AMI COHORT—METHODS OVERVIEW

Cohort Definition for Patients with Acute Myocardial Infarction (AMI)

We studied two cohorts of patients with acute myocardial infarction—a VA cohort and a Medicare cohort. Each cohort was further subdivided according to fiscal year (FY 1997-1999, with a baseline year of FY 1994 for VA patients).

The VA AMI cohort included individuals admitted to a VA facility with an AMI (ICD-9-CM codes 410, excluding 410.x2) in a given fiscal year subject to the following exclusion criteria: (1) those who were enrolled in a Medicare health maintenance organization; (2) those whose AMI was likely a complication of non-cardiac surgery, and for this determination we used criteria developed by Wright et al. [Wright, 1999] (Table A1); (3) those who were likely admitted only to rule out a myocardial infarction (those who were discharged alive in less than 3 days); and (4) those with a length of stay > 180 days[1]. For patients in the Medicare cohort we excluded (1) individuals under the age of 65 (2) those who were enrolled in a Medicare health maintenance organization; and (3) those who were discharged alive in less than 3 days.

Once a patient was identified as meeting the inclusion criteria for a cohort, contiguous inpatient records were linked together to create an index episode of admission. For patients in the VA cohort, all contracted care (care provided to veterans in private sector hospitals on a

[1] Because VHA facilities are sometimes used for long-term care, VA researchers commonly use this exclusion when studying AMI patients (including studies comparing patients treated in Medicare and VA hospitals, see for example Wright, S. M., J. Daley, et al. (1997). "Where do elderly veterans obtain care for acute myocardial infarction: Department of Veterans Affairs or Medicare?" Health Services Research **31**(6): 739-754.

This exclusion led to about 10 patients (out of approximately 9,000 or 0.1%) being excluded in each VA cohort. Because acute care facilities are not generally used for long-term care in the private sector, we did not use this exclusion in the Medicare cohorts. There were about 25 (out of approximately 175,000 or 0.01%) cases with lengths of stay greater than 180 days in each of the Medicare cohorts.

contract basis and paid for by the VHA) captured in the non-VA PTF and OPC files were included[2].

Table A1
ICD-9 codes for non-cardiac surgery used to exclude VA patients with AMI because AMI was likely to be a complication of surgery

If surgical ICD-9 code is:	Include:	Exclude:
0.00-34.99		**Central and peripheral nervous system; endocrine; eye; ear; nose; oral cavity and pharynx; respiratory system**
35.00-35.99		**Cardiac valve or septa surgery**
36.00-36.99	PTCA and CABG	
37.00-37.19		**Pericardial surgery**
37.20-37.23	Cardiac catheterization	
37.24-37.59		**EP studies; other heart repair; heart transplant**
37.60-37.89	IABP and pacemaker	
37.90-37.99		**Open cardiac massage; insertion or re-wiring of AICD**
38.00-39.59		**Non-coronary vascular surgery**
39.60-39.66	Heart-lung bypass; ECMO	
39.70-39.99		**Miscellaneous vascular**
40.00-86.99		**Lymph node and BMT; GI; renal and bladder; genital; orthopedic; skin and breast**
87.00-99.99	Various minor diagnostic and therapeutic procedures	

[2] It was beyond the scope of this project to collect data on care received in the private sector that was covered under private insurance.

Because previous studies have demonstrated that users of VA services age 65 and older who are also eligible for Medicare receive a substantial portion of their care in the private sector (Fleming, Fisher et al. 1992), (Wright, Daley et al. 1997), we obtained Medicare claims for elderly (age $\geq$ 65) patients in the VA cohort. For patients identified in a VA cohort who also received care covered by Medicare in a non-VHA hospital during their index episode, we included their stays in private sector hospitals as part of their index episode. Thus, the VA cohorts consisted of three sub-cohorts of patients; (i) those receiving *all* of the care for the index event in VA facilities, (ii) those receiving a mixture of care for the index event in VA facilities and in non-VA facilities (contracted care) paid for under VHA, and (iii) those receiving a mixture of care for the index event in VA facilities and in private sector facilities under Medicare (Figure 1). The number of patients in each of these sub-cohorts in each of the four fiscal years is reported in Tables A2 and A3. The Medicare cohort consisted of patients who received inpatient care for their index admission only in the private sector although some of these patients may have received follow up care (either inpatient or outpatient) in the VA (Figure 1)[3].

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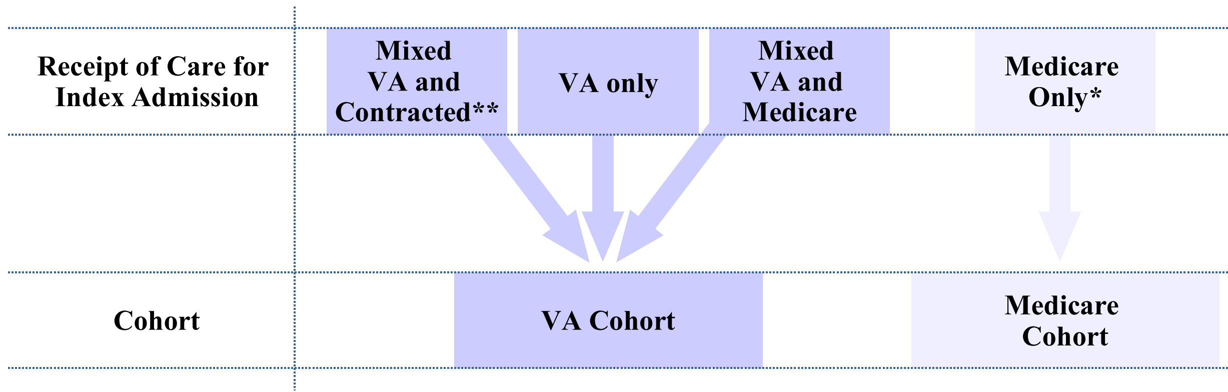
[3] It was beyond the scope of this project to identify and study patients who received care for their index AMI in the private sector but who may have received care in the VA either prior to or following the index event. Previous research suggests that the number of patients in the Medicare cohort with cross utilization in the VA is relatively low. For example, Fleming et al. [Fleming, C., E. S. Fisher, et al. (1992). "Studying outcomes and hospital utilization in the elderly: The advantages of a merged data base for Medicare and Veterans Affairs Hospitals." Medical Care **30**(5): 377-391.

found that only 1.8% of male Medicare patients hospitalized for AMI in New York or New England between 1983 and 1986 received inpatient care in the VA during this time period. However, veterans receiving index care for AMI under Medicare may represent a significant portion of VA users with an AMI. For example, Fleming et al. also found that 36% of hospitalizations for AMI among inpatient users of VA hospitals occurred in the private sector. The authors did not study outpatient care. Similarly Wright et al. [Wright, S. M., J. Daley, et al. (1997). "Where do elderly veterans obtain care for acute myocardial infarction: Department of Veterans Affairs or Medicare?" Health Services Research **31**(6): 739-754.

found that 54% of a national sample of AMI patients with prior inpatient and outpatient use of VA services were initially admitted to a Medicare hospital.

Figure 1: Inclusion of Patients into VA and Medicare Cohorts According to Receipt of Care in the VHA and Private Sector
Patients 65 and over



*Patients who received treatment during the index admission only under Medicare in private sector hospitals; some of these patients may have received care (inpatient or outpatient) in the VA prior to or following discharge.
**Patients receiving a mixture of care for the index event in VA facilities and in non-VA facilities (contracted care) paid for under VHA, for which data were captured in the non-VA PTF.

Table A2
Cross Utilization of Private Sector Services[a] VA AMI Cohorts
Patients Aged 65 and Older

	Cohort			
	FY 1994	FY 1997	FY 1998	FY 1999
Index Care (N)	4744	4521	4736	5013
All VA (N (%))	4310 (90.9%)	3984 (88.1%)	4184 (88.3%)	4473 (89.2%)
Mixed VA/Medicare (N (%))	331 (7.0%)	445 (9.8%)	455 (9.6%)	452 (9.0%)
Mixed VA/Non-VA (N (%))	97 (2.0%)	88 (2.0%)	91 (1.9%)	83 (1.7%)
Mixed VA/Med/Non-VA (N (%))	6 (0.1%)	4 (0.1%)	6 (0.1%)	5 (0.1%)
Admitting Hospital (N)	4744	4521	4736	5013
VA (N (%))	4504 (94.9%)	4209 (93.1%)	4412 (93.2%)	4687 (93.5%)
Medicare (N (%))	217 (4.6%)	296 (6.6%)	315 (6.7%)	322 (6.4%)
Non-VA (N (%))	23 (0.5%)	16 (0.4%)	9 (0.2%)	4 (0.1%)
Catheterization w/in 30 days (N)[b]	1810	1851	1874	2024
VA (N (%))	1675 (92.5%)	1692 (91.4%)	1718 (91.7%)	1849 (91.4%)
Medicare (N (%))	97 (5.4%)	118 (6.4%)	124 (6.6%)	146 (7.2%)
Non-VA (N (%))	52 (2.9%)	55 (3.0%)	48 (2.6%)	51 (2.5%)
PCI w/in 30 days (N)[b]	470	580	643	746
VA (N (%))	400 (85.1%)	484 (83.5%)	564 (87.7%)	645 (86.5%)
Medicare (N (%))	44 (9.4%)	65 (11.2%)	53 (8.2%)	73 (9.8%)
Non-VA (N (%))	27 (5.7%)	34 (5.9%)	28 (4.4%)	31 (4.2%)
CABG w/in 30 days (N)[b]	402	415	380	384
VA (N (%))	296 (73.6%)	305 (73.5%)	260 (68.4%)	285 (74.2%)
Medicare (N (%))	89 (22.1%)	93 (22.4%)	100 (26.3%)	80 (20.8%)
Non-VA (N (%))	17 (4.2%)	17 (4.1%)	21 (5.5%)	19 (5.0%)

[a] We were not able to identify services received in the private sector that may have been covered by private insurance.
[b] The sites listed represent where the procedure took place.

