Annals of Internal Medicine | Review

The Association Between Health Care Quality and Cost

A Systematic Review

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Background: Although there is broad policy consensus that both cost containment and quality improvement are critical, the association between costs and quality is poorly understood.

Purpose: To systematically review evidence of the association between health care quality and cost.

Data Sources: Electronic literature search of PubMed, EconLit, and EMBASE databases for U.S.-based studies published between 1990 and 2012.

Study Selection: Title, abstract, and full-text review to identify relevant studies.

Data Extraction: Two reviewers independently abstracted data with differences reconciled by consensus. Studies were categorized by level of analysis, type of quality measure, type of cost measure, and method of addressing confounders.

Data Synthesis: Of 61 included studies, 21 (34%) reported a positive or mixed-positive association (higher cost associated with higher quality); 18 (30%) reported a negative or mixed-negative association; and 22 (36%) reported no difference, an imprecise or indeterminate association, or a mixed association. The associations were of low to moderate clinical significance in many studies. Of 9 studies using instrumental variables analysis to address confounding by unobserved patient health status, 7 (78%) reported a positive association, but other characteristics of these studies may have affected their findings.

Limitations: Studies used widely heterogeneous methods and measures. The review is limited by the quality of underlying studies.

Conclusion: Evidence of the direction of association between health care cost and quality is inconsistent. Most studies have found that the association between cost and quality is small to moderate, regardless of whether the direction is positive or negative. Future studies should focus on what types of spending are most effective in improving quality and what types of spending represent waste.

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Although there is broad policy consensus that both cost containment and quality improvement are critical, the association between health care costs and quality is one of the more controversial topics in health policy. One possibility is that improvements in quality will require increases in cost (or conversely, cost reductions could reduce quality) (1, 2). On the other hand, improvements in quality could lower costs by reducing complications or hospital readmissions (3). In reality, the association between cost and quality probably falls between these 2 extremes, so that some types of health care costs are associated with high quality and others with poor quality. The effect depends on where the money is spent (4).

The debate over the cost–quality association has been largely framed by several seminal studies that compared geographic areas in the United States. These studies documented large variations in cost across areas, with no evidence that higher-cost areas had better quality or health outcomes (5–8). Both the methods and the interpretation of these studies have been heavily debated (4, 9–11). The Patient Protection and Affordable Care Act mandated that the Institute of Medicine further study the issue of geographic variation in cost and quality (12). Other studies of the cost–quality association have compared units other than geographic areas (such as hospitals) using various methods and have come to different conclusions (13, 14). To our knowledge, there has been no previous systematic literature review of evidence on the cost–quality association in health care.

Among studies on the association between health care costs and quality, several design characteristics may be critical. First, level of analysis is important because area-level studies may yield different results than provider- or patient-level studies (4). Second, there are many ways to measure quality, each of which may have different associations with cost (15). For example, a structural measure of quality, such as nurse staffing per patient, will probably have different cost implications than higher performance on an outcome measure, such as patient functional status. Third, "cost" can be measured in many ways, such as reimbursement from a health plan or the amount of resources used by a provider (16). Fourth, studies may use different statistical methods, particularly in adjusting for the effects of health status on quality and costs.

To document the association between health care cost and quality and identify sources of heterogeneity between studies, we conducted a systematic review of evidence from published literature that assesses the association between health care costs and quality.

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METHODS

Data Sources and Searches

We searched published literature for studies that examined the association between quality and cost or spending measures. Keywords and medical subject headings included *health care costs*, *health spending*, and *quality of health care*, among others. We searched PubMed, EconLit, and EMBASE databases. We also examined the bibliographies of selected studies for other potentially relevant publications and considered studies found by ad hoc searches and consultations with outside experts.

Study Selection

We included studies that empirically tested the direct association between a health care quality measure and a cost or spending measure; were published between 1 January 1990 and 10 June 2012; and focused on health care delivery at the patient, provider, or area level in the United States. We chose these criteria to exclude studies focused on the cost–benefit or cost-effectiveness of specific drugs, devices, or medical treatments (as opposed to the cost and quality of care in different delivery settings) and to ensure that the results would be generalizable to other U.S. delivery settings.

One reviewer reviewed titles and abstracts identified in the initial search for studies potentially meeting inclusion criteria. Two reviewers subsequently reviewed the full text of these studies to make final determinations of study eligibility.

Data Extraction

Two reviewers independently abstracted relevant data from the included studies using a standardized form developed for this review. All discrepancies between reviewers were resolved by consensus. Variables abstracted included unit of analysis, study population, cost measure, quality measure, control for confounders (for example, age, sex, and health status), association between cost and quality measures, and statistical methods used.

Data Synthesis and Analysis

The main study outcomes of interest were the direction, magnitude, and statistical significance of the reported association between quality and costs. Some studies compared the association between costs and quality using several types of measures. Therefore, the number of comparisons (defined as a test of the association between cost measures of a single type and quality measures of a single type) exceeded the number of studies. We analyzed reported findings of the magnitude and statistical significance of the cost–quality association for each comparison.

Comparisons were categorized as demonstrating "positive" quality–spending associations if higher cost was significantly associated with higher quality across all measures and "mixed-positive" if higher cost was significantly associated with higher quality across most, but not all, measures. Similarly, comparisons that reported that higher cost was significantly associated with lower quality were categorized as "negative" or "mixed-negative." Comparisons finding both significant positive and negative associations for different measures or analyses of the same measures were labeled "mixed." Those reporting no significant association were labeled "no difference" if the study reported a precise estimate of a zero or very small association and "imprecise or indeterminate" if the study results did not rule out the possibility of a meaningful association. To facilitate interpretation of results, we sometimes collapsed the associations into 3 groups: positive and mixed-positive findings; mixed, no difference, and imprecise or indeterminate findings; and negative and mixed-negative findings. We did not categorize studies by the magnitude of reported cost–quality associations; magnitudes were difficult to compare across studies because of the heterogeneity of cost and quality measures used and incomplete reporting of information needed to interpret magnitude. However, we present available information about the range of magnitudes of associations reported in included studies and provide examples of studies reporting findings with different levels of clinical significance.

Studies were categorized by 4 criteria: level of analysis, type of quality measure (several types per study were possible), type of cost measure (several types per study were possible, but we found that each reviewed study used only a single type of cost measure), and method of addressing

Table 1. **Examples of Cost Measures in Sample**

Type of Cost Measure Studied	Included Studies Using Cost Measure Type, *n*	Study Author, Year (Reference)	Cost Measure Used in Study Example
Charges	4	Kaestner and Silber, 2010 (18)	Total inpatient charges (spending associated with all resource use and tallied by hospital) per Medicare admission
Care intensity index	13	Fisher et al, 2003 (5)	HRR-level EOL-EI = hospital and physician spending during last 6 mo of life; AC-EI = spending on physician and hospital services provided during the first 6 mo after index hospitalization (care intensity index)
Expenditure	20	Fu and Wang, 2008 (19)	Annual per capita total health expenditure including private insurance, public payers, and other sources (including out-of-pocket costs)
Accounting costs	24	Schreyögg and Stargardt, 2010 (20)	Costs incurred during index hospitalization, from VA cost accounting system

AC-EI = acute care expenditure index; EOL-EI = end-of-life expenditure index; HRR = hospital referral region; VA = Veterans Affairs.

confounding by health status and other factors. The level of analysis was defined as the provider (for example, hospital, nursing home, or physician), patient, or geographic area for which quality and cost or spending were measured and compared. Area-level studies typically measure the association between average health spending in the area and average quality in the area—for example, the association between average state health spending and an index of state health care quality (7). Several studies measured spending at an area level and quality at a patient level (5, 6); these studies were categorized as area-level studies. For reporting purposes, we present health plan level studies in the area category in tables.

