PREFACE

Wonder rather than doubt is the root of all knowledge.
—Abraham Joshua Heschel

How do people choose to allocate resources when it is not possible to pay for all desired goods and services? In principle, the invisible hand of the market guides resource use; with regulators, generally governmental agencies, assuring a level playing field and preventing various forms of abuse, but otherwise trying to stay out of the way. Free markets are guided by a principle called *willingness-to-pay*, which economists define as that price, governed by supply and demand, which consumers are willing to pay for a service *(1)*. Services in society that are deemed a "right," such as education, are not governed by free markets, as society may view that all people have a right to those services, independent of their ability to pay. At the level of the individual consumer, Medicine is largely, although not entirely, in the class of a "right," more like education than a good governed by willingness-to-pay such as automobiles. From the larger point of view of society, there is intense concern over the price of medical services since there is a perception that it is not priced by willingness-to-pay. The concern for value in medicine is a major societal issue. We can define value in health care as good care at a fair price. Whether society is achieving value in health care is a major issue all over the world.

Health care expenditures in the United States have risen dramatically in the last half of the 20th century. Between 1960 and 2000, federal health care expenditures rose from $2.9 billion to $411.5 billion and total national expenditures from $28.65 billion to $1.30 trillion *(2)*. This represents an increase in percent of gross national product over this period from 5.1 to 13.2%. This unprecedented and unparalleled increase in expense for one sector of the American economy is placing American medicine in considerable peril. The Centers for Medicare & Medicaid Services (formerly Health Care Financing Agency) expects expenditures to double in the next 10 years, reaching 17% of the gross national product (Fig. 1) *(3)*.

An understanding of the critical issues involved in health care economics can be understood by assessing the role of Medicare, the federal government health program for the aged and disabled and the largest payer for medical services in the United States (4). The Medicare program is comprised of two parts. Hospital Insurance (HI), or Medicare Part A, pays for hospital, home health, skilled nursing facility, and hospice care for the aged and disabled. The Supplementary Medical Insurance (SMI), or Medicare Part B, pays for physician, outpatient hospital, home health, and other services for the aged and disabled. The HI trust fund is financed primarily by payroll taxes paid by workers and employers. Current tax revenues are used mainly to pay benefits for current beneficiaries. The SMI trust fund is financed primarily by transfers from the general fund of the US Treasury and by monthly premiums paid by beneficiaries. Income not currently needed to pay benefits and related expenses is held in the HI and SMI trust funds, invested in US Treasury

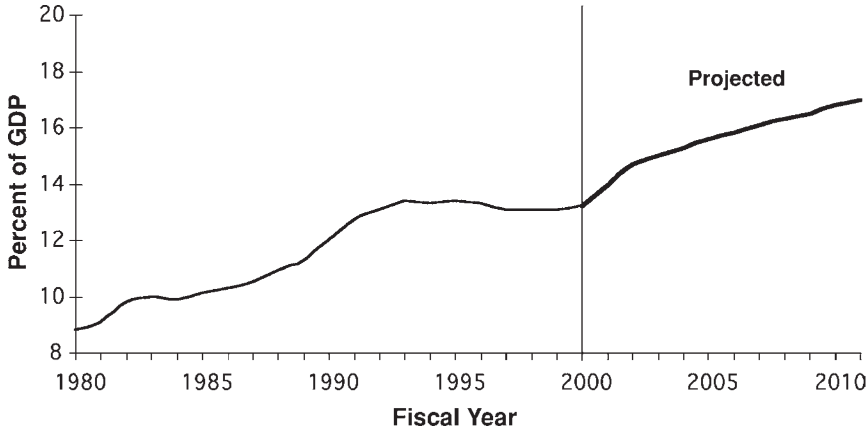

Fig. 1. National health expenditures as a share of gross domestic product (GDP). Between 2001 and 2011, health spending is projected to grow 2.5% per year faster than the GDP, so that by 2011 it will constitute 17% of the GDP (*Source*: CMS, Office of the Actuary, National Health Statistics Group).

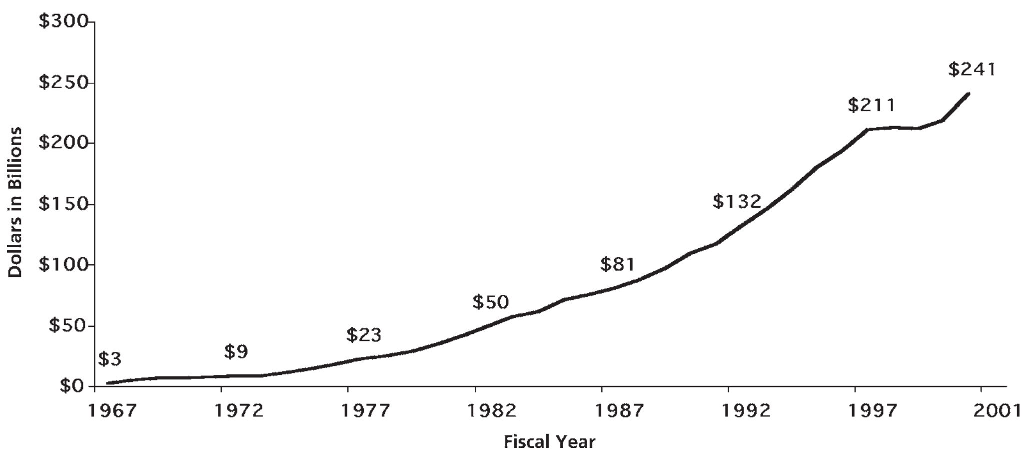

Fig. 2. Medicare spending in the United States. Overall Medicare spending grew from $3.3 billion in 1967 to nearly $241 billion in 2001. Overall spending includes benefit dollars, administrative costs, and program integrity costs. Represents federal spending only (*Source*: CMS, Office of the Actuary).

securities. The growth in expenditures in recent decades is shown in Fig. 2 *(3)*. Although revenue and expenses are currently in balance, this is only maintained by transfer from general revenues. In approximately 13 years, expenses are projected to exceed revenues, which will ultimately exhaust the Medicare trust fund, with a current estimated date of 2030. Current policy does not address the critical issues in health care financing that our society will face over the next several decades if current projections prove correct.