Table A3
Cross Utilization of Private Sector Services[a] VA AMI Cohorts
Patients Under Age 65

	Cohort			
	FY 1994	FY 1997	FY 1998	FY 1999
Index Care (N)	3933	3614	3617	3651
All VA (N (%))	3715 (94.5%)	3363 (93.1%)	3400 (94.0%)	3439 (94.2%)
Mixed VA/Medicare (N (%))	76 (1.9%)	140 (3.9%)	111 (3.1%)	98 (2.7%)
Mixed VA/Non-VA (N (%))	141 (3.6%)	108 (3.0%)	104 (2.9%)	112 (3.1%)
Mixed VA/Med/Non-VA(N (%))	1 (0%)	3 (0.1%)	2 (0.1%)	2 (0.1%)
Admitting Hospital	3933	3614	3617	3651
VA (N (%))	3849 (97.9%)	3493 (96.7%)	3516 (97.2%)	3562 (97.6%)
Medicare (N (%))	58 (1.5%)	98 (2.7%)	86 (2.4%)	77 (2.1%)
Non-VA (N (%))	26 (0.7%)	23 (0.6%)	15 (0.4%)	12 (0.3%)
Catheterization w/in 30 days (N)[b]	2266	2238	2208	2271
VA (N (%))	2194 (96.8%)	2157 (96.4%)	2131 (96.5%)	2186 (96.3%)
Medicare (N (%))	19 (0.8%)	31 (1.4%)	31 (1.4%)	30 (1.3%)
Non-VA (N (%))	69 (3.1%)	59 (2.6%)	61 (2.8%)	67 (3.0%)
PCI w/in 30 days (N) [b]	720	925	968	1081
VA (N (%))	652 (90.6%)	861 (93.1%)	907 (93.7%)	1006 (93.1%)
Medicare (N (%))	11 (1.5%)	26 (2.8%)	19 (2.0%)	25 (2.3%)
Non-VA (N (%))	58 (8.1%)	38 (4.1%)	44 (4.6%)	52 (4.8%)
CABG w/in 30 days (N) [b]	406	411	354	361
VA (N (%))	375 (92.4%)	373 (90.8%)	325 (91.8%)	329 (91.1%)
Medicare (N (%))	9 (2.2%)	16 (3.9%)	11 (3.1%)	8 (2.2%)
Non-VA (N (%))	22 (5.4%)	22 (5.4%)	18 (5.1%)	24 (6.7%)

[a] We were not able to identify services received in the private sector that may have been covered by private insurance.
[b] The sites listed represent where the procedure took place.

Measures of Utilization and Outcomes

For each cohort we created several utilization and outcome measures obtained from administrative sources. Information on the receipt of cardiac procedures, length of stay, and cardiac readmissions was obtained from the PTF and OPC files for the VA cohorts and from Part A, Part B, and hospital outpatient files for the Medicare cohorts. For patients identified in a VA cohort who were also eligible for care under Medicare, we included any admission to or procedure received in a non-VHA hospital identified through Medicare claims[4]. Procedures included cardiac catheterization, percutaneous coronary interventions (PCI) with and without placement of a stent, coronary artery bypass graft surgery (CABG), and any revascularization procedure (either PCI or CABG) (see Table A4 for CPT codes for these procedures). We report the percent of patients undergoing each of these procedures within 30 days of admission (we did not measure repeat procedures). Readmission for AMI (ICD-9-CM codes 410,) was measured within 6 months of admission date. Readmission for ischemic heart disease (IHD, ICD-9-CM codes 411-414) or congestive heart failure (CHF, ICD-9-CM codes 428) was measured both within 30 days and 6 months of admission. Finally, we measured readmission for any one of these cardiac diseases within 6 months. For each of these, we report the percent of patients with at least one readmission (we did not measure repeat readmissions for the same diagnosis). These measures were computed for all cohort years (FY 1994, 1997-1999 for VA and FY 1997-1999 for Medicare).

[4] As we did not obtain VA claims for follow up care that veterans in the Medicare cohort may have received through the VHA, we may have underestimated procedure use and readmissions in the Medicare cohorts. However, we expect the rates of crossover care in the general Medicare population to be low (see previous footnote).

Table A4
Procedure Codes

Procedure Category	Identifying Codes	
	ICD-9	CPT-4
Coronary Artery Bypass Graft (CABG)	36.10	33510
	36.11	33511
	36.12	33512
	36.13	33513
	36.14	33514
	36.15	33516
	36.16	33517
	36.19	33518
		33519
		33521
		33522
		33523
		33533
		33534
		33535
		33536
Percutaneous Coronary Interventions (PCI)	36.01	92980
	36.02	92981
	36.05	92982
	36.06	92984
Catheterization	37.22	93508
	37.23	93510
	88.53	93511
	88.54	93524
	88.55	93526
	88.56	93539
	88.57	93540
		93545

Our primary source of vital status data for patients treated in the VA was the Veterans Affairs Beneficiary Identification and Records Location Subsystem (BIRLS) and the PTF[5]. Previous research has demonstrated that these two data sources in combination have high sensitivity[6]. However, we were unable to match approximately 15% (19,692) of the 127,252 VA patients in all VA cohort years to the BIRLS file; use of military service identification numbers instead of social security numbers for many of the older veterans is likely to explain some portion of this 15%. We thus supplemented vital status information by matching to Medicare enrollment data and to the National Death Index (NDI), for veterans with uncertain vital status data (those we could not match to the BIRLS). Vital status for the Medicare cohorts was determined from the Medicare enrollment[7] and inpatient files.

Mortality was measured at 30 days and 1 year from date of admission for all cohort years (FY 1994, 1997-1999 for VA and FY 1997-1999 for Medicare). Long-term mortality data were not available for the recent cohorts. For VA patients we analyzed 6-year mortality using the FY 1994 cohort, 3-year mortality using the FY 1994 and 1997 cohorts, and 2-year mortality using the FY 1994, 1997 and 1998 cohorts. For comparisons between VA and Medicare, we analyzed 3-year mortality using the FY 1997 cohorts and 2-year mortality using the FY 1997 and 1998 cohorts.

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[5] Date of death is recorded in the BIRLS if a survivor requests the veteran's death benefit while the PTF captures deaths occurring during a VA hospitalization.

[6] Sensitivity of the BIRLS ranged between 80% and 95% [Cowper, D. C., J. D. Kubal, et al. (2002). "A primer and comparative review of major U.S. mortality databases." Archives of Epidemiology.

[7] Vital status in the Medicare enrollment files is based on payment of Social Security benefits and has been demonstrated to be a highly accurate source of mortality data. The Research Data Assistance Center (ResDAC), a center funded by the Centers for Medicaid and Medicare Services to assist researchers using Medicare data, has calculated the likelihood of someone deceased not having a date of death in the denominator file at 0.4% (in other words death information is 99.6% accurate; personal communication with Barbara Frank, ResDAC). We were able to match 98.2% of the males in the AMI Medicare cohort for 1999 to the enrollment files. See sensitivity analysis below on lack of any implications to this 98.2% match.

Statistical Methods

We first describe the VA cohorts from all years under study according to their demographic and clinical characteristics and present unadjusted outcomes by year and by demographic subgroups (age, gender, and race). Because one goal of our analysis was to compare utilization and outcomes across Veterans Integrated Service Networks (VISNs)—a map illustrating the geographic boundaries of each VISN has been included in Appendix A2—and across patient subgroups (gender and race), we also report these comparisons adjusted for differences in disease severity using hierarchical regression models. Finally, we compared utilization and outcomes between male VA patients 65 years of age or older to a matched sample of Medicare patients with similar observed characteristics for the FY 1997, 1998 and 1999 cohorts. We report 90% confidence intervals for all comparisons. Moreover, we studied over 20 utilization and outcome variables, comparing measures between the VHA and Medicare and across 22 service networks and demographic subgroups within the VA. Approximately 10% of these comparisons are expected to be statistically significant due to chance alone. These results are thus best seen as highlighting areas for further study of quality of care received within the VHA. Details of these approaches follow.

Risk Adjustment Variables

We adjusted utilization and outcome measures for the demographic characteristics of the patients (age, gender, and race), a set of clinical comorbidities, and a set of socioeconomic variables derived from the U.S. Census (see Tables A5-A7). Clinical comorbidities were coded based on primary and secondary diagnoses codes from inpatient encounters from the index admission as well as from the prior year[8]. We adapted a previous approach and divided clinical characteristics into those that were *unlikely to be related to any treatment* for an AMI and those that were *possibly related to treatment* for an AMI [Normand, 1995]. Information on comorbidities *unlikely to be related to treatment* (see Table A8) was obtained from the index admission as well as from inpatient claims in the year prior to admission. Information on clinical characteristics *possibly related to treatment* (see Table A8) was obtained from inpatient claims only from the year prior to admission. For example, CHF during the index admission may be related to (potentially inadequate) treatment for AMI. Thus we only considered diagnoses for CHF during the year prior to admission and did not adjust for differences in the prevalence of CHF during the index admission.

We linked the zip code of each patient's residence to data from the 1990 U.S. Census to obtain information on socioeconomic characteristics (median household income, proportion of population with a high school education, proportion of population with professional occupations, proportion of population receiving public assistance, proportion of population over 65 receiving public assistance, proportion of population that are African American, and proportion of population that are Hispanic) (Table A9). All adjusted analyses (both within VA comparisons and comparisons between the VA and Medicare) control for the full set of risk adjustment variables described above.

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[8] Initially we planned on using information on comorbidities obtained from *both* inpatient data as well as outpatient data for the year prior to the index admission. However, outpatient data from the VA were not available for the FY 1994 and 1997 cohorts. For consistency, we wanted to use the same risk adjustment approach for all years within the VA and Medicare cohorts. In order to determine the impact of using comorbidities obtained from inpatient data only, we compared adjusted utilization rates, length of stay, mortality and readmission rates for the FY 1999 VA and Medicare cohorts using inpatient data only and both inpatient and outpatient data.

