The Implications of Regional Variations in Medicare Spending. Part 1: The Content, Quality, and Accessibility of Care

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Background: The health implications of regional differences in Medicare spending are unknown.

Objective: To determine whether regions with higher Medicare spending provide better care.

Design: Cohort study.

Setting: National study of Medicare beneficiaries.

Patients: Patients hospitalized between 1993 and 1995 for hip fracture (*n* = 614 503), colorectal cancer (*n* = 195 429), or acute myocardial infarction (*n* = 159 393) and a representative sample (*n* = 18 190) drawn from the Medicare Current Beneficiary Survey (1992–1995).

Exposure Measurement: End-of-life spending reflects the component of regional variation in Medicare spending that is unrelated to regional differences in illness. Each cohort member's exposure to different levels of spending was therefore defined by the level of end-of-life spending in his or her hospital referral region of residence (*n* = 306).

Outcome Measurements: Content of care (for example, frequency and type of services received), quality of care (for example, use of aspirin after acute myocardial infarction, influenza immunization), and access to care (for example, having a usual source of care).

Results: Average baseline health status of cohort members was similar across regions of differing spending levels, but patients in higher-spending regions received approximately 60% more care. The increased utilization was explained by more frequent physician visits, especially in the inpatient setting (rate ratios in the highest vs. the lowest quintile of hospital referral regions were 2.13 [95% CI, 2.12 to 2.14] for inpatient visits and 2.36 [CI, 2.33 to 2.39] for new inpatient consultations), more frequent tests and minor (but not major) procedures, and increased use of specialists and hospitals (rate ratio in the highest vs. the lowest quintile was 1.52 [CI, 1.50 to 1.54] for inpatient days and 1.55 [CI, 1.50 to 1.60] for intensive care unit days). Quality of care in higher-spending regions was no better on most measures and was worse for several preventive care measures. Access to care in higher-spending regions was also no better or worse.

Conclusions: Regional differences in Medicare spending are largely explained by the more inpatient-based and specialist-oriented pattern of practice observed in high-spending regions. Neither quality of care nor access to care appear to be better for Medicare enrollees in higher-spending regions.

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See related article on pp 288-298 and editorial comments on pp 347-348, 348-349, and 350-351.

Health care spending in the United States is expected to increase dramatically in this decade. By 2011, per capita spending is forecast to increase by 49% in real terms, reaching $9216 per capita or 17% of the gross domestic product (1). The likely consequences of such dramatic growth in health care costs include further increases in the numbers of uninsured persons and reduced public and private spending in other sectors of the economy. Spending growth, however, is seen as an inexorable consequence of the aging of the population and advancing technology (2, 3). Moreover, the effectiveness of specific interventions in cardiovascular disease, neonatal care, and cancer treatment has been used to argue that the overall gains from increased spending are worth the costs (3) and that any constraints on the expansion of the specialist workforce or on further spending growth could be harmful (2–4).

These forecasts and the policy prescriptions that depend on them do not take into account the dramatic regional variations in spending and medical practice observed across the United States (5–8). For example, age-, sex-, and race-adjusted spending for traditional (fee-for-service) Medicare in 1996 was $8414 per enrollee in the Miami, Florida, region compared with $3341 in the Minneapolis, Minnesota, region (9). The greater-than-twofold differences observed across U.S. regions are not due to differences in the prices of medical services (7, 10) or to apparent differences in average levels of illness or socioeconomic status (10–12). Rather, they are due to the overall quantity of medical services provided and the relative predominance of internists and medical subspecialists in high-cost regions (2, 13).

The implications for health and health care of these regional differences in resources and spending, although directly relevant to current policy debates, remain relatively unexplored (14). The financial implications are clear: Savings of up to 30% of Medicare spending might be possible, and the Medicare Trust Fund would remain solvent into the indefinite future (10). However, remarkably little is known about whether the increased spending in high-cost regions results in better care or improved health. Although recent studies have found no improvement in mortality (12, 15, 16), they have been criticized because of weak designs (most were cross-sectional and ecologic), inadequate individual-level measures to control for potential differences in case mix, insufficient clinical detail on the process of care to allow inferences on potential causal pathways to be drawn, and limited outcome measures. We designed a research project to address these concerns.

Context

Per capita Medicare spending varies considerably from region to region. The effect of greater Medicare spending on quality of care and access is not known.

Contribution

Using end-of-life care spending as an indicator of Medicare spending, the researchers categorized geographic regions into five quintiles of spending and examined costs and outcomes of care for hip fracture, colorectal cancer, and acute myocardial infarction. Residents of high-spending regions received 60% more care but did not have better quality or outcomes of care.

Implications

Medicare beneficiaries who live in higher Medicare spending regions do not necessarily get better-quality care than those in lower-spending regions.

–The Editors

We present our findings in two articles. This article, Part 1, provides an overview of the study design and addresses the question, What are the differences in the content, quality, and accessibility of care across U.S. regions that differ in per capita Medicare spending? The second article, Part 2, asks, Do regions with higher Medicare spending achieve better health outcomes and improved patient satisfaction?

METHODS

Design Overview

One approach to determining whether the increased spending in some U.S. regions leads to better care and better outcomes would be to conduct a randomized trial. This would ensure that assignment to the treatment and control groups (those receiving more and less spending) was independent of patient characteristics. Logistic barriers to such a trial, however, would be substantial. We therefore conducted a cohort study in four parallel cohorts using a "natural randomization" approach (17), in which one or more exposure variables allowed assignment of patients into "treatment groups" (different levels of average spending), as would a randomized trial. An overview of the design is provided in **Figure 1.**

Because some of the regional differences in Medicare spending are due to differences in illness levels (enrollees in Louisiana are sicker than those in Colorado) and price (Medicare pays more for the same service in New York than in Iowa), we could not use Medicare spending itself as the exposure. We therefore assigned U.S. hospital referral regions (HRRs), and thus the cohort members residing within them, to different exposure levels. We did this by using the End-of-Life Expenditure Index (EOL-EI), a measure reflecting the component of regional variation in Medicare spending that is due to physician practice rather than regional differences in illness or price. Because regional differences in end-of-life spending are unrelated to underlying illness levels, it is reasonable to consider residence in HRRs with different end-of-life spending as a random event. The index was calculated as standardized spending on hospital and physician services provided to a reference cohort distinct from the study cohorts: Medicare enrollees in their last 6 months of life.

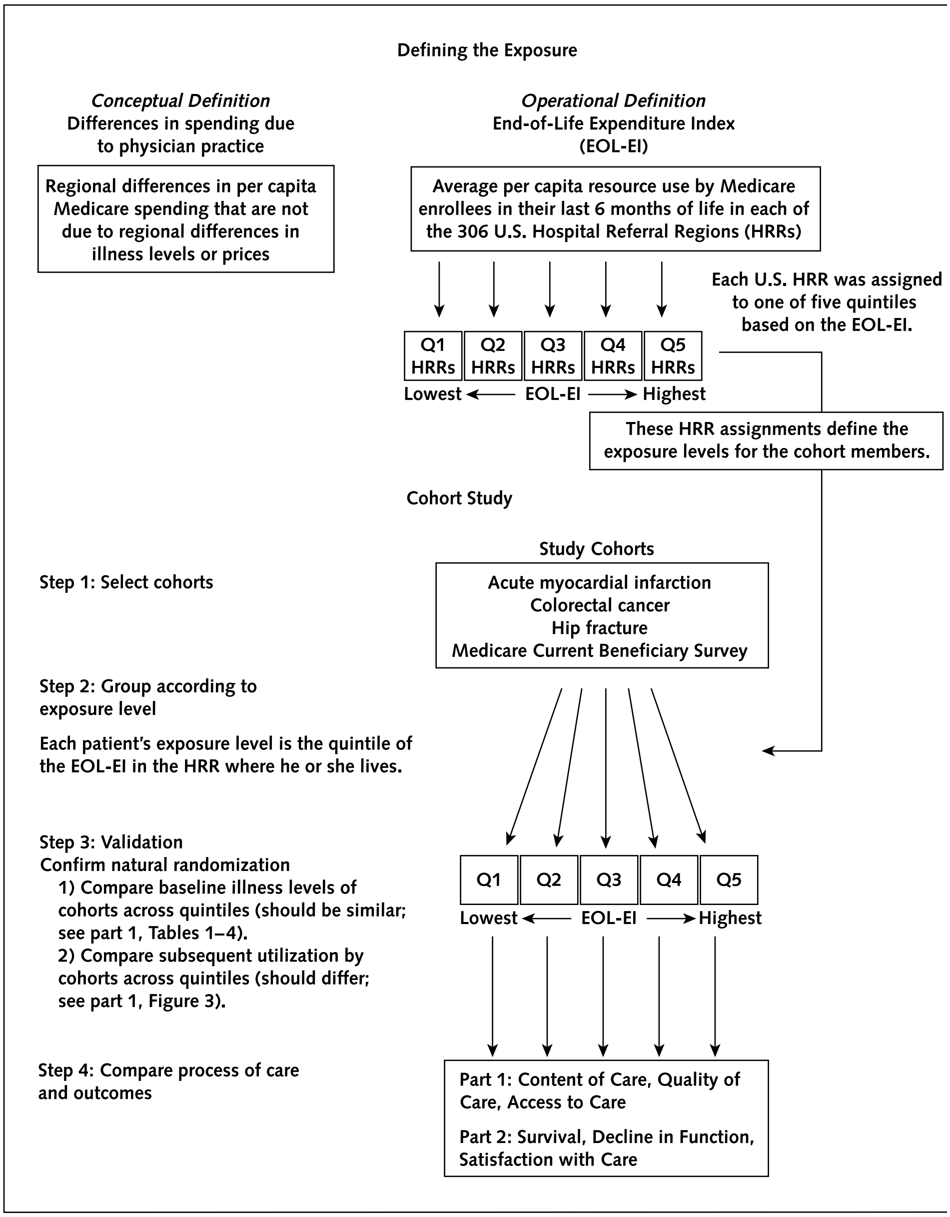
We confirmed that the exposure used to assign the HRRs achieved the goals of "natural randomization": 1) Study samples assigned to different levels of the exposure (the EOL-EI) were similar in baseline health status, and 2) the actual quantity of services delivered to the individuals within the study samples nevertheless differed substantially across exposure levels and was highly correlated with average per capita Medicare spending in the HRRs. We then followed the cohort members for up to 5 years after study enrollment and compared the processes of care (Part 1) and health outcomes (Part 2) across HRRs assigned to different exposure levels.

Study Cohorts

We sought study samples that would be similarly ill across regions based on the occurrence of an incident illness (acute myocardial infarction [MI], hip fracture, colorectal cancer) or in which we had excellent data for case-mix adjustment (acute MI, Medicare Current Beneficiary Survey [MCBS] sample). We restricted the eligible population to Medicare enrollees between the ages of 65 and 99 years who, at the time of study enrollment, were eligible for both Medicare Parts A and B and were not enrolled in a Medicare health maintenance organization (HMO).

The acute MI cohort was drawn from patients included in the Cooperative Cardiovascular Project, which identified from billing records a national sample of Medicare beneficiaries who were discharged after acute MI between February 1994 and November 1995 (18). We excluded patients with an unconfirmed acute MI (with the same criteria as in previous studies [19]) and included only the first episode of acute MI for a given patient. The hip fracture and colorectal cancer cohorts were selected based on a first admission between 1993 and 1995 for a primary diagnosis of hip fracture or colorectal cancer with resection, using the same International Classification of Diseases, Ninth Revision, Clinical Modification codes as in earlier work (20). Hospitalization rates for acute MI, hip fracture, and colorectal cancer vary little across regions (21), and patients with incident cases of these conditions are likely to be similarly ill in different communities (20). We excluded patients with a previous hospitalization for the same diagnosis in the year before their index stay. The general population cohort was drawn from the access-to-care component of the MCBS, a continuous panel survey that is representative of the Medicare population (22). Our

Figure 1. **Overview of study design.**



EOL-EI = End-of-Life Expenditure Index; HRR = hospital referral region; Q1 = quintile 1; Q2 = quintile 2; Q3 = quintile 3; Q4 = quintile 4; Q5 = quintile 5.

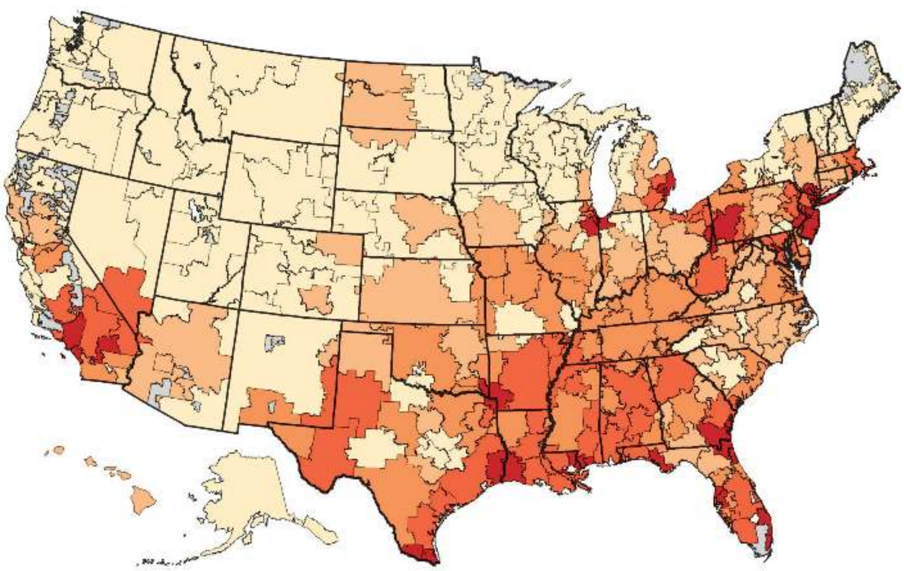
inclusion criteria are detailed in the Appendix (available at www.annals.org).

Baseline Characteristics of the Study Cohorts

Trained abstractors working in the Cooperative Cardiovascular Project obtained characteristics of patients in the acute MI cohort from the medical record (18). Quality of the chart review process was monitored by random re-abstractions, and percentage agreement was generally very high (93.3% to 94.8%) (23). Missing data for clinical variables were handled by including a specific categorical variable for patients with each missing variable (for example, "admission blood pressure missing"). Income was defined based on ZIP code of residence by using 1990 U.S. Census data.

For the hip fracture and colorectal cancer cohorts, we coded the presence of specific comorbid conditions based on diagnoses recorded on the discharge abstract, as was done in previous work (24, 25). Cancer stage was classified as distant versus local or regional because this classification has been found to correspond most closely to reported stage, according to analyses of linked Medicare–Surveillance, Epidemiology, and End Results data (26). Data from the 1990 U.S. Census, measured at the level of the ZIP code, were used to provide measures of income, edu-

Figure 2. **Average per capita Medicare spending, health care resource levels, and other key attributes of U.S. hospital referral regions according to quintiles of spending.**



Attributes of U.S. HRRs in Different Quintiles of the EOL-EI*

Variable	Quintile of EOL-EI: 1 (Lowest)	2	3	4	5 (Highest)	Ratio (Highest to Lowest)
EOL-EI, $†	9074	10 636	11 559	12 598	14 644	1.61
Per capita Medicare spending, $‡	3922	4439	4940	5444	6304	1.61
Hospital characteristics§						
Overall supply (beds per 1000), *n*	2.4	2.6	2.9	2.9	3.2	1.32
Beds in teaching hospitals, %	10.2	18.1	13.8	20.8	28.1	2.76
Beds in hospitals with > 300 beds, %	31.6	37.4	38.7	43.8	57.2	1.81
Physician supply (per 10 000), *n*§	184.8	189.4	184.4	204.6	242.4	1.31
Medical specialists	26.9	28.8	28.6	34.8	44.4	1.65
General internists	21.3	23.4	22.6	28.5	37.3	1.75
Family practitioner/GP	35.9	31.3	29.6	25.9	26.5	0.74
Surgeons	43.8	45.6	46	50.3	56.4	1.29
All other specialties	56.8	60.3	57.5	65.1	77.7	1.37
Medicare enrollees in HMOs, %	12.1	6.8	7.3	7.7	15.3	1.26
Residents in metropolitan areas, %	77.5	81.9	82.3	79.2	97.4	1.26

*EOL-EI = End-of-Life Expenditure Index; GP = general practitioner; HMO = health maintenance organization; HRR = hospital referral region.

† Average age-sex-race–adjusted per capita fee-for-service spending on hospital and physician services in the HRRs within each quintile for Medicare enrollees age 65–99 years who were in their last 6 months of life. For details, see Methods.

‡ Average age-sex-race–adjusted 1996 annual per capita fee-for-service spending in the HRRs within each quintile on all Medicare services among enrollees age 65–99 years (9).

§ Key attributes and average per capita supply of the specified medical resource in the HRRs within that quintile. Per capita supply is calculated per 1000 or per 10 000 residents of the general population within the HRRs (9).

cation, disability status, urban or rural residence, employment, marital status, and Hispanic origin. For all three chronic disease cohorts, we used American Hospital Association data to characterize the hospital teaching status (27) and the Medicare claims files of patients' index hospitals to determine the volume of cases of hip fracture, colorectal cancer, and acute MI treated per year.

Data collection and preparation procedures for the MCBS are described elsewhere (22). Because not all respondents completed all survey items, analyses of utilization, access to care, satisfaction, and survival are based on slightly different numbers of respondents (Appendix, Section C, available at www.annals.org). Among the patient attributes, responses were most likely to be missing for income (5%); patients for whom income data were missing were recoded to the lowest-income group after analyses showed them to be similar in other attributes and survival to other patients in that group. The MCBS includes responses from proxies, which represented a maximum of 8.0% of our initial cohort. There were no differences in the proportion of proxy responses across the quintiles of spending, and excluding proxy responses did not alter our findings.

We used information from Medicare enrollment files to determine the percentage of all Medicare enrollees in each HRR who were enrolled in HMOs, to assign patients to one of nine major regions of the country, to determine whether patients had moved within an HRR or across HRRs within 1 or 2 years before their index admission, and to determine when patients should be censored based on loss of Medicare fee-for-service coverage (for utilization analyses) or based on relocation from their original HRR.

Assignment to Exposure Levels

We used two approaches to determine cohort members' exposure to different levels of Medicare spending in their regions of residence. Previous research has shown that the dramatic differences in end-of-life treatment across U.S. regions are highly predictive of differences in total spending (13, 28) but are not due to differences in case mix or patient preferences (29). Our primary measure of exposure was the EOL-EI, which was calculated as age-sex-race–adjusted spending (measured with standardized national prices) on hospital and physician services provided to Medicare enrollees in their last 6 months of life in each of the 306 U.S. HRRs from mid-1994 to 1997, excluding any members of the study cohorts (Appendix, Sections D and E, available at www.annals.org).

Although Medicare enrollees identified 6 months before death are identical in terms of their risk for death (which is 100%), they may differ in other ways across HRRs (for example, in illness levels unrelated to risk for death). We therefore repeated the major analyses with an alternative exposure measure—an Acute Care Expenditure Index (AC-EI)—which was based on differences across HRRs in risk-adjusted spending during an acute care episode, calculated as follows. For each of the four study cohorts, we determined age-, sex-, race, and illness-adjusted spending on physician and hospital services (measured with standardized national prices) provided during the first 6 months after index hospitalization across the 306 HRRs. The AC-EI subsequently used to assign each cohort to different exposure levels was the average of the age-sex-race-illness–adjusted spending during the acute episode of care in the other cohorts (Appendix, section F, available at www.annals.org).