Cardiovascular disease consumes substantial societal resources in economically advantaged countries, and thus is responsible for a considerable part of the projected economic challenges in the future. In the United States alone, the American Heart Association estimates that the cost of cardiovascular disease in 2002 will total $329.2 billion

(4). Of this total, $199.5 billion will be related to direct consumption of medical resources and an additional $129.7 billion will be related to lost productivity resulting from early death and disability. Costs related to coronary artery disease lead the other categories at $111.8 billion, but this is just a little over one third of the total. Given its magnitude, there is a strong societal interest that the $199.5 billion in direct costs be spent wisely and that the $129.7 billion in lost productivity be minimized.

The field of health care economics has developed as a discipline to address these enormous societal issues. It is not the purpose of this book to address policy. It is the purpose of this book to show how services may be rationally valued, that is, how outcomes may be assessed, how cost can be derived, and how choices can rationally be made. *Cardiovascular Health Care Economics* is divided into two sections; the first concerning methods and the second concerning various cardiovascular health care services. The information in *Cardiovascular Health Care Economics* is not designed on its own to be the sole text to guide health services researchers. It is designed to assist health services researchers by being the first place to look for economic studies in cardiovascular medicine and methods in health care economics and as a guide for further reading. It is also designed to be an introduction and reference to cardiovascular health care economics for health care professionals. Health care economics has grown in recent years, partly to help society make better decisions currently and partly in response to the looming crisis ahead. All people in industrial societies face the issues and decisions presented in this book. Thus, *Cardiovascular Health Care Economics* is a book for all those concerned about making good choices and assuring continuing access to high-quality health care in the decades to come.

ACKNOWLEDGMENTS

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William S. Weintraub, MD

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Estimating the Costs of Cardiac Care Provided by the Hospitals of the US Department of Veterans Affairs

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BACKGROUND

Ischemic heart disease is among the leading causes of death in the United States *(1),* and one of the most frequently treated diseases in US Department of Veterans Affairs (VA) health care facilities. Each year, VA facilities provide more than 150,000 hospital stays for patients with this condition, including some 15,000 stays for myocardial infarction (MI) and some 23,000 stays for unstable angina *(2).* As part of its mission, VA conducts clinical trials to improve the quality and effectiveness of patient care, including several trials examining strategies for treating ischemic heart disease. Cost-effectiveness (CE) is an increasingly important part of these studies.

The VA health care system has unique features that present both opportunities and challenges for clinical trials. Patients have a uniform set of insurance benefits and few copayments, allowing trial participants equal access to health care. VA has comprehensive utilization databases, which make it possible to track the quantity of care received by an individual throughout the health care system. However, health economics studies are more challenging because of the lack of billing data, which are ordinarily used by non-VA hospitals in the United States to estimate the cost of care.

Given the lack of billing data, VA health economics researchers use several alternative methods to estimate the cost of care, including direct measurement, preparation of

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pseudo-bills, and applying cost functions estimated from non-VA data *(3)*. Researchers are also beginning to use the Decision Support System (DSS), a patient care cost accounting system that has been adopted by VA.

This chapter describes methods of estimating VA health care costs, with the goal of identifying methods most suitable for CE studies of treatment for ischemic heart disease. We focus on the cost of hospitalization, ordinarily the most expensive component of treatment. Using hospital stays for MI as an example, we evaluate the accuracy of cost data from DSS. We compare these data to cost-adjusted charges from Medicare claims data at non-VA hospitals. We also examine the effect of DSS data practices, as reported by site managers, on DSS cost estimates.

COST DETERMINATION METHODS

Cost-effectiveness analysis (CEA) ordinarily requires comprehensive information on cost. As a result, VA analysts ordinarily rely on several alternate costing methods *(4)*, which include direct measurement, pseudo-bill, cost functions, and DSS data.

Direct Measurement

Direct measurement is a useful and potentially accurate means of determining health care cost. An activity analysis is used to determine the labor employed. Supply and space costs are also determined. Direct measurement can be used to find the cost of a specific intervention or a few diagnostic tests or procedures. Because this method is labor-intensive, it is not feasible to use it to find all the health care costs incurred by patients.

Pseudo-Bill

The pseudo-bill approach combines VA utilization data and a non-VA reimbursement or charge schedule. The estimate mimics the itemized bills used by health care payers, giving the method its name. Hypothetical Medicare reimbursement for VA ambulatory care can be determined because VA uses the Current Procedures and Terminology (CPT) and Medicare Health Care Procedures Coding System (HCPCS) codes to characterize services and supplies provided to out-patients. The Medicare Resource-Based Relative Value System can be used to determine Medicare reimbursement for physician and other provider visits, laboratory tests, and medical supplies. Medicare makes separate payments to facilities, such as hospital out-patient clinics, ambulatory surgery centers, and free-standing diagnostic centers. These facility reimbursements can be estimated with the new Medicare prospective payment system, which is based on the Ambulatory Payment Category of each procedure. Because Medicare does not reimburse providers for certain types of care, such as preventive services and dental procedures, other charge schedules are needed to estimate the cost of these services.