Quality measures were classified into 6 categories. Five were defined by the Agency for Healthcare Research and Quality's National Quality Measures Clearinghouse (17): structure, process, outcome, patient experience, and access. The sixth category included composites of measures in 2 or more of these categories.

Cost measures were classified into 4 categories. Examples of measures in each category are provided in **Table 1**. "Accounting costs" measures reflect the resources used to produce health care as measured by providers' accounting systems or estimating costs by adjusting charges using facility- or department-level cost–charge ratios from accounting systems. "Charges" measures reflect the amount that providers billed insurers for services rendered. "Expenditure" measures reflected payments for health care services by health plans, beneficiaries, or other payers. Some studies used a "care intensity index" to reflect the relative amount of resources used to produce health care services.

Lastly, studies were classified according to the methods by which they addressed confounders. A main threat to studies examining the cost–quality association is confounding by unmeasured differences in patient characteristics, particularly health status. We documented the methods that studies used to address confounding by health status and separately analyzed the subset of studies that used instrumental variables analysis (21, 22) to address confounding by unobserved differences in health status.

Role of the Funding Source

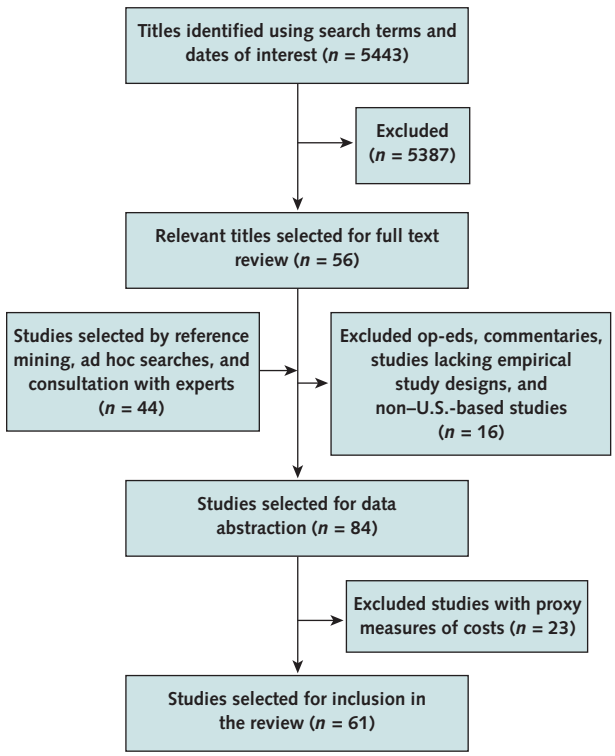
This study was funded by the Robert Wood Johnson Foundation. The funding source provided input on the scope of the study and commented on interim results but was not involved in the collection, analysis, and interpretation of the data, or in the decision to submit the manuscript for publication.

RESULTS

Search Results

The initial search resulted in 5443 citations (**Figure**), 56 of which were selected for full-text review. Reference mining citations in selected studies, ad hoc searches, and expert consultations yielded 44 additional studies. Of these 100 studies, 39 were excluded because they did not empirically test the association between cost and quality or because they examined populations outside the United States. In total, 61 studies were selected for inclusion in the review. Fifteen of these studies included quality measures in several categories; however, none included cost measures in multiple categories. We separately analyzed comparisons by quality measure type.

Figure. **Summary of evidence search and selection.**



Characteristics of Included Studies

Table 2 presents the number of studies using each level of analysis and the types of cost and quality measures used in studies at each level of analysis. The included studies were widely heterogeneous in the level of analysis, cost measure, and quality measure used. There was no clear pattern of cost or quality measure used by level of analysis.

Twelve studies (20%) used area-level analysis. Among provider-level studies, hospitals were the most common level of analysis (29 studies [48%]) and nursing homes were the second most common (8 studies [13%]). Forty-one studies (67%) included outcome measures of quality, 19 studies (31%) included process measures, and other domains of quality appeared in fewer than 10 studies each. Twenty-four studies (39%) measured accounting costs, 20 studies (33%) measured expenditures, 13 studies (21%) used a care intensity index, and 4 studies (7%) measured unadjusted charges. Nine studies (15%) used instrumental

Table 2. **Studies by Type of Cost Measure and Quality Measure**

Level of Analysis	Total Studies, *n*	Studies, by Cost Measure Type, *n*				Studies, by Quality Measure Type, *n**					
		Accounting Costs	Care Intensity Index	Charges	Expenditure	Access	Composite Measure	Outcome	Patient Experience	Process	Structure
Patient	5	1	0	0	4	0	0	2	3	0	0
Provider											
Disease management program	1	0	1	0	0	0	0	1	0	1	0
Hospital	29	18	4	3	4	0	1	23	1	7	1
Nursing home	8	5	0	0	3	0	1	8	0	2	3
Physician	3	0	0	1	2	1	0	2	0	2	1
Provider group	2	0	0	0	2	0	0	0	0	2	0
Region											
Area	12	0	8	0	4	3	0	5	4	4	0
Health plan	1	0	0	0	1	0	0	0	0	1	0
All	61	24	13	4	20	4	2	41	8	19	5

* 15 studies included several types of quality measures.

variables analysis for addressing unobserved patient severity (**Appendix Tables 1** to **3**, available at www.annals.org).

Direction of the Association Between Costs and Quality

Table 3 presents the direction of association between cost and quality documented in included studies, and the **Appendix Tables** include information on the sample, methods, cost and quality measures, and findings abstracted from each study. The findings of the association between health care cost and quality were inconsistent, with 21 studies (34%) reporting a positive or mixed-positive association (higher cost associated with higher quality); 18 studies (30%) reporting a negative or mixed-negative association (lower cost associated with higher quality); and 22 studies (36%) reporting no difference (1 study), an imprecise or indeterminate association (8 studies), or mixed association (13 studies). However, statistical significance alone provides only a limited assessment of the evidence on the association between costs and quality.

Magnitude of the Association Between Costs and Quality

Among studies reporting positive associations, the magnitude of the cost–quality association was typically of low to moderate clinical significance. Examples of smaller associations include a difference of 1 to 5 percentage points on process quality measures for acute myocardial infarction, congestive heart failure, and pneumonia (for example, use of a β-blocker at discharge for acute myocardial infarction) between hospitals in the highest and lowest quartiles of cost (13); a decrease in probability of mortality within 2 years of 0.0043 for each $1000 increase in the cost of a hospital stay (23); and 3% lower mortality (0.25 fewer deaths per 100 discharges) in hospitals at the 50th percentile versus 75th percentile of cost.

However, some studies did find larger, more clinically significant associations and many studies did not present sufficient information for interpretation of clinical significance. Examples of more clinically significant associations include an odds ratio for in-hospital mortality among patients who had an acute myocardial infarction at hospitals in the highest- versus lowest-spending quintile of 0.741 (95% CI, 0.590 to 0.891) (24), 10% greater spending over 3 years associated with a 1.5% greater survival probability (25), and a 3.1% to 11.3% decrease in 30-day mortality (varying by condition) associated with a 10% ($2000 to $5000) increase in hospital charges per admission (18).

