Care following Acute Myocardial Infarction in the Veterans Administration Medical Centers: A Comparison with Medicare

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Objective. To compare patients treated for acute myocardial infarction (AMI) in a Veterans Health Administration (VHA) facility to similar patients treated under Medicare.

Data Sources. Administrative data on 13,129 elderly male veterans hospitalized for AMI in a VHA facility between October 1, 1996, and September 30, 1999, and a matched set of male Medicare beneficiaries with AMI treated in a non-VHA facility during the same time period.

Study Design. We conducted a retrospective cohort study using propensity score methods to identify a matched set of male elderly AMI patients treated either in a VHA facility or in a non-VHA facility under Medicare. We compared the two groups of patients according to characteristics of the admitting hospital, distances traveled for care, the use of invasive procedures, and mortality. We assessed the robustness of our conclusions to biases arising from unmeasured confounders using sensitivity analyses.

Principal Findings. VHA patients were significantly less likely than Medicare beneficiaries to be admitted to high-volume facilities (for example, 25 percent versus 46 percent in 1999, $p<0.001$) or facilities with the capability to perform invasive cardiac procedures. Compared to Medicare patients, VHA patients traveled almost twice as far to their admitting hospital. The VHA patients were significantly less likely to undergo coronary angiography or revascularization in the 30 days following their AMI ($p<0.001$ for all comparisons). Veterans treated in the VHA had significantly higher mortality at one-year in all years studied (for example, 35.2 percent versus 30.6 percent in 1999). The proportion of elderly VHA patients admitted to high-volume facilities increased and 30-day mortality rates decreased between 1997 and 1999. Using sensitivity analyses to assess possible effects of unmeasured confounders, we could explain some but not all of the observed mortality differences.

Conclusions. We observed differences in the way care for AMI patients was structured, in the use of invasive therapies, and in long term mortality between patients treated in VHA hospitals and those treated in non-VHA facilities under Medicare. Future research should focus on explanations for the differences between the two systems and for the reduction in short-term mortality among VHA patients. Further study of these differences both between and within the systems of care may help identify cost-effective strategies to improve care in both sectors.

Key Words. Acute myocardial infarction, Veterans Health Administration, mortality, outcome and process assessment (health care), Medicare

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The Veterans Health Administration (VHA) operates the largest integrated medical system in the United States. In 1996 the system became available to all veterans through an act of Congress. As a result, the number of veterans treated increased from 2.9 million in 1996 to 4.2 million in 2002 (Walsh 2003). This surge in patients and continued interest in monitoring care provided to veterans led the Office of Policy and Planning in the Department of Veterans Affairs to request an external evaluation of care provided to veterans with acute myocardial infarction (AMI). As contractors for this evaluation we compared the care provided to male veterans 65 years of age and older treated for AMI in VHA facilities to that provided to comparable Medicare beneficiaries treated in non-VHA facilities. We compared the two groups of patients according to characteristics of the hospitals to which they were admitted, distances traveled for care, utilization of invasive cardiac procedures, and mortality. We also assessed the robustness of our conclusions to biases arising from unmeasured confounders using sensitivity analyses. Our results complement those of prior studies (Wright et al. 1999; Petersen et al. 2000; Petersen et al. 2003) by comparing utilization and both short- and long-term outcomes in national cohorts of patients treated over the course of three recent years.

METHODS

Study Population

Veterans. We identified all male patients aged 65 and older treated for an AMI (primary diagnoses ICD-9-CM = 410.xx, excluding 410.x2) during the period October 1, 1996, through September 30, 1999 (N = 15,295), using the Patient

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Treatment File (PTF), a national administrative database that documents all inpatient admissions to VHA hospitals. We excluded (1) those whose AMI was likely a complication of noncardiac surgery (to assure that AMI was the primary reason for the admission[1]; $n = 172$, 1.1 percent) (Wright et al. 1999); (2) those who were likely admitted only to rule out a myocardial infarction (discharged alive in less than three days; $n = 246$, 1.6 percent); (3) those who were long-term residents in nursing homes[2] (length of stay > 180 days; $n = 15$, 0.1 percent) (Wright et al. 1999); (4) those who were enrolled in a Medicare health maintenance organization (HMO) at the time of their hospitalization ($n = 814$, 5.3 percent); and (5) those not initially admitted to a VHA facility (to reduce bias associated with patients initially treated at non-VHA facilities who were transferred to a VHA facility for palliative care; $n = 920$, 6.0 percent), leaving a cohort of 13,129 patients (some patients met more than one exclusion criteria).

Medicare Beneficiaries. We identified all male patients aged 65 and older treated for AMI (principal diagnoses ICD-9-CM = 410.xx, excluding 410.x2) during the period October 1, 1996, through September 30, 1999 ($N = 447{,}445$), using Medicare Part A files. We excluded those who were likely admitted only to rule out an AMI (discharged alive in less than three days) ($n = 7{,}497$, 1.7 percent) and those who were enrolled in a Medicare HMO at the time of their hospitalization ($n = 34{,}486$, 7.7 percent).

