The Implications of Regional Variations in Medicare Spending. Part 2: Health Outcomes and Satisfaction with 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 achieve better survival, functional status, or satisfaction with 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 (MCBS) (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: **5-year mortality rate (all four cohorts), change in functional status (MCBS cohort), and satisfaction (MCBS cohort).**

Results: **Cohort members were similar in baseline health status, but those in regions with higher end-of-life spending received 60% more care. Each 10% increase in regional end-of-life spending was associated with the following relative risks for death: hip fracture cohort, 1.003 (95% CI, 0.999 to 1.006); colorectal cancer cohort, 1.012 (CI, 1.004 to 1.019); acute myocardial infarction cohort, 1.007 (CI, 1.001 to 1.014); and MCBS cohort, 1.01 (CI, 0.99 to 1.03). There were no differences in the rate of decline in functional status across spending levels and no consistent differences in satisfaction.**

Conclusions: **Medicare enrollees in higher-spending regions receive more care than those in lower-spending regions but do not have better health outcomes or satisfaction with care. Efforts to reduce spending should proceed with caution, but policies to better manage further spending growth are warranted.**

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See related article on pp 273-287 and editorial comments on pp 347-348, 348-349, and 350-351.

The inexorable growth of health care spending in the United States is widely believed to be due to the greater use of advanced technology of clear-cut benefit (1). Policymakers argue (and the public assumes) that any constraints on growth are likely to be harmful (1, 2). Studies of regional variations in spending and medical practice, however, call these assumptions into question. Earlier research has indicated that the nearly twofold differences in Medicare spending observed across U.S. regions are not due to differences in the prices paid for medical services (3, 4) or to differences in health or socioeconomic status (3, 5, 6). Recent research, some of which is presented in Part 1 of our study, indicates that regional variations in average per capita Medicare spending are not due to more frequent performance of major surgery (7, 8) and that regions with higher per capita spending are no more likely to provide higher-quality care, whether defined in terms of specific evidence-based services or in terms of greater access to basic health care (7, 8). The additional utilization in high-spending regions is largely devoted to discretionary services that have previously been demonstrated to be associated with the local supply of physicians and hospital resources (5, 6). These include the frequency and type of evaluation and management services provided by physicians, the use of specialist consultations, the frequency of diagnostic tests and minor procedures, and the likelihood of treating patients with chronic disease in the inpatient or intensive care unit setting.

Whether the specialist-oriented, more inpatient-based practice observed in high-spending regions offers important health benefits, however, is unknown. Although recent studies have found no benefit in terms of mortality (5, 9, 10), they had limited ability to adjust for possible case-mix differences, inadequate individual-level clinical detail, and limited outcome measures. Our study was designed to address these concerns. In Part 1, we reported on the relationship between regional differences in spending and the content of care, quality of care, and access to care provided to four cohorts of Medicare beneficiaries. In this article, Part 2, we describe associations between increased spending and mortality, functional status, and satisfaction with care.

Methods

Design Overview

As described in greater detail in Part 1, we carried out a cohort study in four parallel populations using a "natural randomization" approach (11). In this approach, one or more exposure variables allow assignment of patients into "treatment groups" (different levels of average spending), as would a randomized trial. 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 using a measure that reflects the component of regional variation in Medicare spending due to physician practice rather than regional differences in illness or price—the End-of-Life Expenditure Index (EOL-EI). Because regional differences in end-of-life spending are unrelated to underlying illness levels, it is reasonable to consider residence in HRRs with differing levels of end-of-life spending as a random event. The index was calculated as 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. In the current paper, we also present several analyses with an alternative exposure measure, the Acute Care Expenditure Index (AC-EI), to decrease concern about possible residual confounding.

We confirmed that the exposures 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 followed the cohorts for up to 5 years after their initial hospitalizations and compared the processes of care (Part 1) and health outcomes (Part 2) across HRRs assigned to different exposure levels.

Context

Per capita Medicare spending varies considerably from region to region. The effect of greater Medicare spending on mortality, functional status, and satisfaction 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 lower mortality rates, better functional status, or higher satisfaction.

Implications

Medicare beneficiaries who live in higher Medicare spending regions do not necessarily have better health outcomes or satisfaction with health care than those in lower-spending regions.

–The Editors

Study Cohorts

The four study cohorts are described in detail in Part 1. Briefly, we studied fee-for-service Medicare enrollees, ages 65 to 99 years, who were eligible for Medicare Parts A and B. The acute myocardial infarction (MI) cohort was drawn from patients included in the Cooperative Cardiovascular Project, who had index hospitalizations between February 1994 and November 1995. The hip fracture and colorectal cancer cohorts were identified based on an incident hospitalization between 1993 and 1995. The general population sample included participants in the Medicare Current Beneficiary Survey (MCBS) who had initial interviews between 1991 and 1996 (for the survival analysis) or between 1992 and 1995 (for the other analyses) (see Appendix, section C, available at www.annals.org).

Each cohort member was placed in a spending group according to the EOL-EI (as defined in detail in Part 1) in their HRR of residence at the time of the index hospitalization (chronic disease cohorts), or initial interview (MCBS cohort). Characteristics of the study cohorts were ascertained from a variety of sources, as described in detail in Part 1, including Medicare administrative files and claims (all four cohorts), chart reviews (acute MI cohort), in-person interview (MCBS cohort), U.S Census data (attributes of ZIP code of residence, such as income, for the three chronic disease cohorts), and American Hospital Association data (to characterize hospitals).