Table A5
Demographic and Clinical Characteristics of the VA and Medicare FY 1997 AMI Cohorts (Male Patients, Age 65 and Older)

	Prior to Matching		Matched Sample	
	VA (n=4102)	Medicare (n=115952)	VA (n=3992)	Medicare (n=3992)
Age 65-69 (%)	**26.2**	**23.2**	26.1	26.6
70-74 (%)	**33.3**	**25.4**	33.1	33.9
75-79 (%)	**25.9**	**22.4**	25.9	24.8
80-84 (%)	**10.4**	**16.4**	10.6	10.6
85 and older (%)	**4.2**	**12.7**	4.3	4.1
Race: White (%)	**79.2**	**92.2**	**81.0**	**83.4**
African American (%)	**12.6**	**5.3**	**12.7**	**10.4**
Hispanic (%)	**5.3**	**0.5**	**3.5**	**3.2**
Missing/other (%)	**2.8**	**2.1**	**2.9**	**3.0**
Distance to Admitting Hospital (miles)	**29.4**	**13.6**	**29.3**	**26.5**
Socioeconomic Variables[a]:				
% with college degree in zip code of residence	**19.8**	**22.8**	**20.0**	**19.1**
Median household income in zip code of residence	**32881.6**	**38311.1**	**33274.5**	**32081.3**
% professionals in zip code of residence	**20.5**	**23.0**	**20.7**	**19.9**
% African American in zip code of residence	**13.4**	**8.7**	**13.6**	**11.6**
% Hispanic in zip code of residence	**5.6**	**4.9**	5.5	5.8
% with public assistance in zip code of residence	**9.6**	**7.9**	9.7	9.6
% > 64 with public assistance in zip code of residence	**10.7**	**9.1**	**10.7**	**11.1**
Missing census data (%)	**7.0**	**5.1**	6.1	6.3
Clinical Variables[b]:				
Prior MI (%)	**11.2**	**12.2**	**11.3**	**9.7**
Chronic angina (%)	**7.8**	**5.4**	7.7	7.3
Unstable angina (%)	**7.4**	**5.5**	7.2	7.2
Arrhythmia (%)	**10.2**	**8.8**	**10.1**	**8.9**
Cardiac arrest (%)	1.5	1.6	1.6	1.4
Arthritis (%)	**12.1**	**8.5**	11.9	12.0
Cancer (%)	**6.9**	**5.2**	6.8	6.3
CHF (%)	**14.9**	**11.7**	14.6	13.7
Coagulation disorder (%)	**1.0**	**0.7**	1.0	0.8
Conduction abnormality (%)	2.6	2.9	2.6	2.4
Conduction disorder (%)	0.5	0.5	0.5	0.5
COPD (%)	**32.7**	**26.9**	32.6	31.5
Connective tissue disease (%)	**0.2**	**0.5**	0.2	0.2
CVA (%)	**5.9**	**3.4**	5.7	5.3
Dementia (%)	**6.0**	**4.8**	6.0	5.4
Diabetes (%)	**31.5**	**22.2**	30.9	30.4
Diabetes w/ end organ damage (%)	**7.5**	**4.3**	7.0	7.2
Alcohol/drug abuse (%)	**4.9**	**2.3**	4.7	4.1

	Prior to Matching		Matched Sample	
	VA (n=4102)	Medicare (n=115952)	VA (n=3992)	Medicare (n=3992)
Thyroid disease (%)	4.7	4.3	4.7	4.6
Fluid disorder (%)	4.6	4.4	4.6	4.4
GI bleeding (%)	**2.1**	**1.0**	1.9	1.9
Hypertension (%)	**58.0**	**44.5**	57.3	57.1
Hypertension w/ complications (%)	**2.7**	**5.0**	2.6	2.6
Liver disease (%)	**0.8**	**0.4**	0.8	0.5
Neurological disorder (%)	**2.9**	**4.0**	3.0	3.0
Paralysis (%)	**0.4**	**0.2**	0.4	0.5
Pneumonia (%)	**4.8**	**3.5**	4.6	4.5
Psychosis[c] (%)	**4.0**	**1.5**	3.5	3.1
Neurotic disorder (%)	**1.7**	**0.8**	**1.7**	**0.8**
Lung disease (%)	0.6	0.7	0.6	0.6
Renal failure (%)	**5.3**	**3.8**	5.1	5.0
Hypotension (%)	**3.7**	**3.5**	3.6	3.3
Syncope (%)	**1.9**	**1.2**	1.9	1.5
Ulcers (%)	**2.2**	**0.9**	2.0	1.9
UTI (%)	**4.7**	**2.5**	4.4	4.5
Endocarditis (%)	**3.4**	**4.2**	3.4	2.9
PVD (%)	**12.7**	**10.5**	12.7	12.1

[a] Obtained from 1990 Census by linking to the zip code of the patient's residence.
[b] Obtained from primary and secondary diagnoses from inpatient claims.
[c] Includes depression.

Bolded numbers represent significant differences at 10% level

Table A6
Demographic and Clinical Characteristics of the VA and Medicare
FY 1998 AMI Cohorts (Male Patients, Age 65 and Older)

	Prior to Matching		Matched Sample	
	VA	Medicare	VA	Medicare
	(n=4344)	(n=114958)	(n=4277)	(n=4277)
Age 65-69 (%)	**26.3**	**22.1**	26.4	27.9
70-74 (%)	**30.8**	**24.6**	30.8	30.8
75-79 (%)	**26.9**	**22.8**	26.8	25.8
80-84 (%)	**11.8**	**16.9**	11.9	11.5
85 and older (%)	**4.1**	**13.6**	4.1	4.0
Race: White (%)	**80.5**	**92.0**	**81.3**	**83.5**
African American (%)	**11.6**	**5.4**	**11.6**	**9.4**
Hispanic (%)	**4.8**	**1.2**	**4.1**	**3.9**
Missing/other (%)	**3.1**	**1.4**	**3.0**	**3.3**
Distance to Admitting Hospital (miles)	**28.5**	**14.1**	28.1	27.0
Socioeconomic Variables[a]:				
% with college degree in zip code of residence	**19.8**	**22.6**	**19.9**	**18.9**
Median household income in zip code of residence	**32694.6**	**38050.4**	**32920.6**	**31704.7**
% professionals in zip code of residence	**20.5**	**22.8**	**20.6**	**19.6**
% African American in zip code of residence	**13.3**	**8.6**	**13.3**	**11.0**
% Hispanic in zip code of residence	5.3	5.0	5.3	5.4
% with public assistance in zip code of residence	**9.6**	**7.8**	**9.6**	**9.1**
% > 64 with public assistance in zip code of residence	**10.7**	**9.1**	10.7	10.5
Missing census data (%)	**7.0**	**5.8**	6.4	7.2
Clinical Variables[b]:				
Prior MI (%)	**11.4**	**12.5**	11.4	11.2
Chronic angina (%)	**6.9**	**5.6**	6.8	7.2
Unstable angina (%)	**7.2**	**5.4**	7.0	7.4
Arrhythmia (%)	**9.8**	**9.5**	9.6	9.8
Cardiac arrest (%)	**1.1**	**1.7**	1.1	1.2
Arthritis (%)	**10.9**	**8.9**	10.8	10.5
Cancer (%)	**6.7**	**5.4**	6.6	6.3
CHF (%)	**14.8**	**12.7**	14.6	14.3
Coagulation disorder (%)	0.9	0.9	0.9	0.8
Conduction abnormality (%)	**2.3**	**2.9**	2.3	2.4
Conduction disorder (%)	**0.4**	**0.5**	0.3	0.4
COPD (%)	**32.5**	**27.2**	32.5	33.8
Connective tissue disease (%)	**0.4**	**0.6**	0.4	0.4
CVA (%)	**4.6**	**2.9**	4.5	4.6
Dementia (%)	**7.0**	**5.5**	7.0	6.4
Diabetes (%)	**33.7**	**23.5**	33.3	32.5
Diabetes w/ end organ damage (%)	**7.8**	**4.9**	7.6	6.9
Alcohol/drug abuse (%)	**4.0**	**2.5**	4.0	3.8

	Prior to Matching		Matched Sample	
	VA	Medicare	VA	Medicare
	(n=4344)	(n=114958)	(n=4277)	(n=4277)
Thyroid disease (%)	**5.4**	**4.8**	5.3	5.0
Fluid disorder (%)	4.3	4.4	4.2	4.2
GI bleeding (%)	**2.2**	**1.1**	1.9	1.8
Hypertension (%)	**60.3**	**46.8**	59.9	59.3
Hypertension w/ complications (%)	**2.6**	**4.8**	2.6	2.4
Liver disease (%)	**0.6**	**0.4**	0.6	0.6
Neurological disorder (%)	**2.5**	**4.3**	2.5	2.3
Paralysis (%)	**0.3**	**0.2**	0.3	0.2
Pneumonia (%)	**5.3**	**4.0**	5.3	5.0
Psychosis[c] (%)	**3.8**	**1.6**	3.5	3.2
Neurotic disorder (%)	**2.1**	**0.9**	2.0	1.6
Lung disease (%)	0.7	0.8	0.7	0.8
Renal failure (%)	**5.6**	**4.1**	5.6	5.7
Hypotension (%)	4.1	3.9	3.9	4.1
Syncope (%)	**1.8**	**1.3**	1.8	1.7
Ulcers (%)	**2.2**	**0.9**	2.0	2.2
UTI (%)	**4.8**	**2.7**	4.6	4.1
Endocarditis (%)	**3.4**	**4.5**	3.3	3.7
PVD (%)	**13.4**	**11.2**	13.3	13.3

[a] Obtained from 1990 Census by linking to the zip code of the patient's residence.
[b] Obtained from primary and secondary diagnoses from inpatient claims.
[c] Includes depression.

