but nonetheless faulty, beliefs about the nature of health care markets, the scientific underpinnings of medicine, and the power of more care to heal. By the same token, CMS and other payers should not cling to old remedies that are not working. Obviously there are many ways for health care reform to fail, but we are optimistic that this legislation, coupled with the growing understanding of geographic variation and the role of supply in influencing utilization, will lead to a better system.

John E. Wennberg and Shannon Brownlee

Appendix on Methods

Defining Hospital Service Areas

Hospital service areas (HSAs) represent local health care markets for community-based inpatient care. HSAs were originally defined in three steps using 1993 provider files and 1992 through 1993 utilization data. First, all acute care hospitals in the fifty states and the District of Columbia were identified from the American Hospital Association Annual Survey of Hospitals and the Medicare Provider of Services files and assigned to a location within a town or city. The list of towns or cities with at least one acute care hospital (N = 3,953) defined the maximum number of possible HSAs. Second, all 1992 and 1993 acute care hospitalizations of the Medicare population were analyzed according to ZIP Code to determine the proportion of residents' hospital stays that occurred in each of the 3,953 candidate HSAs. ZIP Codes were initially assigned to the HSA where the greatest proportion (plurality) of residents was hospitalized. Approximately 500 of the candidate HSAs did not qualify as independent HSAs because the plurality of patients resident in those HSAs was hospitalized in other HSAs.

The third step required visual examination of the ZIP Codes used to define each HSA. Maps of ZIP Code boundaries were made using files obtained from Geographic Data Technologies (GDT) and each HSA's component ZIP Codes were examined. To achieve contiguity of the component ZIP

Codes for each HSA, "island" ZIP Codes were reassigned to the enclosing HSA and/or HSAs were grouped into larger HSAs. (See the Appendix in the 1999 *Dartmouth Atlas of Health Care* for an illustration.) Certain ZIP Codes used in the Medicare files were restricted in their use to specific institutions (e.g., a nursing home) or a post office. These "point ZIPs" were assigned to their enclosing ZIP Code based on the ZIP Code boundary map.

This process resulted in the identification of 3,436 HSAs, ranging in total 1996 population from 604 (Turtle Lake, North Dakota) to 3,067,356 (Houston, Texas) in the 1999 edition of the Atlas. Thus, the HSA boundaries remained the same but the HSA populations might have changed between the two editions of the Atlas. In most HSAs, the majority of Medicare hospitalizations occurred in a hospital or hospitals located within the HSA. (See the Appendix in the 1999 *Dartmouth Atlas of Health Care* for further details.)

Defining Hospital Referral Regions

Hospital referral regions (HRRs) represent health care markets for tertiary medical care. Each HRR contained at least one HSA that had a hospital or hospitals that performed major cardiovascular procedures and neurosurgery in 1992 through 1993. Three steps were taken to define HRRs.

First, the candidate hospitals and HRRs were identified. A total of 862 hospitals performed at least ten major cardiovascular procedures (DRGs 103-107) on Medicare enrollees in both years. These hospitals were located within 458 HSAs, thereby defining the maximum number of possible HRRs. Further checks verified that all 458 HSAs included at least one hospital performing the specified major neurosurgical procedures (DRGs 1-3 and 484).

Second, we calculated in each of the 3,436 HSAs in the United States the proportion of major cardiovascular procedures performed in each of the 458 candidate HRRs in 1992 through 1993. Each HSA was then assigned provisionally to the candidate HRR where most patients went for these services.

Third, HSAs were reassigned or further grouped to achieve (a) geographic contiguity, unless major travel routes (e.g., interstate highways) justified separation (this occurred in only two cases—the New Haven, Connecticut, and Elmira, New York, HRRs), (b) a minimum population size of 120,000, and (c) a high localization index. Because of the large number of hospitals providing cardiovascular services in California, several candidate California HRRs met the above criteria but were found to perform small numbers of cardiovascular procedures. These HRRs were further aggregated according to county boundaries to achieve stability of cardiovascular surgery rates within the areas.

The process resulted in the definition of 306 hospital referral regions, which ranged in total 1996 population from 126,329 (Minot, North Dakota) to 9,288,694 (Los Angeles, California).