Assignment to Exposure Levels

As we summarized here and described in detail in Part 1, we used two approaches to determine cohort members' exposure to different levels of Medicare spending in their HRR 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 (8, 12) but are not due to differences in case mix or patient preferences (13). 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 who were in their last 6 months of life in each of the 306 U.S. HRRs in mid-1994 to 1997, excluding any members of the study cohorts (Appendix, Section E, available at www.annals.org.) We also repeated the major analyses with an alternative exposure measure, the AC-EI, which was based on differences across HRRs in risk-adjusted spending during an acute illness episode (Appendix, Section F, available at www.annals.org). 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, as was shown in Part 1, of the regional differences in utilization experienced by the study cohorts. For many analyses, we grouped HRRs into quintiles of increasing exposure to the expenditure indices.

Statistical Analyses

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 models to determine the average predicted risk for death across quintiles of Medicare expenditure indices.

Mortality Analyses

The association between the HRR-level expenditure index and survival was assessed by using Cox proportional hazards regression models (14), with the expenditure index measured both as a categorical variable (in which each HRR was assigned to a quintile of Medicare spending based on the EOL-EI) and a continuous variable (using the value of the EOL-EI in the HRR of residence as the exposure). The survival models included independent variables to adjust for patient characteristics, hospital characteristics, and attributes of the HRR. Model fit was assessed by using methods for Cox model residuals to examine overall model fit, to test proportional hazards assumptions, and to identify influential observations. The main survival models underpredicted mortality in the first 6 months, possibly because of short-term complications that could not be adequately predicted with the available data; however, the models provided excellent prediction of 1-year mortality rates for each cohort.

The models are presented in **Appendix Tables 6** through **9** (available at www.annals.org). To test whether the overall findings were consistent across subgroups of each cohort, we ran survival models stratified on all major variables. To test whether the findings were sensitive to our choice of the EOL-EI as our primary exposure, we repeated the analyses using the AC-EI. These sensitivity analyses are described in detail in the Appendix, Section F (available at www.annals.org).

Patients in the same hospital are likely to be treated similarly, so their outcomes may not be statistically independent. We adjusted for within-hospital clustering by using overdispersed survival models, clustering by hospital (14). Model fit was assessed by carefully examining the data to identify HRRs that influenced estimates, predicted values, and likelihood ratio tests. Two moderately influential HRRs, Manhattan, New York, and Miami, Florida, were identified, both of which had relatively lower mortality rates and higher spending than predicted. Excluding these regions would have resulted in hazard ratios greater than those we report for quintile 5 (in the categorical model) and overall (in the continuous models). Analyses, however, are presented with these two HRRs included. We used the STCOX routine of Stata 6.0 (Stata Corp., College Station, Texas) to perform survival analyses in the three chronic disease cohorts. 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 (15).

Change in Functional Status

We used the Health Activities and Limitations Index (HALex) as the primary dependent variable in our longitudinal analyses of changes in functional status (16, 17). The HALex was developed by the National Center for Health Statistics as a composite health status measure that can be calculated by using the responses to the National Health Interview Survey. For our longitudinal analyses, we assigned a HALex score of 0 to respondents who died. Loss to follow-up in these analyses occurred when patients failed to answer enough questions to allow a calculation of the score, did not participate in the survey, or entered a nursing home. Loss to follow-up was as follows: quintile 1, 7.8%; quintile 2, 8.9%; quintile 3, 8.4%; quintile 4, 9.6%; and quintile 5, 13.4%.

The effect of HRR spending on HALex score was modeled by using generalized estimating equation methods for the analysis of continuous longitudinal data (18). The dependent variable was the respondent's annual HALex score for up to 3 years. Each model controlled for individual attributes (**Appendix Table 10**, available at www.annals.org) and included a variable for the time since the initial survey (0, 1, 2, or 3 years). Two sets of models were run, one including indicator variables for quintile of spending, the other including spending as a continuous variable. The principal hypothesis, that increased spending in the HRR of residence would be associated with a slower decline in health status, was tested through the interaction between the EOL-EI of the HRR and the length of time since the initial survey. Different model specifications were tested, both including and excluding interaction terms between time and the other control variables. All analyses yielded similar results for the tests of the principal hypothesis. The models are presented in **Appendix Table 10**, available at www.annals.org. We used the longitudinal sampling weight from the final interview for each respondent and then normalized across all cohort members so that the sum of the weights was equal to the total number in the cohort. The numbers of study participants reported incorporate these weights and are rounded to the nearest integer.

Satisfaction with Care

This analysis was restricted to respondents with at least one physician visit in the previous year. The MCBS interview includes 20 questions on satisfaction with care. Eight items rate the general satisfaction with care received from physicians or hospitals within the past year, while 12 questions are asked only of respondents with a usual physician

Table 1. **Crude and Predicted Mortality Rates in Study Cohorts 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)	
	←———		%		———→	
Hip fracture cohort						
Observed 30-day mortality rate	7.8	7.2	6.9	6.9	6.6	↓
Observed 1-year mortality rate	24.4	23.9	23.9	24.3	24.2	>0.05
Predicted 1-year mortality rate	24.5	24.1	24.1	24.1	23.9	↓
Colorectal cancer cohort						
Observed 30-day mortality rate	4.5	4.6	4.8	4.8	4.4	>0.05
Observed 1-year mortality rate	20.6	20.7	21.7	21.1	20.9	>0.05
Predicted 1-year mortality rate	21.1	20.8	21.2	20.8	20.9	>0.05
Acute MI cohort						
Observed 30-day mortality rate	18.5	18.4	19.2	18.2	18.5	>0.05
Observed 1-year mortality rate	30.7	31.3	32.6	31.6	33.3	↑
Predicted 1-year mortality rate	31.2	31.5	31.8	32.0	33.2	↑
MCBS cohort						
Observed 30-day mortality rate	0.2	0.4	0.4	0.3	0.2	>0.05
Observed 1-year mortality rate	4.6	4.8	5.0	5.1	5.3	>0.05
Predicted 1-year mortality rate	4.9	5.1	5.3	5.0	5.1	>0.05