Bolded numbers represent significant differences at 10% level

Table A7
Demographic and Clinical Characteristics of the VA and Medicare FY 1999 AMI Cohorts (Male Patients, Age 65 and Older)

	Prior to Matching		Matched Sample	
	VA	Medicare	VA	Medicare
	(n=4588)	(n=114933)	(n=4502)	(n=4502)
Age 65-69 (%)	**24.6**	**20.6**	24.6	26.3
70-74 (%)	**27.8**	**24.1**	27.5	26.7
75-79 (%)	**27.6**	**23.0**	27.6	26.5
80-84 (%)	**14.5**	**17.5**	14.6	14.8
85 and older (%)	**5.6**	**14.9**	5.7	5.7
Race: White (%)	**79.3**	**91.7**	**80.6**	**83.1**
African American (%)	**11.5**	**5.5**	**11.5**	**9.1**
Hispanic (%)	**5.3**	**1.2**	**4.0**	**3.7**
Missing/other (%)	**3.9**	**1.7**	**3.9**	**4.2**
Distance to Admitting Hospital (miles)	**28.8**	**14.4**	28.8	27.6
Socioeconomic Variables[a]:				
% with college degree in zip code of residence	**19.3**	**22.5**	**19.5**	**18.9**
Median household income in zip code of residence	**32383.7**	**37903.4**	**32783.6**	**31909.4**
% professionals in zip code of residence	**20.1**	**22.7**	**20.3**	**19.8**
% African American in zip code of residence	**12.4**	**8.6**	**12.4**	**10.4**
% Hispanic in zip code of residence	**5.3**	**5.0**	5.3	5.4
% with public assistance in zip code of residence	**9.1**	**7.8**	9.2	9.0
% > 64 with public assistance in zip code of residence	**10.3**	**9.1**	10.4	10.5
Missing census data (%)	**8.6**	**6.1**	7.5	7.5
Clinical Variables[b]:				
Prior MI (%)	12.7	13.1	12.6	12.8
Chronic angina (%)	**6.8**	**5.6**	6.8	6.8
Unstable angina (%)	**8.3**	**5.1**	7.9	8.5
Arrhythmia (%)	10.1	9.6	10.1	9.5
Cardiac arrest (%)	1.4	1.6	1.4	1.2
Arthritis (%)	**10.2**	**9.3**	10.2	10.2
Cancer (%)	**7.0**	**5.6**	7.0	6.5
CHF (%)	**16.5**	**13.0**	16.3	15.7
Coagulation disorder (%)	1.0	1.0	1.0	1.0
Conduction abnormality (%)	2.7	2.7	2.7	3.1
Conduction disorder (%)	0.3	0.5	0.3	0.3
COPD (%)	**33.2**	**28.1**	33.3	34.0
Connective tissue disease (%)	0.5	0.6	0.5	0.5
CVA (%)	**2.9**	**2.3**	2.8	2.7
Dementia (%)	**6.8**	**6.0**	6.8	6.3
Diabetes (%)	**34.9**	**24.6**	34.3	33.7
Diabetes w/ end organ damage (%)	**8.0**	**5.2**	7.9	7.6
Alcohol/drug abuse (%)	**4.6**	**2.5**	4.5	4.9

	Prior to Matching		Matched Sample	
	VA	Medicare	VA	Medicare
	(n=4588)	(n=114933)	(n=4502)	(n=4502)
Thyroid disease (%)	**6.1**	**5.2**	6.1	5.6
Fluid disorder (%)	4.6	4.4	4.6	4.6
GI bleeding (%)	**2.2**	**1.2**	2.2	2.0
Hypertension (%)	**63.6**	**49.0**	63.0	62.2
Hypertension w/ complications (%)	**3.2**	**4.6**	**3.2**	**2.6**
Liver disease (%)	**0.6**	**0.4**	0.5	0.5
Neurological disorder (%)	**2.8**	**4.5**	2.8	2.8
Paralysis (%)	**0.5**	**0.2**	0.4	0.3
Pneumonia (%)	**5.8**	**4.5**	5.8	5.7
Psychosis[c] (%)	**3.5**	**1.7**	3.3	3.1
Neurotic disorder (%)	**1.9**	**0.9**	**2.0**	**1.1**
Lung disease (%)	1.0	0.9	1.0	1.1
Renal failure (%)	**5.9**	**4.2**	5.7	6.1
Hypotension (%)	4.0	4.1	4.0	4.1
Syncope (%)	**2.2**	**1.4**	2.1	1.9
Ulcers (%)	**1.7**	**0.8**	1.6	1.7
UTI (%)	**4.4**	**2.9**	4.4	4.2
Endocarditis (%)	**3.1**	**4.5**	3.1	3.0
PVD (%)	**13.8**	**11.4**	13.6	12.9

[a] Obtained from 1990 Census by linking to the zip code of the patient's residence.
[b] Obtained from primary and secondary diagnoses from inpatient claims.
[c] Includes depression.

Bolded numbers represent significant differences at 10% level

Table A8
Clinical Characteristic of VA AMI Cohorts

	Cohort			
	FY 1994 (n=8677)	FY 1997 (n=8135)	FY 1998 (n=8353)	FY 1999 (n=8664)
Variables not Related to Treatment[a]				
Hypertension (%)	52.6	55.4	58.0	60.8
Diabetes (%)	26.6	28.7	30.7	32.0
COPD (%)	22.4	23.4	22.7	23.6
Arthritis (%)	10.5	9.7	9.4	8.7
Diabetes (end organ damage) (%)	8.0	6.4	6.8	7.3
Psychosis[c] (%)	5.6	4.8	4.6	4.6
Alcohol/drug abuse (%)	7.3	8.2	7.7	8.2
PVD (%)	11.4	10.4	10.8	11.2
Prior MI (%)	12.0	11.5	10.6	11.3
Cancer (%)	5.1	4.7	4.9	4.8
Renal Failure (%)	3.5	4.0	4.2	4.6
Thyroid disease (%)	3.4	4.3	4.2	5.2
Hypertension w/ complications (%)	2.6	2.1	2.0	2.5
Dementia (%)	2.0	3.6	4.1	4.3
Neurological disorders (%)	2.0	2.2	1.9	2.2
Paralysis (%)	4.5	0.4	0.3	0.4
Connective Tissue Disorder (%)	0.4	0.3	0.3	0.5
Liver Disease (%)	0.6	0.8	0.7	0.7
Lung Disease (%)	0.6	0.5	0.4	0.7
Variables Possibly Related to Treatment[b]				
Chronic angina (%)	21.2	6.6	5.9	5.6
CHF (%)	11.1	11.3	11.0	12.5
Unstable angina (%)	7.6	7.1	7.0	7.4
Arrhythmias (%)	7.4	7.1	7.0	7.2
Neurotic disorders (%)	2.9	2.9	3.2	3.0
CVA (%)	5.3	4.5	3.4	2.2
Hypotension (%)	2.7	2.9	3.1	3.2
Ulcer (%)	2.2	1.9	1.7	1.4
Pneumonia (%)	3.1	3.5	3.6	4.1
Fluid disorder (%)	3.8	3.5	3.2	3.7
Urinary tract infection (%)	3.2	3.2	3.3	3.2
Endocarditis (%)	2.3	2.4	2.4	2.3
GI bleeding (%)	1.6	1.5	1.7	1.6
Syncope (%)	1.2	1.6	1.4	1.7
Cardiac arrest (%)	1.3	1.3	0.9	1.1
Coagulation disorders (%)	3.0	1.5	1.5	1.6
Conduction abnormalities (%)	2.6	1.7	1.8	1.8
Conductive disorders (%)	0.4	0.4	0.3	0.3

[a] Coded based on secondary diagnoses from the index admission as well as primary and secondary diagnoses from inpatient claims in the year prior to admission.
[b] Coded based on primary and secondary diagnoses from inpatient claims in the year prior to admission.
[c] Includes depression.

Table A9
Demographic Characteristic of VA AMI Cohorts

	Cohort			
	FY 1994 (n=8677)	FY 1997 (n=8135)	FY 1998 (n=8353)	FY 1999 (n=8664)
Age: Under 45 (%)	4.5	3.2	3.4	2.7
45-54 (%)	13.1	17.0	17.1	16.9
55-64 (%)	27.7	24.3	22.0	22.6
65-74 (%)	37.9	33.1	32.6	30.2
75-84 (%)	15.2	20.2	21.8	24.4
Over 85 (%)	1.6	2.3	2.3	3.2
Gender: Males (%)	98.7	98.4	98.6	98.3
Females (%)	1.3	1.6	1.4	1.7
Race: White (%)	81.7	79.3	79.1	77.7
African American (%)	11.5	12.9	12.5	12.5
Hispanic (%)	4.7	4.4	4.4	4.9
Other/missing (%)	2.2	3.3	4.1	4.1
% with college degree in zip code of residence[a]	21.1	21.3	21.1	21.2
% professionals in zip code of residence[a]	22.1	22.1	21.9	21.2
% with public assistance in zip code of residence[a]	10.2	10.2	10.2	9.9
% over 64 with public assistance in zip code of residence[a]	11.6	11.5	11.5	11.3
% African American in zip code of residence[a]	13.8	14.1	13.8	13.7
% Hispanic in zip code of residence[a]	6.5	6.0	6.1	6.1
Median Household Income in zip code of residence[a]	35546	35540	35384	35455
Missing Census Data (%)	6.9	6.6	7.3	8.8

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

Comparison of Adjusted Utilization and Outcomes for Patients within the VA

Utilization, 30-day and 1-year mortality. In order to increase the precision and reliability of network-level estimates, we fitted hierarchical regression models to data from four cohort years (FY1994, 1997, 1998, and 1999) to estimate adjusted (for clinical and socioeconomic characteristics) utilization and outcomes within each service network and within demographic subgroups (gender and race)[9] [Gatsonis, 1993; Daniels, 1999]. Prior research has demonstrated significant geographic variation in practice patterns and in the adoption of new technologies[10]. We thus assumed that networks differed both in terms of the average level of utilization and outcomes and in terms of trends in utilization or outcome across the cohort years (Bronskill, Normand et al. 2002). Hierarchical modeling techniques fit a regression model to each network. In this case we estimated a linear time trend across the cohort years (FY1994, 1997-1999). Each network-level regression model was then combined to estimate national trends in utilization and outcomes. Hierarchical regression models allowed for the estimation of the network-specific and national models simultaneously and for adjustment with patient-level covariates. For each model we adjusted for gender, race, and severity score; a severity score was defined as the predicted utilization or outcome based on the set of risk adjustment variables described above. Because of the small number of females and minorities in each cohort (see Table A9), we assumed that the

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[9] See Appendix A1 for a more complete description of the models.