Among studies with a negative association, there was also a range of magnitude. Examples of smaller associations include a 10% increase in area-level end-of-life care spending associated with a 1.003-higher relative risk for death among patients with hip fracture (CI, 0.999 to 1.006) (6); a rate of acute reperfusion that was 6 percentage points lower for patients who had an acute myocardial infarction in areas in the highest versus lowest quintile of end-of-life care spending (5); and an additional $10 000 in average hospital spending for end-of-life care associated with a decrease of 5.3 percentage points on a composite of process measures for acute myocardial infarction, pneumonia, and congestive heart failure (14). Examples of larger associations include a difference of 15 percentage points in the proportion of physicians who felt able to obtain high-quality specialist referrals between highest- and lowest-spending areas (26), relative cost of trauma patients treated in hospitals with low risk-adjusted mortality rates of 0.78 (CI, 0.64 to 0.95) compared with average-mortality hospitals, and hospitals with at least 1 missed quality measure associated with 7.8% higher cost than hospitals with none missed (27).

The results presented in many of the imprecise or indeterminate studies do not rule out the possibility of a real and clinically significant cost–quality association. For example, a study of 22 Veterans Affairs geographic networks found that an average increase of $1000 in risk-adjusted

funding was associated with nonstatistically significantly lower odds of death among male patients (odds ratio, 0.943 [CI, 0.880 to 1.010]) (28). With a larger sample size, the study may have identified a statistically and clinically significant association. Only 2 studies included comparisons with a precise estimate of a negligible association between cost and quality (29, 30).

Associations by Level of Analysis

The study findings of the association between cost and quality were also inconsistent at the various levels of analysis studied. The 2 exceptions were that hospital analyses were slightly more likely to report a positive association (13 positive [45%] and 10 negative [34%]) than were studies using other levels of analysis, whereas area-level studies were more likely to report a negative association (2 positive [17%] and 5 negative [42%]).

For hospital studies, a common comparison was between cost per discharge and the in-hospital or posthospitalization mortality rate (31). Another type of common comparison was between hospital costs and process quality measures reported on the Centers for Medicare & Medicaid Services Hospital Compare Web site (13, 14, 32). However, the type of study design did not seem to be systematically associated with the study findings.

Most area-level studies focused on comparisons between hospital referral regions (regional health care markets for tertiary care defined by the Dartmouth Atlas Project [33]), states, or counties. Some studies compared area-level mean spending and quality (7, 10), and others tested for an association between area-level spending and quality of care for patients treated in those areas (5, 6, 34). The results of these studies were also inconsistent, although only 2 of 12 studies (16.7%) reported a positive cost–quality association. Five studies (41.7%) reported no difference, an imprecise or indeterminate association, or a mixed association, and 5 studies (41.7%) reported a negative association.

Findings by Quality Measure Type

Most studies (41 studies [67%]) focused on an outcome measure (most commonly, a mortality measure). Comparisons between outcomes measures and cost had inconsistent findings: 17 (41.5%) resulted in a positive association with costs; 10 (24.4%) resulted in a negative association; and 14 (34.1%) resulted in no difference, an imprecise or indeterminate association, or a mixed association. Comparisons using process measures and costs also had inconsistent results. There were no systematic differences in the results of studies using underuse versus overuse process measures.

Five studies (8%) used structural measures of quality. Three studies examined correlations between spending and staffing levels in nationwide samples of nursing homes; all 3 found positive associations with cost (35–37). Two other studies showed negative associations between quality and cost (3, 38). Studies using access, patient experience, or composite measures of quality also had inconsistent findings.

Findings by Cost Measure Type

The results of the studies did not vary systematically by the type of cost measure used. Findings were mixed among the 24 studies using accounting costs, with 11 studies (45.8%) reporting a positive cost–quality association; 4 (16.7%) reporting a negative association; and 9 (37.5%) reporting no difference or mixed or indeterminate findings.

Studies that compared health expenditures and quality were similarly mixed, with 5 of 20 studies (25%) reporting positive associations, 5 (25%) reporting negative associations, and 10 (50%) with imprecise or indeterminate findings or mixed findings.

Thirteen studies compared quality with various composite measures of spending or care intensity indices. The most commonly used care intensity index was the end-of-life care expenditure index developed by the Dartmouth Atlas Project (5, 6), used in 9 studies (69%). Of these 9 studies, 5 (56%) reported a negative cost–quality association, 2 (22%) reported a positive association, and 2 (22%) had mixed findings or imprecise or indeterminate findings. This index uses a "looking-back" approach, measuring health expenditure at the end of life among a cohort of

Table 3. **Studies by Reported Association Between Health Care Cost and Quality**

Variable	Studies, by Reported Association Between Health Care Cost and Quality, *n*		
	Positive	Negative	Imprecise or Indeterminate, Mixed, or No Difference
Level of analysis			
Patient	3	1	1
Provider			
Disease management program	1	0	0
Hospital	13	10	6
Nursing home	2	1	5
Physician	0	1	2
Provider group	0	0	2
Region			
Area	2	5	5
Health plan	0	0	1
All	21	18	22
Cost measure type			
Accounting costs	11	4	9
Care intensity index	4	6	3
Charges	1	3	0
Expenditure	5	5	10
All	21	18	22
Quality measure type*			
Access	0	3	1
Composite measure	0	1	1
Outcome	17	10	14
Patient experience	2	3	3
Process	6	5	8
Structure	3	2	0
All	28	24	27

* 15 studies included quality measures in multiple domains.

deceased patients. Other studies used a "looking-forward" approach, measuring the intensity of care among a cohort at a similar level of health risk. Four studies used other care intensity indices based on use of services, such as intensive care (39), structured care management (29), hospital days and physician visits (40), and cesarean delivery (41). Two of the studies reported a positive cost–quality association, 1 reported a negative association, and 1 reported an imprecise or indeterminate association.

Methods to Address Confounding

An important methodological challenge is accounting for the effects of patient characteristics, particularly health status, which likely drives estimates of both cost and quality. No reviewed studies used experimental designs, which would account for the effects of observable and unobservable health status using randomization. Within observational studies, potential approaches for accounting for health status include natural randomization, or assignment of patients to treatment groups using a natural feature, as opposed to the controlled assignment used in randomized, controlled trials; instrumental variables analysis, which uses instrumental variables (observable factors that influence treatment but do not directly affect the outcome measure) to mimic randomization (21, 22); and multivariable regression analysis, which adjusts for the effects of observable health status using statistical methods but does not account for unmeasured health status. Of the 61 included studies, 9 (15%) used instrumental variables analysis to address confounding by unobserved patient health status. Seven of the 9 studies (78%) reported a positive cost–quality association and 2 had mixed findings. Forty-seven studies (77%) controlled for observable patient health risk using multivariable regression models. These studies resulted in mixed findings: 13 (28%) reported a positive cost–quality association; 18 (36%) reported a negative association; and 17 (36%) reported imprecise or indeterminate findings, no difference, or mixed findings. Two of these studies compared an "exposure" of area-level end-of-life care spending with patient-level quality measures. The authors argue that this design creates "natural randomization" of patients to spending levels, accounting for confounding by unobserved health status. The 2 studies using natural randomization reported mixed and mixed-negative associations between the end-of-life care expenditure index and quality (5, 6). Including these 2 studies with the 9 studies using instrumental variables analysis would change the results to 7 of 11 (64%) with a positive association, 3 with mixed and 1 with mixed-negative findings.

DISCUSSION

The association between health care quality and costs has been an important consideration in policy debates on whether cuts in health care spending will negatively impact quality or whether quality improvement will decrease health care spending. Unfortunately, the published literature does not provide clear input on these important questions. Our systematic review found inconsistent evidence on both the direction and the magnitude of the association between health care costs and quality.