The EOL-EI measures regional differences in practice at the end of life, while the AC-EI measures regional differences in practice during acute illness (or exacerbation of

Table 1. **Characteristics of the Hip Fracture Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Test for Trend†
	1 (Lowest)	2	3	4	5 (Highest)	
Cohort members, *n*	121 354	129 815	125 412	121 697	116 225	
Demographic, %						
Age 65–74 y	16.4	17.1	17.2	17.9	17.0	↑
Age 75–84 y	41.6	42.7	42.9	42.9	42.4	↑
Age ≥85 y	42.0	40.2	39.9	39.2	40.6	↓
Women	76.6	77.9	78.4	78.1	78.3	↑
Black race	1.1	3.1	4.0	5.2	4.8	↑
Comorbid conditions, %‡						
0	55.4	55.7	55.4	54.7	57.1	↑
1	31.4	31.4	31.8	32.1	30.5	↓
≥2	13.2	12.9	12.8	13.2	12.4	↓
Social Security income, %§						
<$1700	18.8	19.3	19.0	23.6	21.3	↑
$1700–$2600	56.9	56.4	53.7	48.0	39.4	↓
>$2600	24.3	24.3	27.3	28.5	39.2	↑
Burden of illness (predicted 1-year mortality rate), %	24.5	24.1	24.1	24.1	23.9	↓

* EOL-EI = End-of-Life Expenditure Index.
† Arrows show the direction of any statistically significant association ($P \leq 0.05$) between the percentage of patients with a given attribute and regional EOL-EI differences. An arrow pointing upward indicates that as Medicare spending increases across regions, the percentage of patients with a given characteristic increases. For additional information, see Appendix Table 6, available at www.annals.org.
‡ Based on the Charlson Comorbidity Index.
§ Average monthly Social Security income of beneficiaries in ZIP code of residence.

a chronic illness). Both measures were highly predictive of average age-sex-race–adjusted Medicare spending at the HRR level ($r = 0.81$ for the EOL-EI and 0.79 for the AC-EI in the acute MI cohort) and of regional differences in utilization. Both exposure measures produced similar results, so we present our findings on utilization based on the EOL-EI. (A sensitivity analysis of our mortality analyses using the AC-EI is presented in Part 2.) For many analyses, we grouped HRRs into quintiles of increasing exposure to Medicare spending based on the EOL-EI.

Measures To Characterize the Content, Quality, and Accessibility of Care

We used 100% Part A and B Medicare claims for all four cohorts to determine rates of specific physician and hospital services within the first year of follow-up and a 5% sample to examine aggregate physician utilization over the full 5 years of follow-up. The major categories of physician services provided to the Medicare population (MCBS) were defined by using Medicare's Berenson–Eggers Type of Service classification (http://cms.hhs.gov/data/betos/default.asp). The acute MI chart review allowed us to describe the proportion of patients in defined clinical subgroups who received specific medications or interventions during the initial hospitalization. Analyses of the quality of care were restricted to patients who were "ideal" candidates for each therapy (that is, patients with any absolute or potential contraindication to the treatment were excluded), as in the original description of the Cardiovascular Cooperative Project (18). The in-person interviews for the MCBS included specific questions about the types of visits received during the past year, waiting times at these visits, receipt of specific preventive services, and access to care.

Statistical Analyses

All analyses used the patient as the unit of analysis and measured other attributes at progressively higher levels of aggregation where appropriate (ZIP code of residence, hospital of index admission, and HRR of residence). To test whether patients' baseline characteristics differed across HRRs with differing EOL-EI levels, we used logistic regression at the individual level with the attribute (for example, age 65 to 74 years) as a dichotomous dependent variable and the HRR-level EOL-EI as the independent variable. To assess the aggregate impact of any differences in individual attributes on average baseline risk for death across regions of increasing EOL-EI, we used logistic regression to determine each individual's predicted 1-year risk for death as a function of his or her baseline characteristics. The models had modest to excellent predictive ability (c-statistics were 0.61 for the colorectal cancer cohort, 0.68 for the hip fracture cohort, 0.77 for the acute MI cohort, and 0.82 for the MCBS cohort). We used these

Table 2. **Characteristics of the Colorectal Cancer Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Test for Trend†
	1 (Lowest)	2	3	4	5 (Highest)	
Cohort members, *n*	36 806	40 038	37 317	40 001	41 267	
Demographic, %						
Age 65–74 y	42.6	44.1	44.4	45.3	43.3	>0.05
Age 75–84 y	42.5	41.7	41.6	40.6	42.6	>0.05
Age ≥85 y	15.0	14.2	14.1	14.1	14.2	>0.05
Women	53.7	54.1	55.0	53.2	53.6	>0.05
Black race	2.1	5.9	7.7	9.6	9.2	↑
Comorbid conditions, %‡						
0	68.7	68.3	67.6	66.9	67.3	↓
1	23.0	23.5	23.8	24.3	23.8	↑
≥2	8.3	8.2	8.6	8.9	8.9	↑
Cancer stage, %						
Local	59.6	60.2	60.1	60.5	59.7	>0.05
Regional	19.4	19.7	19.2	19.3	19.7	>0.05
Distant	21.1	20.1	20.7	20.2	20.5	↓
Social Security income, %§						
<$1700	17.6	17.3	17.6	22.0	18.9	↑
$1700–$2600	56.7	57.0	53.0	46.9	38.9	↓
>$2600	25.8	25.7	29.5	31.1	42.1	↑
Burden of illness (predicted 1-year mortality rate), %	21.1	20.8	21.2	20.8	20.9	>0.05

* EOL-EI = End-of-Life Expenditure Index.
† Arrows show the direction of any statistically significant association ($P \leq 0.05$) between the percentage of patients with a given attribute and regional EOL-EI differences. An arrow pointing upward indicates that as Medicare spending increases across regions, the percentage of patients with a given characteristic increases. A P value greater than 0.05 was considered not significant. For additional information, see Appendix Table 7, available at www.annals.org.
‡ Based on the Charlson Comorbidity Index.
§ Average monthly Social Security income of beneficiaries in ZIP code of residence.

Table 3. **Characteristics of the Acute Myocardial Infarction Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Test for Trend†
	1 (Lowest)	2	3	4	5 (Highest)	
Cohort members, *n*	28 441	32 193	33 727	33 449	31 583	
Demographic, %						
Age 65–74 y	44.5	46.0	46.3	45.9	41.9	↓
Age 75–84 y	40.3	39.4	38.6	39.2	40.8	>0.05
Age ≥85 y	15.2	14.6	15.0	14.9	17.3	↑
Women	46.6	48.5	49.2	49.1	49.9	↑
Black race	1.9	4.9	6.2	7.7	7.2	↑
Comorbid conditions, %						
Previous revascularization	17.5	17.0	17.1	18.2	16.5	↓
Previous MI	28.7	30.3	28.7	29.6	28.6	>0.05
History of congestive heart failure	19.9	21.4	20.4	21.2	22.2	↑
Diabetes	28.5	30.8	30.5	31.0	31.3	↑
History of angina	44.6	45.0	45.5	45.6	48.4	↑
Peripheral vascular disease	9.0	9.7	10.7	11.1	11.6	↑
Smoker	14.5	15.6	16.3	15.4	13.0	↓
COPD	19.4	20.6	21.2	21.1	19.1	>0.05
Characteristics of acute MI, %						
Non–Q-wave	37.4	39.5	38.9	40.2	42.4	↑
Anterior	31.8	30.7	31.2	31.3	31.1	>0.05
Inferior	21.3	20.7	20.3	19.4	18.0	↓
Other location	9.6	9.1	9.5	9.0	8.4	↓
Received CPR	3.8	3.3	3.6	3.9	3.5	>0.05
Congestive heart failure	25.7	27.9	28.1	28.1	30.9	↑
Shock	2.8	2.2	2.6	2.4	2.6	>0.05
Hypotension	4.1	3.9	3.8	3.6	3.7	↓
Peak creatine kinase level >1000 IU/L	32.1	31.3	31.7	30.2	30.1	↓
Social Security income, %‡						
<$1700	17.5	18.2	17.9	22.4	18.4	↑
$1700–$2600	57.5	57.8	54.2	47.9	38.7	↓
>$2600	25.1	24.0	27.8	29.7	42.9	↑
Burden of illness (predicted 1-year mortality rate), %	31.2	31.5	31.8	32.0	33.2	↑

* COPD = chronic obstructive pulmonary disease; CPR = cardiopulmonary resuscitation; EOL-EI = End-of-Life Expenditure Index; MI = myocardial infarction.
† Arrows show the direction of any statistically significant association ($P \leq 0.05$) between the percentage of patients with a given attribute and regional EOL-EI differences. An arrow pointing upward indicates that as Medicare spending increases across regions, the percentage of patients with a given characteristic increases. A P value greater than 0.05 was considered not significant. For additional information, see Appendix Table 8, available at www.annals.org.
‡ Average monthly Social Security income of beneficiaries in ZIP code of residence.

models to determine the average predicted risk for death across quintiles of EOL-EI. We then determined average predicted 1-year risk for death in each HRR and tested for an association across HRRs using logistic regression.

For the analyses of aggregate utilization, cohort members were censored (no longer followed) if they lost Medicare insurance (either Part A or B eligibility), enrolled in an HMO, or moved out of the original HRR of residence. The average amount of hospital and physician services provided to each cohort member across quintiles of the EOL-EI was calculated by using standardized national prices (Appendix, Section D) and was calculated separately for the acute episode (index admission to 6 months for the three chronic disease cohorts) and for 6 months to 5 years (chronic disease cohorts) or for 5 years (MCBS cohort). To control for baseline differences, we used linear regression, weighting by follow-up time, with the log-transformed utilization of hospital and physician services per person-year as the dependent variable for the individual and the quintile of end-of-life spending as the primary independent variable. Coefficients and confidence intervals were back-transformed to provide estimates of the adjusted relative rates of utilization in the highest compared with the lowest quintile for each cohort.

We analyzed only the first year of follow-up (for which we had 100% physician claims) to compare rates of specific physician services across quintiles. We used Poisson regression to calculate adjusted relative rates of specific services (dependent variable) in quintile 5 compared with quintile 1, controlling for baseline differences (independent variables) (30). We then computed pooled relative rates across the cohorts, using a weighted average of the individual regression coefficients for each cohort and weighting by the inverse of the variance (31).

The specific independent and dependent variables included in each regression are described in **Appendix Table**

5, available at www.annals.org. We used the REG routine of Stata 6.0 (Stata Corp., College Station, Texas) to perform all regression analyses. For the analyses of the MCBS cohort, we used SUDAAN (Research Triangle Institute, Research Triangle Park, North Carolina) to account for sampling weights and the two-stage design.

RESULTS

Assignment of HRRs to Spending Levels

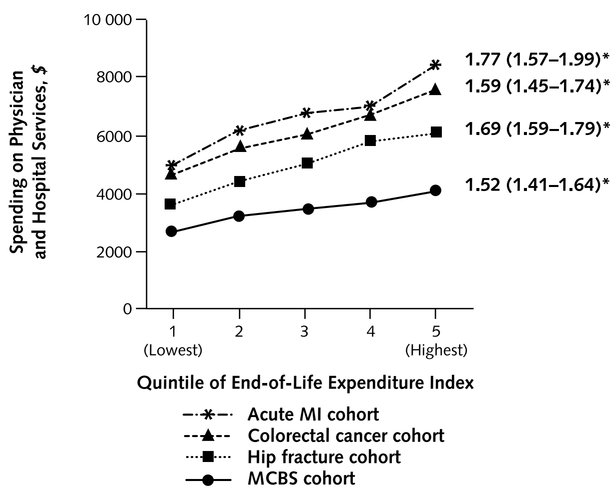
The 306 U.S. HRRs were assigned to quintiles of Medicare spending based on the primary exposure measure, the EOL-EI, which averaged $14 644 in quintile 5 (the highest-spending quintile) and $9074 in quintile 1

Table 4. **Characteristics of the Medicare Current Beneficiary Survey Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Test for Trend†
	1 (Lowest)	2	3	4	5 (Highest)	
Respondents, *n*	4064	3725	2476	3893	4032	
Demographic, %						
Age 65–74 y	55.7	55.1	56.6	57.5	54.7	>0.05
Age 75–84 y	33.6	34.2	32.6	32.6	34.8	>0.05
Age ≥85 y	10.7	10.7	10.8	9.9	10.4	>0.05
Women	58.2	59.3	61.2	59.6	60.3	>0.05
Black race	3.5	5.2	10.4	8.3	9.9	↑
Hispanic origin	2.3	1.7	3.5	3.6	6.8	↑
Divorced, widowed, or unmarried	37.8	42.3	42.1	41.5	41.1	↑
Lives alone	27.3	29.8	29.1	28.1	27.9	>0.05
Metropolitan living status	48.4	44.8	70.6	77.5	87.3	↑
Socioeconomic, %						
Did not complete high school	34.1	41.8	43.5	41.3	40.2	↑
Low income (<$5000/y)	5.9	6.2	7.5	5.8	6.8	>0.05
High income (>$25 000/y)	28.1	23.9	27.2	24.2	26.8	>0.05
Insurance						
Medicare only	11.0	10.1	11.6	11.4	11.5	>0.05
Medicare and Medicaid	11.0	11.2	16.2	10.7	14.1	↑
Medicare and self-purchased	38.2	37.7	36.7	34.3	31.5	↓
Medicare and employer sponsored	39.7	41.0	35.5	43.6	42.9	>0.05
Self-reported health, %						
Excellent or very good	48.7	42.8	42.3	45	41.6	↓
Good	30.7	31.1	27.9	29.2	31.3	>0.05
Fair or poor	20.6	26.1	29.8	25.8	27.1	↑
Smoking, %						
Never	44.6	43.3	44.2	42.5	42.5	>0.05
Current	13.5	13.6	14.3	14.5	13.7	>0.05
Functional status						
Other limitation, %	55.4	58.8	60.8	57.2	55.5	>0.05
ADL limitation, %	32.0	33.8	33.3	31.8	33.1	>0.05
IADL limitation, %	38.4	41.8	44.4	40.4	40.0	>0.05
Bedridden, %	2.7	2.9	2.8	3.0	3.1	>0.05
Facility dwelling, %	5.8	6.0	5.1	4.2	4.7	↓
Mean HALex score	62.5	59.7	59.0	61.3	60.7	↓
Chronic conditions reported, %						
Alzheimer disease	4.1	3.9	3.8	3.8	3.8	>0.05
Arthritis	47.8	50.5	52.0	48.4	46.7	>0.05
Cancer	18.0	16.6	16.5	16.4	17.6	>0.05
Ischemic heart disease or angina	12.7	14.2	14.7	14.1	14.1	>0.05
Diabetes	12.6	14.6	15.7	18.0	15.6	↑
COPD	13.2	12.0	14.1	13.4	11.2	>0.05
Hypertension	49.5	48.6	48.9	52.0	48.8	>0.05
History of MI	12.6	14.3	14.3	15.1	13.8	>0.05
Osteoporosis	9.1	8.8	9.5	8.7	8.0	>0.05
Parkinson disease	1.9	1.7	1.7	1.3	1.6	>0.05
Stroke	10.4	11.7	11.5	10.8	9.9	>0.05
Burden of illness (predicted 1-year mortality rate), %	4.9	5.1	5.3	5.0	5.1	>0.05

* ADL = activities of daily living; COPD = chronic obstructive pulmonary disease; EOL-EI = End-of-Life Expenditure Index; HALex = Health Activities and Limitations Index; IADL = independent activities of daily living; MI = myocardial infarction.
† Arrows show the direction of any statistically significant association ($P \leq 0.05$) between the percentage of patients with a given attribute and regional EOL-EI differences. An arrow pointing upward indicates that as spending increases across regions, the percentage of patients with a given characteristic increases. A P value greater than 0.05 was considered not significant. For additional information, see Appendix Table 9, available at www.annals.org.

Figure 3. **Per capita utilization of hospital and physician services during follow-up by study cohorts.**



MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction. The graph presents unadjusted annual per capita spending on hospital and physician services (using standardized national prices) for each cohort in each quintile of the End-of-Life Expenditure Index. Data shown for the acute myocardial infarction, colorectal cancer, and hip fracture cohorts exclude the first 6 months of follow-up. *Relative rate of utilization in quintile 5 compared with quintile 1, adjusting for baseline differences in patient characteristics. Values in parentheses are 95% CIs.

(the lowest-spending quintile) (**Figure 2**). Average age-sex-race–adjusted per capita Medicare spending was highly correlated with EOL-EI ($r = 0.81$); per capita Medicare spending was $6304 in quintile 5 and $3922 in quintile 1. Residents of the highest quintile received 61% more Medicare resources than those in the lowest quintile whether measured by the EOL-EI or by average Medicare spending. Quintiles with a higher expenditure index had more hospital beds and physicians, a relative predominance of large hospitals and teaching hospitals, and a higher proportion of urban residents. The percentage of Medicare beneficiaries enrolled in HMOs was higher in both the lowest and highest quintiles than in the middle quintiles.

Patient Characteristics

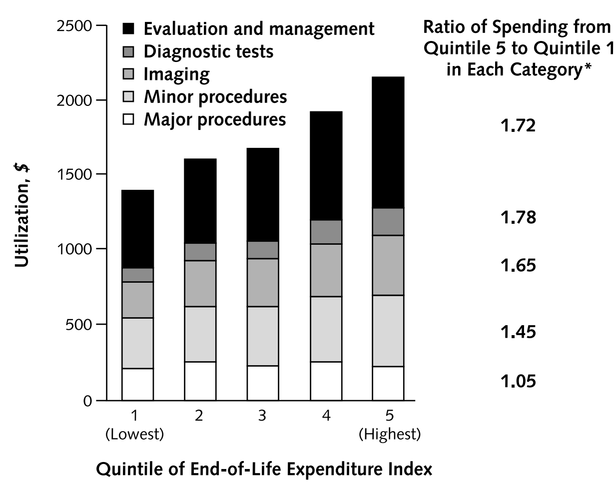
Tables 1 to **4** present selected characteristics of each study cohort in each quintile and a test for trend across HRRs that had a higher EOL-EI. Because of the large sample sizes, many differences in the chronic disease cohorts were statistically significant. Notable differences were found in racial composition (more black patients in higher quintiles) and income (higher quintiles had more enrollees in the highest and lowest income categories). Smaller differences across quintiles were apparent in age, sex, comorbid conditions, and cancer stage. For the acute MI cohort, patients in the highest quintile had a higher prevalence of non–Q-wave infarctions and congestive heart failure but were less likely to have creatine kinase levels over 1000 IU/L. For the MCBS cohort, residents of HRRs in the quintiles with a higher EOL-EI were more likely to report being in fair or poor health but were less likely to live in a facility. Few differences were found, however, in activities of daily living or instrumental activities of daily living, smoking, or reported chronic conditions.

Tables 1 through **4** also present the average predicted risk for death in each quintile and a formal test of trend assessing whether HRRs with a higher EOL-EI had higher predicted mortality at baseline. A higher expenditure index was associated with an increased predicted risk for death for the AMI cohort, a lower predicted risk for death for the hip fracture cohort, and no significant difference in predicted mortality across spending levels for the colorectal cancer or MCBS cohorts. These data indicate that the burden of illness in these cohorts is similar across HRRs that differ by more than 60% in both EOL-EI and, as grouped according to the EOL-EI, average per capita Medicare spending.