Pseudo-bills have also been created using charge schedules from non-VA providers. Regardless of the method used, analysts must adjust charges to reflect actual economic costs. One way for VA investigators to do this is to find all ambulatory charges at a medical center and compare these to the total ambulatory costs reported in the VA department level cost report, the Cost Distribution Report.

Pseudo-bill methods are not a very useful way of estimating in-patient cost. The Medicare reimbursement rate may not be sensitive to the effect of an intervention on hospital costs because Medicare makes a fixed payment based on the diagnosis-related group (DRG) of the hospital stay. Therefore, Medicare-based cost estimates may not accurately capture the resources used that are not reflected in the DRG assignment.

An in-patient pseudo-bill could be constructed to take advantage of a charge schedule of a non-VA hospital, however, it would be very expensive for a VA investigator to do this, as hospital charge schedules are based on very detailed information on each specific resource used in the stays. It is unlikely that such an extreme level of detail is needed for accuracy. Most of the variance in hospital costs can be explained by just a relatively few characteristics of the stay.

Cost Function

The cost-function method requires less detailed utilization data. It relies on the characteristics of hospital stays that explain most of the variation in their cost. A regression is estimated using data from non-VA hospital stays. The dependent variable is cost-adjusted charges. The independent variables are the characteristics of the stay, such as diagnosis and length of stay. The model is then applied to VA utilization data to simulate charges.

This approach has been used to estimate the cost of VA stays for acute MI. A cost function was estimated using a large sample of stays of patients hospitalized for heart attack in Seattle area hospitals *(5)*. Independent variables included total days of stay, days of intensive care, vital status at discharge, and whether the patient had cardiac catheterization (CATH), coronary artery bypass grafting (CABG), or percutaneous transluminal coronary angioplasty (PTCA).

The cost-function method requires data on non-VA patients with comparable conditions. Such data may be available from hospital discharge datasets. A suitable data source represents a relatively economical means of estimating VA hospital costs. The approach requires the assumption that patterns of resource use in the non-VA sample are the same as in the VA sample. Explanatory variables are limited to those that occur in both the VA and non-VA data set.

One obstacle that needs to be addressed is physician services. Charge data from US hospitals do not ordinarily include these costs. Physicians bill payers separately. It is difficult to access physician claims and associate them with a particular hospital stay. One alternative is to create a pseudo-bill for in-patient services provided by physicians. There are two significant problems with this approach. Hospital discharge records characterize procedures using the International Classification of Diseases–9th Revision (ICD-9) codes. These codes are much less specific than the CPT codes used for physician billing. Medicare and other payers do not have schedules of the physician reimbursement associated with ICD-9 procedure codes. Another problem is that hospital discharge data include only procedures and do not characterize other services provided by physicians, such as consultations and daily visits.

An alternative method is to use data on the average payment for physician services found in other studies. One study of Medicare-financed hospital stays provides the average Medicare reimbursement for physician services provided to hospitalized patients for each DRG *(6)*.

Decision Support System

VA has implemented the DSS, a software and database that includes a cost allocation system. DSS is an activity-based costing system that determines the costs of intermediate health care products and tallies them to find the total cost of hospital stays and out-patient encounters. It has the potential of providing cost estimates that are far more accurate than methods currently used in VA CE studies. Indeed, if the system is properly implemented, the cost estimates should be more sensitive to variation in resource use than the cost-adjusted charges used in non-VA CE studies.

There are several concerns about the accuracy of DSS *(7)*. DSS has been implemented relatively recently by VA. It is not known if facilities accurately distribute staff costs among departments or estimate the relative effort required to produce different health care products. Because VA physicians do not bill for their services, they do not have the same incentive that non-VA physicians have to document their work, therefore, VA databases do not reflect the same level of detail found in non-VA physician claims databases. For example, some VA sites do not record CATH procedures in a way that allows DSS to determine their cost *(7)*. The extent of this problem and its effect on DSS cost estimates is unknown.

A previous study estimated the cost of VA hospital stays for acute MI using DSS data from four sites that were reported to have exemplary data *(5)*. The relationship between cost and characteristics of stay was used to estimate the cost of the initial VA hospital stay of patients enrolled in the VA Non-Q Wave Infarction Strategies in Hospital clinical trial. The DSS-based cost estimates yielded the same CE results as non-VA cost estimates. We sought to expand on this work to learn the quality of DSS data at other sites.

METHODS

We evaluated the quality of DSS data from VA by conducting a medical center-level survey of data quality, then evaluating the effect of data quality on cost.

DSS Site Survey

We sent surveys to DSS managers at 71 VA medical centers where CATH are performed. Respondents were asked if CATH was offered at their site, whether CATH workload was collected by DSS, and, if so, whether it was used to estimate cost. They were asked their opinion of the quality of their site's data. The survey was distributed in the summer of 1999, and 63 surveys were completed and returned. Two respondents reported that there was no CATH laboratory at their site, leaving 61 complete responses from sites with CATH laboratories.

VA Cost and Utilization Data

Patients hospitalized for MI were identified in the national VA hospital discharge database, the Patient Treatment File. We selected patients with a primary diagnosis of new MI (ICD-9 code of 410.0–410.9, but excluding codes with the fifth digit of 2, indicating subsequent nonacute treatment of MI). We identified 10,377 stays that ended in the year prior to September 30, 1999. We limited our analysis to the 61 sites that offered CATH and responded to the survey, leaving 6261 observations. We matched these stays to cost data in the VA DSS National Discharge Extract. Because this DSS extract does not separately identify the cost of long-term or rehabilitation care, we excluded 178 stays that involved these types of care. We dropped 18 additional observations because they did not appear in the DSS National Extract with a cost estimate, leaving data on 6065 stays. These data were combined with indicators of the quality of

DSS data at that hospital and the value of the Medicare hospital wage index for the hospital's location. This index is used by Medicare to adjust hospital payments for geographic variation in wages.