* Crude mortality rates were based on 30-day and 1-year follow-up for all cohort members with no censoring (follow-up for mortality was complete at 1 year for all). Predicted mortality rates were based on logistic regression equations that included individual- and ZIP code–level variables only. EOL-EI = End-of-Life Expenditure Index; MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction.

† Arrows show the direction of any statistically significant association ($P \leq 0.05$) between the mortality rate and regional EOL-EI differences. An arrow pointing upward indicates that as spending increases across regions, the mortality rate increases. A P value greater than 0.05 was considered not significant.

(93% of the study sample) and focus on that physician's quality. Following the approach of others (19), we created two summary scores of general satisfaction with care (global quality and accessibility) and three summary scores focused on satisfaction with a usual physician (technical skills, interpersonal manner, and information-giving). To test for significant associations between the expenditure index and each summary scale, we used linear regression with each of the five summary scores as the dependent variable and the exposure measured as the HRR-level EOL-EI. The models controlled for age, sex, race, health status, and major U.S. region of residence ($n = 9$). We also compared satisfaction scores on these scales across quintiles of spending. The analysis of satisfaction was based on respondents' first interview.

RESULTS

Patient Characteristics

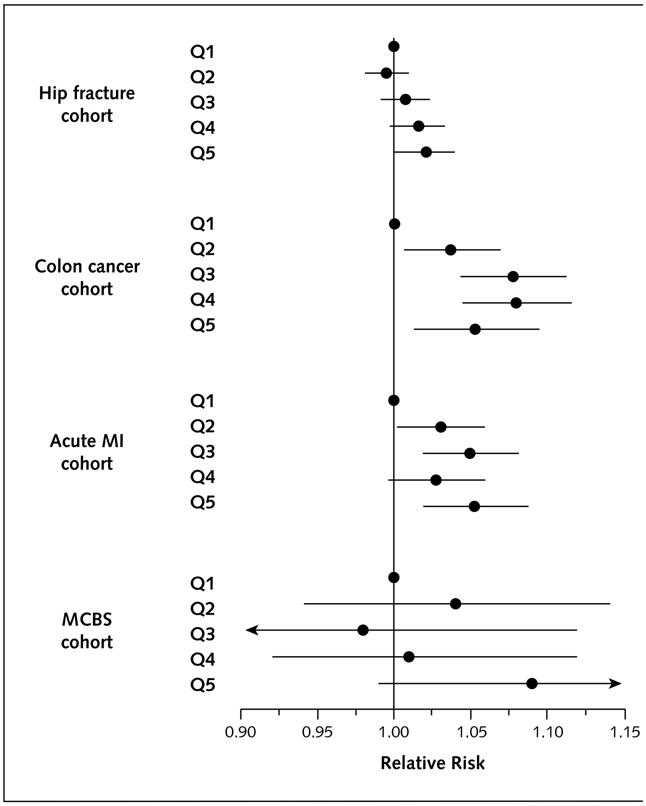
Tables 1 through 4 in Part 1 present selected characteristics of each study cohort grouped into quintiles according to EOL-EI level in their HRRs of residence. Because the sample sizes are large, many small differences for the chronic disease cohorts were statistically significant. Notable differences were found in racial composition (more black persons in higher-expenditure HRRs) and income (higher-expenditure HRRs had more beneficiaries 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 quintiles had a higher prevalence of non–Q-wave infarctions and congestive heart failure but a lower prevalence of creatine kinase levels greater than 1000 IU/L. For the MCBS cohort, residents of HRRs in the quintiles with higher EOL-EIs were more likely to report being in fair or poor health but were less likely to live in a facility.

Crude 30-day and 1-year mortality rates and average predicted 1-year mortality rates for each cohort are shown in **Table 1**. For the hip fracture cohort, average predicted mortality rates at 1 year were slightly but significantly lower in HRRs with a higher EOL-EI. In the acute MI cohort, however, average predicted mortality rates at 1 year were higher in HRRs with a higher expenditure index. No significant differences were found in predicted mortality across HRRs with differing expenditure indices for the colorectal cancer or MCBS cohorts. These findings reveal no consistent trend toward greater illness burden in HRRs with a higher expenditure index. Observed mortality tended to be lower than predicted in the lowest quintile and equal to or higher than predicted in the highest quintile.