Aggregate Utilization of Services

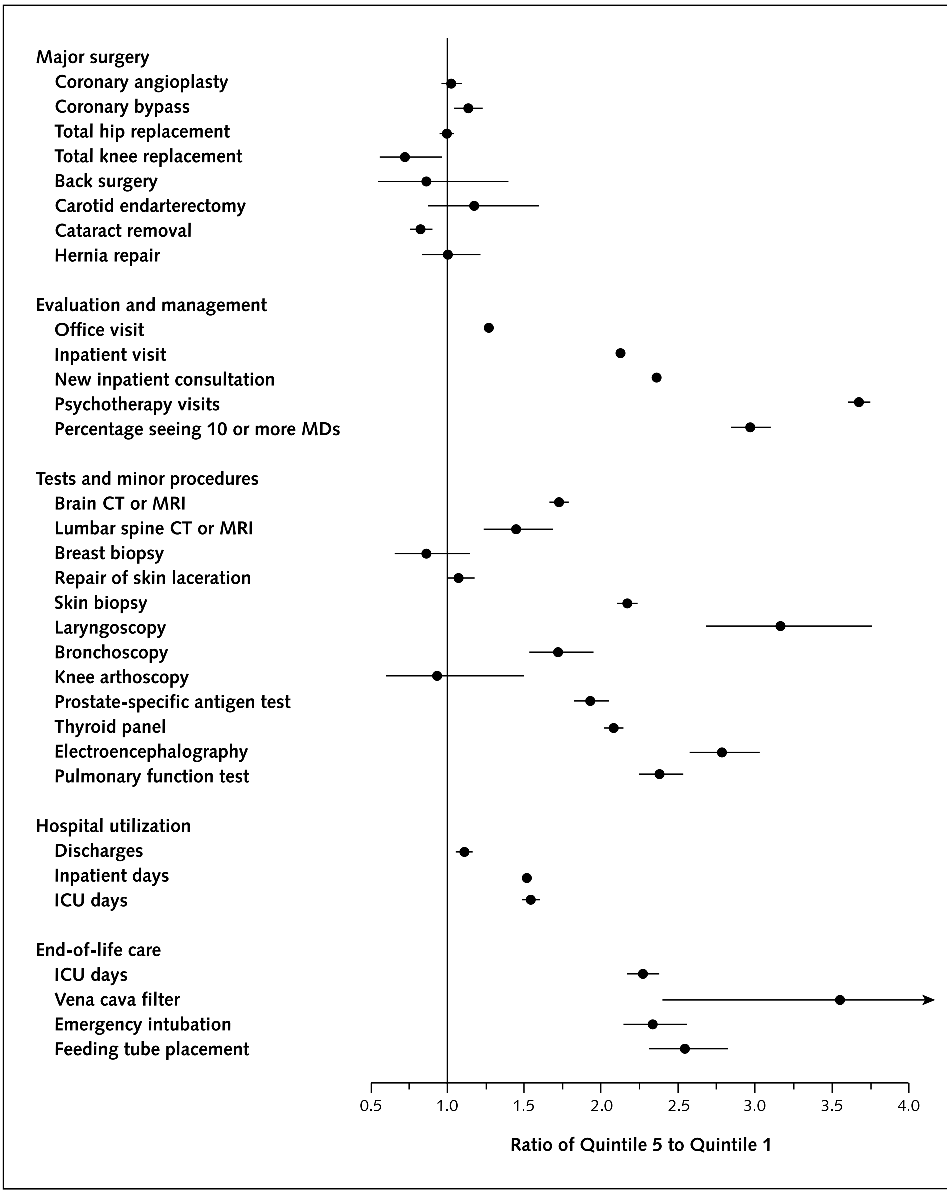
Figure 3 displays the aggregate utilization of hospital and physician services by the study cohorts across quintiles. The data presented exclude the initial acute episode of care for the acute MI, hip fracture, and colorectal cancer cohorts because utilization rates were, as expected, similar during this period. Differences across the cohorts are apparent: Within each quintile, the MCBS cohort received the least care while the acute MI cohort received the most care. Within each cohort, however, patients who resided in regions with a higher EOL-EI received more medical care. After adjustment for baseline differences in health status,

Figure 4. **Utilization of physician services across quintiles of spending for the Medicare Current Beneficiary Survey cohort, 1992–1996.**



Utilization is summarized as unadjusted average annual per capita spending on physician services (using standardized national prices, as described in the Methods section). *Categories defined by using the Berenson–Eggers type of service classification scheme.

Figure 5. **Relative rate and 95% CIs of specific services provided to cohort members residing in the highest quintile of Medicare spending compared with those residing in the lowest quintile for the three chronic disease cohorts combined.**



CIs for office visits, inpatient visits, new inpatient consultations, and inpatient days were narrower than the diameter of the circle used to indicate the point estimate. CT = computed tomography; ICU = intensive care unit; MRI = magnetic resonance imaging.

overall use of hospital and physician services was between 52% higher (MCBS cohort) and 77% higher (acute MI cohort) in the highest compared with the lowest quintile. For each of the cohorts, approximately half of the spending within a quintile was for acute inpatient hospital care and half was for physician services (data not shown).

Content of Care

Figure 4 characterizes the content of physician services provided to the Medicare population (MCBS) across quintiles. Only a small proportion of total physician services in any quintile was for major surgical procedures, and the overall rate of major surgery was relatively constant across quintiles. Evaluation and management services (visits), tests, radiology services, and minor procedures made up the vast majority of physician activity and explained the differences in physician practice found across the quintiles.

Figure 5 provides detailed information on differences in the specific services provided to the chronic disease cohorts across HRRs with differing spending levels. We present the pooled relative rates and 95% CIs for all three chronic disease cohorts combined in quintile 5 (highest expenditure index) compared with quintile 1 (lowest expenditure index) because the relative use rates across quintiles were similar for each cohort. For example, although pulmonary function tests were performed twice as frequently overall in patients with acute MI than in those with hip fracture, they were performed nearly three times more often in the highest quintile than in the lowest quintile in all three cohorts (**Appendix Table 11**, available at www.annals.org).

Rates of major procedures differed little across quintiles and were sometimes lower and sometimes higher in quintile 5. Rates of several minor, relatively nondiscretionary procedures (skin laceration repair, breast biopsy) were also similar across quintiles.

As was found in the general population sample, differences in utilization across quintiles were largely due to increased use of evaluation and management services and associated tests, imaging and minor procedures, and use of the hospital as a site of care. Rates of outpatient physician office visits averaged 1.27 (95% CI, 1.26 to 1.28) times higher in quintile 5 than in quintile 1. Inpatient visits, however, were 2.13 (CI, 2.12 to 2.14) times higher, and inpatient specialist consultations were 2.36 (CI, 2.33 to 2.39) times higher. The proportion of patients seeing more than 10 different physicians during the first year after their index admission was 2.97 (CI, 2.84 to 3.11) times higher in quintile 5. More frequent physician contact was associated with more frequent use of diagnostic tests and minor procedures. Patients in quintile 5 spent more time in the hospital (rate ratio, 1.52 [CI, 1.50 to 1.54]) and in the intensive care unit (rate ratio, 1.55 [CI, 1.50 to 1.60]).

Some of the most dramatic differences were found in rates of services provided to severely ill patients. For example, among patients in their last 6 months of life, intensive care unit days were 2.28 (CI, 2.18 to 2.38) times higher in quintile 5 than in quintile 1 and the use of vena cava filters, feeding tubes, and emergency intubation were all more than 2.3 times as frequent in quintile 5 as in quintile 1.

Quality of Care

Regions with higher expenditure indices did not provide better quality of care on most measures (**Table 5**). Among patients in whom the specific treatment was recommended, patients with acute MI in the highest quintile were no more likely to receive acute reperfusion, were less likely to receive aspirin at admission or discharge and angiotensin-converting enzyme inhibitors in the setting of a low ejection fraction, and were more likely to receive β-blockers. Because some preventive services (for example, influenza vaccination) may be provided in nonreimbursed settings, the results for preventive services are based on patient reports from the MCBS. Although mammography was performed as frequently in high as in low quintiles, influenza and pneumococcal immunization and Papanicolaou smears were provided less frequently in HRRs with higher expenditure indices. Lack of better-quality care in HRRs in the highest quintile was not related to the greater predominance of teaching or large hospitals (**Figure 6**). Major teaching hospitals had somewhat higher quality on several of the measures, but the differences in quality across quintiles were small and inconsistent.

Access to Care

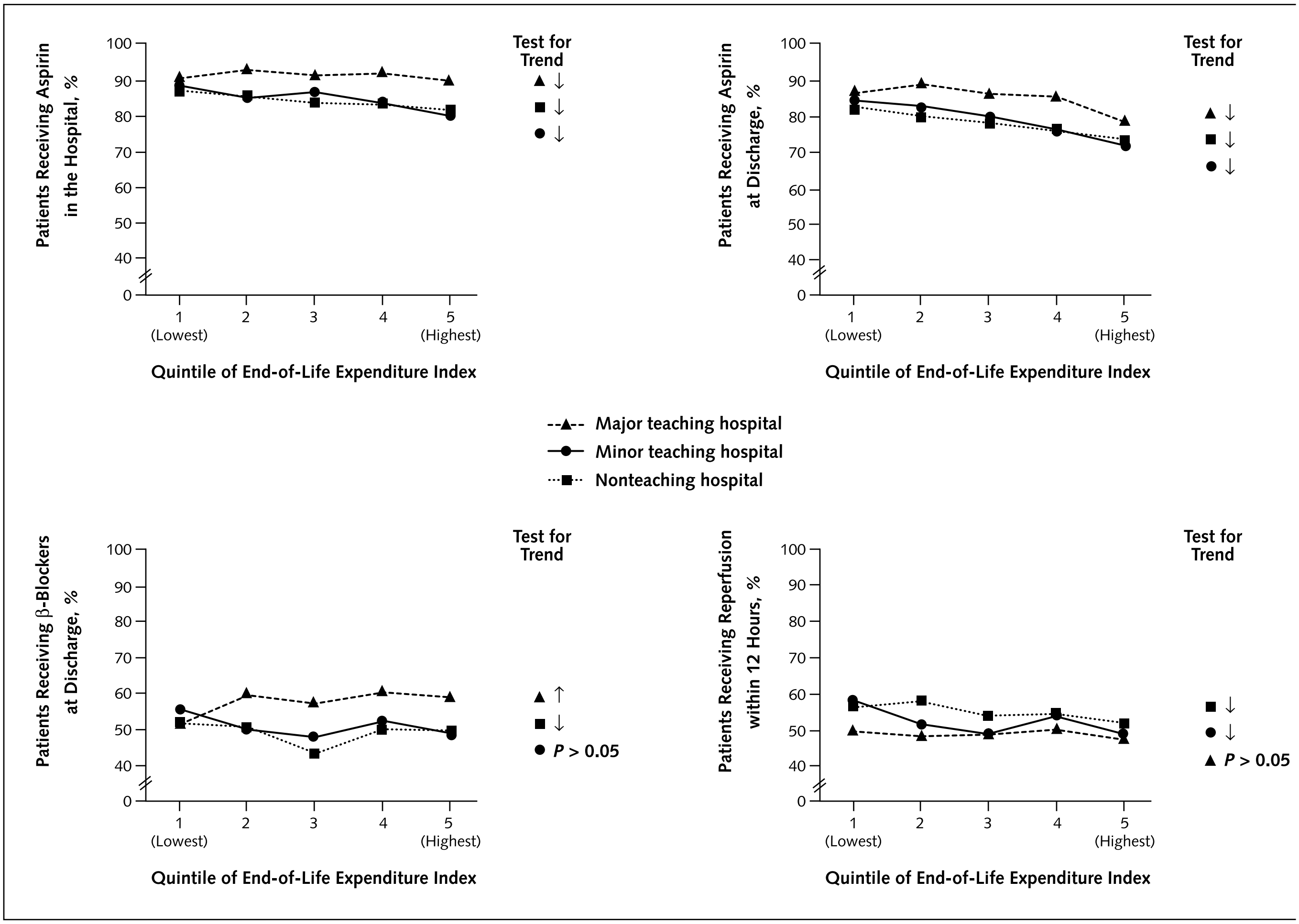
Although the absolute differences in access to care were small, the findings suggest a general pattern of slightly lower access to care in HRRs with higher expenditure indices (**Table 6**). Patients with acute MI who lived in regions with higher expenditure indices were significantly less likely to receive exercise testing and angiography, and a

Table 5. **Quality of Care according to Level of Medicare Spending in Hospital Referral Region of Residence***

Variable	Quintile of EOL-EI					Test for Trend†
	1 (Lowest)	2	3	4	5 (Highest)	
	←——— % ———→					
Acute MI cohort‡						
Received reperfusion within 12 hours	55.8	55.3	52.3	53.3	49.8	↓
Received aspirin in the hospital	87.7	87.0	84.8	85.3	83.9	↓
Received aspirin at discharge	83.5	82.5	79.8	78.5	74.8	↓
Received ACE inhibitors at discharge	62.7	60.0	56.6	58.3	58.5	↓
Received β-blockers in the hospital	61.5	61.0	54.3	61.5	63.9	↑
Received β-blockers at discharge	52.7	53.2	47.1	53.5	53.7	>0.05
MCBS cohort						
Preventive services						
Received influenza vaccine	60.3	56.3	54.3	50.0	48.1	↓
Received pneumonia vaccine	29.4	28.7	27.2	25.3	19.7	↓
Received Papanicolaou smear (among women without hysterectomy)	40.8	36.9	39.6	39.8	33.6	↓
Received mammography (among women age 65–69 y)	48.7	46.9	46.2	47.5	47.6	>0.05

* ACE = angiotensin-converting enzyme; EOL-EI = End-of-Life Expenditure Index; MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction.
† Arrows show the direction of any statistically significant association ($P \le 0.05$) between the percentage of patients receiving a specified service and regional EOL-EI differences. An arrow pointing upward indicates that as spending increases across regions, the percentage of patients receiving a specified service increases. A P value greater than 0.05 was considered not significant.
‡ Values are for patients who were ideal candidates for the specific treatment, defined as having no absolute or relative contraindication.

Figure 6. **Percentage of patients in the acute myocardial infarction cohort who received the specified therapy (among ideal candidates), according to type of hospital and quintile of Medicare spending.**



Arrows show the direction of any statistically significant association ($P \leq 0.05$) between the percentage of patients receiving a specified service and regional End-of-Life Expenditure Index differences. An arrow pointing upward indicates that as spending increases across regions, the percentage of patients receiving a specified service increases. A P value greater than 0.05 was considered not significant.

slightly smaller percentage saw a physician within 30 days of discharge. Larger differences emerged in the type of specialists seen during the first 30 days: Those in HRRs with lower expenditure indices were more likely to see family practitioners, and those in HRRs with higher expenditure indices were more likely to see medical subspecialists.

In HRRs with higher expenditure indices, a slightly smaller proportion of patients in the general population (MCBS) reported having a usual source of care. Some differences in the site of physician visits were seen, with more frequent outpatient and office visits in regions with high expenditure indices. Waiting times for emergency department, outpatient facility, and office visits were significantly longer in higher-spending regions. Finally, on the basis of one of three traditional measures of access (having a problem but not seeing a physician), HRRs with a higher expenditure index provided significantly worse access to care.

DISCUSSION

We conducted a cohort study in four distinct samples of Medicare enrollees to compare the content, quality, and accessibility of care across 306 U.S. HRRs with substantially different spending levels. The primary exposure variable in this study, the EOL-EI, was intended to measure the component of regional variation in Medicare spending that is unrelated to regional differences in illness or price. The goal was to ensure assignment of HRRs (and the patients within them) to "treatment groups" that were similar in baseline health status but that differed in subsequent treatment. The validity of the approach was confirmed by our finding that illness levels in each of the four study cohorts differed little across quintiles but that health care utilization rates and spending (for all four study samples) increased steadily and substantially as the expenditure index for a given HRR increased. Regardless of the measure used to characterize "spending," residents of the highest-spending quintile received about 60% more care than residents of the lowest-spending quintile.

We compared the content, quality, and accessibility of care across regions with different levels of spending. The differences in spending across HRRs were largely due to more frequent use of the hospital as a site of care, more frequent physician visits, greater use of medical subspecialists, and more frequent diagnostic tests and minor procedures. The quality of care was no better in higher-spending regions, and access to care was slightly worse on most measures.

Our analysis has several limitations. First, we had only a limited number of measures of quality and access and studied only four cohorts. The consistency of our findings across cohorts and measures, however, strengthens the causal inferences that can be drawn. Other large studies have also documented substantial differences in resource use that are unrelated to quality of care (32–35).

Second, we must address concerns about potential unmeasured differences in health status. It is highly unlikely that the 60% differences in utilization observed across quintiles of spending could be due to residual confounding by unmeasured illness levels. In each of the four cohorts, we found that patients' predicted risk for death differed little across regions of differing spending levels. Moreover, crude and adjusted utilization analyses yielded nearly identical results. To account for the greater than 60% difference, therefore, an unmeasured confounder would have to be a more powerful predictor of utilization than those we measured (including self-assessed health status or the severity of an acute MI) and at the same time not be correlated with the available measures (because crude and adjusted analyses yielded similar results). The nearly 60% increased utilization observed in higher-spending regions was found in every subgroup of the study samples (**Appendix Tables 12** through **14**, available at www.annals.org).

Third, our findings cannot prove that the strong association we observed between capacity (the supply of hospital beds and medical specialists) and utilization is entirely causal. Differences in the malpractice environment could contribute to the differences in practice we observed. State-level differences in malpractice, however, are associated

Table 6. **Access to Care according to Level of Medicare Spending in Hospital Referral Region of Residence***

Variable	Quintile of EOL-EI					Test for Trend†
	1 (Lowest)	2	3	4	5 (Highest)	
	←——— % ———→					
Acute MI cohort						
Procedures within 30 days of admission‡						
Angiography among all patients	48.2	50.3	49.3	50.2	47.4	↓
Angiography among appropriate patients§	55.8	57.6	56.0	57.2	53.7	↓
Coronary bypass surgery	13.8	14.2	14.6	15.0	14.5	↑
Percutaneous coronary interventions	19.8	20.7	18.9	19.5	18.5	↓
Cardiac stress test	17.9	15.2	14.0	15.7	14.7	↓
Use of services after discharge‡						
Physician office visit within 30 days of discharge	71.3	70.0	67.5	69.4	69.6	↓
Hospital readmission within 30 days of discharge	19.4	20.2	10.0	21.2	21.8	↑
Physician visits within first 30 days‡						
Family or general practitioner	33.9	31.9	32.4	24.3	21.2	↓
General internist	47.7	50.0	52.1	49.9	52.6	↑
Cardiologist	70.1	76.4	72.5	78.3	81.3	↑
Other medical specialist	23.1	27.6	28.2	32.9	42.2	↑
Surgeon	20.9	24.7	25.9	25.9	28.9	↑
MCBS cohort						
Has usual source of care	87.8	89.7	89.0	86.0	86.5	↓
Specific visits received and waiting times at visit						
Emergency department visit	15.8	19.7	17.8	17.7	18.2	>0.05
Waited >30 min	28.4	28.8	29.3	33.8	34.0	↑
Outpatient department visit	28.5	26.2	26.3	26.5	25.3	↓
Waited >30 min	22.9	30.1	35.7	34.9	39.3	↑
Physician visit	81.1	81.0	82.4	83.1	84.5	↑
Waited >30 min	24.8	29.3	29.9	30.3	31.9	↑
Barriers to access						
Had trouble getting care	2.5	2.9	3.4	3.0	3.1	>0.05
Had a problem but did not see MD	8.7	9.9	11.4	11.5	10.1	↑
Delayed care because of cost	9.3	10.2	10.9	11.0	8.9	>0.05

* EOL-EI = End-of-Life Expenditure Index; MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction.
† Arrows show the direction of any statistically significant association ($P \le 0.05$) between the percentage of patients with a given attribute and regional EOI-EL differences. An arrow pointing upward indicates that as spending increases across regions, the percentage of patients with a given characteristic increases. A P value greater than 0.05 was considered not significant.
‡ Percentage of patients receiving one or more.
§ *Appropriate* is defined as patients with class I disease by American Heart Association–American College of Cardiology criteria.

with a less than 10% difference in utilization (36). In addition, while it is possible that Medicare enrollees in high-spending regions prefer a more specialist-intensive pattern of practice, neither preferences nor greater fears of malpractice provide a compelling justification for the differences in public expenditures.