[10] For example, Goldberg KC, Hartz AJ, Jocobsen SJ, Krakauer H, Rimm AA. Racial and community factors influencing coronary artery bypass graft surgery rates for all 1986 Medicare patients. JAMA 1992;267:1473-7. Pliote L, Califf RM, Sapp S, Miller DP, Mark DB, Weaver WD, et al. Regional variation across the United States in the management of acute myocardial infarction. N Engl J Med 1995;333:565-72. O'Connor GT, Quinton HB, Traven ND, Ramunno LD, Dodds TA, Marciniak TA, et al. Geographic variation in the treatment of acute myocardial infarction: the Cooperative Cardiovascular Project. JAMA 1999;281:627-33. Guadagnoli E, Hauptman PJ, Ayanian JZ, Pashos CL, McNeil BJ, Cleary PD. Variation in the use of cardiac procedures after acute myocardial infarction. N Engl J Med 1995;333:573-8. Guadagnoli E, Landrum MB, Normand S-L, Ayanian JZ, Garg P, Hauptman PJ, Ryan TJ, McNeil BJ. Impact of underuse, overuse, and discretionary use on geographic variation in the use of coronary angiography following acute myocardial infraction. Med Care 2001;39:446-58.

effect of race and gender on utilization and outcomes was constant across all cohort years[11]. We modeled each utilization and outcome measure independent of the others. As is standard, logistic and normal linear regression models were employed for binary and continuous variables respectively.

We first compared networks in terms of the level of utilization or outcome and report estimated values in FY 1999 and associated 90% confidence intervals within each network. Estimated rather than actual values are reported to adjust for differences across networks in patients' demographic and clinical characteristics. These estimates are predictions from the network-specific regression lines of the utilization or outcome for a VA patient of average severity treated in a facility located in the VISN in FY 1999. We also compared networks in terms of trends in utilization and outcomes across the cohort years and report the estimated rate of change in utilization or outcome (i.e., the slope from the regression line) within each network and associated 90% confidence interval.

Finally, due to the small number of females and minorities in each cohort (see Table A9), we report gender and race effects pooled across the study years (FY 1994, 1997-1999) as adjusted odds-ratios comparing male to female veterans and comparing African American and Hispanic veterans to white veterans (effects on length of stay are reported as absolute differences between demographic subgroups). Race data were not available for approximately 2 to 4% of the veterans in each cohort, and there were a small number of veterans representing other racial groups. We included these patients in the regression models, but because of difficulty in the interpretation of results for patients with missing race data and small numbers of patients in other

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[11] We also assumed the effect of the severity score was constant across years. We refit models to the use of catheterization within 30 days that relaxed the assumption of constant effects for gender, race, and severity score to test the sensitivity of our results to these assumptions and found similar results.

racial categories, we present only comparisons of white, African American, and Hispanic patients.

Mortality greater than 1-year. We estimated adjusted 6-year mortality using the FY 1994 cohort only, adjusted 3 year mortality using the FY 1994 and 1997 cohorts, and adjusted 2-year mortality using the FY 1994, 1997 and 1998 cohorts. We did this because long-term mortality data were not available for the recent cohorts. Our power to detect differences in long-term mortality across VISNs was thus limited by sample size. Because we had, at most, three cohorts with long-term mortality data, we did not estimate linear trends in long-term mortality across the study cohorts. Instead we fit hierarchical regression models that assumed long-term mortality rates differed across networks and across cohort years[12]. By using these models, which allow for differences across networks and cohort years, we are able to test for the presence of those differences. Network-specific rates were then combined to form national rates for each cohort year. These hierarchical regression models also adjusted for gender, race, and severity score as described above.

National trends in long-term mortality. Finally, for descriptive purposes we report adjusted survival curves for each cohort year (FY 1994, 1997-1999). We also report adjusted survival curves according to gender and racial subgroups. We obtained adjusted curves using stratified Cox proportional hazard models. Specifically, we estimated separate baseline survival curves for each cohort year and demographic subgroup employing a proportional hazard assumption for the risk adjustment variables in order to adjust for differences in severity. Stratified survival models do not allow for the testing of differences in adjusted survival across

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[12] See Appendix A1 for a more complete description of the models.

gender and racial subgroups[13]. Thus, we relied on the hierarchical logistic regression models fitted to binary measures of mortality at fixed time points after AMI described above to test for differences in adjusted mortality across demographic subgroups and cohort years.

Comparison of Adjusted Utilization and Outcomes for Elderly (age ≥ 65) VA and Medicare Patients (the "Matched Cohorts")

Because patients with AMI treated in the VA differed with respect to many important socio-demographic and clinical characteristics (Tables A5, A6, A7) compared to Medicare patients treated in private sector facilities, we created a matched sample comprised of VA and Medicare patients for fiscal years 1997, 1998, and 1999. For example, prior to matching, VA patients were more likely to be African American, more likely to live in areas with lower levels of education and income, were more likely to have a variety of chronic conditions (e.g., angina, arthritis, CHF, COPD and diabetes) and were admitted to hospitals farther from their residence. We used a propensity score approach to take into account these differences and matched patients according to their propensity to receive care in the VA. [Rosenbaum, 1983; Rubin, 1997; D'Agostino, 1998]. As demonstrated in other recent observational studies of health outcomes,(Petersen, Normand et al. 2000; Polanczyk, Rhode et al. 2001; Sundararajan, Mitra et al. 2002) propensity-score methods are a powerful tool to compare groups similar in observed

[13] We could have used unstratified Cox proportional hazard models to test for differences across demographic subgroups and cohort years controlling for differences in severity. However, we were concerned that differences across cohorts or demographic subgroups would not be constant over the years of follow-up, violating the proportional hazard assumption required for Cox regression models. For example, invasive treatments for AMI are known to have differential effects on survival, initially increasing the risk of death due to operative or procedure mortality with an eventual benefit two to three years following the procedure. Thus, if invasive procedures following an AMI were used differentially among demographic subgroups or if use of the procedures increased over time, we would expect differences in survival between demographic subgroups or cohort years to vary according to time following the AMI. Preliminary analyses demonstrated potential violations of the proportional hazard assumption for cohort year and race effects.

characteristics without specifying the relation between confounders and outcomes as required by more traditional multivariate regression approaches.(Rubin 1997)

Creation of the matched cohorts required several steps. For each male VA patient aged 65 or over hospitalized with AMI in a given year, we first selected a group of male Medicare patients treated in the same quarter of the fiscal year who were cared for in a private sector facility located within the geographic boundary of the VISN in which the VA patient was treated. As a proxy for severity of the AMI we also matched according to the distance between the patient's residence and their admitting hospital (within 5 miles, 6 to 20 miles, 21-50 miles or greater than 50 miles)[14]. We then developed a score for each patient that represented their propensity to be treated in the VA system (the so-called "propensity score"); for this purpose we used a logistic regression model that included the entire set of risk adjustment variables described above as well as the socioeconomic status variables. We then matched each male elderly VA patient to the Medicare patient with the closest estimated propensity to be treated in a VA facility[15]. We then compared utilization and outcomes between the VA and Medicare using the matched samples. For each cohort year, we used chi-square and t-tests to test for differences in utilization and outcomes at the national level and noted significant differences at the 10% level. We also plotted utilization and outcomes and corresponding 90% confidence intervals in the matched cohorts within each service network. For each of the matched cohorts, we evaluated all of the utilization and outcome variables mentioned above, with the exception of 3-year mortality, which we analyzed in the FY 1997 matched cohorts, and 2-year mortality, which we

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[14] In order to match VA and Medicare patients according to the distance traveled between their residence and their admitting hospital, we made the following additional exclusions prior to matching: (1) VA and Medicare patients transferred from a facility without a 410 diagnosis (2) VA patients admitted to a non-VA facility that we could not identify and (3) Medicare patients admitted to a facility more than 200 miles from their residence and VA patients admitted to a facility more than 200 miles from their residence and outside their home service network (we assumed that these patients were traveling at the time of their MI).

[15] See Appendix A1 for a more complete description of the propensity score methods.

analyzed in the FY 1997 and 1998 matched cohorts. Finally we compared national trends in mortality between the two systems by plotting survival curves for elderly VA and Medicare patients using the matched sample in each cohort year (FY 1997-1999). For each cohort year, we tested for differences in survival between elderly VA and Medicare patients using the log-rank test and note significant differences at the 10% level.

Because even after matching there were several clinical variables which were more prevalent in the VA sector than in the Medicare sector, we estimated adjusted 30-day, 1-year, 2-year and 3-year mortality in the two sectors using logistic regression models fitted to the matched samples to control for these residual differences. The models adjusted for the age and race of the patient, median household income in zip code of the patient's residence, percentage of residents in zip code that were African American, percentage of residents in zip code that were Hispanic, distance to admitting hospital 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 (see Tables A5-A7).