Most of the reviewed studies focused their discussions of findings on the direction of the association between cost and quality. However, the magnitude of the association is another important dimension of the results. Among studies with statistically significant findings, we interpreted many of the associations to be of low to moderate clinical significance. However, some studies did report clinically significant associations in both positive and negative directions, whereas others reported imprecise, non–statistically significant findings that did not preclude the possibility of a clinically significant association. Many studies did not report sufficient information for interpretation of the magnitude of the association.

The reviewed studies were very heterogeneous both in how they measure costs and quality and their level of analysis (for example, comparison of geographic areas vs. hospitals). These differences probably contributed to the inconsistency of the evidence. However, in stratified analyses, we found inconsistent evidence even among studies using similar cost measures, quality measures, and level of analysis.

Studies were also heterogeneous in methods used. Differences in methods for adjusting for health status may have contributed to inconsistency among study findings. Studies that accounted for confounding by unmeasured health status using instrumental variables analysis or other methods, such as natural randomization, were the strongest designs among reviewed studies; there were no randomized studies. Among the few studies that used instrumental variable analysis methods to address unmeasured health status, most found that higher costs were associated with better quality. However, a relatively small percentage of the studies on this topic to date have used instrumental variables analysis, and these studies differ from other included studies in other ways that may have affected their estimates of the cost–quality association.

Moving forward, several aspects of studies could be improved. Future studies should focus on what types of spending are most effective in improving quality and what types of spending represent waste. In most studies, the cost and quality measures were typically very broad without a strong conceptual linkage. For example, spending on quality improvement may result in lower spending because of fewer complications or readmissions. However, this decrease in spending is likely to be small compared with all other sources of health care spending, which are not captured by current quality measures (4). No study disaggregated the different types of health spending or analyzed the effect of spending on different types of quality. Further, few studies broke down the association by type of patient. Certain populations may benefit more from increased resource use. Future work should also consider that the cost–

quality association may be nonlinear (that is, the quality benefits of additional resources may decline and eventually become negative with increasing cost) (42, 43).

Our study has several limitations. We excluded studies from non-U.S. data sources because of concerns about generalizability. Different categorization methods for level of analysis, cost and quality measurement, or study methods could have led to different interpretations of the results. Assessing the clinical magnitude of an association and the quality of observational studies on the basis of information published was very challenging, and this review (like all systematic reviews) was limited by the quality of the original studies.

This review suggests that the association between health care cost and quality is still poorly understood. Given the immediate policy importance of this research question, additional studies are needed that more carefully disaggregate the association between health care cost and quality while addressing confounding by patient health status.

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Appendix Table 1. **Characteristics and Findings of Reviewed Studies on the Association Between Health Care Cost and Quality for Area-Level Analyses**

Study, Year (Reference), by Area Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Baicker and Chandra, 2004 (7)	FFS Medicare beneficiaries in 50 U.S. states (2000–2001)	Average annual Medicare payments per beneficiary Type: expenditure	24 process quality measures developed by Medicare QIOs for treatment of AMI, breast cancer, diabetes mellitus, CHF, pneumonia, and stroke Type: process	Multivariable regression model	$1000 additional Medicare spending per capita was associated with 10 positions lower in overall state quality ranking ($P < 0.001$). The association between spending and individual quality measures was significant and negative for 15 of 24 measures ($P < 0.050$) and nonsignificant for 9 of 24 measures ($P > 0.050$).	Negative
Baicker et al, 2006 (41)	10.2 million births in counties with populations >250 000 (1995–1998)	Risk-adjusted cesarean delivery rate Type: care intensity index	Maternal mortality; neonatal mortality Type: outcome	Multivariable regression model	Small and insignificant association between county cesarean delivery rate and neonatal or maternal mortality rate. Decreasing cesarean delivery rate by 1 SD was associated with a decrease of 0.2 neonatal deaths per 10 000 births at normal birth weight ($P < 0.97$), a decrease of 0.2 neonatal deaths per 10 000 births at low and very low birth weight ($P < 0.28$), and a decrease of 0.096 maternal deaths per 10 000 births ($P < 0.100$).	Imprecise or indeterminate
Byrne et al, 2007 (28)	22 VA geographic networks (1998–2003)	Average risk-adjusted funding in VA networks Type: expenditure	3-y mortality rates Type: outcome	Multivariable regression model	A $1000 increase in average risk-adjusted funding was associated with non–significantly lower odds of mortality for males (OR, 0.943 [95% CI, 0.880–1.010] and females (OR, 0.950 [CI, 0.839–1.076]).	Imprecise or indeterminate
Cooper, 2009 (10)	FFS Medicare beneficiaries in 50 U.S. states (2000 and 2004)	Total health spending per capita; total Medicare spending per capita Type: expenditure	State ranking of health system performance (composite of 24 Medicare QIO measures and Commonwealth Fund scale) Type: process	2000 Medicare spending was adjusted for age, sex, race, and cost of living; 2004 results unadjusted	Higher 2004 total per-capita spending was associated with lower state quality ranking, where lower quality ranking means better quality (Pearson correlation coefficient = −0.34 using Medicare QIO measures and −0.51 using Commonwealth Fund ranking, $P < 0.050$). However, Medicare spending per capita was associated with higher (worse) state quality ranking (Pearson correlation coefficient = 0.65 using Medicare QIO measures and 0.41 using Commonwealth Fund ranking; $P < 0.050$).	Positive
Doyle, 2007 (34)	Patients visiting Florida from other states hospitalized for AMI, cardiac dysrhythmias, or CHF, in 44 of 67 counties with at least 30 such cases (1996–2003)	County EOL-EI (hospital and physician spending during last 6 mo of life) Type: care intensity index	Inpatient mortality Type: outcome	Natural experiment examining outcomes of patients exposed to health systems not designed for them by focusing on visitors to Florida and multivariable regression model; alternative specification using instrumental variables analysis	A 10% increase in county EOL-EI was associated with a 0.3–percentage point decrease in mortality, or 5% of the mean.	Positive

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Appendix Table 1—**Continued**