Previous research, however, suggests a causal relationship between supply and utilization. Use of physician services is strongly associated with the local workforce composition (7) and supply (9). Chronically ill patients are more likely to receive care in the hospital in communities with more beds (8, 12, 20, 37). In addition, the local bed supply, rather than patient preferences, explained the differences in end-of-life care among patients in the Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments (SUPPORT) (29). Finally, it has been shown that physicians adapt their admission and discharge decisions to the availability of intensive care unit beds, admitting more patients with less severe illness and extending length of stay when more beds are available (38). It appears likely that physicians in all regions are simply managing their patients with available resources and that inpatient management and subspecialist consultation are easier in regions where these resources are readily available.

Regional differences in Medicare spending are due almost entirely to use of discretionary services that are sensitive to the local supply of physicians and hospital resources: more frequent physician visits, greater use of specialists, and greater use of the hospital and intensive care unit as sites of care. Policymakers and purchasers concerned with resurgent growth in health care spending will need to focus on these "supply-sensitive" services. As we discuss in greater detail in Part 2, however, our study provides little guidance on the potential impact of reducing the use of such services, and caution is warranted as policies are developed to control health care spending.

Nevertheless, for the Medicare population, it appears that neither greater local availability of physicians and hospital beds nor the more inpatient-based and specialist-oriented pattern of practice that result are associated with improved access to care, better-quality care, or (as is reported in Part 2) better health outcomes or satisfaction. These findings call into question the notion that additional growth in health care spending is primarily driven by advances in science and technology and that spending more will inevitably result in improved quality of care.

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Appendix

Section A. Overview

The Appendix was developed to provide interested readers with additional detail on the methods of the study as well as supplementary findings referred to in the body of the papers that could not be included there because of space constraints. Section B provides an expanded discussion of the rationale for our study design and its relationship to "instrumental variables" analysis. Section C describes in greater detail our study populations, exclusions applied, and data quality. Section D describes in detail the rationale behind the approach and the methods used to calculate spending and utilization rates using measures free of bias that could be introduced because of differences in wages, prices, or policy payments to physicians or hospitals. Section E describes in greater detail the End-of-Life Expenditure Index (EOL-EI), the primary exposure used in the analysis, including the study population within which it was calculated and how members of each study cohort were excluded from the sample used to calculate the index used as the exposure for that cohort. Section F describes the motivation, methodology, and results of our sensitivity analysis using the Acute Care Expenditure Index.

In addition, the Appendix also includes supplementary tables that present additional detail on individual patient attributes (**Appendix Tables 1** through **4**), a table that lists specifically which variables are included in each of the major models used in the analyses (**Appendix Table 5**), the main models examining survival (**Appendix Tables 6** through **9**) and change in functional status (**Appendix Table 10**), a table presenting specific procedure rates for each chronic disease cohort and for all three cohorts combined (**Appendix Table 11**), and tables summarizing overall health care utilization rates across quintiles for each chronic disease cohort (**Appendix Tables 12** through **14**).

Section B. Natural Randomization: Observational Research, Instrumental Variables, and Why We Did Not Use Formal Instrumental Variables Analysis

As is discussed in the overview of the study design in Parts 1 and 2, the ideal approach to addressing the study question—whether the increased spending observed in some regions of the United States leads to better care or outcomes—would be to carry out a randomized trial. However, such a trial would be difficult and would probably end up answering a slightly different question (depending on the intervention under study).

The field of economic research has addressed this problem through approaches that attempt to create a "natural randomization" through what is termed "instrumental variables" analysis. The key notion is that an exposure is identified that allows the study sample to be assigned to different "treatment groups" in a way that assures that those in different treatment groups are similar in terms of attributes that might affect the outcome (that is, that case mix is similar in the groups). They are nonetheless treated differently.

A good example of this type of natural randomization comes from a study of how serving in the Vietnam War affected the probability of suicides and vehicular deaths (1). Clearly, comparing suicide rates for Vietnam veterans and nonveterans would be statistically suspect, since the underlying characteristics of the two groups would be expected to differ by so much. Draft lottery numbers, chosen randomly on the basis of one's birthday, were used as a natural randomization to place men into the "treatment" group, those most likely to be sent to Vietnam, and the "control" group, those least likely to be sent. This method qualified as an instrument because it fulfilled the two (intuitive) requirements of an instrumental variable: 1) It was highly correlated with the exposure variable, which was serving in Vietnam, and 2) it was plausibly uncorrelated with the underlying mental health of the population (or, more formally, with any unmeasured differences in the populations). In other words, any differences in suicide and accident rates between the two groups were very likely to have been the result of serving (or not serving) in Vietnam, and not individual risks for suicide or poor driving. The article by Hearst and colleagues, like our articles, took a reduced-form approach to the problem. In other words, they compared what they called "draft eligible" (the treatment group) with "draft ineligible" (the control group).

By the same token, in our papers, we compared outcomes of people living in areas where the health system displays a more aggressive approach to end-of-life care with those of people living in areas where the health system displays a less aggressive approach. We have no a priori reason for believing that these populations in these regions should differ in their underlying health status, but they are treated differently.

Why didn't we use the formal instrumental variables approach, in which we would predict how much an additional $1000 in Medicare spending affects survival? There are three main reasons. First, we are interested primarily in the direction and general magnitude of effect, rather than in the cost of achieving that effect. We recognize that if increased expenditures across regions result in improved health outcomes, knowing the magnitude of the effect of an additional 10% increase in regional spending on survival and functional status for Medicare patients would be important for policy research. If we find no association or that higher spending is associated with lower survival, however, the precise estimate of the coefficient (in terms of dollars) is relatively unimportant. Second, instrumental variables analysis is able to provide unbiased estimates only in certain settings, one of which is a linear model. Our need to use Cox proportional hazards regression for our mortality analyses precluded a formal instrumental variables analysis using currently developed statistical tools. Finally, it is important to recognize that the fundamental limitation of instrumental variables analysis would remain. One cannot prove that one has a perfect instrument.

We therefore presented our analysis as an observational study. We recognize that unmeasured confounding remains a possibility, but we nevertheless believe that our findings represent a major advance over previous research and that our conclusions that residence in higher-spending regions does not cause improved quality, access to care, or survival (and may cause worse survival) are sound.

Section C. Additional Detail on the Study Samples

For all three study cohorts, we restricted the eligible population to Medicare enrollees between the ages of 65 and 99 years who, at the time of their index admission, were eligible for both Medicare Parts A and B and were not enrolled in a health maintenance organization (HMO).

Patients with Myocardial Infarction

The acute myocardial infarction (MI) cohort was drawn from the patients included in the Cooperative Cardiovascular Project, which identified from billing records a national sample of Medicare beneficiaries with discharges for acute MI that occurred between February 1994 and November 1995 (2). We excluded patients with an unconfirmed acute MI (using the same criteria as in previous studies [3]) and included only the first episode of acute MI for a given patient. Characteristics of the acute MI cohort were obtained from the medical record by trained abstractors working in the Health Care Financing Administration's Cooperative Cardiovascular Project. They collected extensive data on predefined variables, including presentation characteristics (location of MI, cardiac rhythm, blood pressure, shock, and whether cardiopulmonary resuscitation was performed), initial laboratory values, the presence of comorbid conditions, and functional status before admission. Quality of the chart review process was monitored by random reabstractions; percentage agreement was generally very high (93.3% to 94.8%) (4). Demographic information available through the administrative databases was virtually complete (for example, age, sex, ethnicity, date of death) and is believed to be highly accurate. Clinical variables had some missing values; we created an additional categorical variable (for example, "missing creatine kinase level") where appropriate.

Patients with Hip Fracture and Colorectal Cancer

We used Medicare's 100% national MedPAR files to identify the first admission between 1993 and 1995 for patients with a primary diagnosis of hip fracture or colorectal cancer with resection, using the same International Classification of Diseases, Ninth Revision, Clinical Modification codes as in earlier work (5). Hospitalization rates for these conditions vary little across regions, and incident cases are likely to be similarly ill in different communities. We excluded patients with a previous hospitalization for the same diagnosis in the year before their index stay. Characteristics of the hip fracture and colorectal cancer cohorts were ascertained from claims data and U.S. Census data. Age, sex, race, and date of death were all ascertained from Medicare's denominator file (6). We coded the presence or absence of specific comorbid conditions by using diagnoses recorded on the discharge abstract as in previous work (5, 7). Colorectal cancer stage was defined by using the diagnoses recorded on the discharge abstract and classified as distant versus local or regional because this classification has been found to correspond most closely to reported stage according to analyses of linked Medicare–Surveillance, Epidemiology, and End Results data (8). Data from the 1990 U.S. Census, measured at the level of the ZIP code, were used to provide measures of income, education, disability status, urban or rural residence, employment, marital status, and Hispanic origin. Fewer than 1% of cohort members were missing these census variables. For those with missing values, we assigned the average of the value for other members of the study cohort residing in the same hospital referral region (HRR).

General Population Sample: The Medicare Current Beneficiary Survey

Persons in this study were participants in the access to care component of the Medicare Current Beneficiary Survey (MCBS), a continuous panel survey that is representative of the Medicare population (9). Participants are selected by using a stratified multistage geographic sample design, with oversampling of aged and disabled beneficiaries. Respondents are interviewed in both community settings and health facilities. The access to care component entails annual interviews with respondents and collects information on demographic characteristics, health insurance, health status and functioning, access to care, and satisfaction with services. Response rates to the survey have been high (10): Of the 14 530 initially asked to participate, 83.3% agreed to the interviews. Medicare claims data are available for all participants who are not enrolled in HMOs. Data collection and preparation procedures are described elsewhere (9).

We selected for inclusion in the survival analysis all MCBS participants older than age 65 years with an initial interview between 1991 and 1996, excluding HMO members and those not eligible for Medicare Part A or Part B (n = 23 902). The analysis of utilization were also done on essentially the same cohort (n = 23 498) but excluded several hundred patients because of incomplete utilization data. The analyses of baseline characteristics, access, and satisfaction excluded those with interviews in 1991 because key variables were missing for that year. The study population for analysis of baseline characteristics consisted of 18 190 patients. Analysis of decline in functional status was further restricted to those with at least 1 year of follow-up (n = 15 556).

Demographic data included age, race, sex, marital sta-

Appendix Table 15. **Impact of Chronic Conditions on Functional Status Scores***

Condition	Change in Score Associated with Specified Condition		Rank of Relative Impact of Specified Condition	
	HALex	PCS	HALex	PCS
Arthritis	−8.61	−2.77	5	4
Angina or CAD	−5.86	−3.67	3	7
Cancer	−4.62	−0.83	1	1
Diabetes	−11.13	−3.44	6	6
Hypertension	−4.78	−1.53	2	2
Emphysema or asthma	−12.13	−3.12	7	5
History of MI	−7.42	−2.75	4	3
Stroke	−13.36	−7.15	8	8
Correlation	0.77		0.74	

* The change in each functional status score associated with a given chronic condition was derived from linear regression models that controlled for age, race, sex, and all chronic conditions included in each survey. Only chronic conditions common to each survey are shown. Each pair of columns compares the predicted impact of the specified chronic conditions on PCS score derived from Medical Outcomes Study Short-Form 36 and on the HALex score derived from Medicare Current Beneficiary Survey. CAD = coronary artery disease; HALex = Health Activities and Limitations Index; MI = myocardial infarction; PCS = physical component summary score.

tus, education, household income, and urban residence. Insurance coverage was coded into four mutually exclusive categories, as in others' work (11). Health status variables included self-assessed health, activities of daily living, instrumental activities of daily living, other functional impairments, a list of reported medical conditions, whether a patient was bedridden, facility residence, and smoking status. Questions on access to care included having a usual source of care, having a usual physician, having trouble getting care, delaying care because of cost, having a serious problem and not seeing a physician, as well as receiving specific preventive services. Respondents who had received medical care were asked the site or sites of care and how long they had waited to receive care. Satisfaction with medical care was assessed by using the questions used to evaluate care in previous analyses of the Medicare population (12).

We used the Health Activities and Limitations Index (HALex) to characterize participants' functional status. The HALex was developed by the National Center for Health Statistics to provide a national measure of years of healthy life that can be calculated using the responses to the National Health Interview Survey. The HALex assesses health on a continuum ranging from death (0.0) to the best possible health state (1.0). Each individual is assigned to 1 of 30 unique health states based on his or her self-perceived health (five levels) and degree of activity limitation (six levels). Multiattribute utility theory was used to develop the scoring algorithm (13). First, the best and worst states of each dimension (when examined independently) were assigned the values of 1 and 0, respectively. The distance between each response level for each dimension (activity limitation and self-perceived health) was then defined by using correspondence analysis to maximize the correlation between the two dimensions and thereby define the values for the intermediate responses on each scale. Finally, after the corners of the distribution were anchored by using utilities derived from the Health Utilities Index Mark I (14), a multiplicative model was then used to assign scores to each of the 30 unique health states. A detailed description of the methods is available elsewhere (15) and at www.cdc.gov/nchs/data/statnt/statnt07.pdf.

The MCBS includes the questions required to calculate a HALex score, but because elderly participants are not asked about limitations in their major activity, only 20 of the 30 cells are used to score their responses, as in other analyses of the elderly. Several studies have reported on the construct validity of the HALex and found that the direction of effects of other patient attributes on HALex scores are as hypothesized (16). Our own models further confirm the construct validity of this measure. For example, the impact of increasing age on functional status can be seen in model A (**Appendix Table 10**). In model B, which includes interactions between year and age, sex, and race categories, older individuals face a significantly increased risk for decline in HALex scores over up to 3 years. In model C, which includes interaction terms between year and the chronic conditions, it can be seen that both Alzheimer disease and, to a lesser extent, Parkinson disease are associated with a significantly more rapid decline in functional status than other chronic conditions. All these effects appear plausible.

To further validate the use of HALex scores, we compared the impact of chronic conditions on MCBS participants' HALex scores with the impact of similar chronic conditions on physical component summary scores derived from the Medical Outcomes Study Short-Form 36 (17). We could not make a perfect head-to-head comparison because the wording of the questions in each survey was not identical and the MCBS survey included questions about chronic conditions not included in the Medical Outcomes Study survey. Nevertheless, when we compared the coefficients derived from age- and sex-adjusted models for the specific chronic conditions included in both data sets, we found a strong correlation overall ($r = 0.77$) and in the rank order of the impact of the conditions on functional status ($r = 0.74$) (**Appendix Table 15**).

Section D. Measuring Spending Using Standard National Prices To Avoid Bias from Regional Differences in Prices or Policy Payments

All of our utilization analyses in which dollar amounts are reported were based on measures of expenditures that have been purged of regional differences in prices or policy payments because the use of actual payments would introduce a bias. Actual reimbursements for hospital and physician services vary substantially according to geographic region due to wage, price, and policy differences (such as subsidies for the costs of medical education). To develop a measure of Medicare spending that was free of regional differences in price and policy payments, we followed the general approach developed by the Medicare Prospective Payment Commission in an earlier report (18) to calculate spending as follows. For inpatient hospital services, we based our measure on the diagnosis-related group (DRG) weight. All DRGs are assigned a relative weight proportional to the average national cost for Medicare patients within that DRG compared to the average cost for all Medicare patients. We converted DRG weights to dollars by multiplying the weight times the national average DRG price for 1996 ($3799). The measure reflects average national resource use for this condition. Hospital spending was defined as the sum of all DRG weights for an individual during a specified period times the DRG price. For physician services, we used the Resource-Based Relative Value Scale that forms the basis of the current Medicare physician fee schedule (19). Relative value units (RVUs) are assigned to each physician service to reflect physician work and the associated practice expense. For services included in the physician fee schedule, we assigned the total RVU value for the specific service from the Medicare fee schedule. For services not included in the fee schedule (primarily laboratory services), we calculated an RVU equivalent by dividing either the standard national price (laboratory services) or the median national allowed charge (for physician services without an RVU in the fee schedule) by the average 1996 factor ($36.14) used to convert RVUs to dollars. When DRG weights and RVUs are used, the measure of spending treats the value of a given service equally regardless of where the service is performed in the country. The measure removes the effect of any geographic differences in prices, wages, and policy payments.

Physician spending was defined as the sum of all RVUs for a given beneficiary during a specified period times the conversion factor. Aggregate spending for an individual is calculated in dollars and equals the sum of hospital spending and physician spending.

Section E. Measuring the Primary Exposure: The EOL-EI in U.S. Hospital Referral Regions

Definition of Health Care Service Areas

We used the definition of HRRs developed for the Dartmouth Atlas of Health Care, which is based on where patients travel to receive cardiovascular surgery and neurosurgery (20). More than 90% of Medicare enrollees live in HRRs where over 80% of residents' care is delivered by providers within the HRR (20).

To identify a reference population who should be similarly ill across regions (at least in terms of their risk for death), we used the Medicare denominator file to identify all Medicare beneficiaries who died during the 3.5-year period between 1 July 1994 and 31 December 1997, were between 65.5 and 100 years of age at the time of death, were not enrolled in an HMO during their last 6 months of life, and were eligible for Medicare Part A (hospital insurance) and Part B (physician) coverage. We used the entire sample for analyses of hospital utilization. To measure use of physician services, we used the subset that was included in the 5% national sample (6), as in previous work (21), because complete Medicare Part B files were available to us only for that sample.

Measure of Resource Use

To ensure that regional differences in wages, prices, and policy payments did not bias our measure of regional differences in spending, we used standardized national prices (as described in Section D).

Calculating the End-of-Life Expenditure Index

The reference population—all Medicare enrollees who died between mid-1994 and 1997—includes members of the study cohorts who died during this interval. Although they represent a small percentage of the reference population, we wished to avoid the possibility of spurious correlations (sicker hip fracture patients in a given region would have higher expenditures and might be more likely to die). We therefore calculated an overall EOL-EI including all enrollees that was used to prepare **Figure 2** in Part 1 and to map the regions. For each study population, however, we calculated a specific EOL-EI for use in the survival analyses (for which even a small bias could be problematic) that excluded from the reference population members of that cohort. There were thus four EOL-EIs. (Because <1% of the population were excluded, these measures were extremely highly correlated and resulted in nearly identical quintiles.) The EOL-EI was calculated as age-sex-race–adjusted spending (using the standardized national prices) on physician and hospital services by the reference population in each HRR. We sorted HRRs in order of increasing intensity and divided them into quintiles of approximately equal population size, based on the entire Medicare population older than 65 years of age.

