios: Fully Adherent With a Heart Disease–Related Readmission Versus Those Without a Readmission; Results From Logistic Regressions

	Odds Ratio	SE	95% CI
First Readmission Occurring During 6-9 Months Post Post-MI Discharge			
MPR ≥ 0.75 for all MI drugs	0.79	0.02	(0.75-0.83)
MPR ≥ 0.75 for beta-blockers	0.83	0.03	(0.79-0.89)
MPR ≥ 0.80 for all MI drugs	0.78	0.02	(0.74-0.83)
MPR ≥ 0.80 for beta-blockers	0.84	0.03	(0.79-0.89)
First Readmission Occurring During 9-12 Months Post Post-MI Discharge			
MPR ≥ 0.75 for all MI drugs	0.74	0.02	(0.70-0.79)
MPR ≥ 0.75 for beta-blockers	0.81	0.03	(0.75-0.87)
MPR ≥ 0.80 for all MI drugs	0.73	0.02	(0.68-0.77)
MPR ≥ 0.80 for beta-blockers	0.79	0.03	(0.74-0.85)
MI indicates myocardial infarction; MPR, medication possession ratio. The dependent variable is the indicator for good adherence—we tested separately for MPR ≥ 0.8 and MPR ≥ 0.75 . The covariates include individual-level characteristics for demographic, insurance coverage, and health status, as well as zip code level income and education (see the "Propensity Score Matching Adjustment Variables" section in text).			

confirm that patients with downstream heart disease-related readmissions had poorer adherence for beta-blockers, ACE inhibitors/ ARBs, and statins prior to readmission. These results are after adjustment of all the patient-level and zip code level covariates discussed above. In particular, in the 6-to-9-months cohort, as shown in **Table 3**, the rate regressions demonstrate that the MPRs for all MI drugs were lower among those with a downstream readmission, 0.70 in the case group relative to 0.74 in the control group after adjustment for all covariates. Adherence to beta-blockers was slightly better, with means of 0.75 and 0.78 in the case and control groups, respectively. The results from the analyses of our 9 to 12 months data were similar.

Similarly, logistic regressions shown in **Table 4** demonstrate that the odds ratio of having MPR ≥ 0.80 for all MI drugs was 0.78 (95% CI, 0.74-0.83) in the case group relative to that of the control group; the analogous odds ratio for beta-blockers was 0.84 (95% CI, 0.79-0.89) (**Table 4**). The results were similar when we used MPR ≥ 0.75 as a threshold for good adherence. Results are robust in the sensitivity analysis in the 9 to 12 months cohort.

Probability of having a heart disease–related readmission conditional on adherence status. The first 2 columns of **Table 5** report the probability of having good adherence conditional on whether one had a readmission. These numbers were estimated from the logistic regressions after adjustment of the variables used in the propensity score matching. The last 2 columns of **Table 5** report the prob-

Table 5. Probability of Having a Heart Disease–Related Readmission Conditional on Medication Adherence, Using Bayesian Probability Theory

	Probability (Good Adherence No Readmission)	Probability (Good Adherence Readmission)	Probability (Readmission Good Adherence) ^a	Probability (Readmission Poor Adherence) ^a
First Readmission Occurring During 6-9 Months Post Post-MI Discharge				
MPR ≥0.75 for all MI drugs	0.569	0.510	0.086	0.107
MPR ≥0.75 for beta-blockers	0.661	0.619	0.090	0.106
MPR ≥0.80 for all MI drugs	0.507	0.446	0.085	0.106
MPR ≥0.80 for beta-blockers	0.634	0.593	0.089	0.105
First Readmission Occurring During 9-12 Months Post Post-MI Discharge				
MPR ≥0.75 for all MI drugs	0.578	0.505	0.071	0.093
MPR ≥0.75 for beta-blockers	0.694	0.646	0.075	0.092
MPR ≥0.80 for all MI drugs	0.522	0.442	0.069	0.092
MPR ≥0.80 for beta-blockers	0.674	0.621	0.075	0.092
MI indicates myocardial infarction; MPR, medication possession ratio.				
^a The probability of having a readmission conditional on whether one was a good adherent or not was calculated using Bayes' rule.				

ability of having a readmission conditional on whether one was a good adherent or not, converted using Bayes' rule. For example, the probability of having a readmission 6 to 9 months post MI discharge was 8.6% for beneficiaries with good adherence (MPR ≥0.75) for all MI drugs, whereas the probability was 10.7% for those beneficiaries with an MPR <0.75.