Although the combination of matching on propensity scores and regression modeling can be very effective in controlling for *observed* differences between patients treated in the VA and those treated under Medicare, they are unable to control for *unobserved* differences between patients treated in the two sectors (Rubin 1997). For example, although we matched patients based on the percentage of residents with a college degree in the patients' zip code, veterans treated in the VA may still be more likely to have lower levels of education compared to Medicare patients. In addition, we were unable to control for potential differences in severity of disease on admission. Therefore, we also performed a series of sensitivity analyses to evaluate whether patients' unmeasured characteristics, such as socioeconomic status, health behaviors including smoking, or disease severity, might explain mortality differences between the two sectors (Lin, Psaty et al. 1998). We examined the effect of four unmeasured potential confounders—two related to disease severity on admission (systolic blood pressure < 100 and cardiac arrest); one health behavior (smoking); and one measure of socioeconomic status (a college degree)—on the robustness of our results. Specifically, we updated estimates of the differences in mortality between VA and Medicare patients after adjusting for these additional unmeasured variables under specific assumptions regarding differences between VA and Medicare patients in the prevalence of the confounders and the confounders' relationship with mortality following an AMI. We obtain estimates of these relationships from prior literature where available (Krumholz, Chen et al. 1999; Petersen, Normand et al. 2000; Hardarson, Gardarsdottir et al. 2001; Rea, Heckbert et al. 2002). 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 the prevalence of these two factors (and their correlation) in male patients over the age of 65 with either VHA or Medicare insurance. NHIS respondents were coded as having VA insurance if they a) said they had health care coverage through military health/VA and b) were a veteran; respondents were coded as having Medicare if they said they had health care coverage through Medicare and did *not* have coverage through military/VA. Details of the calculations can be found in appendix A1.

In addition, because we performed an NDI match on the patients in the VA cohort with uncertain vital statistics (approximately 15% of all VA patients could not be matched to BIRLS), and we did <u>not</u> perform a NDI match on Medicare patients with uncertain vital status data (those we could not match to the enrollment files – approximately 2%), we repeated analyses comparing mortality in the two sectors excluding the deaths of VA patients identified through the NDI match.

Finally, while patients who travel longer distances to their admitting hospital may have experienced less severe infarctions, there are several important limitations in this approach. First, distance to admitting hospital is only serving as a proxy for unmeasured aspects of disease severity. The causal effect of distance could have the opposite sign – greater distance produces inferior outcomes, since it leads to delays in instituting effective treatment. These limitations are important because the relationship between distance traveled to the admitting hospital and severity of infarction may be different for VA and Medicare patients. We test the robustness of our conclusions to this important assumption by removing distance as a matching criterion.

Stratification by age. If comorbid conditions within veterans were of greater severity than those for patients in the Medicare system, then we would expect that such individuals would die at a younger age. If so, older veterans would be more comparable in disease severity than would younger veterans. Thus as an additional sensitivity analysis, we compare mortality for VA and Medicare patients according to several groupings: 65-69 years, 70-74 years, 75-79 years, 80-84, and ≥ 85 years. We expected unobserved differences in comorbidity in the two populations to lead to decreased differences in mortality between the VA and Medicare populations as age increases.

Results—Descriptive Characteristics of Patients

The clinical and demographic characteristics of VA patients in the cohorts studied are shown in Tables A8 and A9. Severity scores by VISN, cohort year, by race and by gender for the predicted 30-day mortality rate are plotted in Figures A1-A4. These scores summarize the clinical characteristics of the patients as the predicted risk of death. Severity scores differed across the cohort years, by race and by VISN, suggesting variability in the clinical characteristics of patients and highlighting the need for risk-adjustment. Note that for comparisons of utilization and outcomes across cohort years, by demographic subgroups, and by VISN we used outcome-specific severity scores for risk adjustment. For illustrative purposes we only report the severity scores for predicted 30-day mortality.

Cross utilization of services in the private sector (both Medicare and contract care—paid for by the VA and captured in the non-VA PTF) are reported in Tables A2 and A3.

VA Cohort Findings

- These tables demonstrate that a majority of care for patients in the VA cohort was received in VA facilities: over 90% of the patients were admitted to a VA facility and most of these experienced their entire index episode in a VA facility.
- A small, but significant fraction of the VA patients 65 and older received invasive cardiac procedures following their AMI under Medicare, particularly for CABG (at least 20% of the elderly VA patients who received CABG obtained the procedure under Medicare).
- Cross-utilization of services under Medicare was rare in the under 65 VA population. However, we were not able to identify services received in the private sector that may have been covered by private insurance.

We observed levels of cross utilization similar to those reported in previous studies. For example, Wright et al. (Wright, Daley et al. 1997) found 28% of AMI patients admitted to a VA facility between 1988 and 1990 who underwent bypass surgery in the 90 days following admission obtained their procedure in a private sector facility under Medicare.

Program Evaluation of Cardiac Care Programs in the VHA

Socio-demographic and clinical characteristics of the FY 1997, 1998, and 1999 VA (male patients age 65 and older) and Medicare cohorts are reported in Tables A5, A6, A7. Characteristics of the patients prior to matching are reported in the second and third columns. Characteristics of the matched cohorts are reported in the last two columns.

Matched Cohort (VA and Medicare) Findings

- Patients with AMI treated in the VA were younger, but were more likely to have comorbid diseases such as heart failure, stroke, diabetes, and chronic obstructive pulmonary disease, compared to Medicare patients with AMI.
- The VA cohorts also had larger numbers of racial and ethnic minorities and VA patients were more likely to live in areas with lower levels of education and income.
- VA patients traveled longer distances to their admitting hospital compared to Medicare patients.
- Medicare patients selected into the matched sample were younger, were more likely to have comorbid disease, more likely to be a racial minority, more likely to live in areas with lower levels of education and income, and traveled farther distances to their admitting hospital compared to the general population of Medicare beneficiaries with AMI.

After matching, the cohorts were more similar, allowing us to make more valid comparisons of the use of procedures and outcomes in the two systems. However, because even after matching there were significant differences in a few of the clinical variables and several of the sociodemographic characteristics, we also estimated adjusted 30-day, 1-year, 2-year and 3-year mortality in the two sectors using logistic regression models fit to the matched samples to control for these residual differences.