Section F. Sensitivity Analyses on Survival: The Acute Care Expenditure Index

Because of concern that our primary exposure (the EOL-EI) may not have fully accounted for differences in population characteristics in different regions, we developed an alternative measure and repeated the analyses using this measure. Although the ideal measure would be risk-adjusted differences in total Medicare spending, we know of no way to calculate such a measure using currently available data. An alternative was to define study populations in which we were reasonably confident in our case-mix measures. Given the probable similarity of the cohorts at baseline across regions, and the high quality of the risk-adjustment data for short-term mortality (for example, 6 months), we decided to use as our alternative exposure measure the regional differences in risk-adjusted 6-month utilization in the complementary cohorts as our measure of

Appendix Table 16. **Reference Populations Used To Calculate the Acute Care Expenditure Index for Each Cohort***

Study Population	Reference Population in Which the Expenditure Index Was Developed
Hip fracture cohort	Colorectal cancer cohort and acute MI cohort
Colorectal cancer cohort	Hip fracture cohort and acute MI cohort
Acute MI cohort	Hip fracture cohort and colorectal cancer cohort
General population (MCBS)	Hip fracture cohort, colorectal cancer cohort, and acute MI cohort

* MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction.

the exposure. We describe this approach, and our findings, in the sections that follow.

Methods

We performed four parallel analyses, one for each of our cohorts. The regional spending measure for each cohort was developed using the other cohorts, as shown in **Appendix Table 16**. The expenditure index was developed by using a linear regression model. To determine risk-adjusted expenditures, we used the following equation:

$$U_{ij} = Z_I\, \beta + W_j\, \Pi_j + v_{ij},$$

in which U_{ij} is the total hospital and physician resource use per person in the first 6 months of follow-up by patient i in HRR j; Z_I is a vector of patient covariates, including demographic (age, sex, race, income), severity (for example, stage), and comorbidity measures; β is the effects of patient-level factors on utilization; W_j is the coefficient estimating regional intensity in HRR j; Π_j is a set of HRR-level indicator variables (1 to 306); and v_{ij} are patient-level error terms. The regression model is run with no intercept. The expenditure index used for the colorectal cancer cohort, for example, is the average of the coefficients Π_j for the specific HRR generated from the hip fracture and acute MI regressions. We chose the first 6 months of utilization because the risk measures available in the data sets, especially for the acute MI cohort, are clearly most appropriate for this interval. The index for each study population was the weighted average of the coefficients for the specific HRR from each of the relevant models. We then repeated the key analyses related to survival: 1) comparing average predicted 1-year mortality rate across quintiles of the expenditure index; 2) comparing risk-adjusted utilization during both the first 6 months after the original hospitalization (where utilization rates should be relatively similar, given that all patients in the three hospitalized cohorts had an index hospitalization), and after the first 6 months of follow-up (where the most dramatic differences in utilization were seen); and 3) comparing survival across quintiles and in a model in which the expenditure index was included as a continuous variable.

Results

The first question—whether individuals residing in HRRs classified as higher- and lower-spending have similar baseline risk factors for 1-year mortality—is addressed below. The results are similar to those with the EOL-EI. Average risk for death was flat for both hip fracture and colorectal cancer, increased for the acute MI cohort, and decreased for the MCBS sample (**Appendix Table 17**).

As in the analyses using the EOL-EI, risk-adjusted utilization rates increased across regions with higher levels of the Acute Care Expenditure Index, with a consistent but small increase during the first 6 months and a dramatic difference apparent after the acute episode. (It is important to recall that the first 6-month analysis includes the index hospitalization, which all three chronic disease cohorts experienced, resulting in smaller relative differences.) The results are similar to the findings using the EOL-EI, except in the hip fracture and colorectal cancer cohorts. In the current analyses, the ratio of utilization rates in the highest to lowest quintiles was somewhat lower than in the original analyses (1.42 vs. 1.75 and 1.58 vs. 1.75) (**Appendix Table 18**).

Further analyses indicated that the range of spending rates was probably lower across quintiles of the Acute Care Expenditure Index because the two cohorts in which the risk-adjusted expenditure index were developed for the hip fracture cohort were comparatively small, introducing greater measurement error.

Finally, we repeated the survival models (**Appendix Table 19**). The findings are similar but not identical to those presented in Part 2. Instead of the findings of statistically significant coefficients showing a small increase in the risk for death in the highest quintiles (and in the continuous models that are the appropriate test for trend), the analyses with the Acute Care Expenditure index are essentially flat.

Appendix Table 17. **Average Predicted Mortality Rate across Quintiles of the Acute Care Expenditure Index***

Cohort	Average Predicted Mortality Rate				
	Quintile of the Acute Care Expenditure Index				
	1 (Lowest)	2	3	4	5 (Highest)
	←——— % ———→				
Hip fracture	24.1	24.1	24.2	24.0	24.0
Colorectal cancer	21.2	20.8	20.9	20.9	20.9
Acute MI	31.2	31.3	32.0	31.9	33.1
MCBS	6.2	5.7	6.0	6.0	5.5

* Average predicted mortality rate = percentage of patients dead at 1 year. MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction.

Appendix Table 18. **Ratio of Risk-Adjusted Utilization Rates for Each Cohort in the Specified Quintile of Medicare Spending to Spending in the Lowest-Cost Regions***

Variable	Ratio of Risk-Adjusted Utilization Rates for Each Quintile of the Acute Care Expenditure Index Compared with Quintile 1					Ratio of Quintile 5 to Quintile 1 Based on EOL-EI
	Quintile					
	1 (Lowest)	2	3	4	5 (Highest)	
First 6 months						
Hip fracture cohort	1.00 (referent)	1.04	1.08	1.09	1.15	1.17
Colorectal cancer cohort	1.00 (referent)	1.01	1.03	1.05	1.09	1.12
Acute MI cohort	1.00 (referent)	1.05	1.06	1.14	1.15	1.18
MCBS cohort	1.00 (referent)	1.18	1.20	1.48	1.62	NA
After 6 months						
Hip fracture cohort	1.00 (referent)	1.04	1.23	1.30	1.42	1.69
Colorectal cancer cohort	1.00 (referent)	1.15	1.25	1.46	1.58	1.59
Acute MI cohort	1.00 (referent)	1.21	1.30	1.37	1.82	1.77
MCBS cohort	1.00 (referent)	1.09	1.14	1.29	1.55	1.52

* EOL-EI = End-of-Life Expenditure Index; MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction; NA = not applicable.

Discussion

In summary, we found that our overall results using the new expenditure index were similar to the findings using the EOL-EI, especially if it is considered that our essential message is that there are dramatic differences in utilization across regions of increasing Medicare expenditures, that these utilization differences are not explained by underlying illness rates, and that the increased utilization is not associated with any gain in life expectancy. The relative consistency of these findings across the cohorts strengthens our confidence in this inference.

At the same time, because the findings are not identical, it may be worth considering a closely related question: Which measure is "better"? It could be argued that the EOL-EI is better because 1) it has less measurement error because it was calculated using much larger sample sizes; 2) it may be a better measure of the propensity of physicians in a region for "overuse"; and 3) it leads to slightly better stratification of HRRs into regions of higher and lower spending.

The argument for the Acute Care Expenditure Index based on first 6-month cohort-specific use is the following: 1) It may allow for better adjustment for possible differences in illness across regions of differing spending levels; and 2) it may be a better measure of regional differences in the propensity of physicians to provide extra care to patients with specific, clear-cut needs (for example, in the acute phase of an injury or illness).

We cannot know which measure is "right" or gives the "better" answer. The new index suggests that even when regions are stratified according to differences in how they treat patients during an acute illness episode, however, those regions that take the more intensive approach do not achieve consistently better survival.

Table 19. **Association between Acute Care Expenditure Index in Hospital Referral Region of Residence and Cohort-Specific Risk-Adjusted Long-Term Mortality Rates (Sensitivity Analysis)***

Cohort	Relative Risk (95% CI)					Continuous Models
	Quintile of AC-EI					
	1 (Lowest)	2	3	4	5 (Highest)	
Hip fracture	1.00 (referent)	1.003 (0.989–1.016)	0.998 (0.984–1.013)	0.993 (0.978–1.009)	0.996 (0.979–1.014)	0.990 (0.983–0.998)
Colorectal cancer	1.00 (referent)	1.024 (0.994–1.055)	1.028 (0.995–1.062)	1.022 (0.987–1.057)	0.995 (0.959–1.032)	1.000 (0.985–1.016)
Acute MI	1.00 (referent)	1.025 (0.999–1.053)	1.029 (1.000–1.058)	1.027 (0.997–1.059)	1.037 (1.004–1.071)	1.009 (0.996–1.023)
MCBS	1.00 (referent)	1.19 (1.04–1.36)	1.16 (0.98–1.37)	1.05 (0.92–1.18)	1.08 (0.95–1.23)	0.99 (0.94–1.05)

* Data were obtained from Cox regression models testing the association between residence in higher-spending hospital referral regions (defined on the basis of the AC-EI) and mortality for up to 5 years. For the quintile models, hospital referral regions were grouped into quintiles of increasing AC-EI levels. For the continuous models, data represent the relative risk for death associated with a 10% increase in AC-EI score in the hospital referral region of residence. For additional details, see Appendix, Section F, available at www.annals.org. AC-EI = Acute Care Expenditure Index; MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction.

Appendix Table 1. **Characteristics of the Hip Fracture Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Odds Ratio (95% CI)†
	1 (Lowest)	2	3	4	5 (Highest)	
Cohort members, *n*	121 354	129 815	125 412	121 697	116 225	
Demographic, %						
Age 65–74 y	16.4	17.1	17.2	17.9	17.0	1.007 (1.003–1.010)
Age 75–84 y	41.6	42.7	42.9	42.9	42.4	1.003 (1.001–1.006)
Age ≥85 y	42.0	40.2	39.9	39.2	40.6	0.992 (0.990–0.995)
Women	76.6	77.9	78.4	78.1	78.3	1.017 (1.014–1.020)
Black race	1.1	3.1	4.0	5.2	4.8	1.202 (1.194–1.210)
Comorbid conditions, %‡						
0	55.4	55.7	55.4	54.7	57.1	1.013 (1.010–1.016)
1	31.4	31.4	31.8	32.1	30.5	0.991 (0.989–0.994)
2	9.1	9.0	8.9	9.1	8.6	0.990 (0.985–0.994)
3	2.3	2.2	2.2	2.3	2.1	0.982 (0.974–0.991)
4	0.5	0.5	0.4	0.4	0.4	0.964 (0.946–0.983)
≥5	1.3	1.2	1.2	1.3	1.3	1.007 (0.996–1.019)
Social Security income, %§						
<$1700	18.8	19.3	19.0	23.6	21.3	1.055 (1.052–1.059)
$1700–$2099	21.5	24.9	24.3	22.5	17.3	0.963 (0.960–0.966)
$2100–$2600	35.3	31.5	29.3	25.4	22.2	0.887 (0.884–0.890)
>$2600	24.3	24.3	27.3	28.5	39.2	1.111 (1.108–1.114)
Migration status, %						
Moved in previous 1 or 2 years	2.99	2.68	2.51	3.06	2.76	1.008 (1.002–1.014)
Region of residence, %						
New England	6.4	7.6	5.4	10.3	0.0	‖
Mid-Atlantic	9.4	6.9	8.2	6.3	50.9	‖
South Atlantic	6.7	21.7	16.0	31.7	18.7	‖
Great Lakes	15.0	32.2	9.9	16.0	14.1	‖
East South Central	0.0	0.7	22.7	11.4	0.4	‖
Great Plains	20.7	10.6	13.3	0.1	0.0	‖
West South Central	3.6	8.6	18.1	18.9	4.1	‖
Mountain	15.8	5.5	0.4	1.5	0.0	‖
Pacific	22.4	6.3	6.1	3.7	11.8	‖
Other regional attributes, %						
Patients residing in rural ZIP codes	22.5	17.8	17.3	10.4	2.7	0.735 (0.732–0.738)
Index hospital characteristics, %						
Lowest volume (<30¶)	14.7	9.3	10.6	9.1	6.7	0.867 (0.863–0.871)
Low volume (30–≤74¶)	29.2	31.6	28.8	29.3	30.1	0.994 (0.991–0.997)
Medium volume (75–≤150¶)	39.5	40.3	43.9	39.3	42.7	1.008 (1.006–1.011)
High volume (>150¶)	16.6	18.8	16.7	22.3	20.5	1.078 (1.074–1.081)
Nonteaching hospital	70.9	67.6	71.6	63.4	48.9	0.833 (0.831–0.835)
Minor teaching hospital	14.9	13.1	12.8	15.6	18.1	1.062 (1.059–1.066)
Major teaching hospital	14.1	19.2	15.6	21.0	33.0	1.225 (1.221–1.229)

* EOL-EI = End-of-Life Expenditure Index.
† Odds ratio for $1000 change in EOL-EI.
‡ Based on the Charlson Comorbidity Index.
§ Monthly income of ZIP code of residence.
‖ Significance of difference between quintiles not tested.
¶ Number of cohort members treated during the enrollment period.

Appendix Table 2. **Characteristics of the Colorectal Cancer Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Odds Ratio (95% CI)†
	1 (Lowest)	2	3	4	5 (Highest)	
Cohort members, *n*	36 806	40 038	37 317	40 001	41 267	
Demographic, %						
Age 65–74 y	42.6	44.1	44.4	45.3	43.3	1.001 (0.996–1.006)
Age 75–84 y	42.5	41.7	41.6	40.6	42.6	1.000 (0.995–1.005)
Age ≥85 y	15.0	14.2	14.1	14.1	14.2	0.998 (0.992–1.004)
Women	53.7	54.1	55.0	53.2	53.6	1.000 (0.996–1.005)
Black race	2.1	5.9	7.7	9.6	9.2	1.206 (1.196–1.217)
Cancer stage, %						
Local	59.6	60.2	60.1	60.5	59.7	1.004 (0.999–1.009)
Regional	19.4	19.7	19.2	19.3	19.7	1.002 (0.996–1.008)
Distant	21.1	20.1	20.7	20.2	20.5	0.992 (0.987–0.998)
Comorbid conditions, %‡						
0	68.7	68.3	67.6	66.9	67.3	0.989 (0.984–0.994)
1	23.0	23.5	23.8	24.3	23.8	1.007 (1.002–1.013)
2	6.5	6.4	6.8	6.9	7.0	1.013 (1.004–1.022)
3	1.6	1.5	1.5	1.6	1.7	1.011 (0.993–1.029)
4	0.3	0.2	0.3	0.3	0.3	1.036 (0.992–1.082)
≥5	0.0	0.0	0.0	0.1	0.0	1.011 (0.904–1.130)
Social Security income, %§						
<$1700	17.6	17.3	17.6	22.0	18.9	1.052 (1.046–1.058)
$1700–$2099	21.1	24.2	23.6	22.1	16.9	0.962 (0.956–0.967)
$2100–$2600	35.6	32.8	29.4	24.9	22.0	0.878 (0.874–0.883)
>$2600	25.8	25.7	29.5	31.1	42.1	1.121 (1.115–1.126)
Migration status, %						
Moved in previous 1 or 2 years	5.31	4.99	4.47	5.51	5.65	0.992 (0.978–1.005)
Region of residence, %						
New England	7.4	8.6	6.2	11.3	0.0	‖
Mid-Atlantic	9.5	9.8	10.2	7.3	53.8	‖
South Atlantic	5.9	19.4	18.0	32.4	17.2	‖
Great Lakes	18.0	32.7	10.7	17.0	15.9	‖
East South Central	0.0	0.3	20.8	10.3	0.1	‖
Great Plains	21.1	9.8	12.6	0.1	0.0	‖
West South Central	3.0	7.3	15.2	17.1	3.6	‖
Mountain	13.7	5.3	0.3	1.4	0.0	‖
Pacific	21.4	6.8	5.9	3.1	9.4	‖
Other regional attributes, %						
Patients residing in rural ZIP codes	25.3	18.7	18.0	10.5	3.0	0.708 (0.702–0.713)
Index hospital characteristics, %						
Lowest volume (≤10¶)	19.4	13.7	15.7	11.6	7.3	0.838 (0.832–0.844)
Low volume (10–≤24¶)	31.0	28.9	29.6	25.5	22.4	0.922 (0.917–0.927)
Medium volume (25–≤50¶)	35.4	39.0	34.4	34.5	40.6	1.013 (1.008–1.018)
High volume (>50¶)	14.3	18.5	20.3	28.5	29.8	1.201 (1.194–1.207)
Nonteaching hospital	70.0	64.3	67.0	58.8	45.5	0.823 (0.819–0.827)
Minor teaching hospital	14.3	13.3	13.4	15.4	16.4	1.043 (1.036–1.050)
Major teaching hospital	15.6	22.5	19.6	25.8	38.0	1.242 (1.236–1.249)

* EOL-EI = End-of-Life Expenditure Index.
† Odds ratio for $1000 change in EOL-EI.
‡ Based on the Charlson Comorbidity Index.
§ Income of ZIP code of residence.
‖ Significance of difference between quintiles not tested.
¶ Number of cohort members treated during the enrollment period.