Index Episode. Based on date of admission we created three cohorts of patients according to fiscal year (1997, 1998, and 1999) for each of the two sectors of care. We linked contiguous inpatient records to define an index episode of admission. Because VHA patients may be transferred to non-VHA facilities to receive invasive procedures if they are not available at the VHA hospital (Fleming et al. 1992; Wright et al. 1997; Wright et al. 1999), we included transfers to non-VHA hospitals paid for by either the VHA or Medicare. Patients initially admitted to a VHA facility and then transferred to a non-VHA facility were classified as VHA patients. As they represented less than 10 percent of the VHA cohort, we did not analyze these transferred patients as a separate subgroup and all reported results are for the combined cohort.

Comparison Variables

Characteristics of Admitting Hospitals. We calculated the volume of AMI patients per hospital as the number of admissions for patients aged 65 or older with a primary diagnosis of AMI using data from the PTF and Medicare Part A files for the VHA and non-VHA facilities, respectively. We determined a hospital's capability to perform coronary angiography and coronary artery bypass graft (CABG) based on data contained in PTF and Outpatient Clinic (OPC) files for VHA facilities and from Part A, hospital outpatient, and Part B files for the non-VHA facilities. We counted the number of claims for these procedures for patients age 65 and older with a diagnosis of ischemic heart disease (ICD-9-CM = 410-414) and considered a hospital as having coronary angiography capabilities if there were five or more claims for angiography and as having CABG capabilities if ten or more procedures were performed within a given year (McClellan, McNeil, and Newhouse 1994). We then created three binary variables to indicate whether VHA and Medicare patients were admitted to a high-volume facility (more than 2.8 AMI admissions per week, the upper quartile in the distribution across all non-VHA facilities), a facility with angiography capabilities, and a facility with CABG capabilities.

Distances Traveled for Care. We obtained the latitude and longitude representing the geographic center of the zip code of each patient's residence from the United States Census Bureau and the hospital's longitude and latitude from the American Hospital Association's 1999 Survey. We approximated the distance traveled by patients to their admitting hospital as the arc distance along the earth's surface from the geographic center of the zip code of the patient's residence to the hospital. We also estimated the distance between each patient's home and the closest facility. Finally, we determined if VHA and Medicare patients were transferred to a different facility to receive either coronary angiography or a revascularization procedure and estimated the distance from the patient's home to the transfer facility as described above.

Utilization. Utilization measures included the receipt of coronary angiography, percutaneous interventions (PCI), CABG, or any revascularization procedure (either PCI or CABG) within 30 days of admission and the fraction of patients who received a stent when undergoing PCI, which we identified using PTF and OPC claims for VHA patients and Part A, outpatient, and Part B claims for Medicare patients. For VHA patients who were also eligible for care under Medicare, we included all procedures received in a non-VHA hospital identified through Medicare claims.

Mortality. Vital status for Medicare patients was determined from the Medicare enrollment and Part A files. These files have been shown to be highly accurate with sensitivity as high as 99.6 percent (B. Frank, Research Data Assistance Center [ResDAC], personal communication, June 2002). Because previous studies have shown that mortality data from VA sources, the Veterans Affairs Beneficiary Identification and Record Location Subsystem (BIRLS), and the PTF, only capture 91.1 percent to 94.5 percent of deaths (Cowper et al.

2002), vital status for VHA patients was determined using the BIRLS, the PTF, the National Death Index (NDI), and Medicare enrollment files.

To avoid a proportional hazard assumption that restricts differences between VHA and Medicare patients to be constant over the years of follow-up, we analyzed mortality at fixed time points following admission for AMI (30-day and 1-year). Due to the availability of longer follow-up data on older cohorts, we also assessed 2-year mortality for the 1997 and 1998 cohorts and 3-year mortality for the 1997 cohort.

Control Variables

Comorbid conditions were coded based on secondary diagnosis codes from the index admission as well as primary and secondary diagnosis codes from inpatient encounters in the prior year (Normand et al. 1995). We linked the zip code of each patient's residence to data from the 1990 U.S. Census to obtain information on socioeconomic characteristics.

Data Analysis

Because VHA patients differed from Medicare patients with respect to many important sociodemographic and clinical characteristics (Table 1), we used propensity score methods to create cohorts of matched patients with similar observed characteristics (Rosenbaum and Rubin 1983; Rubin 1997; D'Agostino 1998). We first developed a score for each patient that represented his propensity to be treated in a VHA facility using a logistic regression model that included all of the variables contained in Table 1. For each VHA patient hospitalized with AMI in a given year, we selected a group of Medicare patients treated in the same quarter of the year who were cared for in a non-VHA facility located within the geographic boundary of the Veteran Integrated Service Network (VISN) in which the VHA patient was treated. We then matched each VHA patient to the Medicare patient in this subset with the closest estimated propensity to be treated in a VHA facility within a specified range expected to reduce differences between groups by at least 90 percent (Rosenbaum and Rubin 1985).