Mortality

Figure 1 presents the relative risk for death over 5 years for residents of HRRs in EOL-EI quintiles 2, 3, 4, and 5 (the higher quintiles) compared with residents of HRRs in the lowest quintile. In each cohort, an increase in EOL-EI was associated with a small increase in the risk for death. We repeated these analyses using the HRR-specific EOL-EI as a continuous variable both overall and in specific subgroups (**Figures 2** through **4**). A relative risk

Figure 1. **Adjusted relative risk for death during follow-up across quintiles of Medicare spending.**



Circles represent adjusted relative risk for death among residents of hospital referral regions in the specified quintile of the End-of-Life Expenditure Index (EOL-EI) compared to the risk for death among residents of hospital referral regions in quintile 1 of the EOL-EI; bars represent 95% CIs. MCBS = Medicare Current Beneficiary Survey; MI = myocardial infarction; Q1 = quintile 1; Q2 = quintile 2; Q3 = quintile 3; Q4 = quintile 4; Q5 = quintile 5.

greater than 1 indicated that residence in an HRR with a higher EOL-EI (higher expenditures) was associated with increased mortality. For every 10% increase in the EOL-EI, the relative risk for death over 5 years was as follows: hip fracture cohort, 1.003 (CI, 0.999 to 1.006); colorectal cancer cohort, 1.012 (CI, 1.004 to 1.019); acute MI cohort, 1.007 (CI, 1.001 to 1.014); and MCBS cohort, 1.01 (CI, 0.99 to 1.03). In none of the subgroups examined was a higher expenditure index associated with a statistically significantly lower mortality rate.

We repeated the mortality analyses using the alternate approach: assigning HRRs to different exposure levels based on the AC-EI. Residents of higher-spending HRRs, according to the AC-EI, had relatively similar baseline health status (**Appendix Table 17**, available at www.annals.org) and yet received substantially more care (**Appendix Table 18**, available at www.annals.org). The results of the mortality analyses are summarized in **Table 2**. For the hip fracture cohort, higher AC-EIs were associated with a small decrease in mortality rates. For all of the other cohorts, mortality rates did not differ or increased slightly in regions with a higher AC-EI.

Change in Functional Status

The average decline in functional status, as measured by using the HALex score, was about 2 points per year (on a 100-point scale) but did not differ across HRRs grouped according to quintiles of the EOL-EI (**Table 3**). In none of the models examined was an increased expenditure index associated with a statistically significant difference in the average rate of decline in health status (**Appendix Table 10**, available at www.annals.org).

Satisfaction with Care

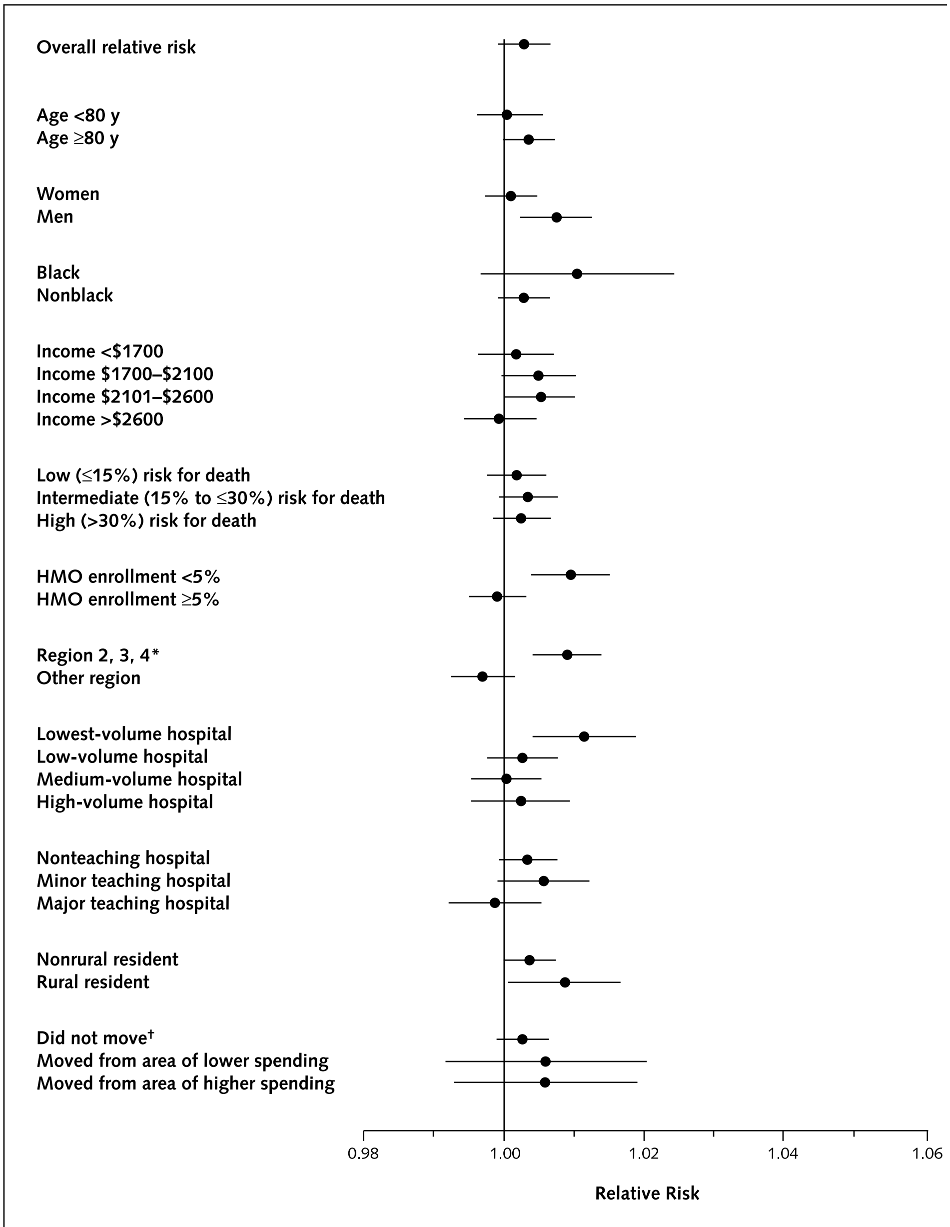
Figure 5 presents average change in adjusted satisfaction scores across quintiles (compared with quintile 1) for the five summary scales. Each scale ranges from 0 to 100, with higher scores implying greater satisfaction. We found substantial variation in satisfaction with care across the nine major U.S. regions (for example, Northeast and Mid-Atlantic), with satisfaction on each scale averaging over five points higher in the Northeast than in the South, controlling for other factors (data not shown). The differences in satisfaction across EOL-EI quintiles, however, were smaller than these regional differences and did not reveal a consistent pattern of greater satisfaction in HRRs with a higher expenditure index. The overall test for trend across HRRs indicated less global satisfaction with care and more satisfaction with interpersonal aspects of care in higher-spending HRRs. No differences were found across HRRs of differing expenditure indices for the other three measures of satisfaction with care.