Figure A1

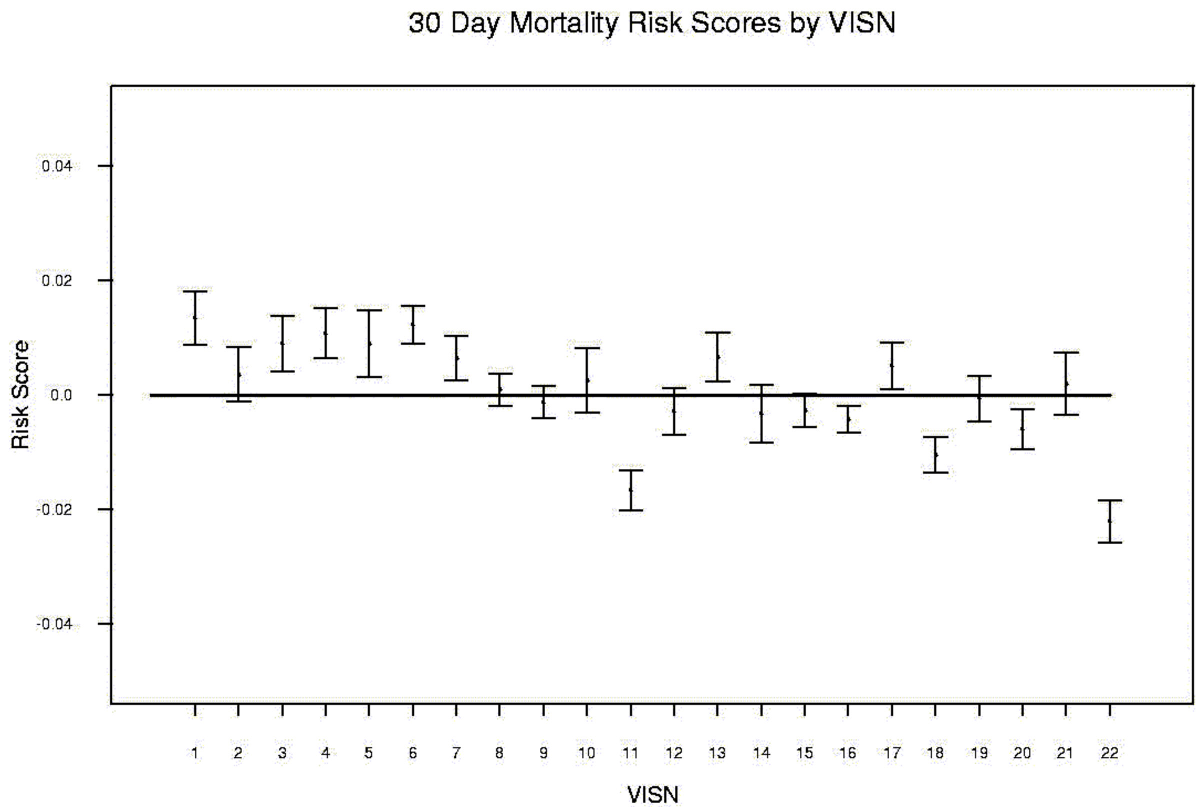


Figure A2

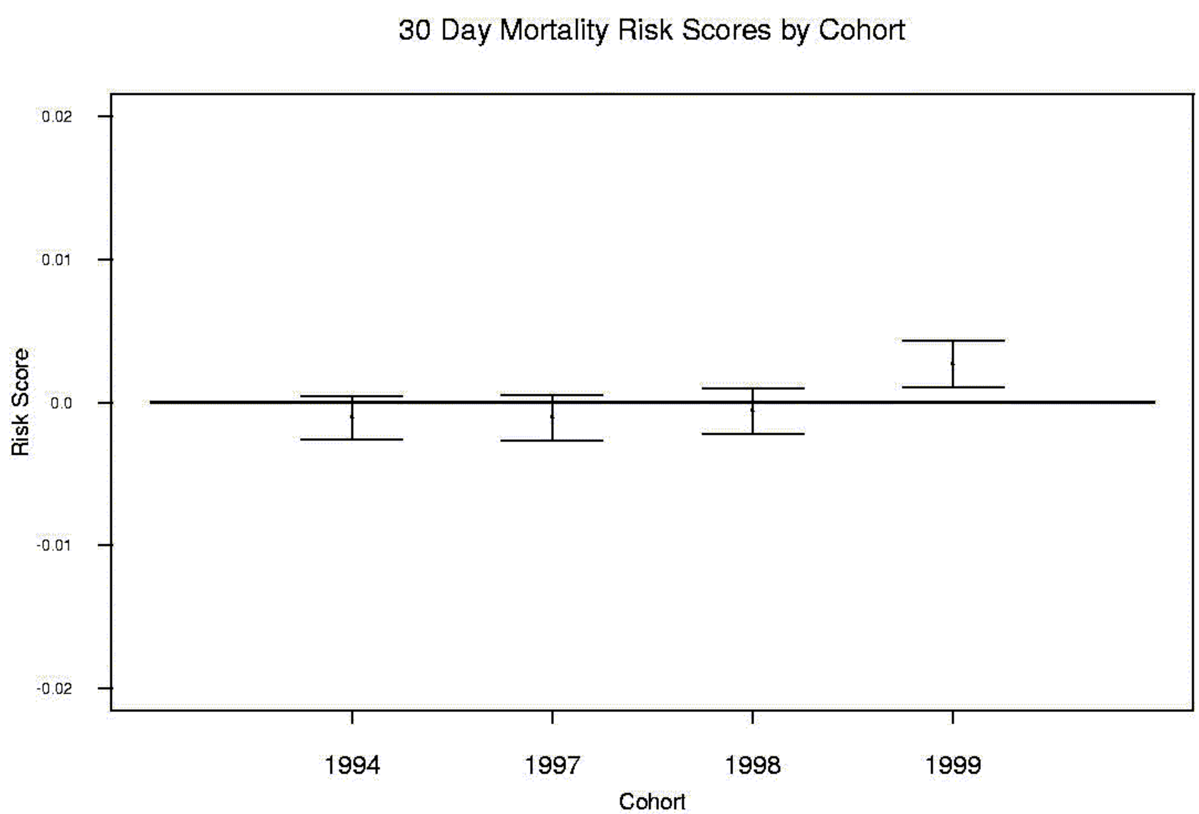


Figure A3

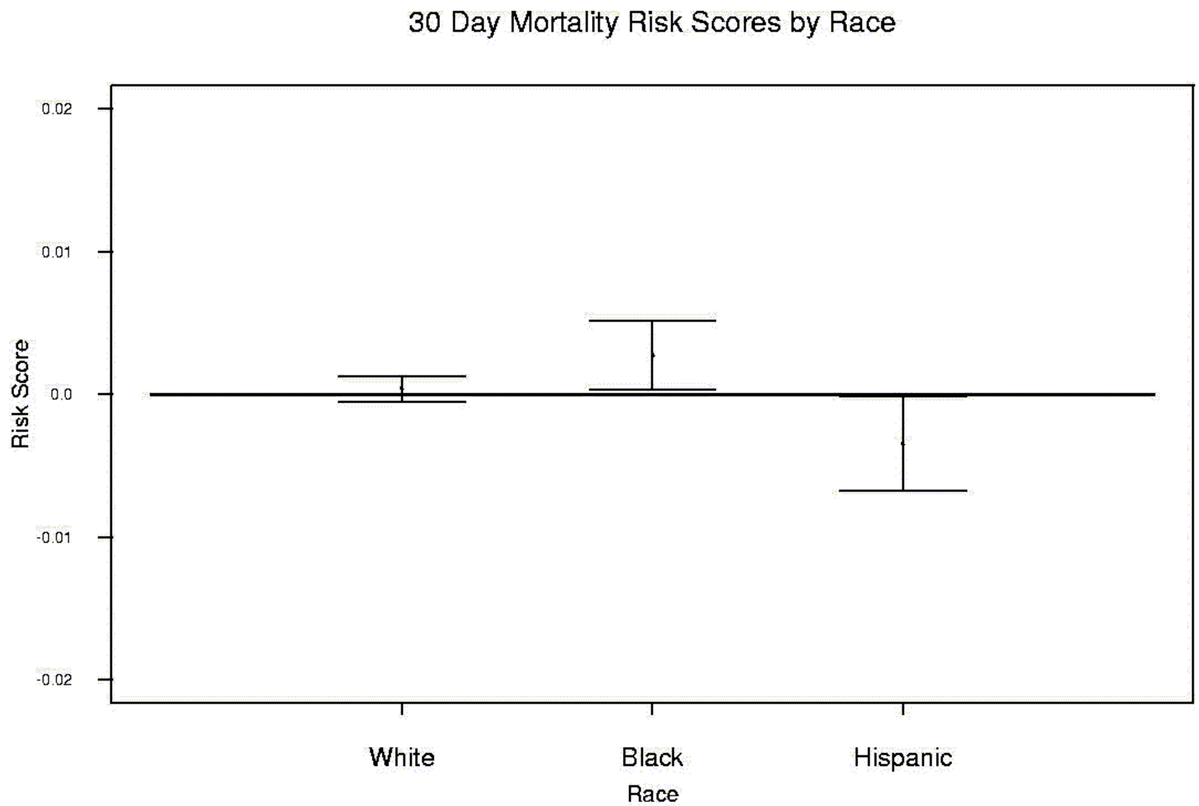
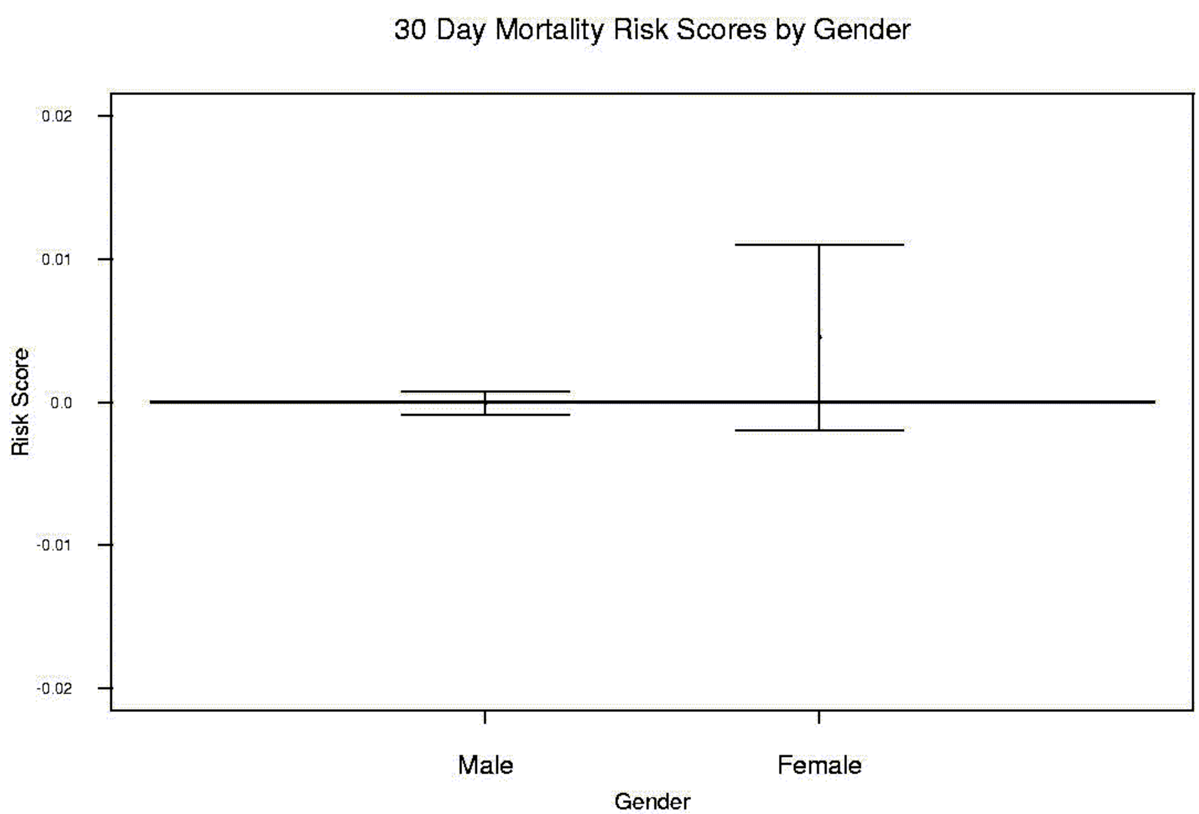


Figure A4



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BACKGROUND: Some have the opinion that patients cared for in Veterans Health Administration (VHA) hospitals receive care of poorer quality than those cared for in non-VHA institutions. To assess the quality of care in VHA hospitals, we compared the outcome of acute myocardial infarction among patients in VHA and non-VHA institutions while controlling for potential confounders, including coexisting conditions and severity of illness. METHODS: We studied 2486 veterans discharged from 81 VHA hospitals and 29,249 Medicare patients discharged from 1530 non-VHA hospitals, restricting our samples to men at least 65 years of age who were discharged with confirmed acute myocardial infarction. We compared coexisting conditions, severity of illness, and 30-day and 1-year mortality in the two samples. RESULTS: VHA patients were significantly more likely than Medicare patients to have a recorded history of hypertension (64.3 percent vs. 57.3 percent), chronic obstructive pulmonary disease or asthma (30.9 percent vs. 23.5 percent), diabetes (34.8 percent vs. 29.0 percent), stroke (20.4 percent vs. 14.2 percent), or dementia (7.2 percent vs. 4.8 percent) ($P<0.001$ for all comparisons). According to both multivariate logistic regression and an analysis using 2265 matched pairs of VHA and Medicare patients, there were no significant differences in 30-day or 1-year mortality. The matched-pairs analysis found that the difference in mortality at 30 days (the mortality rate among Medicare patients minus the mortality rate among VHA patients), averaged over the 5-year age groups, was -0.8 percent (95 percent confidence interval, -2.8 percent to 1.3 percent), and the difference in mortality at 1 year was -1.3 percent (95 percent confidence interval, -3.9 percent to 1.3 percent). CONCLUSIONS: VHA patients had more coexisting conditions than Medicare patients. Nevertheless, we found no significant difference in mortality between VHA and Medicare patients, a result that suggests a similar quality of care for acute myocardial infarction.