VA does not pay the cost of financing capital acquisitions, which are borne by the US Treasury Department. We added to the VA DSS costs an estimate of the average cost of capital of US hospitals. The Medicare capital reimbursement to US hospitals was an average of $727 per discharge in 1996. We assumed that capital costs are proportionate to total costs. The average Medicare hospital stay had a case-mix index of 1.42 DRG relative value units. Stays in this cohort of VA patients had an average case-mix index of 1.845 (1.29 times the Medicare average). We estimated the average capital cost of these VA stays as $1003 ($727 × 1.29, adjusted to 1999 dollars). Because this was 8.3% of the average VA cost, we added 8.3% to all DSS costs estimates. DSS cost estimates do include the cost of depreciation. As we have no way of deducting depreciation cost from DSS estimates, we have double-counted this cost. The cost of financing capital acquisitions exceeds depreciation, especially in VA, as many facilities are fully depreciated.

Medicare Data

To compare the DSS data to non-VA cost estimates, we identified a comparable sample of Medicare claims. Medicare predominantly serves adults over 65 years of age, but it also covers younger individuals with disabilities. We studied hospital stays of all individuals who obtained care from VA between 1992 and 1994 who appeared in the 1996 Medicare Provider Analysis and Review file. We identified 13,809 stays with primary diagnosis of new MI at non-VA hospitals in the continental United States. There were 9552 stays at hospitals that provided at least one CATH. We found the Medicare wage index for each hospital; there were 144 stays at hospitals that we could not identify the wage index, leaving 9408 observations in our data set.

The cost of each stay was estimated by multiplying charges by a hospital-specific cost-to-charge ratio. We estimated the cost of physician services using the average DRG-specific Medicare physician payment *(6)*. We adjusted this cost by $51 for every day that the stay deviated from the national mean length of stay for that DRG. This is the typical Medicare reimbursement for a daily physician visit to an in-patient.

Definition of Comorbid Conditions

We used ICD-9 diagnostic codes to identify the following additional conditions reported in the hospital discharge record: cardiogenic shock (785.51), cardiac arrest (427.5), tachycardia (785.0, 427.0, 427.1, 427.2), and pulmonary edema (428.0, 428.1, 518.4). We characterized 12 comorbidities using the ICD-9 codes used to create a modified Charlson index from discharge data *(8)*. These were previous MI, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatologic disease, liver disease, diabetes, hemiplegia or paraplegia, renal disease, cancer, and AIDS. We characterized psychiatric and substance abuse conditions with the same ICD-9 codes used in a study of substance abuse treatment *(9)*.

Inflation Adjustment

All costs were adjusted to 1999 dollars using the consumer price index for all urban consumers.

Statistical Analysis

Statistical tests were conducted with hospital-level error terms. We estimated random effects regressions to avoid the bias in the standard errors that would occur if there is correlation among patients treated at the same hospital.

RESULTS

The study data include 6065 stays for MI at VA hospitals that occurred in 1999. The average DSS cost estimate for these stays was $13,238. The average length of stay was 7.1 days. Data from Medicare hospitals include 9408 stays for MI that occurred in 1996. The average cost-adjusted charges for these stays was $18,860. The average length of stay was 7.4 days.

There were many significant differences in the care provided in the two systems and in the characteristics of patients (Table 1). These characteristics are associated with differences in cost. Patients treated at Medicare hospitals were more likely to undergo some procedures. CABG was performed in 15.9% of the stays at Medicare hospitals, significantly more than the 5.1% rate at VA hospitals. PTCA was performed in 24.4% of Medicare stays and in 22.1% of the VA stays (difference not statistically significant). CATH was performed during 59.7% of Medicare stays. This rate was significantly lower for VA, where it was performed in 50.6% of stays.

Patients treated in a VA hospital were more likely to be treated in an intensive care unit (ICU). Of the 73.5% of VA stays that involved some time in the ICU, the average length of stay in the ICU was 4.1 days. Although a smaller percent (53.7%) of Medicare stays involved time spent in the ICU, the average length of stay in the ICU was a little longer (4.5 days).

Patients treated in Medicare hospitals were, on average, 72 years old, whereas those treated in VA hospitals were significantly younger, an average of 65.5 years of age. Medicare patients were more likely to have many of the diagnoses associated with more severe heart disease, including higher rates of cardiogenic shock, cardiac arrest, tachycardia, pulmonary edema, and previous heart attack. In addition, they had higher rates of comorbid conditions, including chronic pulmonary disease and peripheral vascular disease. They were also more likely to die during their hospital stay. Patients hospitalized in VA facilities were more likely to have diabetes, renal disease, AIDS, and psychiatric and substance abuse comorbidities.

DSS Survey Results

Of the 61 VA medical centers that offered CATH and completed a survey, 51 (83.6%) reported that they gathered CATH workload data in a way that could be used by DSS. There were 31 sites (50.8% of the total) that estimated the costs of this workload. We asked DSS site managers to give their opinion about the quality of this cost and workload data. Managers at 27 of these 31 sites were at least moderately confident in the quality of the workload data. There were 24 managers who were at least moderately confident in the quality of the data on CATH products, and 21 who were at least moderately confident in the quality of the units of relative value used to estimate the cost of these products.