DISCUSSION

We conducted a cohort study in four distinct samples of Medicare enrollees, comparing the outcomes of care across 306 U.S. HRRs that differed dramatically in levels of Medicare spending and utilization. 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 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 our four study cohorts) increased steadily and substantially across quintiles. Regardless of the measure used to characterize spending, residents of the highest-spending quintile received about 60% more care than those of the lowest-spending quintile.

As shown in detail in Part 1, these differences in spending were explained almost entirely by greater frequency of physician visits, more frequent use of specialist consultations, more frequent tests and minor procedures,

Figure 2. **Adjusted relative risk for death associated with a 10% increase in Medicare spending overall and among specified subgroups of the hip fracture cohort.**

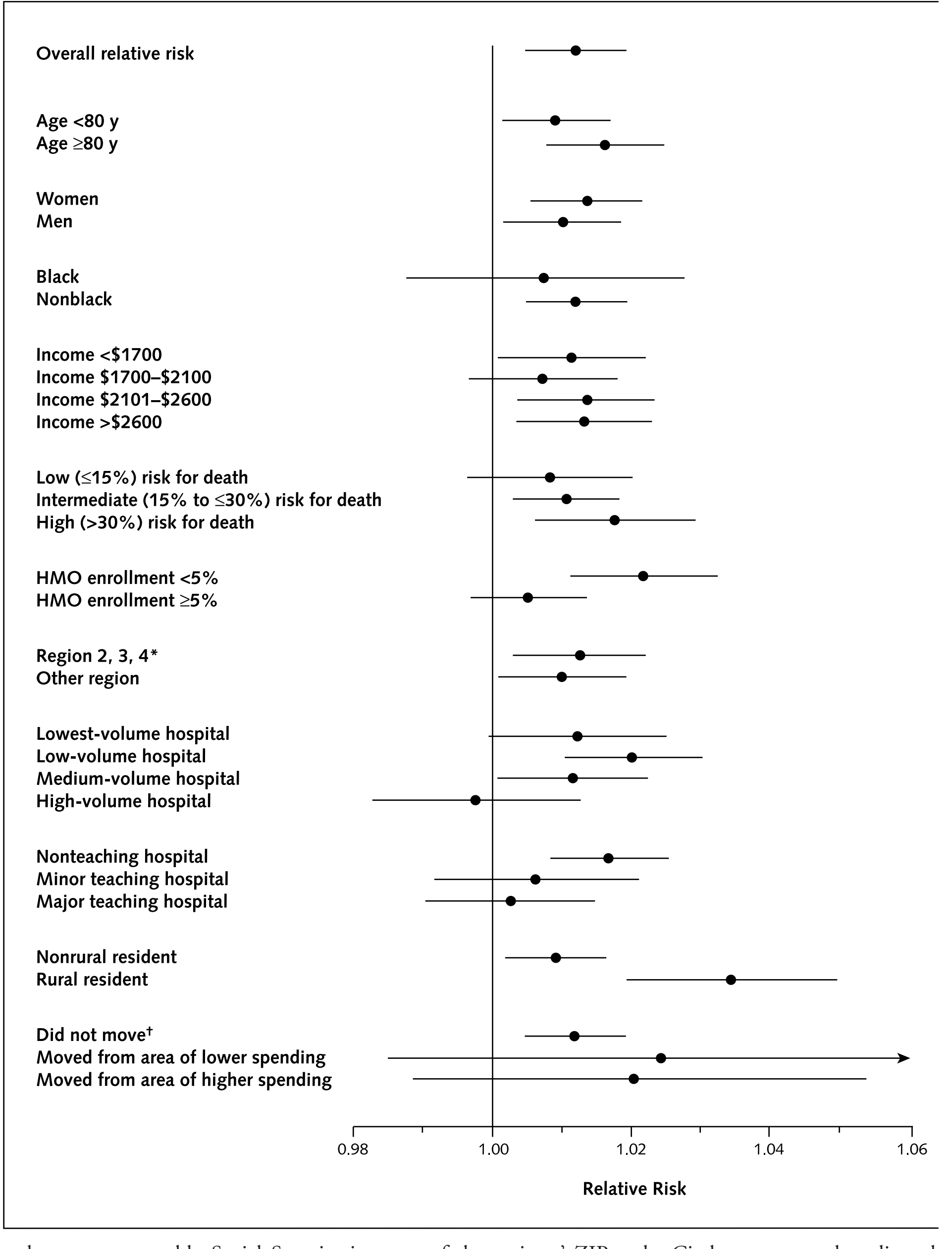


Income figures refer to the average monthly Social Security income of the patients' ZIP codes. Circles represent the adjusted relative risk for death associated with a 10% increase in the End-of-Life Expenditure Index across U.S. hospital referral regions; bars represent 95% CIs for the relative risk. *Mid-Atlantic, South Atlantic, and Great Lakes regions. †Did not change hospital referral region of residence in the 1 to 2 years before index admission. HMO = health maintenance organization.

and greater use of the hospital and intensive care unit in high-spending regions. In this paper, Part 2, we found no evidence to suggest that the pattern of practice observed in higher-spending regions led to improved survival, slower decline in functional status, or improved satisfaction with care.