We compared characteristics of the admitting hospital, distances traveled for care, utilization of invasive cardiac procedures, and mortality between the VHA and Medicare using the matched samples. Because, even after matching, there were minor imbalances in observed characteristics between VHA and Medicare patients, we adjusted the use of cardiac procedures and mortality in the two groups using logistic regression models fit to the matched

Table 1: Characteristics of Male Patients Aged 65 and Older Treated for AMI in VHA Facilities and in Non-VHA Facilities under Medicare, FY 1997–1999

	Unmatched Patients			*Matched Patients*		
	VHA (*N* = *13,129*)	*Medicare* (*N* = *384,470*)	*P*	*VHA* (*N* = *12,985*)	*Medicare* (*N* = *12,985*)	*P*
Age (Mean)	73.9	75.9	<0.001	73.9	74.0	0.67
Race:			<0.001			0.007
White (%)	79.6	91.9		80.2	81.3	
African American (%)	11.8	5.3		11.9	10.9	
Hispanic (%)	5.3	0.9		4.5	4.1	
Missing/other (%)	3.4	1.9		3.3	3.7	
Percent with college degree in zip code of residence[a]	19.6	22.7	<0.001	19.7	19.7	0.93
Median household income in zip code of residence[a] (dollars)	32,594	38,174	<0.001	32,823	32,440	0.03
Percent professionals in zip code of residence[a]	20.3	22.9	<0.001	20.5	20.3	0.26
Percent African American in zip code of residence[a]	13.0	8.5	<0.001	13.1	11.7	<0.001
Percent Hispanic in zip code of residence[a]	5.3	4.9	<0.001	5.4	5.8	0.007
Percent with public assistance in zip code of residence[a]	9.4	7.8	<0.001	9.5	9.3	0.02
Percent >64 with public assistance in zip code of residence[a]	10.5	9.1	<0.001	10.6	10.6	0.79
Missing census data (%)	7.9	5.8	<0.001	7.2	7.3	0.90
Prior MI[b] (%)	12.0	12.9	0.003	11.7	11.7	0.97
Chronic angina[b] (%)	7.4	5.9	<0.001	7.4	7.4	0.98
Unstable angina[b] (%)	8.1	6.7	<0.001	8.0	7.9	0.91
Arrhythmia[b] (%)	10.2	10.0	0.57	10.2	10.0	0.51
Cardiac arrest[b] (%)	1.3	1.9	<0.001	1.4	1.3	0.63
Arthritis[b] (%)	11.0	9.0	<0.001	11.0	11.3	0.39
Cancer[b] (%)	6.9	5.4	<0.001	6.9	6.9	0.86
CHF[b] (%)	15.6	13.5	<0.001	15.6	15.0	0.24
Coagulation disorder[b] (%)	1.1	0.9	0.06	1.1	0.9	0.14
Conduction abnormality[b] (%)	2.5	3.1	<0.001	2.5	2.7	0.23

Conduction disorder[b] (%)	0.4	0.5	0.23	0.4	0.5	0.65
COPD[b] (%)	32.5	27.5	<0.001	32.5	33.3	0.22
Connective tissue disease[b] (%)	0.4	0.6	0.003	0.4	0.4	0.92
CVA[b] (%)	4.8	3.0	<0.001	4.4	4.1	0.26
Dementia[b] (%)	6.5	5.4	<0.001	6.5	6.2	0.26
Diabetes[b] (%)	33.1	23.6	<0.001	32.9	33.3	0.45
Diabetes w/ end organ damage[b] (%)	7.8	4.9	<0.001	7.7	7.5	0.48
Alcohol/drug abuse[b] (%)	4.5	2.5	<0.001	4.6	4.5	0.98
Thyroid disease[b] (%)	5.4	4.8	<0.001	5.4	5.6	0.57
Fluid disorder[b] (%)	4.5	4.7	0.27	4.5	4.6	0.81
GI bleeding[b] (%)	2.1	1.2	<0.001	2.1	2.3	0.47
Hypertension[b] (%)	60.0	47.2	<0.001	59.7	59.4	0.66
Hypertension w/ complications[b] (%)	2.7	4.9	<0.001	2.7	2.7	0.97
Liver disease[b] (%)	0.6	0.4	<0.001	0.6	0.6	1.00
Neurological disorder[b] (%)	2.8	4.3	<0.001	2.8	2.5	0.19
Paralysis[b] (%)	0.4	0.2	<0.001	0.4	0.2	0.04
Pneumonia[b] (%)	5.4	4.3	<0.001	5.4	5.2	0.41
Psychosis[b] (%)	3.7	1.7	<0.001	3.5	3.6	0.74
Neurotic disorder[b] (%)	2.0	0.9	<0.001	2.0	1.5	0.001
Lung disease[b] (%)	0.8	0.8	0.86	0.8	0.8	0.94
Renal failure[b] (%)	5.6	4.1	<0.001	5.6	5.5	0.85
Hypotension[b] (%)	3.9	4.1	0.43	3.9	3.8	0.48
Syncope[b] (%)	1.9	1.5	<0.001	2.0	1.9	0.79
Ulcers[b] (%)	2.1	0.9	<0.001	2.0	1.9	0.37
UTI[b] (%)	4.7	2.8	<0.001	4.6	4.6	0.88
Endocarditis[b] (%)	3.4	4.7	<0.001	3.4	3.2	0.43
PVD[b] (%)	13.2	11.2	<0.001	13.2	13.3	0.80

P-values are based on the Pearson chi-square test for categorical variables and T-test for continuous variables.