Table 1
Mean of Variables Characterizing Stays in Medicare and VA Hospitals

Variable		*Medicare hospitals*	*VA hospitals*
CAC	Total cost	18,860	13,238[a]
ACUTDAYS	Acute days of stay	7.4	7.1
ICUDAYS	Intensive care days of stay	2.4	2.8
ICUSTAY	Stay with intensive care days (%)	53.7	73.5[a]
WAGINDX	Medicare wage index for hospital	0.977	0.993
CABG	Bypass surgery (%)	15.9	5.1[a]
PTCA	Angioplasty (%)	24.4	22.1
CATH	Cardiac catheterization (%)	59.7	50.6[a]
AGE	Age in years	72.0	65.5[a]
SEX	Gender (% female)	2.4	1.5[a]
DIED	Died in hospital stay (%)	10.2	8.2[a]
SHOCK	Cardiogenic shock (%)	4.8	1.8[a]
EDEMA	Pulmonary edema (%)	34.8	22.9[a]
ARREST	Cardiac arrest (%)	4.0	2.2[a]
TACHY	Tachycardia (%)	12.1	7.0[a]
OLDMI	Previous heart attack (%)	8.4	4.2[a]
PVD	Peripheral vascular disease (%)	5.9	5.7
CVDIS	Cerebrovascular disease (%)	2.5	3.3[b]
CPD	Chronic pulmonary disease (%)	25.8	20.0[a]
RHEUM	Rheumatologic disease (%)	1.1	1.0
HEMIPARA	Hemiplegia-paraplegia (%)	1.6	0.5[a]
RENAL	Renal disease (%)	2.3	4.1[a]
CANCER	Cancer (%)	2.9	3.3
ANYDIAB	Any diabetes diagnosis (%)	29.4	33.7[a]
AIDS	AIDS (%)	0.0	0.3[a]
CHARL	Modified Charlson comorbidity index	0.819	0.776[b]
DEMENTIA	Dementia (%)	1.2	0.8[c]
SCHIZO	Schizophrenia (%)	0.4	1.4[a]
PTSD	Post-traumatic stress disorder (%)	0.1	1.3[a]
DEPRES	Depression (%)	1.6	2.9[a]
NSYKD	Number of psychiatric diagnoses	0.058	0.110[a]
NSADX	Number of substance abuse diagnoses	0.088	0.174[a]
ANYSADX	Any substance abuse diagnosis (excluding nicotine) (%)	2.4	5.6[a]
ANYSYKDX	Any psychiatric diagnosis (%)	5.5	10.4[a]

[a] Denotes significant difference ($p < .001$).
[b] Denotes $p < .01$.
[c] Denotes $p < .05$.

We used the survey responses to assign the 61 sites to three mutually exclusive groups. The 20 (32.8%) sites that responded to all three data-quality questions with at least moderate confidence were called "GOODDATA" sites. The 11 sites (18%) that estimated costs, but lacked confidence in data quality, were assigned to a group called "LACKCONF." The remaining 30 sites (49.2%) that do not estimate the costs of their CATH laboratory were called the "NOESTIM" sites.

Table 2
Mean Cost of Stay by Most Complex Procedure Performed and Type of Hospital

		VA hospitals		
	Medicare hospitals	*GOODDATA*	*LACKCONF*	*NOESTIM*
CABG	45,006	41,697	40,682	34,789[a]
PTCA	20,711	16,263[a]	16,131[a]	11,693[a,b,c]
CATH	12,710	15,256[a]	13,410	10,682[c,d,e,]
NONE	10,205	10,920	10,181	9824[e]
All stays	18,860	15,248	15,520	11,484[a]

[a] Denotes significant difference from Medicare hospitals ($p < .001$).
[b] Difference from VA GOODDATA hospitals ($p < .001$).
[c] Difference from VA LACKCONF hospital ($p < .05$).
[d] Difference from Medicare hospitals ($p < .05$).
[e] Difference from VA GOODDATA hospitals ($p < .05$).

Mean Cost by Type of Hospital

The mean cost of stays appears in Table 2. This table distinguishes costs based on the four types of hospital: Medicare hospitals and VA hospitals' three levels of data quality. Table 2 distinguishes stays according to the most complex procedure performed.

Stays that involved CABG had an average cost of $45,006 at Medicare hospitals. Stays involving CABG were less costly at VA hospitals, but the difference was statistically significant only at the NOESTIM sites. Both CABG and PTCA were performed during some of these stays. The 100 stays at the Medicare hospitals had an average cost of $51,561. There were 14 of these stays at VA hospitals with an average of $54,347 in reported cost.

The next category of stay was those in which PTCA was performed. Medicare stays of this type cost an average of $20,711. All three types of VA hospital reported a lower cost.

Stays that involved neither of these procedures, but included a diagnostic CATH, cost an average of $12,710 at Medicare hospitals. Reported VA costs were significantly higher at GOODDATA sites and significantly lower at NOESTIM sites.

Stays in which none of these procedures were performed had an average cost of $10,205 at Medicare hospitals. Costs reported at VA hospitals were not significantly different, except for the NOESTIM sites, which reported significantly lower costs.

There were also some statistically significant differences between the types of VA sites. Stays were shorter at NOESTIM sites than they were at GOODDATA sites. The NOESTIM sites were also less likely to perform PTCA than either the LACKCONF or GOODDATA sites and less likely to perform CATH than the LACKCONF sites. Patients at the GOODDATA sites were more likely to be discharged with a diagnosis of cardiogenic shock than were the patients from the other sites. Patients at the GOODDATA sites were more likely to have a diagnosis of pulmonary edema than the LACKCONF sites.