DISCUSSION

We found that patients with better adherence to MI drugs had lower downstream heart disease–related readmission rates, after controlling for observed patient-level and zip code level characteristics. Using the Medicare population who had a recent history of MI, our study demonstrates that medication adherence is an independent factor associated with lower downstream readmission after adjustment for other patient characteristics.

Few studies have examined readmission after 30-day post discharge. One study by Jencks and colleagues noted that among all Medicare fee-for-service beneficiaries in 2003 and 2004, the accumulative rate of rehospitalizations within 3 months postdischarge regardless of medical conditions was 34%; the accumulative rate within 6 months was 47.9%; and within 12 months postdischarge, 59.4%.¹⁶ Our study shows that better medication adherence can potentially reduce readmission and may therefore save money for Medicare.

Limitations

Our study has some limitations. First, because there was not random assignment to the case and control groups, we

used a propensity score matching method. However, there may have been unobserved variables that were related to both adherence and readmission, which may have biased our estimates. Second, our matching algorithm was not perfect; even after matching, the case and control groups differed significantly on risk scores, but the magnitude was small. Third, there may be some errors with measuring adherence using claims data: we cannot observe patients who were prescribed a drug but refused to take it, and we cannot observe all contraindications to the studied drugs (eg, we cannot see measures such as low left ventricular ejection fraction, a contraindication for ACE inhibitors). In those cases where we saw a prescription filled in the claims for an ACE inhibitor, we assumed that the physician who prescribed the drug had evaluated the patient's profile for contraindications. We also cannot distinguish whether an MI is an ST-segment elevation or not, which is associated with higher early mortality and morbidity. Finally, claims data do not have individual level demographic variables such as education and income, but we used zip code level data.

CONCLUSIONS

Beginning in 2013, hospitals began receiving decreased Medicare payments if they had higher than expected 30-day readmission rates for MI, heart failure, and pneumonia. Under ACA, the list of conditions will be expanded. We found that patient compliance to medication treatment is a significant independent predictor of readmission occurring between 6 and 12 months post MI discharge. This implies that patients need to be moni-

tored past the typical 30-day time period regarding their medication use.

Acknowledgments

We would like to thank Shang-Hua (Sean) Wu, The UCLA Center for Health Policy Research for his excellent programming assistance.

Author Affiliations: Department of Health Policy and Management, Graduate School of Public Health (YZ, SHB, JRL) and Department of Medicine, School of Medicine (C-CHC), University of Pittsburgh, Pittsburgh, PA; Department of Preventative Medicine, College of Medicine, University of Tennessee Health Science Center (CMK), Memphis, TN.

Source of Funding: National Institute of Mental Health (No. R01 MH088510) and Agency for Healthcare Research and Quality (No. R01 HS018657).

Author Disclosures: Dr Zhang received grants from the National Institute of Mental Health and the Agency for Healthcare Research and Quality to fund this project. Drs Hyon Baik, Chang, Kaplan, and Lave report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (YZ, SHB, C-CHC, CMK, JRL); acquisition of data (YZ, SHB, JRL); analysis and interpretation of data (YZ, SHB, C-CHC, CMK, JRL); drafting of the manuscript (YZ, SHB, C-CHC, CMK, JRL); critical revision of the manuscript for important intellectual content (YZ, C-CHC, JRL); statistical analysis (YZ, SHB, C-CHC, CMK); obtaining funding (YZ); administrative, technical, or logistic support (YZ); supervision (YZ).