Appendix Table 3. **Characteristics of the Acute Myocardial Infarction Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Odds Ratio (95% CI)†
	1 (Lowest)	2	3	4	5 (Highest)	
Cohort members, *n*	28 448	32 193	33 727	33 449	31 583	
Demographic, %						
Age 65–74 y	44.5	46.0	46.3	45.9	41.9	0.976 (0.970–0.981)
Age 75–84 y	40.3	39.4	38.6	39.2	40.8	1.004 (0.999–1.010)
Age ≥85 y	15.2	14.6	15.0	14.9	17.3	1.040 (1.033–1.048)
Women	46.6	48.5	49.2	49.1	49.9	1.022 (1.017–1.027)
Black race	1.9	4.9	6.2	7.7	7.2	1.185 (1.172–1.198)
Comorbid conditions and other risk factors, %						
Previous revascularization	17.5	17.0	17.1	18.2	16.5	0.991 (0.984–0.998)
Previous MI	28.7	30.3	28.7	29.6	28.6	0.996 (0.990–1.002)
History of congestive heart failure	19.9	21.4	20.4	21.2	22.2	1.023 (1.016–1.029)
History of low ejection fraction	3.7	4.1	4.0	4.1	3.6	0.996 (0.982–1.010)
History of hypertension	58.7	61.0	61.8	62.6	63.6	1.038 (1.033–1.044)
History of angina	44.6	45.0	45.5	45.6	48.4	1.029 (1.024–1.035)
Peripheral vascular disease	9.0	9.7	10.7	11.1	11.6	1.056 (1.047–1.065)
Diabetes	28.5	30.8	30.5	31.0	31.3	1.023 (1.017–1.029)
Dementia	5.1	5.6	5.9	6.0	6.3	1.040 (1.029–1.052)
Leukemia	0.6	0.6	0.5	0.6	0.6	0.985 (0.951–1.021)
Metastatic cancer	0.8	0.7	0.7	0.7	0.9	1.030 (0.999–1.061)
Nonmetastatic cancer	1.5	1.5	1.4	1.5	1.5	1.004 (0.982–1.026)
Terminal illness	0.4	0.3	0.4	0.4	0.4	0.988 (0.945–1.032)
Smoker	14.5	15.6	16.3	15.4	13.0	0.975 (0.968–0.982)
COPD	19.4	20.6	21.2	21.1	19.1	0.997 (0.990–1.003)
Characteristics of acute MI, %						
Non–Q-wave	37.4	39.5	38.9	40.2	42.4	1.037 (1.031–1.042)
Anterior	31.8	30.7	31.2	31.3	31.1	0.999 (0.993–1.004)
Inferior	21.3	20.7	20.3	19.4	18.0	0.960 (0.953–0.966)
Other location	9.6	9.1	9.5	9.0	8.4	0.977 (0.968–0.986)
Fibrillation	9.4	8.9	8.9	8.9	9.5	1.004 (0.995–1.013)
Heart block	15.6	15.4	15.1	15.3	15.7	1.003 (0.995–1.010)
Received CPR	3.8	3.3	3.6	3.9	3.5	1.001 (0.987–1.015)
Congestive heart failure	25.7	27.9	28.1	28.1	30.9	1.045 (1.039–1.051)
Shock	2.8	2.2	2.6	2.4	2.6	0.997 (0.981–1.014)
Hypotension	4.1	3.9	3.8	3.6	3.7	0.983 (0.970–0.997)
Peak creatine kinase level >1000 IU/L	32.1	31.3	31.7	30.2	30.1	0.983 (0.977–0.988)
Transferred from emergency department	3.6	3.9	4.1	3.2	1.2	0.863 (0.850–0.877)
Transferred from the hospital	7.7	7.9	7.4	6.3	5.2	0.916 (0.906–0.926)
Social Security income, %‡						
<$1700	17.5	18.2	17.9	22.4	18.4	1.045 (1.038–1.052)
$1700–$2099	22.1	25.9	23.9	22.7	16.6	0.947 (0.941–0.953)
$2100–$2600	35.4	31.9	30.3	25.2	22.1	0.880 (0.875–0.886)
>$2600	25.1	24.0	27.8	29.7	42.9	1.142 (1.135–1.148)
Region of residence, %						
New England	7.4	9.0	5.2	11.7	0.0	§
Mid-Atlantic	11.0	6.1	9.8	6.7	42.5	§
South Atlantic	8.0	24.1	17.6	32.0	16.8	§
Great Lakes	15.7	32.4	19.0	17.5	26.9	§
East South Central	0.0	0.5	20.1	6.2	0.4	§
Great Plains	13.9	12.6	7.1	0.0	0.0	§
West South Central	5.9	4.2	15.7	20.6	4.8	§
Mountain	17.4	5.3	0.9	2.4	0.0	§
Pacific	20.6	5.9	4.6	2.9	8.7	§
Migration status, %						
Moved in previous 1 or 2 years	3.57	3.46	2.96	3.85	3.56	1.000 (0.985–1.014)
Other regional attributes, %						
Patients residing in rural ZIP codes	26.4	21.5	20.2	12.4	3.5	0.718 (0.712–0.724)
Index hospital characteristics, %						
Lowest volume (≤57‖)	35.8	26.2	27.6	22.3	13.9	0.811 (0.806–0.816)
Low volume (57–≤116‖)	23.3	27.3	24.2	22.6	27.2	1.022 (1.016–1.028)
Medium volume (116–≤201‖)	22.0	23.2	21.5	26.4	30.8	1.080 (1.073–1.086)
High volume (>201‖)	18.9	23.3	26.7	28.6	28.1	1.102 (1.095–1.109)
Nonteaching hospital	71.7	66.3	71.1	62.9	47.8	0.823 (0.818–0.827)
Minor teaching hospital	12.9	12.3	13.0	13.9	18.2	1.105 (1.096–1.113)
Major teaching hospital	15.5	21.4	15.9	23.2	34.0	1.203 (1.196–1.211)

* COPD = chronic obstructive pulmonary disease; CPR = cardiopulmonary resuscitation; EOL-EI = End-of-Life Expenditure Index; MI = myocardial infarction.
† Odds ratio for $1000 change in EOL-EI.
‡ Monthly income of ZIP code of residence.
§ Significance of difference between quintiles not tested.
‖ Number of cohort members treated during the enrollment period.

Appendix Table 4. **Characteristics of the Medicare Current Beneficiary Survey Cohort according to Level of Medicare Spending in Hospital Referral Region of Residence***

Characteristic	Quintile of EOL-EI					Odds Ratio (95% CI)†
	1 (Lowest)	2	3	4	5 (Highest)	
Respondents, *n*	4064	3725	2476	3893	4032	
Demographic, %						
Age 65–74 y	55.7	55.1	56.6	57.5	54.7	0.999 (0.984–1.014)
Age 75–84 y	33.6	34.2	32.6	32.6	34.8	1.004 (0.990–1.019)
Age ≥85 y	10.7	10.7	10.8	9.9	10.4	0.993 (0.974–1.011)
Women	58.2	59.3	61.2	59.6	60.3	1.010 (0.995–1.026)
Black race	3.5	5.2	10.4	8.3	9.9	1.199 (1.130–1.271)
Hispanic origin	2.3	1.7	3.5	3.6	6.8	1.230 (1.390–1.560)
Divorced, widowed, unmarried	37.8	42.3	42.1	41.5	41.1	1.022 (1.000–1.044)
Lives alone	27.3	29.8	29.1	28.1	27.9	0.999 (0.977–1.021)
Metropolitan living status	48.4	44.8	70.6	77.5	87.3	1.508 (1.294–1.758)
Socioeconomic status, %						
Did not complete high school	34.1	41.8	43.5	41.3	40.2	1.040 (1.010–1.070)
Low income (<$5000/y)	5.9	6.2	7.5	5.8	6.8	1.036 (0.987–1.087)
High income (>$25 000/y)	28.1	23.9	27.2	24.2	26.8	0.989 (0.955–1.024)
Insurance type						
Medicare only	11.0	10.1	11.6	11.4	11.5	1.032 (0.994–1.072)
Medicare and Medicaid	11.0	11.2	16.2	10.7	14.1	1.068 (1.035–1.102)
Medicare and self-purchased	38.2	37.7	36.7	34.3	31.5	0.939 (0.911–0.968)
Medicare and employer sponsored	39.7	41.0	35.5	43.6	42.9	1.016 (0.982–1.052)
Self-reported health, %						
Excellent	18.9	16.0	18.0	18.9	17.0	0.984 (0.957–1.011)
Very good	29.8	26.8	24.3	26.1	24.6	0.952 (0.934–0.970)
Good	30.7	31.1	27.9	29.2	31.3	1.000 (0.980–1.020)
Fair or poor	20.6	26.1	29.8	25.8	27.1	1.064 (1.038–1.091)
Smoking, %						
Never	44.6	43.3	44.2	42.5	42.5	0.982 (0.958–1.007)
Current	13.5	13.6	14.3	14.5	13.7	1.005 (0.977–1.033)
Functional status						
Other limitation, %	55.4	58.8	60.8	57.2	55.5	0.997 (0.974–1.021)
ADL limitation, %	32.0	33.8	33.3	31.8	33.1	1.007 (0.986–1.029)
IADL limitation, %	38.4	41.8	44.4	40.4	40.0	1.011 (0.989–1.035)
Bedridden, %	2.7	2.9	2.8	3.0	3.1	1.020 (0.969–1.074)
Facility dwelling, %	5.8	6.0	5.1	4.2	4.7	0.948 (0.917–0.979)
Mean HALex score	62.5	59.7	59.0	61.3	60.7	
Chronic conditions reported, %						
Alzheimer disease	4.1	3.9	3.8	3.8	3.8	0.985 (0.946–1.025)
Arthritis	47.8	50.5	52.0	48.4	46.7	0.988 (0.972–1.006)
Cancer	18.0	16.6	16.5	16.4	17.6	0.990 (0.968–1.013)
Ischemic heart disease or angina	12.7	14.2	14.7	14.1	14.1	1.022 (0.998–1.047)
Diabetes	12.6	14.6	15.7	18.0	15.6	1.049 (1.026–1.073)
COPD	13.2	12.0	14.1	13.4	11.2	0.977 (0.948–1.007)
Hypertension	49.5	48.6	48.9	52.0	48.8	1.004 (0.982–1.026)
History of MI	12.6	14.3	14.3	15.1	13.8	1.019 (0.997–1.041)
Osteoporosis	9.1	8.8	9.5	8.7	8.0	0.974 (0.946–1.002)
Parkinson disease	1.9	1.7	1.7	1.3	1.6	0.958 (0.897–1.024)
Stroke	10.4	11.7	11.5	10.8	9.9	0.982 (0.957–1.008)

* ADL = activity of daily living; COPD = chronic obstructive pulmonary disease; EOL-EI = End-of-Life Expenditure Index; HALex = Health Activities and Limitations Index; IADL = independent activity of daily living; MI = myocardial infarction.
† Odds ratio for $1000 change in EOL-EI.

Appendix Table 5. **Summary of Variables Used in Cohort Analyses***

Independent Variable	Class of Dependent Variables Used in the Model†					
	Predicted Mortality	Utilization	Survival	Content of Care	Change in HALex Score	Satisfaction Indices
Hip fracture cohort						
Demographic characteristics	X	X	X	X	NA	NA
ZIP code–level variables	X	X	X	X		
Disease burden	X	X	X	X		
Hospital characteristics	–	–	X	–		
Variables ascertained at the HRR level	–	–	X	–		
Colorectal cancer cohort						
Demographic characteristics	X	X	X	X	NA	NA
ZIP code–level variables	X	X	X	X		
Disease burden	X	X	X	X		
Hospital characteristics	–	–	X	–		
Variables ascertained at the HRR level	–	–	X	–		
Acute MI cohort						
Demographic characteristics	X	X	X	X	NA	NA
Comorbid conditions and other risk factors	X	X	X	X		
MI location	X	X	X	X		
Presentation and preadmission status	X	X	X	X		
ZIP code–level variables	–	–	X	–		
Hospital characteristics	–	–	X	–		
Variables ascertained at the HRR level	–	–	X	–		
MCBS cohort						
Demographic characteristics	X	X	X	NA	X	X
Income status	–	X	X		X	X
Self-reported health	X	X	X		–	X
Marital status	X	X	X		X	–
Smoking and functional status	X	X	X		X‡	–
Chronic conditions reported	X	X	X		X	–
Educational background	X	X	X		X	X
Insurance status§	–	–	–		X	X
Metropolitan region	–	–	–		X	X
Hispanic origin	–	–	–		–	X

* HALex = Health Activities and Limitations Index; HRR = hospital referral region; MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction; NA = analysis not run.
† See Appendix Tables 6 through 9 for the full set of variables included in each category.
‡ Activities of daily living and independent activities of daily living were not included in the model because they are used to create the outcome.
§ Medicare only, Medicare and Medicaid, Medicare and self-purchased insurance, or Medicare and employer-provided insurance.

Appendix Table 6. **Survival Model for the Hip Fracture Cohort***

Variable	Hazard Ratio (95% CI)	Standard Error†	Chi-Square Test	*P* Value
Demographic characteristics				
Age 65–69 y, white man (excluded)	1.000			
Age 65–69 y, black man	1.225 (1.107–1.355)	0.063	3.9	<0.001
Age 65–69 y, white woman	0.694 (0.667–0.723)	0.014	−17.8	<0.001
Age 65–69 y, black woman	0.851 (0.763–0.949)	0.047	−2.9	<0.001
Age 70–74 y, white man	1.288 (1.239–1.339)	0.025	12.8	<0.001
Age 70–74 y, black man	1.448 (1.315–1.595)	0.071	7.5	<0.001
Age 70–74 y, white woman	0.826 (0.797–0.856)	0.015	−10.5	<0.001
Age 70–74 y, black woman	1.027 (0.948–1.112)	0.042	0.7	>0.2
Age 75–79 y, white man	1.687 (1.627–1.749)	0.031	28.3	<0.001
Age 75–79 y, black man	1.883 (1.729–2.051)	0.082	14.5	<0.001
Age 75–79 y, white woman	1.013 (0.979–1.048)	0.018	0.7	>0.2
Age 75–79 y, black woman	1.162 (1.086–1.245)	0.041	4.3	<0.001
Age 80–84 y, white man	2.192 (2.117–2.270)	0.039	44.2	<0.001
Age 80–84 y, black man	2.320 (2.156–2.498)	0.087	22.4	<0.001
Age 80–84 y, white woman	1.305 (1.262–1.349)	0.022	15.7	<0.001
Age 80–84 y, black woman	1.348 (1.273–1.427)	0.039	10.3	<0.001
Age ≥85 y, white man	3.209 (3.102–3.320)	0.056	67.2	<0.001
Age ≥85 y, black man	3.041 (2.850–3.245)	0.101	33.6	<0.001
Age ≥85 y, white woman	2.018 (1.953–2.085)	0.033	42.3	<0.001
Age ≥85 y, black woman	1.957 (1.866–2.053)	0.048	27.6	<0.001
ZIP code–level variables				
Proportion below the poverty level	0.999 (0.998–1.000)	0.000	−2.2	0.028
Proportion with less than a high school education	1.001 (1.000–1.002)	0.000	3.0	0.002
Proportion with a high school or college education	1.002 (1.001–1.002)	0.000	5.2	<0.001
Proportion of people ≥65 y of age living in a nursing home	1.002 (1.001–1.003)	0.000	6.3	<0.001
Proportion residing in a rural area	1.000 (0.999–1.000)	0.000	−3.6	<0.001
Proportion residing in an urban area	1.000 (1.000–1.000)	0.000	3.0	0.003
Proportion Hispanic	0.998 (0.998–0.999)	0.000	−6.2	<0.001
Proportion single	1.000 (1.000–1.001)	0.000	0.3	>0.2
Proportion employed	1.001 (1.000–1.002)	0.000	2.7	0.006
Proportion of people ≥65 y of age with a working disability	1.002 (1.001–1.003)	0.000	3.9	<0.001
Proportion of people ≥65 y of age with self-care limitation	1.000 (0.998–1.001)	0.001	−0.3	>0.2
Proportion of people ≥65 y of age with a mobility limitation	1.000 (0.999–1.002)	0.001	0.6	>0.2
Social Security income‡				
<$1700 (reference)	1.000			
$1700–$2099	0.993 (0.981–1.005)	0.006	−1.2	>0.2
$2100–$2600	0.979 (0.967–0.991)	0.006	−3.3	0.001
>$2600	0.967 (0.952–0.982)	0.008	−4.2	<0.001
Comorbid conditions§				
0 (excluded)	1.000			
1	1.579 (1.566–1.593)	0.007	104.6	<0.001
2	1.965 (1.939–1.990)	0.013	102.0	<0.001
3	2.512 (2.455–2.571)	0.030	78.4	<0.001
4	3.263 (3.122–3.409)	0.073	52.8	<0.001
≥5	5.034 (4.887–5.186)	0.076	106.7	<0.001
Hospital characteristics				
Nonteaching (excluded)	1.000			
Minor teaching	0.999 (0.986–1.012)	0.007	−0.2	>0.2
Major teaching	1.017 (1.003–1.032)	0.007	2.4	0.016
Lowest volume (excluded)	1.000			
Low volume	0.959 (0.944–0.974)	0.008	−5.3	<0.001
Medium volume	0.946 (0.931–0.961)	0.008	−6.9	<0.001
High volume	0.919 (0.902–0.936)	0.009	−8.9	<0.001
Variables ascertained at HRR level				
HRR residents in an HMO				
<1%	1.000			
1%–<5%	1.010 (0.996–1.024)	0.007	1.4	0.154
5%–<15%	1.017 (1.003–1.032)	0.007	2.4	0.019
≥15%	1.032 (1.014–1.050)	0.009	3.6	<0.001
Region of residence				
New England (excluded)	1.000			
Mid-Atlantic	0.998 (0.975–1.021)	0.012	−0.2	>0.2
South Atlantic	1.052 (1.028–1.076)	0.012	4.4	<0.001
Great Lakes	1.056 (1.033–1.079)	0.012	4.9	<0.001
East South Central	1.054 (1.026–1.084)	0.015	3.8	<0.001
Great Plains	1.044 (1.019–1.071)	0.013	3.4	0.001
West South Central	1.077 (1.050–1.105)	0.014	5.7	<0.001
Mountain	1.080 (1.048–1.114)	0.017	5.0	<0.001
Pacific	1.075 (1.047–1.103)	0.014	5.4	<0.001
Log of total EOL-EI	1.028 (0.990–1.068)	0.020	1.4	0.155

* Cox regression and the Breslow method were used for ties. Number of observations = 614 503; number of failures = 295 612; time at risk = 516 799 100 days; Wald chi-square test = 71 731.18; probability > chi-square test = 0.0000; log likelihood = −3 765 818.2. EOL-EI = End-of-Life Expenditure Index; HMO = health maintenance organization; HRR = hospital referral region.
† Adjusted for clustering by hospital.
‡ Monthly income of ZIP code of residence.
§ Based on the Charlson Comorbidity Index.