[a]Obtained from 1990 U.S. Census by linking to the zip code of the patient's residence.

[b]Obtained from primary and secondary diagnoses from inpatient claims.

samples. These models included all of the variables that comprised the propensity score model listed above. We report p-values associated with system of care based on two-sided tests. We then used the estimated regression models and the observed characteristics in the matched cohorts to compute adjusted proportions for each outcome in the two groups. Specifically, we estimated adjusted outcomes in the VHA by averaging the predicted probability of the outcome assuming that each patient was treated in a VHA facility and that all other variables remained unchanged. We then repeated this calculation assuming that each patient was treated under Medicare.

Sensitivity Analyses

To assess the effect of *unobserved* differences between patients treated in the two sectors, we performed a series of sensitivity analyses to evaluate whether patients' unmeasured characteristics, such as socioeconomic status, health behaviors, or disease severity, might explain mortality differences between the two groups. We examined the effect of four unmeasured variables—two related to disease severity on admission (systolic blood pressure <100 and cardiac arrest); one health behavior (smoking status); and one measure of socioeconomic status (having a college degree)—on the robustness of our results. We chose these four variables because they were strongly associated with both sector of care and outcomes and because they represented three major categories of variables that we were unable to adequately adjust for in our analysis. We updated the estimates of differences in mortality between VHA and Medicare patients after adjusting for these additional unmeasured variables (Lin, Psaty, and Kronmal 1998). The adjustments were based on specific assumptions regarding differences in the prevalence of confounders in VHA and Medicare patients and their relationship with mortality following an AMI. We obtained estimates of these relationships from prior literature where available (Krumholz et al. 1999; Petersen et al. 2000; Hardarson et al. 2001; Rea et al. 2002). We used the 1997, 1998, and 1999 National Health Interview Surveys (NHIS) to estimate the prevalence of smoking and a college education (and their correlation) in men aged 65 and older with either VHA or Medicare insurance.

RESULTS

Patient Characteristics

Prior to matching, VHA patients were younger, but were more likely to have comorbid disease compared to Medicare patients with AMI (Table 1). The

VHA cohort also had larger numbers of racial and ethnic minorities and VHA patients were more likely to live in areas with lower levels of education and income. After matching, differences between the two systems were substantially reduced (Table 1).

Unadjusted Results

In all years unadjusted procedure rates were substantially higher in the Medicare cohort. Pooling across years, Medicare patients underwent angiography 1.5 times more often than VHA patients did (60 percent versus 39 percent; $p < 0.001$), and revascularization procedures were used twice as often (43 percent versus 21 percent; $p < 0.001$). Pooling across years, unadjusted mortality was 16.9 percent at 30 days in both sectors, but 3.6 percentage points higher at one year among VHA patients (34.5 percent versus 30.9 percent; $p < 0.001$).

Characteristics of Admitting Hospital and Distances Traveled for Care

The proportion of elderly VHA patients admitted to high-volume facilities (more than 2.8 AMI admissions per week, the upper quartile in the distribution across all non-VHA facilities) increased from 9.6 percent in 1997 to 24.7 percent in 1999 (Table 2). However, in each year elderly VHA patients were much less likely to be admitted to high-volume facilities or to facilities with the capability to perform invasive cardiac procedures than matched Medicare patients (Table 2). Moreover, VHA patients traveled on average almost twice as far (30 versus 17 miles in 1999) to their admitting hospital, even though they lived slightly closer to acute care facilities on average than matched Medicare patients (Table 2). In addition, VHA patients were less likely to be transferred to a different facility to receive angiography or revascularization and, if transferred, traveled greater distances to the transfer hospital (Table 2).

Utilization

In each year elderly VHA patients were much less likely to undergo invasive cardiac procedures (coronary angiography, PCI, and CABG) within 30 days of the AMI compared to matched Medicare patients (Table 3). For example, in 1999 Medicare patients underwent angiography 1.5 times more often than VHA patients did (61 percent versus 40 percent), and revascularization procedures were used twice as often (45 percent versus 22 percent). The proportion of VHA and Medicare patients that received a stent when undergoing PCI increased dramatically over the study years. Except in 1998, equal proportions of VHA and Medicare patients received a stent.