Address correspondence to: Yuting Zhang, PhD, Department of Health Policy and Management, University of Pittsburgh, 130 De Soto St, Crabtree Hall A664, Pittsburgh, PA 15261. E-mail: ytzhang@pitt.edu.

REFERENCES

1. Roger VL, Go AS, Lloyd-Jones DM, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2011 update: a report from the American Heart Association. *Circulation*. 2011;123(4):e18-e209.
2. Rodriguez F, Joynt KE, Lopez L, Saldaña F, Jha AK. Readmission rates for Hispanic Medicare beneficiaries with heart failure and acute myocardial infarction. *Am Heart J*. 2011;162(2):254-261.e3.
3. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for medicare beneficiaries by race and site of care. *JAMA*. 2011;305(7):675-681.
4. Joynt KE, Jha AK. Thirty-day readmissions—truth and consequences. *N Engl J Med*. 2012;366(15):1366-1369.
5. Wald NJ, Law MR. A strategy to reduce cardiovascular disease by more than 80%. *BMJ*. 2003;326(7404):1419.
6. Antman EM, Hand M, Armstrong PW, et al; 2004 Writing Committee Members. 2007 focused update of the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines: developed in collaboration with the Canadian Cardiovascular Society endorsed by the American Academy of Family Physicians: 2007 Writing Group to review new evidence and update the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction, writing on behalf of the 2004 Writing Committee. *Circulation*. 2008;117(2):296-329.
7. Choudhry NK, Patrick AR, Antman EM, Avorn J, Shrank WH. Cost-effectiveness of providing full drug coverage to increase medication adherence in post-myocardial infarction Medicare beneficiaries. *Circulation*. 2008;117(10):1261-1268.
8. Stuart B, Davidoff A, Lopert R, Shaffer T, Shoemaker JS, Lloyd J. Does medication adherence lower Medicare spending among beneficiaries with diabetes? *Health Serv Res*. 2011;46(4):1180-1199.
9. Sokol MC, McGuigan KA, Verbrugge RR, Epstein RS. Impact of medication adherence on hospitalization risk and healthcare cost. *Med Care*. 2005;43(6):521-530.
10. Roebuck MC, Liberman JN, Gemmill-Toyama M, Brennan TA. Medication adherence leads to lower health care use and costs despite increased drug spending. *Health Aff (Millwood)*. 2011;30(1):91-99.
11. Choudhry NK, Avorn J, Glynn RJ, et al; Post-Myocardial Infarction Free Rx Event and Economic Evaluation (MI FREEE) Trial. Full coverage for preventive medications after myocardial infarction. *N Engl J Med*. 2011;365(22):2088-2097.
12. Hochhalter AK, Basu R, Prasla K, Jo C. Retrospective cohort study of medication adherence and risk for 30-day hospital readmission in a Medicare cost plan. *Manag Care*. 2014;23(1):43-47.
13. Bonito AJ, Bann C, Eicheldinger C, Carpenter L. Creation of new race-ethnicity codes and socioeconomic status (SES) indicators for Medicare beneficiaries. final report. Agency for Healthcare Research and Quality website. <http://www.ahrq.gov/qual/medicareindicators/medicareindicators.pdf>. Published January 2008. Accessed October 21, 2013.
14. 2011 Model diagnosis and model software—RxHCC model software. 2011; CMS website. <http://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/Risk-Adjustors-Items/Risk2006-2011.html?DLPage=1&DLSort=0&DLSortDir=descending>. Published 2011. Accessed November 6, 2013.
15. Zhang Y, Lave JR, Donohue JM, Fischer MA, Chernew ME, Newhouse JP. The impact of Medicare Part D on medication adherence among older adults enrolled in Medicare-Advantage products. *Med Care*. 2010;48(5):409-417.
16. Kang JDY, Schafer JL. Demystifying double robustness: a comparison of alternative strategies for estimating a population mean from incomplete data. *Statist Sci*. 2007;22(4):523-539.
17. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. 2009;360(14):1418-1428. ■

www.ajmc.com Published as a Web Exclusive