Measures of Association (R^2 and Regression Lines)

In this book, I am often interested in examining the degree to which one factor is related another—for example, how the number of beds that are available to serve the population of a region relates to the utilization of hospitals by those enrolled in the Medicare program. To capture the extent of the association between two factors or "variables" such as beds and hospitalization, we constructed a figure relating beds per 1,000 and Medicare hospitalizations per 1,000. Figure A.1 illustrates this relationship for Medicare enrollees who were hospitalized for medical (nonsurgical) conditions among the 306 hospital referral regions. If beds and hospitalization rates were negatively correlated, so that regions with higher acute care beds per 1,000 had lower hospitalization rates, the "dots" in the figure—each of which represents one of the 306 regions—would be tilted downward, running from northwest to southeast. Conversely, if positively correlated—which they in fact are—the dots would run from southwest to northeast.

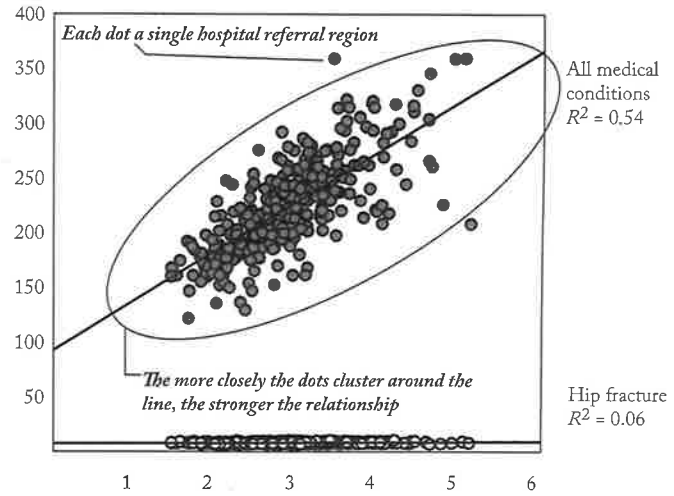

Figure A.1. The association between hospital beds per 1,000 (1996) and discharges for medical conditions and for hip fracture (1995 through 1996) among hospital referral regions.

It is sometimes difficult to discern the relationship by inspection of the figure. A linear regression line provides the best fit of the data and summarizes the relationship between them. A measure of the "goodness of fit" or the extent to which hospital beds per 1,000 population predicts hospitalization per 1,000 Medicare enrollees is the coefficient of determination[1] or the "R^2 statistic," which measures the proportion of total variation in the Medicare hospitalization that is explained by variation in hospital beds. The R^2 statistic ranges from 0 to 1, where 1 is perfect correlation and 0 means the two variables are completely unrelated. In Figure A.1, the R^2 statistic is 0.56, which means the two are closely related—that 56% of the variation in medical hospitalization is related to bed supply.

Methods for Evaluating Care in the Last Two Years of Life

The methods were developed over the course of several years and have been described in detail in peer-reviewed publications.[2–4] This appendix provides a summary of these methods.

Databases used in the Analysis

The primary database is derived from seven Centers for Medicare & Medicaid Services (CMS) research files for traditional (fee-for-service) Medicare: the Denominator File (which provides information on all Medicare enrollees' demographic data, eligibility status, and date of death) and files that contain records of Medicare claims—the MedPAR file (acute care discharges and stays in skilled nursing, rehabilitation, psychiatric, and other long-stay facilities); the Inpatient File (used to classify intermediate- and high-intensity subtypes of intensive care unit stays); Physician/Supplier Part B (physician services for a 20% sample of Medicare enrollees); the Outpatient File (the facility [versus professional] component of outpatient services); and Home Health Agency, Hospice, and Durable Medical Equipment Files.

Study Populations

The follow-back from death studies are for two study populations, one based on assignment of decedents to the hospital they most frequently used in the last two years of life, and the other on the place of residence at time of death. To allow for two years of follow-back for all patients, the populations are restricted to those whose age on the date of death was 67 to 99 years, and to those having full Part A and Part B entitlement throughout the last two years of life. Persons enrolled in managed care organizations were excluded from the analysis.