Study, Year (Reference), by Area Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Fisher et al, 2003 (5)	Medicare FFS beneficiaries aged 65–99 y hospitalized between 1993 and 1995 for hip fracture (n = 614 503), colorectal cancer (n = 195 429), or AMI (n = 159 393) and a representative sample (n = 18 190) drawn from the MCBS (1992–1995)	HRR EOL-EI and AC-EI = spending on physician and hospital services provided during the first 6 mo after index hospitalization Type: care intensity index	Percentage of "ideal" AMI patients that received recommended treatment; percentage of the general Medicaid population that received recommended preventive services Type: process	Natural experiment using area EOL-EI as a measure of spending due to physician practice rather than illness or price; multivariable regression models	In regions in the highest-spending compared with the lowest-spending quintile, patients with AMI were less likely to receive acute reperfusion (49.8% vs. 55.8%), aspirin at admission (83.9% vs. 87.7%) or discharge (74.8% vs. 83.5%) and ACE inhibitors at discharge (58.5% vs. 62.7%), and were more likely to receive β-blockers in the hospital (61.5% vs. 63.9%; test for linear trend, all $P < 0.050$). Association between spending and receipt of β-blockers at discharge was not significant (53.7% vs. 52.7%, $P > 0.050$). Flu immunizations (48.1% vs. 60.3%), pneumonia immunizations (19.7% vs. 29.4%), and Pap smears (33.6% vs. 40.8%) were provided less frequently in higher-spending regions (test for linear trend, all $P < 0.050$). Association between mammography tests and spending was not significant (47.6% vs. 48.7%; $P < 0.050$).	Mixed-negative
Fisher et al, 2003 (5)	Medicare FFS beneficiaries age 65–99 y hospitalized between 1993 and 1995 for hip fracture (n = 614 503), colorectal cancer (n = 195 429), or AMI (n = 159 393) and a representative sample (n = 18 190) drawn from the MCBS (1992–1995)	HRR EOL-EI and AC-EI = spending on physician and hospital services provided during the first 6 mo after index hospitalization Type: care intensity index	Usual source of care; health problem but did not see physician; trouble getting care; delaying care due to cost; waiting for visits Type: access	Natural experiment using area EOL-EI as a measure of spending due to physician practice rather than illness or price; multivariable regression models	In regions in the highest-spending compared with the lowest-spending quintile, patients were less likely to report a usual source of care (86.5% vs. 87.8%) and more likely to report having a health problem but not seeing a physician (10.1% vs. 8.7%; test for linear trend, both $P < 0.050$). There was no significant association between reporting trouble getting care (3.1% vs. 2.5%) and delaying care because of cost and spending (8.9% vs. 9.3%; test for linear trend, both $P < 0.050$). Compared with patients in the lowest-spending areas, those in the highest-spending areas were more likely to report waiting >30 min for an ED visit (34.0% vs. 28.4%), outpatient department visit (39.3% vs. 22.9%), and physician visit (31.9% vs. 24.8%, test for linear trend, all $P < 0.050$).	Mixed-negative
Fisher et al, 2003 (6)	Medicare FFS beneficiaries aged 65–99 y hospitalized from 1993 to 1995 for hip fracture (n = 614 503), colorectal cancer (n = 195 429), or AMI (n = 159 393) and a representative sample (n = 18 190) drawn from the MCBS (1992–1995).	HRR-level EOL-EI; AC-EI Type: care intensity index	5-y mortality rate; change in functional status Type: outcome	Natural experiment using area EOL-EI as a measure of spending due to physician practice rather than illness or price, multivariable regression models	Each 10% increase in regional end-of-life spending was associated with the following RRs for death: hip fracture cohort, 1.003 (95% CI, 0.999–1.006); colorectal cancer cohort, 1.012 (CI, 1.004–1.019); AMI cohort, 1.007 (CI, 1.001–1.014); and MCBS cohort, 1.01 (CI, 0.99–1.03). No significant difference in functional status index decrease between the highest- and lowest-spending regions (−1.96 [CI, −2.36 to −1.55] vs. −1.96 [CI, −2.42 to −1.50]).	Mixed

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Appendix Table 1—**Continued**

Study, Year (Reference), by Area Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Fisher et al, 2003 (6)	Medicare FFS beneficiaries aged 65–99 y hospitalized from 1993 to 1995 for hip fracture (n = 614 503), colorectal cancer (n = 195 429), or AMI (n = 159 393) and a representative sample (n = 18 190) drawn from the MCBS (1992–1995)	HRR-level EOL-EI; AC-EI Type: care intensity index	2 summary scores of general satisfaction with care (global quality and accessibility) and 3 summary scores focused on satisfaction with a usual physician (technical skills, interpersonal manner, and information-giving) Type: patient experience	Natural experiment using area EOL-EI as a measure of spending due to physician practice rather than illness or price, multivariable regression models	EOL-EI was negatively associated with global satisfaction and positively associated with satisfaction with interpersonal aspects of care (specific magnitude not reported, $P > 0.050$). Associations with patient experience of access to care, information giving, and technical skills were not significant (specific magnitude not reported, $P < 0.050$).	Mixed
Fowler et al, 2008 (44)	2515 community-dwelling Medicare FFS beneficiaries responding to a survey	HRR-level mean per-capita Medicare Parts A and B spending Type: expenditure	Perceived unmet need for care Type: access	Multivariable regression model	There were no significant differences between highest- and lowest-expenditure areas in perceived unmet need for tests or treatment (5.0% vs. 3.9%; $P = 0.25$ for linear trend) and cardiac tests (14.2% vs. 12.5%; $P = 0.14$ for linear trend). Respondents in highest-expenditure areas reported perceived unmet need for specialists more frequently than those in lower-expenditure areas (8.0% vs. 3.3%; $P < 0.001$ for linear trend).	Article-level: mixed This comparison: mixed-negative
Fowler et al, 2008 (44)	2515 community-dwelling Medicare FFS beneficiaries responding to a survey	HRR-level mean per-capita Medicare Parts A and B spending Type: expenditure	Perceived quality of ambulatory care; perceived quality of overall care Type: patient experience	Multivariable regression model	There was no significant difference between highest- and lowest-expenditure areas for 5 of 7 measures of perceived quality of care (physicians always or usually spent enough time, 87.0% vs. 88.7%, $P = 0.94$; physicians always or usually explained new medications, 86.1% vs. 90.3%, $P = 0.75$; physicians knew medication adverse effects, 89.8% vs. 97.3%, $P = 0.27$; health care better than average, 32.1% vs. 33.3%, $P = 0.67$; community care better than average, 29.7% vs. 29.8%, $P = 0.33$). Respondents in highest-expenditure areas were more likely to report that physicians knew about pain (97.8% vs. 93.2%, $P = 0.01$ for linear trend) and less likely to provide an overall rating of care of 9 or 10 out of 10 (55.4% vs. 63.3%, $P = 0.008$).	Mixed

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Appendix Table 1—**Continued**

Study, Year (Reference), by Area Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Landrum et al, 2008 (45)	Medicare beneficiaries in the national SEER database, aged >66 y, and with first diagnosis of colorectal cancer (1992–1999)	HRR-level EOL-EI; AC-EI Type: care intensity index	Stage at diagnosis; adjuvant chemotherapy for colon cancer; adjuvant chemotherapy for rectal cancer; receipt of surveillance colonoscopy; complete diagnostic colonoscopy; surveillance testing for carcinoembryonic antigen; receipt of chemotherapy within 6 mo of colon cancer diagnosis Type: process	Multivariable regression model	A $1000 increase in area-level EOL-EI was associated with 0.3% higher probability of being diagnosed with late-stage cancer (95% CI, 0.1–0.4), 1.6% higher probability of adjuvant chemotherapy for stage III cancer (CI, 0.8–2.5), and 2.5% higher probability of surveillance testing for carcinoembryonic antigen (CI, 1.3–3.7). There was no significant association between EOL-EI and adjuvant chemotherapy for rectal cancer ($1000 increase associated with 0.3% higher probability [CI, −0.7 to 1.2]), diagnostic colonoscopy (0.2 [CI, −0.2 to 0.7]), or surveillance colonoscopy (0.3 [CI, −0.9 to 1.4]). Increased EOL-EI was associated with increased use of chemotherapy among patients for which it is recommended, not recommended, and discretionary (among all patients, $1000 increase in spending associated with 0.9% higher probability of chemotherapy [CI, 0.5–1.3]).	Mixed
Landrum et al, 2008 (45)	Medicare beneficiaries in the national SEER database, aged >66 y, and with first diagnosis of colorectal cancer (1992–1999)	HRR-level EOL-EI; AC-EI Type: care intensity index	Overall and colorectal cancer-specific mortality at 3 y after diagnosis Type: outcome	Multivariable regression model	EOL-EI was not significantly associated with cancer or all-cause mortality but was significantly associated with increased noncancer mortality (magnitude not reported, $P < 0.001$).	Mixed
Sirovich et al, 2006 (26)	10 577 physicians who provided care to adults in 51 metropolitan and 9 nonmetropolitan areas of the United States and a supplemental national sample (1998 or 1999)	HRR-level EOL-EI; AC-EI Type: care intensity index	Physician-perceived ability to provide high quality care, perceived availability of clinical services, and career satisfaction Type: access	Multivariable regression model	The proportion of physicians who felt able to obtain elective hospital admissions ranged from 50% in high-intensity regions to 64% in the lowest-intensity regions ($P < 0.001$); the proportion of physicians who felt able to obtain high-quality specialist referrals ranged from 64% in high-intensity regions to 79% in low-intensity regions ($P < 0.001$). Compared with low-intensity regions, fewer physicians in high-intensity regions felt able to maintain good ongoing patient relationships (62% vs. 70%; $P < 0.001$) or able to provide high-quality care (72% vs. 77%; $P = 0.009$).	Negative
Wennberg et al, 2009 (40)	Random sample of patients hospitalized at 2473 hospitals; care intensity measure based on 20% national Medicare sample (2006–2007)	HRR hospital care intensity summary measure based on number of days in hospital and number of inpatient physician visits (not EOL-EI) Type: care intensity index	10 patient experience measures from the HCAHPS Type: patient experience	All measures adjusted for age, sex, race, and comorbid conditions	The proportion of patients reporting a negative overall experience and care intensity were positively associated ($r = 0.51$; $P < 0.001$).	Negative