Although the means reported in Table 2 are informative, these comparisons may be misleading. Other characteristics might explain differences in cost. Medicare stays involved older patients with more severe cardiac conditions and medical comorbidities, whereas VA patients were more likely to have psychiatric and substance abuse diagnoses. We conducted a regression analysis to compare costs while controlling for case-mix.

Cost Regression

We regressed costs on characteristics of the hospital, patient, and treatment provided. This random-effects regression included a hospital-level error term to estimate unbiased standard errors.

Patient level variables included procedures, length of stay, days in the ICU, and indicators of comorbid conditions. To avoid the assumption that costs were proportionate to the length of stay, we included the square and cube of both the length of stay and the number of days in the ICU. Hospital level variables included the Medicare wage index and indicators of hospital type. There were three indicators for VA sites, associated with the reported quality of DSS data (GOODDATA, LACKCONF, and NOESTIM). Medicare hospitals were the reference category. The hospital site indicators were interacted with procedure and length of stay terms. The results of this regression appear in Table 3.

As expected, procedures, additional days of stay, and additional days of stay in intensive care were all associated with higher costs. Stays at hospitals in areas with higher wages (WAGINDX) cost more. Higher costs were associated with death during the stay (DIED) and the cardiac comorbidities of cardiogenic shock (SHOCK), tachycardia (TACHY), pulmonary edema (EDEMA). Lower costs were associated with diabetes (ANYDIAB), cancer, and the presence of any psychiatric diagnosis (ANYSYKDX) and greater age. Patients who were at least 70 years old (AGE70) did not incur any significantly higher cost, controlling for these other factors.

Hospital scale, measured as the annual number of stays for MI, was not a statistically significant predictor of cost, nor were its log or multiplicative inverse. Interactions between site character and ICU days were not significant. These variables were not included in the model.

Effect of Hospital Type on Cost

We wanted to determine if cost differed by the type of hospital, holding all other factors equal. This could not have been determined by simple inspection of the 21 parameters that involved the type of hospital. We simultaneously evaluated the parameters for each type of hospital using a Chow test.

We evaluated the parameters using the characteristics of the average patient for each type of stay. We divided stays into four types based on the most complex procedure performed. Because our concern was estimating VA costs, we used the average VA patient to construct our estimates. For each type of stay, we calculated the mean of all variables observed in VA stays. Given the characteristics of the average VA patient, we calculated the fitted value for the regression for each type of hospital. We then calculated the difference in the fitted value for different types of hospital for this typical patient and calculated the confidence interval surrounding this difference using the variance–covariance matrix from the regression. This analysis is reported in Table 4.

For all patients who received CABG at VA hospitals, we found the mean length of stay and days in ICU and the mean value of all other variables. Simulating cost using the regression revealed that this stay would have been reported to cost $49,518 if it

Table 3
Random-Effects Regression of Cost of Hospital Stays for MI

	Parameter	*SE*	*P value*
WAGINDX	11,195.83	800.24	0.001
DIED	4168.16	262.99	0.001
CATH	2422.76	195.44	0.001
PTCA	8494.20	225.49	0.001
CABG	18,746.27	275.89	0.001
GOODDATA	–1142.77	846.19	0.177
LACKCONF	–3268.75	1,113.11	0.003
NOESTIM	–973.36	673.13	0.148
GOODDATA*CABG	–6220.66	915.16	0.001
GOODDATA*PTCA	–5557.72	546.23	0.001
GOODDATA*CATH	228.20	471.67	0.629
LACKCONF*CABG	–3,489.51	1189.60	0.003
LACKCONF*PTCA	–4,269.98	605.06	0.001
LACKCONF*CATH	1078.37	569.96	0.058
NOESTIM*CABG	–10,440.21	836.20	0.001
NOESTIM*PTCA	–8053.84	511.42	0.001
NOESTIM*CATH	–1883.59	380.84	0.001
AGE	–36.18	12.00	0.003
AGE70	–63.93	207.50	0.758
ACUTDAYS	1220.85	40.78	0.001
$(ACUTDAYS)^2$	13.09	1.47	0.001
$(ACUTDAYS)^3$	–0.11	0.01	0.001
GOODDATA*ACUTDAYS	–77.11	110.67	0.486
GOODDATA*$(ACUTDAYS)^2$	1.50	5.05	0.766
GOODDATA*$(ACUTDAYS)^3$	–0.12	0.06	0.032
LACKCONF*ACUTDAYS	715.99	169.29	0.001
LACKCONF*$(ACUTDAYS)^2$	–56.01	9.73	0.001
LACKCONF*$(ACUTDAYS)^3$	0.70	0.13	0.001
NOESTIM*ACUTDAYS	196.32	78.97	0.013
NOESTIM*$(ACUTDAYS)^2$	–20.08	2.91	0.001
NOESTIM*$(ACUTDAYS)^3$	0.13	0.02	0.001
ICUDAYS	610.16	37.36	0.001
$(ICUDAYS)^2$	13.06	1.58	0.001
$(ICUDAYS)^3$	–0.04	0.01	0.001
ANYDIAB	–411.32	144.23	0.004
CANCER	–818.21	381.86	0.032
SHOCK	5081.47	373.91	0.001
ARREST	646.64	399.01	0.105
TACHY	865.56	239.28	0.001
EDEMA	526.11	155.53	0.001
ANYSYKDX	–543.53	252.65	0.031
INTERCEPT	–8425.07	1115.80	0.001

took place at a Medicare hospital. This same stay would have been reported to cost \$39,017 at a VA GOODDATA hospital, and \$34,033 at a VA NOESTIM hospital, amounts that are significantly less than the Medicare cost. The cost at VA LACKCONF sites was not significantly different from Medicare hospitals. The cost of NOESTIM