Populations assigned to specific hospitals: We identified Medicare enrollees who died over the five-year period from January 1, 2001 through December 31, 2005 and who were hospitalized at least once during the last two years of life for a medical (nonsurgical) condition. Patients with surgical admissions only were excluded because the surgery may not have been offered by the hospital and medical staff that usually provide their care (e.g., patients with bypass surgery can only be assigned to hospitals that perform the surgery). Excluding these patients also reduces the likelihood that a surgical complication was the cause of death. We further restricted the analysis to patients who had one or more of nine chronic illnesses associated with a high probability of death.[3] Claims data were used to assign each patient to the hospital the patient was admitted to most often during the last two years of life. In the case of a tie, patients were assigned to the hospital associated with the discharge closest to the date of death. Because seriously ill patients are highly loyal to the hospital where they receive their care—as has been shown elsewhere[5]—hospital-specific utilization rates reflect the approach to chronic disease management of the physicians who practice in association with that hospital. In some instances there were too few deaths at that hospital to calculate reliable measures and the measure is listed as missing. The minimum population count for reporting measures based on the MedPAR, Inpatient, Home Health Agency, Hospice, and Durable Medical Equipment Files is 80 deaths; for the Part B and Outpatient Files it is 400 deaths.

Populations grouped by place of residence: The state and regional level analyses include patients who were residents of a given geographic area at the date of death. Data are a 20% sample of deaths occurring over the five-year period from 2001 through 2005 (i.e., those deaths that were included in the CMS Part B claims of a 20% enrollee sample). The state and regional analyses includes all hospitalizations (including the patients excluded in the hospital-specific studies who only had surgical hospitalizations) and all patients who had one or more of nine chronic illnesses, whether or not they were hospitalized. Nonhospitalized patients with chronic illness were identified as those with two or more physician encounters (on different days), with a diagnosis of one or more of the nine chronic conditions.

Table A.1 provides information on the number of decedents according to diagnosis for the *hospital-specific chronic illness cohort* and the *geographic chronic illness cohort.* Table A.2 describes the characteristics of decedents who were hospitalized, according to their cause of hospitalization (and thus whether they are included in the hospital-specific chronic illness cohort). Table A.3 describes the characteristics of decedents and chronic illness and hospitalization status.

Table A.1. Number of Decedents according to Cohort and Primary Chronic Condition, 2001 through 2005

Primary Chronic Condition	*2001 to 2005 Hospital-Specific Chronic Illness Cohort**	*2001 to 2005 Geographic Chronic Illness Cohort†*
	Number of Decedents	*Number of Decedents*
Malignant cancer/leukemia	815,409	207,807
Congestive heart failure	1,519,795	381,972
Chronic pulmonary disease	914,867	231,486
Dementia	614,170	166,396
Diabetes with end organ damage	56,906	18,196
Peripheral vascular disease	120,654	37,996
Chronic renal failure	277,821	59,240
Severe chronic liver disease	52,843	35,280
Coronary artery disease	359,983	109,568
Total number of decedents	**4,732,448**	**1,247,941**

*From a 100% sample of Medicare enrollees.
†From a 20% sample of Medicare enrollees.

Table A.2. Hospital-Specific Chronic Illness Cohort and Excluded Hospitalized Decedents, 2001 through 2005

	2001 to 2005 Hospitalized Decedents	
	Number of Decedents	*Percent of Decedents*
Hospital-specific chronic illness cohort*	4,732,448	69.99
Hospitalized decedents excluded from cohort		
Chronic illness, surgery only	344,241	5.09
Other medical illness	487,331	7.21
Other surgery	99,568	1.47
Assigned to non-U.S. hospitals†	635	0.01
All hospitalized decedents	5,664,223	83.77

*Data are based on a 100% sample of Medicare enrollees.
†Non-U.S. hospitals include those in U.S. territories such as Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and others.