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Appendix Table 1—**Continued**

Study, Year (Reference), by Area Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Yasaitis et al, 2009 (46)	National sample of 64 088 respondents aged 19–69 y to an online interactive patient assessment (2003–2008)	HRR-level EOL-EI Type: care intensity index	Patient satisfaction with care efficiency, continuity, access, and overall quality; patient-centeredness; physician–patient communication; safety Type: patient experience	Multivariable regression model	Compared with patients receiving care in lower-intensity regions, patients receiving care in higher-intensity regions reported lower satisfaction with the efficiency (61% vs. 72%), continuity (75% vs. 76%), accessibility (45% vs. 49%), overall quality of care (33% vs. 40%), and patient centeredness (23% vs. 32%) than patients in lower-intensity regions (all $P < 0.001$).	Negative
Health plan						
Roski et al, 2008 (47)	Patients with diabetes aged 18–75 y insured by a volunteer sample of 35 health plans (2005)	Relative resource use defined as actual vs. expected price-standardized annual health plan spending for patients with diabetes Type: expenditure	Composite measure based on percentage of diabetics with evidence of annual hemoglobin A_{1c} screen, LDL screen, eye examination, nephropathy care Type: process	Indirect standardization of costs for age, sex, diabetes type 1 or 2, and comorbid condition	No significant association between health plan total diabetes relative resource use and quality (magnitude not reported). No significant association for inpatient facility, procedure and surgery, or evaluation and management subcategories of resource use and quality (magnitude not reported). Significant positive association between pharmacy resource use and quality (Pearson correlation coefficient = 0.513; $P < 0.003$).	Imprecise or indeterminate

ACE = angiotensin-converting enzyme; AC-EI = Acute Care Expenditure Index; AMI = acute myocardial infarction; CHF = congestive heart failure; ED = emergency department; EOL-EI = End-Of-Life Expenditure Index; FFS = fee-for-service; HCAHPS = Hospital Consumer Assessment of Healthcare Providers and Systems; HRR = hospital referral region; LDL = low-density lipoprotein; MCBS = Medicare Current Beneficiary Survey; OR = odds ratio; QIO = quality improvement organization; RR = relative risk; SEER = Surveillance, Epidemiology and End Results; VA = Veterans Affairs.

Appendix Table 2. **Characteristics and Findings of Reviewed Studies on the Association Between Health Care Cost and Quality for Provider-Level Analyses**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Disease management programs						
Mangione et al, 2006 (29)	8661 adults with diabetes sampled from 63 physician groups nested in 11 health plans (2000–2001)	Disease management intensity measured by use of physician reminders, performance feedback, and structured care management Type: care intensity index	Dilated retinal examination, nephropathy screening, foot examination, hemoglobin A_{1c} testing, serum lipid panel, recommendation for influenza vaccine, and recommendation to take aspirin and quit smoking Type: process	Multivariable regression model	The association between disease management intensity and process quality measures was positive and significant for 6 of 8 measures (difference between 3rd and 1st tercile, 8–15 percentage points; $P < 0.050$) and positive but nonsignificant for 2 measures (difference between 3rd and 1st tercile, 4 and 2 percentage points; $P > 0.050$).	Article-level: mixed-positive This comparison: positive
Mangione et al, 2006 (29)	8661 adults with diabetes sampled from 63 physician groups nested in 11 health plans (2000–2001)	Disease management intensity measured by use of physician reminders, performance feedback, and structured care management Type: care intensity index	Serum LDL cholesterol level, hemoglobin A_{1c} level, systolic blood pressure Type: outcome	Multivariable regression model	No significant association between disease management intensity and intermediate outcomes (difference between 3rd and 1st tercile in hemoglobin A_{1c} level, 0.1 percentage point [95% CI, −0.2 to 0.4]; systolic blood pressure, 2 mm Hg [CI, 0–4]; serum LDL cholesterol, 0 mmol/L [0 mg/dL] [CI, −4 to 4]).	No difference
Hospitals						
Auerbach et al, 2010 (27)	81 289 patients cared for by 1451 physicians at 164 hospitals participating in Premier Perspective, admitted for coronary artery bypass graft, aged ≥18 y (1 Oct 2003–1 September 2005)	Premier Perspective hospital cost per discharge from hospital accounting systems or cost/charge ratios Type: accounting costs	Antimicrobial use to prevent surgical site infection on the operative day, discontinued antimicrobial use within 48 h, serial compression device use for venous thromboembolism prevention in 2 d after surgery, use of aspirin, β-blockers, and statin drugs in 2 d after surgery Type: process	Multivariable regression model	Individual quality measures had inconsistent associations with costs but patients who had no quality measures missed (composite measure) had lower costs than those who missed ≥1 (1 missed quality measure associated with 7.8% higher cost than none missed, $P < 0.001$).	Mixed-negative
Barnato et al, 2010 (39)	1 021 909 patients aged ≥65 y, incurring 2 216 815 admissions in 169 Pennsylvania hospitals (April 2001–March 2005)	Index of hospital end-of-life treatment intensity calculated by empirically weighting 6 Bayes shrunken case-mix standardized treatment ratios (ICU admission, ICU LOS, intubation or mechanical ventilation, tracheostomy, hemodialysis, and gastrostomy) among admissions aged >65 y at end-of-life (care intensity index)	30- and 180-d mortality Type: outcome	Multivariable regression model	Compared with admission at an average intensity hospital, admission to a hospital 1 SD below vs. 1 SD above average intensity resulted in an adjusted OR of mortality for admissions at low PPD of 1.06 (95% CI, 1.04–1.08) vs. 0.97 (CI, 0.96–0.99); average PPD, 1.06 (CI, 1.04–1.09) vs. 0.97 (CI, 0.96–0.99); and high PPD, 1.09 (CI, 1.07–1.11) vs. 0.97 (CI, 0.95–0.99), respectively. By 180 d, the benefits to intensity attenuated: low PPD, 1.03 (CI, 1.01–1.04) vs. 1.00 (CI, 0.98–1.01); average PPD, 1.03 (CI, 1.02–1.05) vs. 1.00 (CI, 0.98–1.01); and high PPD, 1.06 (CI, 1.04–1.09]) vs. 1.00 (CI, 0.98–1.02), respectively.	Positive