Table 2: Characteristics of Admitting Hospital and Distances Traveled for Care in Matched Cohorts: Male Patients Aged 65 and Older Treated for AMI in VHA Facilities and in Non-VHA Facilities under Medicare, FY 1997–1999

	FY 1997			*FY 1998*			*FY 1999*		
	VHA *(N = 4,076)**	*Medicare* *(N = 4,076)**	*P*	*VHA* *(N = 4,348)**	*Medicare* *(N = 4,348)**	*P*	*VHA* *(N = 4,561)**	*Medicare* *(N = 4,561)**	*P*
Admitted to high-volume (>2.8 AMIs per week) facility (%)	9.6	41.7	<0.001	14.8	44.8	<0.001	24.7	45.6	<0.001
Admitted to facility with angiography capabilities (%)	68.1	75.6	<0.001	68.5	76.3	<0.001	69.1	77.1	<0.001
Admitted to facility with bypass capabilities (%)	40.2	49.5	<0.001	38.2	51.2	<0.001	37.4	52.0	<0.001
Average distance to admitting hospital (miles)	29.1	17.1	<0.001	29.0	16.7	<0.001	30.0	17.3	<0.001
Average distance to closest hospital (miles)	5.6	6.0	0.02	5.6	6.4	<0.001	5.9	6.2	0.01
Transferred to another facility for angiography (%)	6.2	15.5	<0.001	5.3	14.3	<0.001	6.1	13.8	<0.001
Average distance traveled to transfer facility for angiography	83.5	47.3	<0.001	79.8	45.7	<0.001	88.7	44.5	<0.001
Transferred to another facility for revascularization (%)	5.8	15.9	<0.001	4.8	14.6	<0.001	5.2	14.5	<0.001
Average distance traveled to transfer facility for revascularization	74.0	43.7	<0.001	69.1	41.3	<0.001	75.0	41.8	<0.001

*Medicare patients admitted to a facility more than 200 miles from their residence and VHA patients admitted to a facility more than 200 miles from their residence and outside their home service network were excluded in distance calculations as we assumed these patients were traveling at the time of their AMI.

Table 3: Adjusted Utilization in Matched Cohorts: Male Patients Aged 65 and Older Treated for AMI in VHA Facilities and in Non-VHA Facilities under Medicare, FY 1997–1999

	FY 1997			*FY 1998*			*FY 1999*		
	VHA (N = 4,076)	*Medicare (N = 4,076)*	*P*	*VHA (N = 4,348)*	*Medicare (N = 4,348)*	*P*	*VHA (N = 4,561)*	*Medicare (N = 4,561)*	*P*
Catheterization w/in 30 days (%)	40.9	60.4	<0.001	39.0	60.5	<0.001	39.9	61.4	<0.001
CABG w/in 30 days (%)	9.4	18.9	<0.001	7.9	17.8	<0.001	7.6	16.5	<0.001
PCI w/in 30 days (%)	12.8	25.1	<0.001	13.4	27.0	<0.001	14.5	29.4	<0.001
% of PCI procedures using stents	53.8	55.0	0.63	67.0	73.7	0.003	83.4	84.3	0.60
Revascularization w/in 30 days (%)	21.8	43.1	<0.001	21.0	43.6	<0.001	22.0	44.9	<0.001

CABG = Coronary artery bypass graft; PCI = percutaneous interventions; Adjusted for age, race, median household income in zip code of residence, percentage of residents in zip code that are African American, percentage of residents in zip code that are Hispanic, and a set of clinical variables based on primary and secondary diagnoses codes from inpatient encounters from the index admission as well as from the prior year.

Mortality

Elderly VHA patients had significantly higher mortality compared to matched Medicare patients at one year and beyond in each of the fiscal years under study (Table 4). For example, in 1999 there was a 4.6 percentage point absolute difference in mortality at one year (35.2 percent versus 30.6 percent). The VHA patients also had significantly higher mortality at 30 days in 1997, but mortality at 30 days among VHA patients decreased over the study period and by 1999 differences between VHA and Medicare patients were not significant.

Sensitivity Analyses

When we adjusted for four unobserved characteristics representing differences in socioeconomic status, health behaviors, and disease severity on admission, we were able to explain some, but not all, of observed mortality differences at one year and beyond (Table 5). For example, for one-year mortality for the 1999 cohort (bottom row, Table 5), adjusting for previously observed differences in the prevalence of cardiac arrest on admission between VHA and Medicare patients (Petersen et al. 2000) would have decreased the observed difference between VHA and Medicare patients from 4.6 percentage points to 4.4 percentage points. If we had been able to adjust for the combined effect of these four confounders we estimate that the observed difference in 1999 would have decreased to 3.0 percentage points (a 35 percent reduction). Although these four confounders might explain 20 percent to 35 percent of the observed differences in mortality at one year and beyond, except in 1999, statistically significant differences between the two systems in long-term mortality persisted even after accounting for the combined influence of the four confounders. Because differences in 30-day mortality were smaller and not always significant, these results were more sensitive to unobserved confounders. In fact, if we had been able to adjust for the combined effect of these four confounders we estimate that adjusted 30-day mortality in 1999 would have been slightly lower, although not significantly so, among VHA patients.