In Part 1, we discussed the major limitations related to the analyses of utilization. Here we focus primarily on the limitations related to our analysis of health outcomes. First, because of the observational nature of our study, the small increase in mortality rate observed in regions with higher spending levels as assigned by end-of-life spending must be interpreted with caution. It is possible that the higher mortality rates observed in high-spending regions could be caused by the patterns of practice in regions where patients near the end of life are treated more intensively because of either relative overuse of such services as diagnostic tests and hospital-based care (for example, complications of treatment) or lower-quality care (for example, failure to provide such evidence-based services as immunizations).

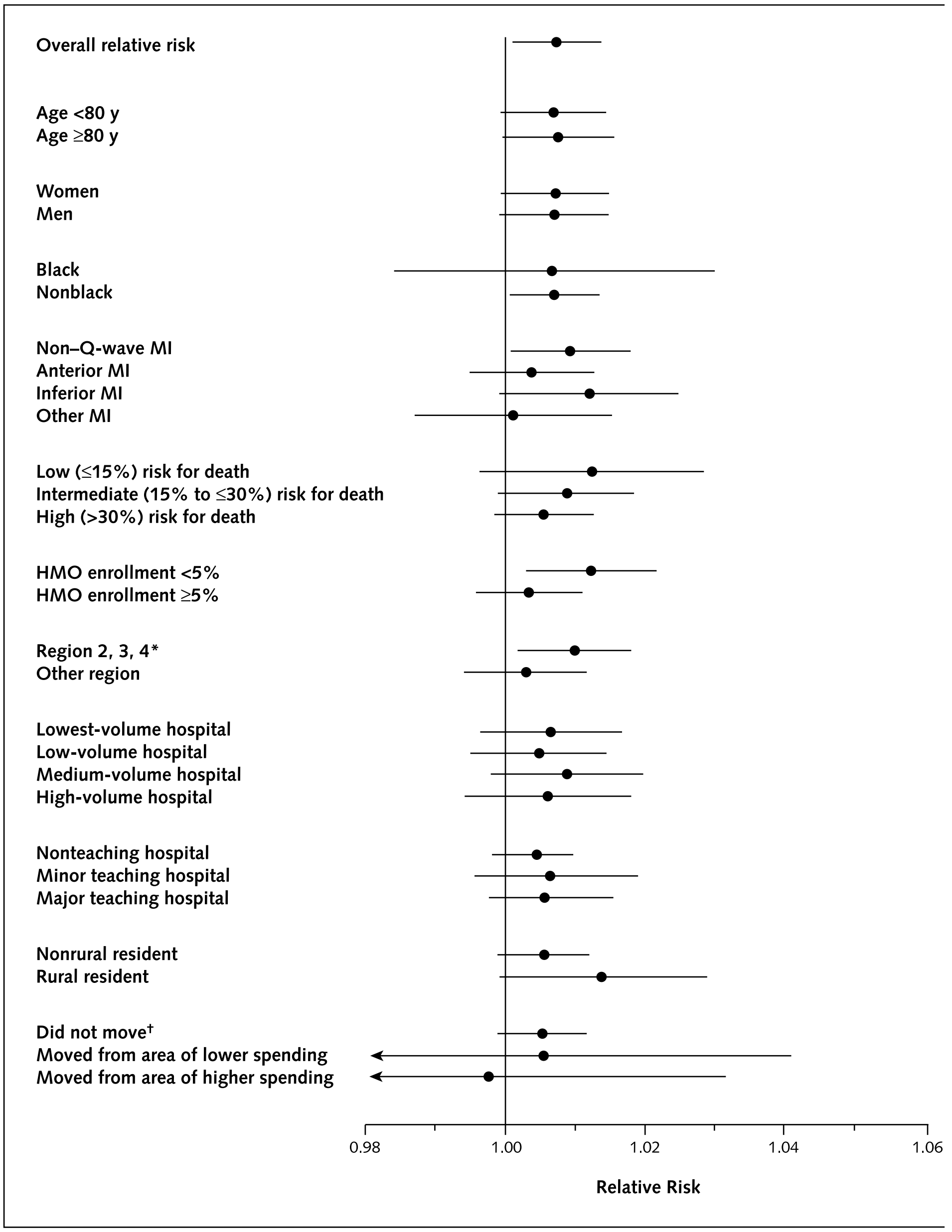
Figure 3. **Adjusted relative risk for death associated with a 10% increase in Medicare spending overall and among specified subgroups of the colorectal cancer cohort.**



Income figures refer to the average monthly Social Security incomes of the patients' ZIP code. Circles represent the adjusted relative risk for death associated with a 10% increase in the End-of-Life Expenditure Index across U.S. hospital referral regions; bars represent 95% CIs for the relative risk. *Mid-Atlantic, South Atlantic, and Great Lakes regions. †Did not change hospital referral region of residence in the 1 to 2 years before index admission. HMO = health maintenance organization.