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Birkmeyer et al, 2012 (48)	All hospitals performing selected surgical procedures for FFS Medicare beneficiaries (number of hospitals: coronary artery bypass graft, 1060; colectomy, 1227; abdominal aortic aneurysm repair, 728; hip replacement, 1839) (2005–2007)	Medicare payments for all services from admission date to 30 d after discharge Type: expenditure	Mortality within 30 d of index surgical procedure; complications selected from the Complication Screening Project Type: outcome	Multivariable regression models	Compared with hospitals in the lowest complications quintile, hospitals in the highest quintile had higher spending for all studied procedures (highest vs. lowest complications quintile: coronary artery bypass graft, $46 024 vs. $40 671, $P < 0.001$; colectomy, $28 199 vs. $25 481; abdominal aortic aneurysm repair, $33 002 vs. $27 723; hip replacement, $22 051 vs. $19 615). Small, inconsistent differences in spending by quartile of mortality (highest vs. lowest mortality quintile: coronary artery bypass graft, $43 249 vs. $43 583; colectomy, $26 756 vs. $27 530; abdominal aortic aneurysm repair, $30 334 vs. $30 612; hip replacement, $21 092 vs. $20 907).	Mixed-negative
Bradbury et al, 1994 (49)	43 Pennsylvania hospitals (1989–1990)	Total hospital charges per discharge, ancillary charges per discharge Type: charges	In-hospital mortality and morbidity, defined as continued clinical instability determined by presence of MedisGroups key clinical findings Type: outcome	Multivariable regression model	Total charges showed a positive, significant ($P < 0.050$) association with morbidity (all patients) and mortality (patients with LOS ≥4 d); nonsignificant association between charges and mortality for patients with LOS 1–3 d; insufficient information presented to abstract magnitude of associations.	Mixed-negative
Bradbury et al, 1997 (50)	10 043 cholecystectomy patients treated by 218 surgeons in 43 Pennsylvania hospitals (1990–1991)	Total hospital charges per discharge, ancillary charges per discharge Type: charges	In-hospital morbidity, defined as continued clinical instability determined by presence of MedisGroups key clinical findings Type: outcome	Multivariable regression model	Total charges showed a positive, significant ($P < 0.010$) association with morbidity; insufficient information presented to abstract magnitude of associations.	Negative
Carey and Burgess, 1999 (51)	Nonpsychiatric patients at 137 VA hospitals (1988–1993)	Total variable cost from VA hospital accounting data Type: accounting costs	Observed or expected 30-d mortality; observed/expected 14-d readmission rates Type: outcome	Instrumental variables analysis	A 1-unit increase in observed or expected mortality index was associated with 24%–44% higher cost in instrumental variables regressions for each of 4 y ($P < 0.100$). A 1-unit increase in observed or expected readmissions was associated with 25%–29% higher cost in instrumental variables regressions for each of 2 y ($P < 0.100$).	Article-level: mixed This comparison: negative
Carey and Burgess, 1999 (51)	Nonpsychiatric patients at 137 VA hospitals (1988–1993)	Total variable cost from VA hospital accounting data Type: accounting costs	Observed or expected outpatient follow-up within 30 d after inpatient discharge Type: process	Instrumental variables analysis	A 1-unit increase in observed or expected outpatient follow-up rate was associated with 12%–21% higher cost in instrumental variable regressions for each of 4 y ($P < 0.100$ for 3 y, $P < 0.100$ for 1 y).	Positive
Chen et al, 2010 (32)	3146 hospitals, 518 473 discharges, and 400 068 unique Medicare patients with CHF; 3152 hospitals, 443 564 discharges, and 399 841 unique Medicare patients with pneumonia (2006)	Relative cost index based on cost per discharge calculated from cost to charge ratios and charges Type: accounting costs	Process quality of care Type: process	Multivariable regression model	Hospitals in the highest-cost quartile had higher quality scores than the lowest-cost quartile hospitals for CHF care (89.9% vs. 85.5%, $P < 0.001$) and lower quality scores for pneumonia (85.7% vs. 86.6%, $P < 0.002$).	Mixed

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Chen et al, 2010 (32)	3146 hospitals, 518 473 discharges, and 400 068 unique Medicare patients with CHF; 3152 hospitals, 443 564 discharges, and 399 841 unique Medicare patients with pneumonia (2006)	Relative cost index based on cost per discharge calculated from cost to charge ratios and charges Type: accounting costs	30-d mortality; readmission rates Type: outcome	Multivariable regression model	Mortality: Hospitals in the highest-cost quartile had lower mortality for CHF compared with the lowest-cost quartile (9.8% vs. 10.8%, $P < 0.001$) and higher mortality for pneumonia (11.7% vs. 10.9%, $P < 0.001$). Readmissions: high-cost hospitals had lower readmission rates for CHF than low-cost hospitals (22.0% vs. 24.7%, $P < 0.0001$) and similar readmission rates for pneumonia (17.3% vs. 17.9%, $P = 0.20$).	Mixed
Deily and McKay, 2006 (52)	416 urban, acute care Florida hospitals (1999–2001)	Hospital inefficiency score (percentage difference between a hospital's actual cost and the most efficient frontier cost level) Type: accounting costs	Risk-adjusted in-hospital mortality rate Type: outcome	Multivariable regression model	A reduction in inefficiency from the mean value of approximately 13% to 12% was associated with a significant reduction in the mortality rate of 0.01%.	Positive
Englesbe et al, 2009 (53)	43 393 high-cost Medicare kidney transplant patients (2003–2006)	Medicare payments for readmissions and outlier cases Type: expenditure	Composite measure of 30-d mortality and kidney transplant volume Type: composite measure	Multivariable regression model	Hospitals determined to be lower quality in 2003–2004 had an average payment for high-cost patients that was $1185 larger ($P < 0.001$) than the average payments made to high-quality centers in 2005–2006.	Negative
Fisher et al, 2004 (54)	Medicare FFS beneficiaries aged 65–99 y with initial hospitalization for AMI, colorectal cancer, or hip fracture at 299 teaching hospitals (1993–1995)	HRR-level EOL-EI, assigned to patients by location of hospital of initial hospitalization Type: care intensity index	6 AMI process measures from the Cooperative Cardiovascular Project Type: process	Multivariable regression model	Compared with hospitals in the lowest quintile of intensity, hospitals in the highest quintile did not have significantly different rates of reperfusion within 12 h (44.4% vs. 41.9%) or use of in-hospital aspirin (92.1% vs. 93.8%), discharge ACE inhibitor (62.0% vs. 66.2%), and discharge β-blocker (60.3% vs. 65.5%); all $P > 0.050$. High-intensity hospitals had lower rates of discharge aspirin (82.2% vs. 90.5%) and in-hospital β-blocker (60.0% vs. 62.0%) use both $P < 0.050$.	Mixed-negative
Fisher et al, 2004 (54)	Medicare FFS beneficiaries aged 65–99 y with initial hospitalization for AMI, colorectal cancer, or hip fracture at 299 teaching hospitals (1993–1995)	HRR-level EOL-EI, assigned to patients by location of hospital of initial hospitalization Type: care intensity index	5-y mortality rate Type: outcome	Multivariable regression model	A 10% increase in practice intensity was associated with the following mortality relative risk: hip fracture, 1.003 (95% CI, 0.999–1.007); colorectal cancer, 1.007 (CI, 1.000–1.013); and AMI, 1.012 (CI, 1.005–1.020).	Mixed-negative
Fleming, 1991 (42)	Medicare beneficiaries hospitalized at 659 hospitals (1985)	Total variable cost as reported on AHA annual survey Type: accounting costs	Ratio of actual to expected mortality index; ratio of actual to expected readmission index. Type: outcome	Multivariable regression model	Higher cost had a cubic association with the readmission index and surgical mortality index ($P < 0.010$). Total and medical mortality were not significantly associated with cost.	Mixed
Glance et al, 2010 (31)	67 124 trauma patients admitted to 73 trauma centers drawn from HCUP NIS (2006)	Relative cost of care per admission using charges and cost-to-charge ratios Type: accounting costs	Predicted probability of mortality at admission compared with admission at average hospital, controlling for patient risk factors. Type: outcome	Multivariable regression model	The relative cost of trauma patients treated in hospitals with low risk-adjusted mortality rates was 0.78 (CI, 0.64–0.95) compared with average-mortality hospitals. The cost of treating patients in high-mortality trauma centers was 1.08 times higher than average-mortality hospitals, but the difference was not significant (CI, 0.92–1.27).	Mixed-negative