Table A.3. Decedents 2001 through 2005, according to Cohort Membership Status

	2001 to 2005 Geographic Database		
	Number of Decedents	*Percent of Decedents*	
		Percent of Chronically Ill	*Percent of all Decedents*
Chronic illness cohort	1,247,941	100.00	92.36
Hospital-specific cohort*	946,458	75.84	70.05
Chronic illness, hospital surgery only	68,738	5.51	5.09
Hospital, other medical illness	65,361	524	4.84
Hospital, other surgery	13,656	1.09	1.01
Assigned to non-U.S. hospitals	179	0.01	0.01
Not hospitalized	153,549	12.30	11.36
Excluded decedents (without chronic illness)			
Hospitalized decedents	37,997		2.81
Not hospitalized	65,215		4.83
Total decedents	1,351,153		100.00

*The hospital-specific chronic illness cohort corresponds to the cohorts described in Tables A.1 and A.2, but is smaller due to the use of a 20% sample of enrollees.

Measures of Resource Inputs

Measures of resource inputs, including physician labor, hospital beds, intensive care beds, and Medicare program spending (reimbursements), are presented as summary measures over the last six months or two years of life. Bed input rates are calculated by summing patient days and dividing by 365. Physician labor inputs are measured by summing the work relative value units (RVUs) on a specialty-specific basis and dividing by the average annual number of work RVUs produced by that specialty. The measure is used to estimate the standardized full-time equivalent (FTE) physician clinical labor input. Both bed and FTE physician resources are expressed as inputs per 1,000 decedents. Inpatient reimbursements were calculated by summing Medicare reimbursements from the MedPAR record and reflect *total* reimbursements, including indirect costs for medical education, disproportionate share payments, and outlier payments. Part B payments are for all services included in the Part B Physician Supplier File; likewise, payments for Outpatient, Skilled Nursing Facilities, Hospice, Home Health, and Durable Medical Equipment services reflect all services included in their respective files. Inpatient reimbursements and payments from Part B and all other files are measured as

spending per decedent. All resource input rates were calculated based on the total experience of the population over the given period of time, not only from the care received at the assigned hospital or physicians associated with that hospital. In the case of the geographic studies, it includes care given by providers located outside of the region as well as within the region.

Measures of Utilization

The measures of utilization are for inpatient care and physician services. We calculated hospital days, intensive care unit days (high-intensity and intermediate-intensity days, separately), and physician visits (overall and separately for primary care physicians and medical specialists) for each patient over the last six months and the last two years of life; additional measures included home health visits, and days spent in skilled nursing facilities, long-term and rehabilitation hospitals, and hospice. Physician visits were also calculated by the place of service. Utilization rates were calculated on the total experience of the cohort, not just the services provided by the hospital and the physicians associated with the hospital to which the decedent was assigned. The proportion of total hospital care provided by the assigned hospital (loyalty) is high, so the variations in utilization among hospital cohorts primarily reflect clinical choices made by the associated physicians. Similarly, in the geographic studies, most care is provided by hospitals and physicians located within the state or region. The measures of utilization—patient days in the hospital and other facilities, patient days in intensive care units, and physician visits—are traditional epidemiologic, population-based rates of events occurring over a designated period of time.

Quality of Care Indicators

Two claims-based quality-of-care measures were used. The percentage of patients seeing ten or more physicians is a measure of the propensity to refer patients. High scores on this measure may indicate lack of continuity of care. The percentage of deaths occurring during a hospitalization that involved one or more stays in an intensive care unit is an indicator of the aggressiveness with which terminal patients are treated. Similarly, the percentage of decedents receiving hospice benefits indicates less aggressive care at the end of life. In light of the evidence that more aggressive care in managing patient populations with chronic illness does not lead to longer length of life or improved quality of life, higher scores on this measure can be viewed as an indicator of lower quality of death.

We also report quality measures regarding the processes of care, specifically the underuse of effective care derived from the consensus measure set of the Hospital Quality Alliance (HQA), the first initiative to routinely report data on U.S. hospitals nationally. Data are posted on the CMS website.[6] We provide summary scores on five measures for managing acute myocardial infarction (AMI), two for congestive heart failure (CHF), and three for pneumonia, for all reporting hospitals located within each HRR. In addition, we report a composite score, which is the weighted average of the three condition-specific summary scores. For individual hospitals, summary scores are based on measures for which there are twenty-five or more eligible patients in calendar year 2005.[7]

Statistical Methods

We compared measures of resource inputs, utilization, and quality at fixed intervals prior to death among geographic regions and hospitals. All utilization and resource input measures are further adjusted for differences in age, sex, race, and the relative predominance of the nine chronic conditions, using ordinary least squares for Medicare spending variables[8] and overdispersed Poisson regression models for all other variables; 95th percentile confidence limits were calculated for all variables. The HQA technical process quality of care measures were not adjusted for differences in case mix among hospitals, as they are specifically restricted to those patients eligible for the specific treatment, and therefore do not need adjustment.