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Appendix A

APPENDIX A1

Statistical Analyses

Hierarchical Models

We fitted hierarchical regression models to data from four cohort years (FY 1994, FY 1997, FY 1998, and FY 1999) to estimate adjusted utilization and outcomes within each service network and within demographic subgroups (gender and race). In this section we illustrate our approach by describing a model for the likelihood of a VA patient undergoing catheterization within 30 days of their AMI. Similar hierarchical models were fit to the other utilization and outcome measures.

Let *i* index VISN; *j* index patients within a VISN; and *t* denote year. We let s_{ijt} be the deviation from the average severity score across all patients for patient *j* treated in VISN *i* in year *t* (severity score minus the average severity score), m_{ijt} be a binary variable equal to 1 if the patient was male, b_{ijt} be a binary variable equal to 1 if the patient was African American, h_{ijt} be a binary variable equal to 1 if the patient was Hispanic, o_{ijt} be a binary variable equal to 1 if the patient's race was missing or if the patient represented another racial minority and y_{ijt} be a binary variable equal to 1 if patient received catheterization in the 30 days following their AMI. We estimated the following model:

1. Patient-Level (Within-VISN and Time): log-odds$[P(y_{ijt} = 1)] = \eta_{0it} + \eta_1 s_{ijt} + \eta_2 m_{ijt} + \eta_3 b_{ijt} + \eta_3 h_{ijt} + \eta_4 o_{ijt}$;

where η_{0it} represents the adjusted log-odds of receiving catheterization for an average patient treated in VISN *i* in year *t*, and η_1, η_2, η_3, and η_4 describe the impact of severity, gender and race on the log-odds of receiving angiography. This model hypothesized that the log-odds of receiving angiography varied across VISNs and cohort years.

2. Within-VISN: $\eta_{0it} = \beta_{0i} + \beta_{1i}T + \varepsilon_{it}$;

where T is a variable equal to –5 for t=1994, -2 for t=1997, -1 for t=1998, and 0 for t=1999, and ε_{it} represents random error, which we assumed was approximately normally distributed. This model hypothesized that the likelihood of receiving catheterization within a VISN followed a linear trend (on the log-odds scale) across the cohort years. β_{0i} represents the log-odds of receiving catheterization in VISN *i* in 1999, and β_{1i} estimates the linear trend in VISN *i*.

3. Between VISN: $(\beta_{0i}, \beta_{0i})^T = \boldsymbol{\gamma}_0 + \boldsymbol{\omega}_i$;

where $\boldsymbol{\omega}_i$ is a vector of VISN random effects, which we assumed were approximately bivariate-normally distributed. The components of $\boldsymbol{\gamma}_0$ represent the national trend in the receipt of catheterization across the cohort years.

<u>Hierarchical Model for greater than 1-year mortality</u>

Because we had at most three cohorts with long-term mortality data, we did not estimate linear trends in long-term mortality across the study cohorts. Instead we fit hierarchical regression models that assumed long-term mortality rates differed across networks and across cohort years. For example we estimated the following model for 2-year mortality (available for the FY 1994, 1997 and 1998 cohorts):

1. Patient-Level (Within-VISN and Time): log-odds[$P(y_{ijt} = 1)$] = $\eta_{0it} + \eta_1 s_{ijt} + \eta_2 m_{ijt} + \eta_3 b_{ijt} + \eta_3 h_{ijt} + \eta_4 o_{ijt}$;

where η_{0it} represents the adjusted log-odds of dying within 2 years for an average patient treated in VISN *i* in year *t*, t=1994, 1997, and 1998, and η_1, η_2, η_3, and η_4 describe the impact of the severity, gender and race on the log-odds of dying within 2 years. This model hypothesized that mortality varied across VISNs and cohort years.

2. Between VISN: $(\eta_{0i,1994}, \eta_{0i,1997}, \eta_{0i,1999})^T = \boldsymbol{\gamma}_0 + \boldsymbol{\omega}_i$;

where $\boldsymbol{\omega}_i$ is a vector of VISN random effects, which we assumed were approximately tri-variate-normally distributed. The components of $\boldsymbol{\gamma}_0$ represent the national 2-year mortality rates in FY 1994, 1997 and 1998 respectively.

Models were estimated using the BUGS software (Gilks, Thomas A et al. 1994).

Propensity Score Analyses

We created matched samples of VA and Medicare patients for fiscal years 1997, 1998, and 1999 using a propensity score approach. Creation of the matched cohorts required several steps. For each male VA patient aged 65 or over hospitalized with AMI in a given year, we first selected a group of male Medicare patients treated in the same quarter of the fiscal year who were cared for in a private sector facility located within the geographic boundary of the VISN in which the VA patient was treated. As a proxy for severity of the AMI we also matched according to the distance between the patient's residence and their admitting hospital (within 5 miles, 6 to 20 miles, 21-50 miles or greater than 50 miles).

We then developed a score for each patient that represented his propensity to be treated in the VA system (the so-called "propensity score"). The propensity score was estimated by fitting a logistic regression model to estimate the probability that a patient was treated in a VHA hospital:

$$\text{logit}(P(VA_{it}=1)) = \beta_{0t} + \beta_{1t} X_{it}$$

where VA_{it} is a dichotomous variable equal to 1 if the i^{th} patient receiving treatment for AMI in year t was treated in a VHA hospital and equal to zero if the patient was a Medicare beneficiary, X_{it} is a vector of clinical and socioeconomic risk adjustment variables previously described. Models were fit to each cohort year independently. The area under the ROC curve was equal to 0.72, 0.72, and 0.70 for the FY 1997, 1998, and 1999 models respectively.

After fitting the propensity score models we estimated a predicted propensity score, p_{it}, for each patient where

$$p_{it} = \frac{\exp(\hat{\beta}_{0t} + \hat{\beta}_{1t} X_{it})}{1 + \exp(\hat{\beta}_{0t} + \hat{\beta}_{1t} X_{it})}.$$

Within cells defined by quarter of discharge, VISN, and distance between the patients' residence and their admitting hospital, we then matched each male elderly VA patient to the Medicare patient with the closest estimated propensity (on the logit scale) to be treated in a VA facility within a specified range ($\leq$0.6 of the pooled standard deviation of estimated logits) to reduce differences between treatment groups by at least 90% (Rosenbaum and Rubin 1985). VA patients for whom suitable matches could not be found were removed from the analysis (fewer than 10% in each cohort year). The adequacy of the propensity score model to adjust for differences between VA and Medicare patients was assessed by calculating standardized difference statistics in the observed characteristics between the groups pre and post matching on the estimated propensity score. Standardized differences between VA and Medical patients in their clinical and socioeconomic characteristics were substantially reduced after matching on the estimated propensity score (all standardized differences were less than 10% and most were less than 5% in each cohort year).

Sensitivity Analyses

We performed a series of sensitivity analyses to evaluate whether patients' unmeasured characteristics (systolic blood pressure < 100 and cardiac arrest, smoking status, and having a college degree) might explain mortality differences between the two groups. Specifically, we updated estimates of the odds of mortality among VHA patients compared to that among Medicare patients after adjusting for these additional unmeasured variables under specific assumptions regarding differences between VHA and Medicare patients in the prevalence of the confounders and the confounders' relationship with mortality following an AMI. We used several sources to obtain estimates of these parameters for each of the potential confounders. 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 over the age of 65 treated in VHA facilities or private sector 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 (Hardarson, Gardarsdottir et al. 2001) and the relative risk of CAD mortality associated with having a university education to approximate the relative risk of death at 30 days, 1 year, 2 years and 3 years associated with smoking and education respectively (Rea, Heckbert et al. 2002). 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 male patients over the age of 65 with either VHA or Medicare insurance. We used logistic regression models to estimate the prevalences 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

For each mortality outcome we estimated the effect of each of these four potential confounders by adjusting the estimated odds ratios obtained from the logistic regression models we fit to the matched sample for each cohort year. We made the adjustments using the following formula: (Lin, Psaty et al. 1998)

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

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

Γ is the relative risk of mortality associated with the confounding variable of interest, and P_1 and P_0 are the prevalences of a confounder among VHA and Medicare patients, respectively. For example, in a logistic regression model fit to the matched 1999 cohorts, we estimated that the odds of death within 1 year were 1.39 times higher among VHA patients compared to similar

Medicare patients, after adjustment for the observed confounders available in this study. 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 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 from 1.39 to 1.38 or that 2.5% of the observed relationship between sector of care and mortality is explained by differences in this unmeasured factor.

Combined effect of confounders

To adjust our estimated effects 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 decrease the adjusted odds ratio from 1.38 to 1.35, or that these two variables in combination explain 10.5% of the observed relationship (odds ratio equal to 1.39) between sector of care and mortality.

Obtaining the combined effect required estimating the independent effects of each individual confounder on mortality and then accounting for differences in their prevalences 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 of 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 prevalences of smoking controlling for the difference in the prevalence of having a college education between groups, and of a college education controlling for the difference in prevalence of smoking status, we fit logistic regression models to the NHIS data that controlled for the other confounder, 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).

Program Evaluation of Cardiac Care Programs in the VHA

Appendix A2—Map of Veterans Integrated Service Networks (VISNs)