On the other hand, it is possible that the increased mortality rate could be explained by unmeasured differences in case mix across regions of differing spending levels. We tried to account for this contingency in our study design (by use of the natural randomization approach) by controlling for numerous patient and regional attributes in our models. The stratified analyses (**Figure 2**) also suggest that unmeasured confounding is unlikely. Any potential confounder would have to operate similarly across all of these strata. Some might argue, for example, that even among similarly ill patients, those who are aware of increased risk might move closer to teaching hospitals or to higher-spending regions (that is, that differences in patterns of migration, with sicker retirees moving to areas where capacity is greatest, explain our findings). That our findings are consistent across patients in teaching and nonteaching hospitals and among patients who had recently moved and those who had not argues against such con-

Figure 4. **Adjusted relative risk for death associated with a 10% increase in Medicare spending overall and among specified subgroups of the acute myocardial infarction (*MI*) cohort.**



Income figures refer to the average monthly Social Security income of the patients' ZIP codes. Circles represent the adjusted relative risk for death associated with a 10% increase in the End-of-Life Expenditure Index across U.S. hospital referral regions; bars represent 95% CIs for the relative risk. *Mid-Atlantic, South Atlantic, and Great Lakes regions. †Did not change hospital referral region of residence in the 1 to 2 years before index admission. HMO = health maintenance organization.

founding. Nevertheless, the fundamental limitation of observational studies must be acknowledged: We cannot determine whether the small increase in mortality rate is due to the treatment differences (regional differences in practice) or to unmeasured differences in the comparison groups.

Our analyses using the AC-EI provide additional evidence that the regional differences in Medicare spending observed across the United States are unlikely to provide important benefits in terms of improved survival. These findings suggest that even when HRRs are stratified according to differences in how patients are treated during an episode of acute illness, regions that take the more intensive approach to acute care do not achieve better survival. For unmeasured confounding to have led to our findings, the unmeasured confounder would have to be correlated both with end-of-life spending and with regional differences in risk-adjusted acute care spending and would have to predict increased risk for death in all four cohorts. While this possibility must be acknowledged, it appears unlikely.

Table 2. **Adjusted Relative Risk for Death across Quintiles of Medicare Spending and Relative Risk Associated with a 10% Increase in Medicare Spending, as Estimated by Using the Acute Care Expenditure Index (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 the level of the AC-EI in the hospital referral registry 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.

The consistency of our findings across different measures of the exposure and different study cohorts argues that the increased Medicare spending in high-cost regions provides no important benefits in terms of survival.

A second limitation of this study is that we were able to examine functional outcomes and satisfaction with care only in the general population sample and not in our three high-risk, chronic disease cohorts. Although the quality of care provided to the three chronic disease cohorts appeared no better in higher-spending regions, it remains possible that the increased use of specialists, diagnostic tests, and hospital-based care led to better functional outcomes, quality of life, or satisfaction with care. Further research is warranted to address this possibility.

It is also possible, however, that the increased intensity of treatment provided to severely ill patients could lead to poorer quality of life and less satisfaction. The most striking differences in practice in higher-spending regions are found in the care of patients near the end of life, regardless of whether the definition of a "high-spending" region is based on one of the indices used here or on average per capita Medicare spending (8). Our findings suggest that the more aggressive patterns of practice observed in high-spending regions offer no benefit in terms of their major aim, which is improving survival. In addition, we know of no evidence to suggest that the nearly threefold greater use of invasive life support (intensive care unit utilization, emergency intubation, and feeding tubes) seen in high-spending regions results in improved quality of life or satisfaction with care.

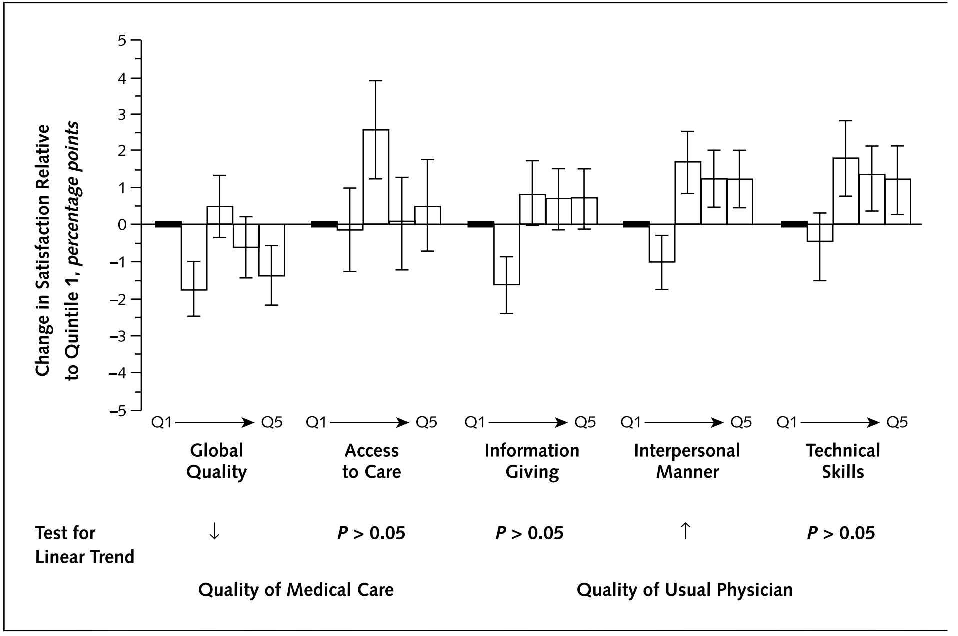
Finally, because our primary exposure variable is ecological, in the sense that residence in a region with higher Medicare spending is a characteristic of patients' environment, some may be concerned that our inferences are suspect because of the "ecological fallacy" (39, 40). The ecological fallacy occurs when one tries to answer a purely individual-level question (for example, Is high saturated fat intake associated with a person's risk for heart disease?) with data derived from groups of people (for example, the average risk for heart disease in a group). The fallacy lies in assuming that an association observed at one level of aggregation (for example, countries) automatically implies the association at a different level (for example, individual patients). It is most likely to occur when both outcomes and predictors of that outcome (including measures of exposure and measures used to adjust for group differences) are ascertained only for the groups and not for individuals. Our research interest was to determine whether a system-level variable—increased Medicare spending in a given region—leads to better care or better outcomes for the average individual Medicare enrollee residing in that region. We chose an ecological (system-level) exposure measure because it is the appropriate exposure measure for this specific research question. In addition, because we were interested in the effects of regional spending on the care of individual patients, our unit of analysis was the patient.