DISCUSSION

In this federally mandated external evaluation of care for patients with AMI received in VHA hospitals, we observed differences in distances traveled for

Table 4: Adjusted Mortality in Matched Cohorts: Male Patients Aged 65 and Older Treated for AMI in VHA Facilities and in Non-VHA Facilities under Medicare, FY 1997–1999

	FY 1997			*FY 1998*			*FY 1999*		
	VHA (*N* = 4,076)	*Medicare* (*N* = 4,076)	*P*	*VHA* (*N* = 4,348)	*Medicare* (*N* = 4,348)	*P*	*VHA* (*N* = 4,561)	*Medicare* (*N* = 4,561)	*P*
Thirty-day mortality	18.4	14.9	< 0.001	16.3	14.8	0.05	16.0	15.1	0.20
One-year mortality	34.5	28.0	< 0.001	34.0	28.7	< 0.001	35.2[a]	30.6[a]	0.01
Two-year mortality	43.8	36.3	< 0.001	43.4	35.0	< 0.001	NA	NA	
Three-year mortality	49.9	42.3	< 0.001	NA	NA		NA	NA	

Adjusted for age, race, median household income in zip code of residence, percentage of residents in zip code that are African American, percentage of residents in zip code that are Hispanic, and a set of clinical variables based on primary and secondary diagnoses codes from inpatient encounters from the index admission as well as from the prior year.

[a]Due to lack of longer follow-up data, one-year mortality was assessed only on patients admitted in the first quarter of the fiscal year (N= 1,285 VHA patients and N= 1,264 Medicare patients).

Table 5: Sensitivity Analyses: Estimated Difference in Mortality between VHA and Medicare Patients after Adjustment for Unobserved Variables

	Unobserved Confounder					
	Systolic BP < 100	*Cardiac Arrest*	*Smoking*	*College Degree*	*Combined Effect*	*Observed Difference*
Prevalence in VHA patients	10.0%†	5.0%†	21.4%*	16.1%*		
Prevalence in Medicare patients	7.5%†	4.5%†	10.4%*	19.9%*		
Effect on mortality (relative risk)	2.0††	2.5††	1.5†††	0.6††††		
FY 1997						
Thirty-day mortality	3.2%	3.4%	2.8%	3.3%	2.4%	3.5%
One-year mortality	6.0%	6.3%	5.5%	6.2%	4.9%	6.5%
Two-year mortality	7.0%	7.3%	6.4%	7.1%	5.8%	7.5%
Three-year mortality	7.2%	7.5%	6.6%	7.3%	6.0%	7.7%
FY 1998						
Thirty-day mortality	1.2%**	1.4%	0.9**	1.3%**	0.5%**	1.5%
One-year mortality	4.8%	5.2%	4.3%	5.0%	3.7%	5.3%
Two-year mortality	7.9%	8.2%	7.3%	8.0%	6.7%	8.4%
FY 1999						
Thirty-day mortality	0.7%**	0.9%**	0.3%**	0.7%**	– 0.1%**	0.9%***
One-year mortality	4.1%	4.4%	3.6%	4.2%	3.0%**	4.6%

*Estimated from 1997 to 1999 the National Health Interview Surveys.

**Difference in mortality is not statistically significant after controlling for observed and unobserved factors.

***Difference in mortality not statistically significant controlling for only observed factors.

†(Petersen et al. 2000);

††(Krumholz et al. 1999);

†††(Rea et al. 2002);

††††(Hardarson et al. 2001).

care, in the technological capabilities of the facilities in which patients were treated, and in use of invasive therapies compared to a cohort of similar patients treated in non-VHA hospitals financed under Medicare. In addition we found a decline in 30-day mortality rates among VHA patients over the three-year period and equivalent short-term mortality among VHA and Medicare patients in the most recent years studied, likely reflecting recent efforts in the VHA to improve hospital care (Jha et al. 2003).

Our long-term mortality results conflict with several prior studies (Wright et al. 1999; Petersen et al. 2000; Petersen et al. 2003) comparing outcomes in VHA and Medicare AMI patients. There are several potential explanations for these differences. First, Petersen et al. used data abstracted from medical records, which allowed them to better control for a large number of important clinical measures. However, in contrast to our study, Petersen et al. (2000, 2003) observed no difference in *unadjusted* mortality at one year between the two sectors and identified higher prevalence among VHA patients of factors that are associated with both lower (younger age, less likely to have chest pain lasting more than 60 minutes after arrival, less likely to have measured ejection fraction less than 35 percent) and higher (more comorbid disease, more likely to have ST elevation on admission electrocardiography) mortality. Adjustment for these clinical factors actually led to increased mortality among VHA patients relative to Medicare beneficiaries, suggesting that differences in risk adjustment strategies alone cannot explain the differences in the two studies.

Alternatively, differences in sample characteristics and mortality ascertainment may explain some of the discrepancies. For example, unadjusted mortality rates were 0.7 percentage points higher at one year (31.6 percent versus 30.9 percent) when we restricted the Medicare sample to the seven states used in the Petersen et al. studies (2000, 2003). In addition, we obtained mortality data for the VHA cohorts not only from VA sources but also from Medicare enrollment files, which increased mortality rates in the VHA by 1.4 percentage points at one year (from 33.1 percent to 34.5 percent). Together, these two factors might explain a 2.1 percentage point higher mortality rate at one year in VHA patients compared to Medicare patients relative to the Petersen et al. study (2000, 2003).