Appendix Table 7. **Survival Model for the Colorectal Cancer Cohort***

Variable	Hazard Ratio (95% CI)	Standard Error†	Chi-Square Test	*P* Value
Demographic characteristics				
Age 65–69 y, white man (excluded)	1.000			
Age 65–69 y, black man	1.200 (1.105–1.302)	0.050	4.3	<0.001
Age 65–69 y, white woman	0.893 (0.862–0.926)	0.016	−6.2	<0.001
Age 65–69 y, black woman	1.030 (0.951–1.117)	0.042	0.7	>0.2
Age 70–74 y, white man	1.129 (1.094–1.164)	0.018	7.6	<0.001
Age 70–74 y, black man	1.422 (1.320–1.533)	0.054	9.3	<0.001
Age 70–74 y, white woman	1.022 (0.990–1.055)	0.017	1.3	0.183
Age 70–74 y, black woman	1.188 (1.101–1.281)	0.046	4.4	<0.001
Age 75–79 y, white man	1.398 (1.354–1.442)	0.023	20.7	<0.001
Age 75–79 y, black man	1.670 (1.529–1.824)	0.075	11.4	<0.001
Age 75–79 y, white woman	1.236 (1.199–1.275)	0.019	13.5	<0.001
Age 75–79 y, black woman	1.380 (1.283–1.483)	0.051	8.7	<0.001
Age 80–84 y, white man	1.852 (1.791–1.916)	0.032	36.1	<0.001
Age 80–84 y, black man	2.108 (1.907–2.330)	0.108	14.6	<0.001
Age 80–84 y, white woman	1.528 (1.480–1.577)	0.025	26.3	<0.001
Age 80–84 y, black woman	1.698 (1.570–1.835)	0.068	13.3	<0.001
Age ≥85 y, white man	2.706 (2.607–2.808)	0.051	52.6	<0.001
Age ≥85 y, black man	2.779 (2.456–3.144)	0.175	16.2	<0.001
Age ≥85 y, white woman	2.208 (2.138–2.279)	0.036	48.4	<0.001
Age ≥85 y, black woman	2.501 (2.300–2.720)	0.107	21.5	<0.001
ZIP code–level variables				
Proportion below the poverty level	0.998 (0.997–1.000)	0.001	−1.8	0.068
Proportion with less than a high school education	1.003 (1.002–1.005)	0.001	5.2	<0.001
Proportion with a high school or college education	1.002 (1.000–1.003)	0.001	2.7	0.007
Proportion of people ≥65 y of age living in a nursing home	1.000 (0.999–1.001)	0.001	−0.1	>0.2
Proportion residing in rural areas	1.000 (0.999–1.000)	0.000	−1.9	0.052
Proportion residing in urban areas	1.000 (1.000–1.000)	0.000	−0.3	>0.2
Proportion Hispanic	1.000 (0.999–1.001)	0.000	0.1	>0.2
Proportion single	1.001 (1.000–1.002)	0.001	2.1	0.036
Proportion employed	1.001 (1.000–1.002)	0.001	1.7	0.092
Proportion of people ≥65 y of age with a working disability	1.003 (1.002–1.005)	0.001	3.7	<0.001
Proportion of people ≥65 y of age with self-care limitation	0.999 (0.996–1.002)	0.001	−0.7	>0.2
Proportion of people ≥65 y of age with a mobility limitation	1.001 (0.998–1.004)	0.001	0.7	>0.2
Social Security income‡				
<$1700 (excluded)	1.000			
$1700–$2099	0.982 (0.959–1.006)	0.012	−1.5	0.135
$2100–$2600	0.975 (0.952–1.000)	0.012	−2.0	0.047
>$2600	0.970 (0.942–0.999)	0.015	−2.0	0.044
Disease burden				
Local or regional cancer (excluded)	1.000			
Distant cancer	3.716 (3.636–3.797)	0.041	118.3	<0.001
Comorbid conditions§				
0 (excluded)	1.000			
1	1.203 (1.184–1.223)	0.010	22.2	<0.001
2	1.374 (1.336–1.412)	0.020	22.3	<0.001
3	1.753 (1.665–1.846)	0.046	21.3	<0.001
4	1.872 (1.650–2.124)	0.121	9.7	<0.001
≥5	2.499 (1.890–3.305)	0.356	6.4	<0.001
Hospital characteristics				
Nonteaching (excluded)	1.000			
Minor teaching	1.041 (1.012–1.071)	0.015	2.8	0.006
Major teaching	0.996 (0.969–1.025)	0.014	−0.3	>0.2
Lowest volume (excluded)	1.000			
Low volume	0.917 (0.893–0.941)	0.012	−6.6	<0.001
Medium volume	0.870 (0.846–0.893)	0.012	−10.2	<0.001
High volume	0.802 (0.773–0.833)	0.015	−11.5	<0.001
Variables ascertained at HRR level				
HRR residents in an HMO				
<1% (excluded)	1.000			
1%–<5%	1.008 (0.981–1.036)	0.014	0.6	>0.2
5%–<15%	1.011 (0.982–1.041)	0.015	0.7	>0.2
≥15%	1.002 (0.966–1.040)	0.019	0.1	>0.2
Region of residence				
New England (excluded)	1.000			
Mid-Atlantic	1.016 (0.972–1.063)	0.023	0.7	>0.2
South Atlantic	0.950 (0.908–0.992)	0.021	−2.3	0.022
Great Lakes	1.021 (0.980–1.064)	0.022	1.0	>0.2
East South Central	0.975 (0.921–1.033)	0.028	−0.9	>0.2
Great Plains	0.953 (0.908–0.999)	0.023	−2.0	0.047
West South Central	0.984 (0.936–1.033)	0.025	−0.7	>0.2
Mountain	1.045 (0.986–1.108)	0.031	1.5	0.137
Pacific	0.949 (0.901–1.000)	0.025	−2.0	0.050
Log of total EOL-EI	1.128 (1.044–1.219)	0.044	3.1	0.002

* Cox regression and the Breslow method were used for ties. Number of observations = 195 429; number of failures = 85 599; time at risk = 174 733 470 days; Wald chi-square test = 21 913.16; probability > chi-square test = 0.0000; log likelihood = −991 748.48. EOL-EI = End-of-Life Expenditure Index; HMO = health maintenance organization; HRR = hospital referral region.
† Adjusted for clustering by hospital.
‡ Monthly income of ZIP code of residence.
§ Based on the Charlson Comorbidity Index.

Appendix Table 8. **Survival Model for the Acute Myocardial Infarction Cohort***

Variable	Hazard Ratio (95% CI)	Standard Error†	Chi-Square Test	*P* Value
Demographic characteristics				
Age 65–69 y, white man (excluded)	1.000			
Age 65–69 y, black man	1.221 (1.108–1.346)	0.061	4.0	<0.001
Age 65–69 y, white woman	1.113 (1.064–1.163)	0.025	4.7	<0.001
Age 65–69 y, black woman	1.297 (1.177–1.429)	0.064	5.3	<0.001
Age 70–74 y, white man	1.337 (1.290–1.386)	0.024	15.9	<0.001
Age 70–74 y, black man	1.414 (1.247–1.604)	0.091	5.4	<0.001
Age 70–74 y, white woman	1.366 (1.314–1.420)	0.027	15.8	<0.001
Age 70–74 y, black woman	1.425 (1.299–1.564)	0.068	7.5	<0.001
Age 75–79 y, white man	1.806 (1.742–1.872)	0.033	32.3	<0.001
Age 75–79 y, black man	1.748 (1.577–1.939)	0.092	10.6	<0.001
Age 75–79 y, white woman	1.716 (1.653–1.782)	0.033	28.3	<0.001
Age 75–79 y, black woman	1.616 (1.476–1.769)	0.075	10.4	<0.001
Age 80–84 y, white man	2.419 (2.332–2.510)	0.045	47.1	<0.001
Age 80–84 y, black man	2.112 (1.872–2.383)	0.130	12.1	<0.001
Age 80–84 y, white woman	2.184 (2.105–2.266)	0.041	41.8	<0.001
Age 80–84 y, black woman	2.131 (1.949–2.329)	0.097	16.7	<0.001
Age ≥85 y, white man	3.258 (3.130–3.391)	0.067	57.6	<0.001
Age ≥85 y, black man	2.566 (2.243–2.935)	0.176	13.7	<0.001
Age ≥85 y, white woman	2.874 (2.769–2.983)	0.054	55.7	<0.001
Age ≥85 y, black woman	2.490 (2.273–2.728)	0.116	19.6	<0.001
Comorbid conditions and other risk factors				
Previous revascularization	1.072 (1.050–1.095)	0.011	6.5	<0.001
Previous MI	1.128 (1.109–1.148)	0.010	13.6	<0.001
History of congestive heart failure	1.378 (1.352–1.405)	0.013	32.9	<0.001
History of dementia	1.320 (1.282–1.360)	0.020	18.5	<0.001
History of diabetes	1.294 (1.273–1.316)	0.011	30.6	<0.001
History of hypertension	0.970 (0.955–0.986)	0.008	−3.7	<0.001
History of leukemia	1.516 (1.386–1.657)	0.069	9.1	<0.001
History of low ejection fraction	1.249 (1.208–1.292)	0.021	13.0	<0.001
History of metastatic cancer	3.069 (2.891–3.258)	0.093	36.8	<0.001
History of nonmetastatic cancer	1.604 (1.513–1.700)	0.048	15.9	<0.001
Peripheral vascular disease	1.296 (1.267–1.326)	0.015	22.4	<0.001
COPD	1.244 (1.221–1.268)	0.012	22.5	<0.001
History of angina	0.962 (0.947–0.978)	0.008	−4.6	<0.001
History of angina missing	0.929 (0.890–0.971)	0.021	−3.3	0.001
Terminal illness	1.438 (1.297–1.596)	0.076	6.9	<0.001
Smoker	1.058 (1.034–1.083)	0.012	4.8	<0.001
Characteristics of MI				
Non–Q-wave (excluded)	1.000			
Anterior	1.187 (1.166–1.210)	0.011	18.2	<0.001
Inferior	0.907 (0.886–0.929)	0.011	−8.0	<0.001
Other	1.215 (1.184–1.248)	0.016	14.6	<0.001
Fibrillation	1.179 (1.150–1.208)	0.015	13.2	<0.001
Received CPR	1.888 (1.803–1.977)	0.044	27.0	<0.001
Heart block	1.198 (1.174–1.222)	0.012	17.7	<0.001
Congestive heart failure	1.540 (1.513–1.567)	0.014	48.5	<0.001
Hypotension	1.763 (1.688–1.842)	0.039	25.4	<0.001
Admission blood pressure missing	1.919 (1.709–2.156)	0.114	11.0	<0.001
Shock	1.891 (1.787–2.000)	0.054	22.2	<0.001
Peak creatine kinase level missing	1.289 (1.198–1.387)	0.048	6.8	<0.001
Peak creatine kinase level >1000 IU/L	1.275 (1.253–1.299)	0.012	26.5	<0.001
Transferred from emergency department	0.892 (0.850–0.937)	0.022	−4.6	<0.001
Transferred from the hospital	0.881 (0.848–0.915)	0.017	−6.6	<0.001
Preadmission status				
Admitted from nursing home	1.322 (1.281–1.364)	0.021	17.3	<0.001
Admitted from other institution	1.177 (1.118–1.238)	0.030	6.3	<0.001
Unable to walk	1.760 (1.690–1.832)	0.036	27.3	<0.001
Needed assistance to walk	1.319 (1.292–1.346)	0.014	26.7	<0.001
Ambulatory status missing	2.150 (2.054–2.249)	0.050	33.1	<0.001
ZIP code–level variables				
Social Security income‡				
<$1700 (excluded)	1.000			
$1700–$2099	1.028 (1.003–1.054)	0.013	2.2	0.030
$2100–$2600	1.026 (1.002–1.051)	0.012	2.2	0.032
>$2600	1.027 (1.003–1.052)	0.013	2.2	0.028
Hospital characteristics				
Nonteaching (excluded)	1.000			

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Appendix Table 8—**Continued**

Variable	Hazard Ratio (95% CI)	Standard Error†	Chi-Square Test	*P* Value
Minor teaching	0.999 (0.975–1.024)	0.013	−0.1	>0.2
Major teaching	1.000 (0.977–1.024)	0.012	0.0	>0.2
Lowest volume (excluded)	1.000			
Low volume	0.957 (0.935–0.979)	0.011	−3.8	<0.001
Medium volume	0.930 (0.908–0.953)	0.012	−5.8	<0.001
High volume	0.897 (0.874–0.922)	0.012	−7.9	<0.001
Variables ascertained at HRR level				
HRR residents in an HMO				
<1% (excluded)	1.000			
1%–<5%	0.994 (0.970–1.019)	0.013	−0.5	>0.2
5%–<15%	0.979 (0.954–1.005)	0.013	−1.6	0.114
≥15%	0.976 (0.947–1.006)	0.015	−1.6	0.116
Region of residence				
New England (excluded)	1.000			
Mid-Atlantic	1.083 (1.043–1.125)	0.021	4.2	<0.001
South Atlantic	1.078 (1.038–1.120)	0.021	3.9	<0.001
Great Lakes	1.070 (1.033–1.109)	0.019	3.8	<0.001
East South Central	1.128 (1.071–1.188)	0.030	4.6	<0.001
Great Plains	1.060 (1.011–1.111)	0.025	2.4	0.015
West South Central	1.157 (1.110–1.205)	0.024	6.9	<0.001
Mountain	1.049 (0.996–1.106)	0.028	1.8	0.071
Pacific	1.107 (1.055–1.161)	0.027	4.1	<0.001
Log of total EOL-EI	1.076 (1.006–1.151)	0.037	2.1	0.032

* Cox regression and the Breslow method were used for ties. Number of observations = 159 393; number of failures = 71 787; time at risk = 114 399 525 days; Wald chi-square test = 35 204.56; probability > chi-square < 0.0001; log likelihood = −815 726.21. COPD = chronic obstructive pulmonary disease; CPR = cardiopulmonary resuscitation; EOL-EI = End-of-Life Expenditure Index; HMO = health maintenance organization; HRR = hospital referral region; MI = myocardial infarction.
† Adjusted for clustering by hospital.
‡ Monthly income of ZIP code of residence.

Appendix Table 9. **Survival Model for the Medicare Beneficiary Survey Cohort***

Variable	Hazard Ratio (95% CI)
Demographic characteristics	
Age 65–69 y, white man (excluded)	1.00
Age 65–69 y, black man	1.18 (0.88–1.57)
Age 65–69 y, white woman	0.53 (0.43–0.65)
Age 65–69 y, black woman	0.48 (0.32–0.72)
Age 70–74 y, white man	1.45 (1.23–1.70)
Age 70–74 y, black man	1.89 (1.40–2.54)
Age 70–74 y, white woman	0.89 (0.75–1.05)
Age 70–74 y, black woman	0.79 (0.54–1.16)
Age 75–79 y, white man	2.02 (1.73–2.35)
Age 75–79 y, black man	2.22 (1.45–3.40)
Age 75–79 y, white woman	1.34 (1.14–1.57)
Age 75–79 y, black woman	1.27 (0.97–1.65)
Age 80–84 y, white man	3.11 (2.71–3.58)
Age 80–84 y, black man	2.58 (1.98–3.35)
Age 80–84 y, white woman	1.95 (1.67–2.28)
Age 80–84 y, black woman	2.01 (1.47–2.76)
Age ≥85 y, white man	4.45 (3.82–5.19)
Age ≥85 y, black man	4.43 (3.18–6.17)
Age ≥85 y, white woman	3.24 (2.80–3.74)
Age ≥85 y, black woman	3.07 (2.38–3.97)
Marital status	
Married	0.88 (0.82–0.94)
Educational background	
College (excluded)	1.00
Did not complete high school	0.95 (0.88–1.03)
High school	1.06 (0.97–1.16)
Income status	
>$25 000/y (excluded)	1.00
<$10 000/y	1.20 (1.06–1.37)
$10 000–$15 000/y	1.17 (1.06–1.30)
$15 000–$25 000/y	1.16 (1.06–1.27)
Information missing	1.23 (1.09–1.39)
Self-reported health	
Excellent (excluded)	1.00
Very good	1.18 (1.05–1.34)
Good	1.39 (1.24–1.56)
Fair	1.74 (1.53–1.97)
Poor	2.36 (2.05–2.72)
Smoking	
Never (excluded)	1.00
Former smoker	1.38 (1.27–1.49)
Current smoker	1.75 (1.58–1.93)
Functional status	
ADL limitations	
0 (excluded)	1.00
0–1	1.38 (1.26–1.52)
1–2	1.60 (1.43–1.79)
2–4	1.73 (1.54–1.95)
4–5	2.17 (1.84–2.57)
5–6	2.95 (2.53–3.44)
IADL limitations	
0 (excluded)	1.00
0–≤3	1.00 (0.92–1.09)
3–6	1.24 (1.12–1.38)
Other limitation	1.20 (1.06–1.36)
Bedridden	1.19 (1.05–1.35)
Facility-dwelling	1.44 (1.25–1.65)
Chronic conditions reported	
Alzheimer disease	1.18 (1.05–1.32)
Arthritis	0.75 (0.70–0.80)
Cancer	1.28 (1.18–1.39)
Ischemic heart disease or angina	1.02 (0.93–1.11)
Diabetes	1.34 (1.24–1.44)
COPD	1.19 (1.08–1.31)
Hypertension	1.00 (0.94–1.05)
History of MI	1.33 (1.22–1.44)
Osteoporosis	0.97 (0.89–1.06)
Parkinson disease	1.37 (1.16–1.62)
Stroke	1.19 (1.10–1.29)
Log of total EOL-EI	1.12 (0.93–1.34)

* Number of observations read = 23 902; weighted count = 23 902; denominator degrees of freedom = 728; $-2 \times$ normalized log-likelihood with β(s) = 89 696.39; $-2 \times$ normalized log-likelihood full model = 84 651.09; approximate chi-square value ($-2 \times$ log-1 ratio) = 5045.30; approximate P value = 0.00; variance estimation method Taylor series (with replacement). ADL = activity of daily living; COPD = chronic obstructive pulmonary disease; EOL-EI = End-of-Life Expenditure Index; IADL = independent activity of daily living; MI = myocardial infarction.

Appendix Table 10. **Models Testing the Association between the End-of-Life Expenditure Index and Change in Scores on the Health Activities and Limitations Index***

Variable	Adjusted Change in HALex Scores in Models Based on Quintiles of EOL-EI			Adjusted Change in HALex Scores in Models with EOL-EI as a Continuous Variable			Final Model†
	Model A	Model B	Model C	Model A	Model B	Model C	
Intercept	96.96	78.23	98.01	100.43	79.87	101.57	
Year	−1.91	−0.80	−2.40	−2.77	−1.38	−3.29	
Intensity (continuous)				−0.38	−0.24	−0.39	
Year × intensity				0.06	0.04	0.06	
Quintile 1							1.65
Quintile 2	−1.47	−2.52	−1.37				0.56
Quintile 3	−1.33	−2.03	−1.16				0.90
Quintile 4	−0.74	−0.66	−0.66				1.26
Quintile 5	−1.77	−1.15	−1.78				ref
YR × quintile 1							−1.96
YR × quintile 2	−0.20	−0.08	−0.25				−2.18
YR × quintile 3	−0.38	−0.44	−0.47				−2.28
YR × quintile 4	0.00	−0.09	−0.03				−1.94
YR × quintile 5	−0.21	−0.26	−0.21				−1.96
Age 65–69 y, white man (reference)							95.10
Age 65–69 y, white woman	−3.42	−6.90	−3.42	−3.42	−6.89	−3.42	94.48
Age 65–69 y, black man	−0.58	−9.61	−0.56	−0.53	−9.40	−0.51	91.69
Age 65–69 y, black woman	−4.65	−14.31	−4.65	−4.65	−14.10	−4.65	90.39
Age 70–74 y, white man	−2.81	−2.48	−2.81	−2.82	−2.49	−2.82	92.31
Age 70–74 y, white woman	−4.71	−6.88	−4.72	−4.75	−6.92	−4.76	87.44
Age 70–74 y, black man	−7.60	−6.16	−7.60	−7.71	−6.14	−7.71	90.39
Age 70–74 y, black woman	−8.13	−22.34	−8.13	−8.32	−22.41	−8.32	86.91
Age 75–79 y, white man	−7.36	−9.07	−7.37	−7.35	−9.06	−7.36	87.73
Age 75–79 y, white woman	−10.02	−12.82	−10.03	−10.04	−12.79	−10.04	89.18
Age 75–79 y, black man	−5.84	−16.39	−5.88	−5.77	−16.17	−5.81	85.08
Age 75–79 y, black woman	−12.05	−20.38	−12.06	−12.03	−20.25	−12.04	83.00
Age 80–84 y, white man	−11.42	−10.73	−11.42	−11.41	−10.75	−11.42	83.70
Age 80–84 y, white woman	−15.65	−21.27	−15.66	−15.67	−21.32	−15.68	89.84
Age 80–84 y, black man	−5.16	−12.24	−5.12	−5.31	−12.27	−5.27	79.45
Age 80–84 y, black woman	−14.04	−24.16	−14.05	−14.10	−24.08	−14.11	81.03
Age ≥85 y, white man	−19.04	−14.67	−19.06	−19.07	−14.72	−19.09	76.07
Age ≥85 y, white woman	−21.46	−28.54	−21.46	−21.51	−28.61	−21.51	79.37
Age ≥85 y, black man	−15.66	−17.86	−15.67	−15.71	−17.92	−15.72	73.63
Age ≥85 y, black woman	−18.67	−31.43	−18.67	−18.73	−31.49	−18.73	76.31
Arthritis	−9.37		−11.24	−9.41		−11.27	−9.38
Alzheimer disease	−6.47		−1.03	−6.40		−1.01	−6.43
Cancer	−5.79		−4.35	−5.78		−4.35	−5.79
Angina or CAD	−5.04		−6.22	−5.07		−6.21	−5.06
Diabetes	−9.97		−8.62	−9.91		−8.58	−9.95
Obstructive lung disease	−10.25		−11.45	−10.22		−11.43	−10.24
Hypertension	−5.06		−5.73	−5.02		−5.69	−5.06
History of MI	−6.30		−6.83	−6.30		−6.81	−6.30
Osteoporosis	−9.06		−10.73	−9.04		−10.72	−9.05
Parkinson disease	−15.31		−10.34	−15.28		−10.35	−15.30
History of stroke	−10.77		−9.73	−10.83		−9.77	−10.77
Current smoker	−5.29		−5.29	−5.31		−5.31	−5.30
Former smoker	−1.90		−1.89	−1.90		−1.90	−1.90
Bedridden	−14.70		−14.79	−14.67		−14.75	−14.72
Facility resident	−15.86		−15.88	−15.94		−15.95	−15.85
Metropolitan area resident	1.71		1.72	1.79		1.80	1.60
Medicare only (reference)							
Medicare and Medicaid	−5.07		−5.08	−5.11		−5.12	−5.11
Medicare and self-purchased	2.93		2.92	2.90		2.89	2.95
Medicare and employer sponsored	2.99		3.00	2.94		2.94	2.99
At least some college (reference)							
Completed high school	−2.39		−2.37	−2.43		−2.42	−2.38
Did not complete high school	−6.14		−6.13	−6.22		−6.21	−6.16
Income >$25 000/y (reference)							
Income $15 000–$25 000/y	−3.71		−3.71	−3.65		−3.65	−3.69
Income $5000–$15 000/y	−6.35		−6.34	−6.33		−6.33	−6.33
Income <$5000/y	−5.69		−5.71	−5.67		−5.69	−5.66
Married	0.05		0.05	0.06		0.05	0.07
YR × age 65–69 y, white woman		0.26			0.26		