Caveats and Limitations

Certain limitations of our measures need to be mentioned.

Sample sizes and data issues. The data are for traditional Medicare (Part A and Part B) and do not include Medicare enrollees enrolled in managed care organizations under Medicare Part C. The measures of physician resource input and utilization are based on a 20% sample, reducing the precision of our estimates. For hospital-specific cohorts, we addressed this by limiting reporting for these services to 2949 hospitals with 400 decedents (expected 20% sample size for five years = 80 deaths). Data fields for measures based on Part B are left blank for hospitals with less than 400 decedents. Approximately 15% of

hospitals failed to report on their use of intensive care beds, and for these hospitals, this measure is left blank. Our measure of the use of multiple physicians—the percentage of decedents seeing ten or more physicians—depends on the accuracy of the coding of individual physician encounters using the physician identification number; if a given patient is seen by multiple physicians but only one physician identification number is recorded, this would result in an underestimate of the number of individual physicians seen.

Denominator for hospital-specific cohorts. The hospital-specific studies are based on Medicare decedents with one or more medical hospitalizations during the last two years of life (as shown in Table A.2). Because we had no reliable method for assigning non-hospitalized patients with chronic illness to hospitals, decedents who were not hospitalized are not included in the denominator used in calculating population-based resource input and utilization rates for the hospital-specific cohort. This limitation does not exist at the regional level where patients are assigned to regions on the basis of their place of residence, making it possible to identify patients who were not hospitalized.

To estimate the impact of not including nonhospitalized patients with chronic illness in the denominator for calculating rates for the hospital-specific cohort, we compared rates for regions calculated without the inclusion of nonhospitalized chronically ill decedents in the denominator (Hospitalized Cohort Denominator Method) to rates calculated with the inclusion of nonhospitalized decedents (Full Cohort Denominator Method).

This analysis compared rates under each of these two methods, which were calculated for the 306 regions for deaths occurring in 2000 through 2003. The key findings were as follows:

- First, the proportion of Medicare decedents with severe chronic illness who were not hospitalized at least once for a medical (nonsurgical) admission varied substantially from region to region—from less than 15% to more than 35% among regions.
- Second, regions with *lower* percentages of decedents not hospitalized tended to have *higher* per capita utilization rates. The correlation among regions between the percentage of chronically ill decedents who were not hospitalized during the last two years of life and patient days per decedent calculated under the Hospitalized Cohort Denominator Method had an $R^2 = 0.39$ (negative association); the same correlation using the patient days calculated under the Full Cohort Denominator Method had an $R^2 = 0.49$ (negative association).

- Third, when we examined the estimates of patient days per decedent obtained by the two methods, it became apparent that (1) the correlation between the rates generated using the two methods was very high: $R^2 = 0.97$ (Figure C); and (2) variation was less (measured by the extremal range, interquartile ratio, and coefficient of variation) when the rates were calculated using the Hospitalized Cohort Denominator Method.

These studies show that the Hospitalized Cohort Denominator Method (which we use for our hospital-specific analyses) underestimates the "true" population-based rates to a greater extent in regions with lower utilization rates. A reasonable inference would be that our hospital-specific analyses underestimate the variation across hospitals and that those hospitals with lower patient day rates would actually be even more conservative (and have even lower rates) than we report if we were able to include all decedents cared for by the hospital and its associated physicians.

Exclusion of isolated surgical hospitalizations. The hospital-specific follow-back studies of chronic illness were designed to require at least one medical (nonsurgical) hospitalization to qualify for inclusion. This was done to avoid confusing (1) a surgical referral as evidence that a given hospital was involved in the medical management of chronic illness and (2) a surgical death as a death from chronic illness. In the regional analysis, our interest in accounting for all Medicare spending and utilization in patients with chronic illness led us to include all Medicare hospitalizations (and Part B services) in the rates.