The reasons for differences in outcomes at one year and beyond between the two systems cannot be elucidated from these data. However, at least two hypotheses are possible. First, unobserved differences in disease severity, comorbid illness, and socioeconomic factors may explain the observed mortality difference. Our sensitivity analysis, which expands on those that have been used in other studies (Conners et al. 1996; Cornfield et al. 1959; Normand et al. 2001; Ayanian et al. 2002), demonstrates the potential for relatively large effects associated with unmeasured confounders. Because adjustment for observed covariates increased differences between the two systems while adjustment for unobserved effects decreased differences, it is difficult to predict the effect of perfect risk adjustment. However, the mortality differences would likely be reduced even further if more extensive and accurate measures of disease severity and socioeconomic status had been available.

On the other hand, mortality differences may be due to important differences in patterns of care between the two systems. Consistent with previous research (Wright et al. 1999; Petersen et al. 2003), we observed differences in the use of invasive treatments between the two sectors. While we were unable to assess the appropriateness of invasive interventions, Petersen et al. (2003) recently found that compared to Medicare patients with AMI, patients treated in VHA facilities were significantly more likely to have indications for angiography and were less likely to receive indicated angiography according to ACC/AHA guidelines. However, differences in use of invasive therapies likely explain some but not all of the differences we observed. For example, studies have consistently demonstrated the benefits of CABG surgery for important subsets of patients with severe forms of coronary artery disease (Mark et al. 1994; Yusuf et al. 1994). To get an upper bound on the effect of increased procedure use among Medicare beneficiaries we assumed that all additional utilization of CABG surgery among Medicare beneficiaries was in patients with severe coronary artery disease who would receive the maximal benefit. Under this assumption, we estimate that equalizing the rate of CABG in the two systems would decrease the one-year mortality rate in the VHA by approximately 1.3 percentage points.

Other potential differences that may explain some of the observed mortality differences include distances traveled for care, volume (Thiemann et al. 1999), and availability and quality of ambulatory care after discharge. While we were not able to address whether differences in outpatient care after AMI influence mortality, past research shows that outcomes are better when cardiologists are involved in post-AMI care (Ayanian et al. 2002; Subramamian et al. 2002) and a recent study suggests that VHA patients may have limited access to cardiologists in the outpatient setting following an AMI (Subramamian et al. 2002). In addition, we observed the largest differences in outcomes at one year post-MI and beyond, suggesting the potential importance of post-acute care. Further research should examine differences in outpatient care between the two systems and the effect of these differences on long-term outcomes.

Strengths of our study included large representative cohorts, multiple years of recent data, use of data derived from the U.S. Census to partially control for socioeconomic status (Alter et al. 1999; Hardarson et al. 2001; Shen, Wan, and Perlin 2001; Bassuk, Berkman, and Amick 2002), rigorous propensity-score methods to minimize selection bias, and a novel approach to sensitivity analyses to assess the robustness of our conclusions to unobserved factors. Its major weakness is its basis on administrative data. Differences in financial incentives may result in undercoding of comorbidities in the VHA cohorts relative to Medicare patients and we cannot exclude the possibility that mortality differences might have vanished if more extensive and accurate measures of disease severity and socioeconomic status had been available.

However, a national multiyear study with medical records data would have been prohibitively expensive and we believe careful analyses of administrative data such as this can serve as indicators of when and where more extensive data collection efforts are warranted. Future research should focus on the collection and analysis of medical records data to confirm and understand our results. Finally, a more precise comparison might have included just veterans; those treated exclusively in the VHA, those treated in both the VHA and under Medicare, and those treated exclusively under Medicare. Unfortunately, with the available data sources we were not able to identify veterans treated exclusively under Medicare.

In conclusion, we observed differences in the way care for AMI patients was structured, in the use of invasive therapies, and in long-term mortality between patients treated in VHA hospitals and those treated in non-VHA facilities under Medicare. As a result of the data reported here, Anthony Principi, Secretary of Veterans Affairs, immediately introduced several changes related to the care of VHA patients with coronary artery disease (Heart1.com 2003). Our results confirm the serious nature of AMI in an elderly population—one-third of the patients in both sectors died within one year and almost half within three years. Future research should focus on explanations for the differences between the two systems and for the reduction in short-term mortality among VHA patients as further study of these differences, both between and within the systems of care, which may help identify cost-effective strategies to improve care in both sectors.

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NOTES

1. Primary diagnosis in VA data designates the condition responsible for the longest length of stay. We applied this exclusion in order to identify patients who were admitted to a facility for the evaluation and treatment of AMI. In contrast, primary diagnosis in Medicare data designates the condition that was the primary cause of the admission, so this exclusion is not needed for Medicare patients.
2. Because VHA facilities are sometimes used for long-term care (in contrast to non-VHA acute care facilities), we applied this exclusion only to the VHA cohorts. Approximately 0.01 percent of cases in each of the Medicare cohorts had lengths of stay greater than 180 days.