Table 4
Effect of Hospital Type on Cost of Stay with Mean Characteristics, Holding all Other Factors Equal

		VA hospitals		
	Medicare hospitals	*GOODDATA*	*LACKCONF*	*NOESTIM*
CABG	49,518	39,017[a]	47,027[b]	34,033[a,c,d]
PTCA	21,816	14,759[a]	16,967[a]	11,235[a,b,d]
CATH	14,292	12,792[e]	13,780	11,453[a,f]
NONE	11,526	9801[e]	9670[e]	10,465
All stays	16,464	13,191[a]	14,291[e]	12,102[a]

[a] Denotes significant difference from Medicare hospitals ($p < .001$).
[b] Difference from VA GOODDATA hospitals ($p < .001$).
[c] Difference from VA GOODDATA hospitals ($p < .05$).
[d] Difference from VA LACKCONF hospital ($p < .001$).
[e] Difference from Medicare hospital ($p < .05$).
[f] Difference from VA LACKCONF hospital ($p < .05$).

sites was significantly lower than other VA sites. The cost of NOESTIM hospitals was 12.8% lower than GOODDATA sites and 27.6% lower than LACKCONF sites.

The stay of the typical VA heart attack patient who received PTCA would have cost $21,816 at Medicare hospitals. All three types of VA hospitals would have reported significantly lower costs. Again, the cost of NOESTIM sites was significantly lower than other VA sites. The cost of NOESTIM hospitals was 23.9% lower than GOODDATA sites and 33.8% lower than LACKCONF sites.

The typical VA stay that involved neither of these procedures, but included a diagnostic CATH, would have cost $14,292 at a Medicare hospital. The GOODDATA and LACKCONF sites would have reported costs that were not significantly different, but costs at NOESTIM sites would have been significantly lower. The cost of NOESTIM hospitals were 10.5% lower than GOODDATA sites and 16.9% lower than the LACKCONF sites.

The stay of the typical VA patient who had none of these procedures performed would cost an average cost of $11,526 at Medicare hospitals. Cost reported at VA hospitals was not significantly different, except for the GOODDATA sites, which reported significantly lower cost. The cost at NOESTIM hospitals was 6.8% higher than GOODDATA sites and 8.2% higher than LACKCONF sites, but these differences were not statistically significant.

To explore the source of the differences, we conducted additional regressions of VA hospital stays using subtotals of different types of cost as the dependent variable, including cost of laboratory, pharmacy, radiology, nursing care, surgery, and all other costs (regressions not shown). The cost of the CATH laboratory is reported in the “all other” category.

For stays involving CABG, NOESTIM sites had significantly lower costs in all cost categories except pharmacy. For stays involving PTCA or CATH alone, the NOESTIM sites had significantly lower costs in the “all other” category. LACKCONF sites had significantly higher “all other” costs for CABG stays, higher laboratory costs for

CABG and PTCA stays, and higher pharmacy cost for stays in which catheterization was the most complex cardiac procedure performed.

DISCUSSION

As VA hospitals do not routinely bill patients, billing data are not available to estimate VA costs. We estimated a cost function that can be used to estimate the cost of VA stays for acute MI. The function was estimated using data from Medicare and the VA implementation of the DSS. Using the parameters based on Medicare data, we estimated the cost of a typical stay to be $16,464. Using the parameters estimated with DSS data from VA sites that use good data practices, yielded a cost of $13,191.

These estimates represent the cost of a typical VA stay for MI. The cost function can also be used to estimate the cost of stays that are not typical. The estimate reflects multiple factors that affect resource use, including procedures performed, length of stay, number of days spent in the ICU, patient vital status at discharge, patient age, and comorbid conditions. However, cost functions may not accurately simulate the cost of extreme cases.

This regression analysis also provides two ways of validating DSS data. We compared groups of VA hospitals with groups assigned according to self-reported data quality. We also compared VA cost data with cost-adjusted charges from Medicare hospitals.

We found that VA DSS captured the effect of procedures and length of stay on resource use. We also found that DSS data practices are important. About half of the VA stays took place at sites that did not incorporate data on CATH workload when calculating cost. These sites assigned the cost of the CATH laboratory to all patients who received medical care in proportion to their length of stay, regardless of whether they obtained this service. It is not surprising that these sites reported significantly lower costs for stays involving catheterization procedures than did the sites that assigned catheterization laboratory costs to the patients who were actually catheterized. We identified the magnitude of the problem. In comparison to sites with good data practices, sites that did not appropriately assign CATH costs had 12.8% lower cost for stays involving CABG, 23.9% lower cost for the remaining stays that involved PTCA, and costs that were 10.5% lower for stays with diagnostic catheterization. These sites reported 6.8% higher cost for stays in which none of these procedures was performed, but this difference was not statistically significant.

It appears that cost estimates were less seriously flawed at VA sites that gathered CATH workload data, but lacked confidence in the quality of their DSS data. These sites estimated costs that were higher than the sites that were more confident in their data quality, but the difference was statistically significant only for stays that involved CABG.

A number of VA sites responded to the DSS survey, indicating that they planned to gather CATH workload in the near future. The quality of DSS cost estimates will improve as additional sites measure workload and improve the quality of their data. At present, those who wish to use DSS to estimate the cost of this type of care are advised to inquire about the basis of cost estimates, especially to learn if the cost of medical procedures has been allocated to the patients who received them.