Table 3. **Average Change per Year in Functional Status on Health Activities and Limitation Index among Participants in the Medicare Current Beneficiary Survey according to Medicare Spending in the Hospital Referral Region of Residence***

Variable	Quintile of EOL-EI				
	1 (Lowest)	2	3	4	5 (Highest)
Change in functional status (95% CI)	−1.96 (−2.36 to −1.55)	−2.18 (−2.65 to −1.71)	−2.28 (−2.84 to −1.71)	−1.94 (−2.40 to −1.47)	−1.96 (−2.42 to −1.50)

* Scores on the Health Activities and Limitations Index at follow-up ranged from 0 (death) to 100 (excellent self-assessed health and no limitations). Results controlled for differences in age, sex, race, chronic conditions, residence in a facility, residence in a metropolitan region, whether respondent was bedridden, smoking status, income, education, marital status, and supplemental insurance coverage. EOL-EI = End-of-Life Expenditure Index.

Figure 5. **Satisfaction with care.**



An arrow pointing upward indicates a positive association between increased spending and satisfaction. Bars represents 95% CIs. Q1 = quintile 1; Q5 = quintile 5.

We measured outcomes and variables used to adjust for group differences at the patient level and could therefore control effectively for individual characteristics in the analysis. The ecological fallacy therefore applies neither to our design nor to our analysis. We can legitimately conclude that the average Medicare patient in higher-spending regions (and the average patient in each subgroup examined) receives much more care than those in lower-spending regions and that this additional care is not associated with better access to care, higher-quality care, or better health outcomes.

Previous research on regional variations in utilization and outcomes has been largely ecological in design, examining cross-sectional correlations at the area level between spending and utilization (5) or between spending or utilization and mortality (9, 12, 22). These earlier studies have been criticized for weak designs, 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. Our study addressed each of these concerns. We adopted a longitudinal design and obtained extensive baseline data on patients' health and socioeconomic status that allowed us to control for potential differences in need for care. We were also able to characterize in detail patients' access to care, use of services, and quality of care. Finally, we showed that these regional differences in utilization and outcomes were consistently seen in each subgroup of the samples. Black or white, poor or rich, high-risk or low-risk, patients in higher-spending regions received much more care (**Appendix Tables 12 through 14**, available at www.annals.org) but did not have better outcomes.

Our study provides limited guidance on the potential impact of reducing regional disparities in spending or the implementation of policies to constrain the use of these supply-sensitive services. From a clinical perspective, it is important to recognize that our study does not address the question of how the amount of care for an individual patient in a specific case would affect that patient's clinical outcome. What may appear to be relatively low-risk interventions (such as hospitalization or ordering a diagnostic test) may cause harm in some settings, just as failure to provide these or other services (such as bypass surgery in high-risk patients) may cause harm in other settings. From a policy perspective, our study does not tell us definitively that it is possible to reduce Medicare spending within a particular region without affecting patient care or outcomes. Previous research has shown that vulnerable populations may be harmed by reduced access to care (23, 24) or as a consequence of public hospital closures (25). It is not always clear, for example, whether services such as specialist consultations are wasteful or beneficial. The potential adverse impact of reductions in the use of beneficial services and disruptions in current practice patterns underscores the importance of further research on these issues and of the implementation and evaluation of demonstration projects intended to improve quality of care and promote conservative approaches to managing patients with chronic disease (8).

Debates over the need for further growth in medical spending and expansion of the medical workforce are largely based on the assumption that additional services will provide important health benefits to the population served. Our study suggests that this assumption is unwarranted. Our study also underscores the need for research to determine how to safely reduce spending levels. If the United States as a whole could safely achieve spending levels comparable to those of the lowest-spending regions, annual savings of up to 30% of Medicare expenditures could be achieved (3). Such savings could provide the resources to fund important new benefits, such as prescription drugs or expanded Medicare coverage to younger age groups, or to extend the life of the Medicare Trust Fund to better cover the health care needs of future retirees.

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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 × normalized log-likelihood with β(s) = 89 696.39; −2 × normalized log-likelihood full model = 84 651.09; approximate chi-square value (−2 × 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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