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APPENDIX: SENSITIVITY ANALYSES

Sensitivity analyses were based on specific assumptions regarding differences in the prevalence of confounders in VHA and Medicare patients and their relationship with mortality following an AMI. We used several sources to obtain estimates of these relationships for four unmeasured factors that were believed to influence patient outcomes. We assumed that the prevalence of systolic blood pressure < 100 and cardiac arrest were the same as those observed in a previous comparison of AMI patients treated in VHA facilities and non-VHA facilities (Petersen, Normand et al. 2000) and used a previously developed risk-adjustment model for 30-day mortality following an AMI to estimate the relative risk of mortality associated with these clinical factors (Krumholz, Chen et al. 1999).

We used the relative risk of recurrent coronary events (nonfatal MI or coronary death) associated with continuing to smoke after an AMI (Rea, Heckbert et al. 2002) and the relative risk of CAD mortality associated with having a college education (Hardarson, Gardarsdottir et al. 2001) to approximate the relative risk of death associated with smoking and education, respectively. Because estimates of the prevalence of smoking and having a college education were not available for veterans and Medicare beneficiaries with AMI, we used the 1997, 1998 and 1999 National Health Interview Surveys (NHIS) to estimate their prevalence in men age 65 and older with either VHA or Medicare insurance. We used logistic regression models to estimate the prevalence of these two factors controlling for the observed risk factors in our study. Specifically, we used NHIS data to fit two separate logistic regression models with either smoking status or college education as the dependent variable and age, region, self-reported history of angina, cancer, chronic bronchitis, congestive heart failure, diabetes, stroke, hypertension, and heart disease as well as insurance status (VHA or Medicare) as independent variables. The estimated regression models and the observed characteristics in the NHIS data were then used to compute adjusted proportions of each outcome (smoking status and education) for respondents with VHA and Medicare insurance. Specifically, we estimated adjusted outcomes in the VHA by averaging the predicted probability of the outcome assuming that each respondent had VHA insurance and that all other variables remained unchanged. We then repeated the calculation assuming that each respondent had Medicare.

Effect of individual confounders:

We estimated the effect of each of these four potential confounders by first adjusting the estimated odds ratios obtained from logistic regression models fit to the matched samples using the following formula (Lin, Psaty et al. 1998):

$$OR^{adj}=OR^{\text{logistic regression}}/A,$$

$$A=\frac{\Gamma P_1+(1-P_1)}{\Gamma P_0+(1-P_0)},$$

where, Γ is the relative risk of mortality associated with the confounding variable of interest, and P_1 and P_0 are the prevalence of the confounder among VHA and Medicare patients, respectively. We applied the same formula to the upper and lower bound of the 95% confidence interval around the estimated odds ratio to determine if the observed relationship between sector of care and mortality remained statistically significant even after adjustment for the unobserved factor. We then computed absolute differences in mortality rates based on the newly adjusted odds ratio as described in the data analysis section of the Methods. For example, using a logistic regression model fit to the matched 1999 sample, we estimated that the odds of death within 1 year were 1.27 times higher among VHA patients compared to similar Medicare patients, corresponding to a 4.6 percentage point difference in mortality (Table 4). Assuming that after controlling for the observed confounders, 5% of VHA patients had cardiac arrest on admission compared to only

4.5% of Medicare patients and that cardiac arrest on admission is associated with a 2.5 fold increased likelihood of death within 1 year, the above equation suggests that controlling for the difference in the prevalence of cardiac arrest on admission would decrease the observed odds ratio to 1.26, corresponding to a 4.4 percentage point absolute difference (Table 5).

Combined effect of confounders:

To adjust observed mortality differences for the combination of the four confounders, we applied the adjustment equation described above recursively to adjust for the additional independent effect of each new confounder. For example, assuming that after controlling for the observed confounders and differences in the prevalence of cardiac arrest on admission, 10% of VHA patients had systolic blood pressure less than 100 on admission compared to only 7.5% of Medicare patients and that low blood pressure on admission is associated with a 2 fold increase in the likelihood of death within 1 year, a second application of the above equation suggests that controlling for the difference in the prevalence of low blood pressure in *addition* to cardiac arrest on admission would further decrease the adjusted odds ratio from 1.26 to 1.23, corresponding to a 13.0% reduction of the observed difference in mortality from 4.6 percentage points to 4.0 percentage points.

Obtaining the combined effect required estimating the independent effects of each individual confounder on mortality and also accounting for differences in their prevalence among VHA and Medicare patients, controlling for the other three confounders. We used the same relative risks associated with low blood pressure, cardiac arrest, smoking and education described above, assuming that each of these represented the independent effect controlling for the other three confounders. In addition, we were unable to obtain measures of the correlation between the clinical factors and education and smoking status among AMI patients. To obtain estimates of the sensitivity of our results to the combined effects of low blood pressure, cardiac arrest, smoking and education, we made the conservative assumption that the clinical variables were independent of smoking status and education. However, based on previous literature, we expected a strong relationship between education and smoking status. To obtain estimates of the prevalence of smoking controlling for the difference in the prevalence of having a college education, and of a college education controlling for the difference in prevalence of smoking, we refit logistic regression models described above to the NHIS data, adding the other confounder to each model in addition to the variables listed above (that is, the model with college education as the dependent variable contained smoking status as an independent variables and the model with smoking status as the dependent variable contained education as an independent variable).