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Appendix Table 10—**Continued**

Variable	Adjusted Change in HALex Scores in Models Based on Quintiles of EOL-EI			Adjusted Change in HALex Scores in Models with EOL-EI as a Continuous Variable			Final Model†
	Model A	Model B	Model C	Model A	Model B	Model C	
YR × age 65–69 y, black man		0.63			0.57		
YR × age 65–69 y, black woman		0.20			0.12		
YR × age 70–74 y, white man		−1.24			−1.23		
YR × age 70–74 y, white woman		−0.68			−0.68		
YR × age 70–74 y, black man		−4.74			−4.81		
YR × age 70–74 y, black woman		0.33			0.22		
YR × age 75–79 y, white man		−1.25			−1.25		
YR × age 75–79 y, white woman		−1.57			−1.59		
YR × age 75–79 y, black man		−0.66			−0.73		
YR × age 75–79 y, black woman		−2.94			−2.99		
YR × age 80–84 y, white man		−2.78			−2.77		
YR × age 80–84 y, white woman		−1.98			−1.98		
YR × age 80–84 y, black man		−1.97			−2.06		
YR × age 80–84 y, black woman		−2.30			−2.39		
YR × age ≥85 y, white man		−6.00			−6.00		
YR × age ≥85 y, white woman		−3.72			−3.72		
YR × age ≥85 y, black man		−4.56			−4.63		
YR × age ≥85 y, black woman		−2.49			−2.54		
YR × arthritis			0.88			0.87	
YR × Alzheimer disease			−2.78			−2.75	
YR × cancer			−0.68			−0.67	
YR × angina or CAD			0.55			0.53	
YR × diabetes			−0.64			−0.63	
YR × obstructive lung disease			0.56			0.57	
YR × hypertension			0.32			0.31	
YR × history of MI			0.25			0.24	
YR × osteoporosis			0.80			0.80	
YR × Parkinson disease			−2.43			−2.41	
YR × history of stroke			−0.49			−0.50	

* The dependent variable (HALex score) can range from 0 to 100. Nonsignificant comparisons ($P > 0.05$) are shaded in gray. The variables YR × quintile and YR × intensity test whether the change in HALex score over time differs across quintiles of EOL-EI or across all levels of EOL-EI. Three models are presented for each of the different measures of EOL-EI (by quintile, and continuous). The main model (model A) includes main effects for potential confounders, while models B and C include additional interactions between YR and each of the other major classes of variables. CAD = coronary artery disease; EOL-EI = End-of-Life Expenditure Index; HALex = Health Activities and Limitations Index; MI = myocardial infarction; YR = year.
† Used to estimate average annual change in HALex scores shown in Part 1, Table 4.

Appendix Table 11. **Specific Services Provided to Chronic Disease Cohorts during First Year of Follow-up***

Service	Cohort-Specific Rates (per 1000) in Quintile 1 unless Otherwise Specified			Pooled Ratio of Rate in Specified Quintile Compared with Quintile 1			
	Hip Fracture Cohort	Colorectal Cancer Cohort	Acute MI Cohort	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Preventive care, %							
Influenza vaccine	22.2	35.3	32.4	1.0	1.0	1.0	0.9
Pneumonia vaccine	2.7	4.6	5.2	1.0	1.0	0.9	0.9
Mammography (among women age 65–69 y)	18.3	26.1	19.1	0.9	0.9	1.0	1.0
Eye examination (among diabetic persons)	27.2	31.8	26.8	1.0	1.0	1.1	1.2
Lipid panel (among diabetic persons)	11.8	15.8	19.3	1.3	1.4	1.6	2.2
Evaluation and management†							
Office visits per person	4.9	12.7	9.3	1.1	1.0	1.1	1.3
Inpatient visits per person	13.0	11.7	21.0	1.3	1.6	1.8	2.3
Initial inpatient consultations per person	1.5	1.4	1.8	1.3	1.5	1.8	2.5
Psychotherapy visits per person	0.8	0.2	0.3	1.2	1.3	2.0	3.4
Mean different MDs seen, *n*	5.2	4.9	6.0	1.1	1.2	1.2	1.5
Seeing >10 MDs, %	9.6	9.6	16.4	1.4	1.5	1.7	2.7
Endoscopic procedures							
Laryngoscopy	5.1	9.2	12.3	1.3	1.4	1.8	3.4
Bronchoscopy	11.7	18.4	26.1	1.2	1.4	1.7	1.9
Cystoscopy	38.6	103.6	53.1	1.1	1.2	1.2	1.4
Imaging tests							
Chest radiography	3529.7	3936.5	7180.4	1.2	1.3	1.4	1.6
CT or MRI of head or brain	210.6	159.9	237.9	1.3	1.5	1.6	1.8
CT or MRI of lumbar spine	9.1	16.8	11.9	1.0	1.2	1.3	1.5
Bone scan	64.6	77.5	33.4	1.2	1.3	1.5	1.7
Ventilation–perfusion scan	54.5	51.1	60.6	1.2	1.2	1.6	1.7
Minor or diagnostic procedures							
Repair of laceration	50.5	29.1	25.2	1.0	1.0	1.2	1.1
Excision or repair of malignant lesion	27.4	41.1	35.1	1.1	1.1	1.3	1.4
Skin biopsy	225.2	209.8	221.3	1.1	1.2	1.4	2.2
Breast biopsy	3.7	7.8	4.0	1.0	0.9	1.0	0.9
Pulmonary function test	34.5	61.2	120.8	1.1	1.3	1.6	2.8
Holter monitor	25.8	25.4	98.3	1.5	1.8	2.3	3.9
Diagnostic upper-GI endoscopy	54.7	122.8	76.0	1.2	1.4	1.6	1.6
Electroencephalography	29.5	21.1	44.8	1.6	2.0	2.4	3.0
Major procedures							
Cataract removal	48.2	50.7	50.4	1.0	1.0	1.0	0.9
Back surgery	1.4	1.4	2.2	1.0	1.0	1.2	0.9
Total knee arthroplasty	6.3	2.4	2.9	1.0	0.9	0.9	0.8
End-of-life care‡							
Inpatient days during last 6 months of life§	20.6	26.1	20.0	1.2	1.3	1.4	1.8
ICU days during last 6 months of life§	1.9	3.6	7.6	1.3	1.6	1.8	2.2
Vena cava filter‖	2.1	5.2	2.3	1.4	1.8	2.4	3.7
Emergency intubation‖	31.0	39.8	133.3	1.3	1.5	1.8	2.6
Feeding tube placement‖	44.8	55.4	25.5	1.7	2.0	2.4	2.9

* Rates are shown per 1000 person-years of follow-up after index admission, except as indicated. CT = computed tomography; GI = gastrointestinal; ICU = intensive care unit; MI = myocardial infarction; MRI = magnetic resonance imaging.
† Rates were calculated per person-year of follow-up after index admission.
‡ Rates were calculated only for those who died.
§ Rate per person who died.
‖ Rate per 1000 deaths.

Appendix Table 12. **Unadjusted Utilization Rates of Hospital and Physician Services, by Specified Subgroups of the Hip Fracture Cohort***

Variable	Quintile of EOL-EI					Ratio of Quintile 5 to Quintile 1
	1 (Lowest)	2	3	4	5 (Highest)	
Utilization during the first 6 months of follow-up						
Demographic characteristics						
Age <80 y	12.6	13.3	13.6	14.6	15.1	1.2
Age ≥80 y	12.1	12.6	13.0	13.8	14.9	1.2
Man	12.5	13.5	14.1	15.3	16.0	1.3
Woman	12.1	12.7	13.0	13.8	14.7	1.2
Nonblack race	12.2	12.9	13.2	14.0	14.8	1.2
Black race	13.9	13.6	13.5	15.5	18.1	1.3
Social Security income†						
<$1700	12.4	12.8	13.5	14.0	15.3	1.2
$1700–$2099	12.2	13.1	13.3	14.0	14.9	1.2
$2100–$2600	12.2	12.8	13.1	14.0	15.0	1.2
>$2600	12.1	12.8	13.0	14.2	14.8	1.2
Variables ascertained at HRR level						
HRR residents in an HMO						
<5%	12.1	12.8	13.1	14.0	14.8	1.2
≥5%	12.4	13.0	13.4	14.2	15.0	1.2
Region of residence						
2, 3, 4†	12.4	12.9	12.9	14.2	15.0	1.2
Other	12.2	12.8	13.4	14.0	14.8	1.2
Predicted mortality risk§						
Low	12.3	12.8	12.9	13.8	14.6	1.2
Intermediate	12.0	12.8	13.0	13.7	14.6	1.2
High	12.4	13.1	13.6	14.8	15.7	1.3
Utilization (per person per year) during all subsequent follow-up						
Demographic characteristics						
Age <80 y	4.8	6.1	6.9	7.5	7.8	1.6
Age ≥80 y	3.6	4.5	5.3	6.4	6.7	1.9
Man	4.9	6.1	6.6	8.6	8.6	1.7
Woman	3.7	4.8	5.6	6.3	6.6	1.8
Nonblack race	4.0	5.0	5.8	6.7	6.8	1.7
Black race	5.3	6.3	6.9	8.2	11.6	2.2
Social Security income†						
<$1700	4.1	4.9	6.2	7.0	7.2	1.7
$1700–$2099	4.2	5.1	6.3	6.5	7.2	1.7
$2100–$2600	4.0	5.1	5.7	7.0	6.8	1.7
>$2600	3.8	5.1	5.2	6.6	7.1	1.9
Variables ascertained at HRR level						
HRR residents in an HMO						
<5%	4.0	5.1	6.0	6.6	7.8	2.0
≥5%	4.0	4.7	5.5	6.9	6.9	1.7
Region of residence						
2, 3, 4‡	4.6	5.4	6.0	6.8	7.1	1.6
Other	3.8	4.5	5.8	6.8	6.7	1.8
Predicted mortality risk§						
Low	4.2	5.0	6.0	6.3	6.6	1.6
Intermediate	3.6	5.0	5.5	6.6	6.7	1.8
High	4.2	5.1	6.0	7.4	8.0	1.9

* Values are in thousands of dollars. EOL-EI = End-of-Life Expenditure Index; HMO = health maintenance organization; HRR = hospital referral region.
† Monthly income of ZIP code of residence.
‡ Mid-Atlantic, South Atlantic, and Great Lakes Regions.
§ Based on logistic regression models used for determining average predicted risk for death.

Appendix Table 13. **Unadjusted Utilization Rates of Hospital and Physician Services, by Specified Subgroups of the Colorectal Cancer Cohort***

Variable	Quintile of EOL-EI					Ratio of Quintile 1 to Quintile 5
	1 (Lowest)	2	3	4	5 (Highest)	
Utilization during the first 6 months of follow-up						
Demographic characteristics						
Age <80 y	19.2	19.4	19.7	20.5	21.8	1.1
Age ≥80 y	18.9	19.1	19.2	19.8	20.8	1.1
Man	19.6	19.5	19.7	20.6	22.2	1.1
Woman	18.6	19.1	19.5	20.0	20.9	1.1
Nonblack race	19.1	19.4	19.6	20.3	21.3	1.1
Black race	19.5	18.6	19.6	19.8	22.9	1.2
Social Security income†						
<$1700	19.3	18.5	19.2	20.3	21.7	1.1
$1700–$2099	19.3	19.6	19.0	20.4	20.5	1.1
$2100–$2600	19.1	19.5	19.9	19.7	21.5	1.1
>$2600	18.6	19.3	19.9	20.5	21.7	1.2
Variables ascertained at HRR level						
HRR residents in an HMO						
<5%	19.1	19.3	19.6	20.3	21.4	1.1
≥5%	19.1	19.3	19.6	20.2	21.5	1.1
Region of residence						
2, 3, 4‡	19.4	19.4	19.5	20.4	21.4	1.1
Other	18.9	19.1	19.6	20.1	21.8	1.2
Predicted mortality risk‡						
Low	18.6	18.3	18.5	19.5	21.2	1.1
Intermediate	19.2	19.3	19.8	20.2	21.3	1.1
High	19.5	20.3	20.4	21.0	22.0	1.1
Utilization (per person per year) during all subsequent follow-up						
Demographic characteristics						
Age <80 y	6.3	7.4	8.6	8.7	8.9	1.4
Age ≥80 y	5.3	5.8	6.5	6.9	9.2	1.7
Man	6.1	7.7	8.4	9.2	9.7	1.6
Woman	5.9	6.3	7.5	7.1	8.4	1.4
Nonblack race	6.0	6.9	7.9	8.0	8.9	1.5
Black race	7.6	6.5	7.7	8.5	10.0	1.3
Social Security income†						
<$1700	5.6	5.8	8.4	7.5	10.0	1.8
$1700–$2099	6.3	7.6	7.8	8.9	9.0	1.4
$2100–$2600	5.5	7.5	8.0	7.8	8.4	1.5
>$2600	6.6	6.3	7.7	8.3	8.9	1.3
Variables ascertained at the HRR level						
HRR residents in an HMO						
<5%	6.3	7.2	7.9	8.4	9.0	1.4
≥5%	5.5	5.9	7.9	7.8	9.0	1.6
Region of residence						
2, 3, 4‡	6.6	7.3	8.2	8.3	9.1	1.4
Other	5.7	6.2	7.8	7.9	8.4	1.5
Predicted mortality risk§						
Low	5.7	7.1	7.4	7.4	7.8	1.4
Intermediate	6.2	6.6	7.6	8.2	9.5	1.5
High	6.0	7.0	8.9	8.7	9.7	1.6

* Values are in thousands of dollars. EOL-EI = End-of-Life Expenditure Index; HMO = health maintenance organization; HRR = hospital referral region.
† Monthly income of ZIP code of residence.
‡ Mid-Atlantic, South Atlantic, and Great Lakes Regions.
§ Based on logistic regression models used for determining average predicted risk for death.

Appendix Table 14. **Unadjusted Utilization Rates of Hospital and Physician Services, by Specified Subgroups of the Acute Myocardial Infarction Cohort***

Variable	Quintile of EOL-EI					Ratio of Quintile 5 to Quintile 1
	1 (Lowest)	2	3	4	5 (Highest)	
Utilization during the first 6 months of follow-up						
Demographic characteristics						
Age <80 y	20.0	21.1	21.5	22.1	23.7	1.2
Age ≥80 y	13.1	13.5	14.9	15.4	15.3	1.2
Man	18.6	19.5	20.1	20.7	22.1	1.2
Woman	16.9	17.7	18.4	19.1	18.9	1.1
Nonblack race	17.8	18.7	19.3	20.1	20.8	1.2
Black race	15.1	15.3	19.1	17.6	17.9	1.2
Social Security income†						
<$1700	17.4	18.5	20.0	20.0	20.4	1.2
$1700–$2099	18.6	18.1	18.5	18.8	21.1	1.1
$2100–$2600	17.0	19.3	19.0	20.4	20.9	1.2
>$2600	18.5	18.3	19.8	20.2	20.3	1.1
Variables ascertained at HRR level						
HRR residents in an HMO						
<5%	17.6	18.6	18.8	19.8	19.9	1.1
≥5%	18.2	18.7	20.3	20.0	20.7	1.1
Region of residence						
2, 3, 4‡	17.9	18.4	20.1	19.7	20.7	1.2
Other	17.8	19.1	18.8	20.1	19.7	1.1
Predicted mortality risk§						
Low	20.3	21.5	22.2	21.8	24.0	1.2
Intermediate	17.7	18.8	20.6	21.3	21.7	1.2
High	14.7	15.6	14.7	16.4	16.5	1.1
Utilization (per person per year) during all subsequent follow-up						
Demographic characteristics						
Age <80 y	5.8	6.6	7.2	7.0	8.5	1.4
Age ≥80 y	4.3	5.4	6.4	7.4	8.2	1.9
Man	5.9	6.2	7.0	7.6	8.7	1.5
Woman	4.8	6.3	6.9	6.7	8.0	1.7
Nonblack race	5.3	6.2	6.8	7.0	8.3	1.6
Black race	7.0	6.9	8.4	8.9	9.7	1.4
Social Security income†						
<$1700	5.3	4.7	7.3	7.0	7.5	1.4
$1700–$2099	5.7	6.7	6.9	9.1	8.1	1.4
$2100–$2600	5.3	6.8	8.0	5.7	8.4	1.6
>$2600	5.2	6.1	5.4	6.9	8.9	1.7
Variables ascertained at HRR level						
HRR residents in an HMO						
<5%	5.7	6.5	7.2	6.8	6.7	1.2
≥5%	4.8	5.3	6.4	7.5	8.7	1.8
Region of residence						
2, 3, 4‡	6.6	6.5	7.5	6.9	8.7	1.3
Other	4.8	5.8	6.5	7.5	6.4	1.3
Predicted mortality risk§						
Low	4.2	5.4	6.2	6.5	6.8	1.6
Intermediate	6.3	7.2	7.4	7.3	9.4	1.5
High	5.8	6.1	7.1	7.6	8.8	1.5

* Values are in thousands of dollars. EOL-EI = End-of-Life Expenditure Index; HMO = health maintenance organization; HRR = hospital referral region.
† Monthly income of ZIP code of residence.
‡ Mid-Atlantic, South Atlantic, and Great Lakes Regions.
§ Based on logistic regression models used for determining average predicted risk for death.

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