We sought to further validate DSS data from VA hospitals by comparing it to data on similar stays funded by Medicare. We found the 20 VA medical centers that have high-quality DSS data had lower costs than Medicare hospitals. The average cost was $18,660 at Medicare hospitals, $15,248 at VA hospitals that use good data practices, or 18.2% lower. When we controlled for differences in patient age, case-mix, length of stay, procedures performed, and geographic differences in wages, costs at these VA hospitals were still 19.9% lower than the cost of Medicare hospitals, a difference that remained statistically significant. Costs at these 20 VA hospitals were 21.2% lower for stays involving CABG, 32.3% lower for stays involving PTCA, and 10.5% lower for stays with CATH, but no revascularization procedure. Stays in which none of the procedure were performed cost 15% less.

We cannot conclude that VA hospitals had lower costs than Medicare hospitals because the data from the two systems were not contemporaneous. The Medicare stays occurred in 1996, which are our most recent data available. The VA stays occurred in the year that ended on September 30, 1999, the first year in which a national file of DSS cost data are available. Although these time frames are less than 3 years apart, and we adjusted for the effects of inflation, there were significant changes in practice patterns that undoubtedly affected resource use.

There is evidence that the cost for hospitalization for cardiac care has been declining. A study of CABG patients between 1988 and 1996 reported that costs declined by an average of $1118 per year *(10)*. This is consistent with our finding that there was lower cost in the more contemporary data, the VA observations.

One factor associated with lower cost is reduced length of stay. We found that stays for acute MI at VA medical centers are becoming shorter. Among VA hospitals that provide CATH, stays for MI were an average of 8.7 days long in 1996, significantly longer than the 7.4-day average length of stay in our Medicare cohort for 1996. This observation is consistent with the findings of other studies *(11)*. VA stays were longer even though VA hospitals had lower rates of CABG, and CABG is associated with longer stays.

Shorter stays are associated with lower costs. The trend of decreasing length of stays at both VA and Medicare hospitals makes it impossible for us to draw any conclusions about the difference in cost between Medicare and VA care. Unfortunately, we do not yet have Medicare data from 1999 that can be compared to VA costs.

Through negotiation of national contracts, VA pharmaceutical costs are lower than those of the non-VA sector. Lower pharmaceutical costs may contribute to the lower cost of VA hospital stays.

We found that VA patients had lower rates of the comorbidities that are associated with higher cost. We controlled for the effect of these comorbidities in making our cost comparison. Unmeasured case-mix intensity may explain some of the cost differences we observed. Other studies have found higher rates of comorbidities in VA patients than in Medicare patients *(11)*. We found lower rates in VA patients. This difference is not surprising, however, given the restricted nature of our Medicare group. It was made up only of veterans who had previously used VA services. These Medicare-using veterans were not only sicker than other VA patients, they were also an average of 6.5 years older.

Patients treated at Medicare hospitals were cared for by physicians who bill Medicare on a fee-for-service basis. Patients treated at VA hospitals were treated by salaried physicians and medical residents, perhaps at a lower cost.

To make the two data sources similar, we estimated the cost of VA capital and the cost of physician services received by Medicare patients. We used simplifying assumptions to assign these costs to individual stays. We assigned capital cost in proportion to the other costs of VA stays. We assigned physician cost in proportion to the DRG weight of the Medicare stay, with some adjustment for length of stay. Although these assumptions may have resulted in erroneous estimates of the cost of a particular stay, the average cost that was assigned represented reasonable estimates that likely do not explain the differences we observed.

Finally, we used a hospital-level cost-to-charge ratio to adjust charges of Medicare hospitals. This was required because department-level charges were not available from the hospital discharge data. The conventional wisdom is that the charges for ancillary services are higher relative to costs than are the charges for routine daily services. The use of a hospital-wide cost-to-charge ratio would overstate the cost of stays in which a disproportionate amount of ancillary charges were incurred.

The DSS estimate of VA costs includes physician costs, but does not include the cost of malpractice liability. VA incurs liability for malpractice expense, but this cost is paid by settlements from the US Department of Justice. This expense is relatively small, however, it represents $60 million in comparison to the $18 billion VA health care budget. It is unlikely to account for much of the differences we observed.

Our primary concern was not whether VA costs were higher or lower than non-VA hospitals, but whether DSS cost estimates are plausible. We found VA costs were lower than Medicare cost-adjusted charges. This finding needs to be placed in the context of other cost studies.

The literature reports a wide range of costs for cardiac hospital stays. The mean cost of stays for acute MI in 1994–1995 varied from $10,038 at small rural hospitals to $14,306 at teaching hospitals, where bypass surgery was twice as likely *(12)*. This estimate did not include the physician component.

Patients in the Emory Angioplasty vs Surgery Trial incurred $41,972 in hospital and physician costs when CABG was performed and $27,793 if angioplasty was performed *(10)*. Although these amounts are expressed in 1997 dollars, the data reflects resource use patterns of the late 1980s. A study of DSS data of cardiac patients at the University of Colorado between 1992 and 1995 found stays in which CABG was performed cost an average of $27,091; stays involving angioplasty cost an average of $8982 *(13)*. These data do not include the physician component, and many stays did not involve diagnosis of heart attack.

The values that we observed for the Medicare sites and the VA sites using good data practices were within the range of estimates found in previous studies. Both cost estimates reflect the effect of the characteristics of hospital, treatment, and patient on resource use and should be useful for estimating CE in clinical trials.

The cost of stays at VA hospitals that do not have high-quality DSS data may be simulated using the cost-function that we estimated. Simulations based on Medicare data for 1996 will have costs that are about 20% greater than simulations based on VA data from 1999.

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