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Huerta et al, 2008 (3)	273 hospitals in 19 markets (2005)	X-inefficiency based on data envelopment analysis using expenses, case-mix-adjusted admissions, LOS, and number of beds Type: accounting costs	Leapfrog Group safe practice score Type: structure	Multivariable regression model	Higher safe practice scores were significantly associated with higher hospital efficiency (increase of 1 quintile in safe practice score associated with 0.105 increase in X-inefficiency scale, $P = 0.050$).	Negative
Jha et al, 2009 (13)	4048 acute care hospitals (2004)	Relative cost index based on ratio of actual average cost per case (from CMS Hospital Cost Reports) for Medicare patients divided by predicted average cost per case for Medicare patients Type: accounting costs	15 HQA process measures for AMI, CHF, and pneumonia; condition-specific composites constructed as ratio of number of times a hospital performed appropriate action across total number of opportunities to provide appropriate care Type: process	Multivariable regression model	Compared with hospitals in the highest cost quartile, hospitals in the lowest cost quartile had, on average, lower AMI performance (88.9 vs. 90.8%, $P < 0.001$) and CHF performance (77.0 vs. 81.7%, $P < 0.001$). There was no significant association between risk-adjusted hospital costs and performance on pneumonia quality metrics (76.9 vs. 77.4%, $P = 0.68$).	Article-level: mixed-positive This comparison: mixed-positive
Jha et al, 2009 (13)	4048 acute care hospitals (2004)	Relative cost index based on ratio of actual average cost per case (from CMS Hospital Cost Reports) for Medicare patients divided by predicted average cost per case for Medicare patients Type: accounting costs	30-d mortality Type: outcome	Multivariable regression model	No significant difference in mortality rates between low- and high-cost hospitals for AMI (19.4 vs. 19.5, $P = 0.56$), CHF (13.3 vs. 13.2, $P = 0.80$), and pneumonia (14.4 vs. 14.2, $P = 0.18$).	Imprecise or indeterminate
Kaestner and Silber, 2010 (18)	Medicare patients hospitalized for surgery (general, orthopedic, vascular) and medical conditions (AMI, CHF, stroke, and gastrointestinal bleeding) (2001–2005)	Total inpatient charges per Medicare admission Type: charges	30-d mortality Type: outcome	Instrumental variables analysis	For all conditions except AMI, a 10% ($2000–$5000) increase in charges was associated with a 3.1%–11.3% decrease in 30-d mortality ($P < 0.050$), varying by condition.	Positive
Lagu et al, 2011 (30)	Patients aged ≥18 y with sepsis in 309 nationwide hospitals in the Premier Perspective database (2004–2006)	Observed − expected costs from hospital cost accounting systems Type: accounting costs	Severity-adjusted in-hospital mortality rate Type: outcome	Multivariable regression model	An additional $1000 in patient costs was associated with a 0.1% increase in adjusted hospital-level mortality (95% CI, 0%–0.2%).	No difference
McKay and Deily, 2008 (55)	National sample of 3384 short-term, acute-care hospitals in operation for full year, with at least 16 beds and 100 discharges (1999–2001)	Cost inefficiency estimated using stochastic frontier analysis of costs from Medicare cost reports and AHA survey Type: accounting costs	In-hospital mortality and complication rate Type: outcome	Multivariable regression model	Cost inefficiency was not significantly associated with in-hospital mortality or complication rates (1-unit increase in cost inefficiency score associated with 0.00002–percentage point decrease in mortality rate and 0.0008–percentage point decrease in complication rate, $P > 0.050$).	Imprecise or indeterminate
Morey et al, 1992 (56)	National sample of 300 hospitals (1981)	Cost inefficiency estimated using data envelopment analysis of hospital costs from AHA survey Type: accounting costs	Ratio of actual to predicted in-hospital deaths Type: outcome	Multivariable regression model	A reduction of 1 death was associated with an increase in efficient cost of $28 926 ($P < 0.001$).	Positive
Mukamel et al, 2002 (57)	338 hospitals in California with available data (1982–1989)	Hospital costs (from AHA cost reports) per adjusted discharge Type: accounting costs	Risk-standardized mortality rates from all causes and from AMI, CHF, pneumonia, and stroke Type: outcome	Multivariable regression model	An additional $1000 in cost per adjusted discharge was associated with 0.47 fewer deaths per 100 discharges ($P < 0.001$).	Positive

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Mukamel et al, 2001 (58)	FFS Medicare beneficiaries	Wage-adjusted hospital costs per adjusted admission reported to AHA Type: accounting costs	30-d mortality Type: outcome	Multivariable regression model	Compared with hospitals at the 50th percentile of cost per admission, hospitals at the 75th percentile had lower mortality rates (9.11 vs. 9.36 deaths per 100 discharges; $P < 0.001$), with the largest effect observed for hospitals with expenditures at or above the 90th percentile (8.84 vs. 9.36; $P < 0.001$).	Positive
Ong et al, 2009 (59)	3999 patients hospitalized with CHF at 6 California hospitals from 1 January 2001 to 30 June 30 ("looking forward" cohort); 1650 patients in the "looking forward" cohort who died between 1 July 2001 and 31 December 2005 ("looking back" cohort)	Total hospital direct costs (from hospital cost accounting systems) per discharge Type: accounting costs	180-d mortality Type: outcome	Multivariable regression model	Spearman rank correlation between adjusted cost and adjusted mortality for the "looking forward" cohort was −0.93 ($P < 0.010$). Patterns of resource utilization across hospitals were not the same between the "looking forward" and "looking back" cohorts.	Positive
Picone et al, 2003 (23)	5332 Medicare beneficiaries aged >65y with hip fracture, stroke, coronary heart disease, or CHF diagnosis and surviving initial admission	Total cost of inpatient admission, calculated as sum of adjusted hospital charges (using cost-to-charge ratios) and physician Part B payments Type: accounting costs	2-y mortality Type: outcome	Instrumental variables analysis and quasi-maximum-likelihood estimator with discrete factor approximations	Probability of dying within 2 y decreased 0.0043 for each $1000 increase in cost of a hospital stay ($P < 0.010$).	Positive
Romley and Goldman, 2008 (60)	Medicare beneficiaries aged >65 y with pneumonia diagnosis	Hospital total costs per discharge measured as adjusted charges using cost-to-charge ratios Type: accounting costs	"Revealed quality" measured by patient choice of hospital Type: patient experience	Instrumental variables analysis	Quality improvement from the 25th to 75th percentile would increase costs at the average hospital by approximately 50%.	Positive
Romley et al, 2011 (24)	Patients hospitalized with 1 of 6 major medical conditions	Average hospital spending in the last 2 y of life for patients with chronic conditions Type: expenditure	Inpatient mortality Type: outcome	Multivariable regression model	For each of 6 diagnoses at admission, higher-spending hospitals were associated with lower risk-adjusted inpatient mortality (highest- vs. lowest-spending quintile in 2004–2008: AMI OR, 0.741 [95% CI, 0.590–0.891]; CHF OR, 0.755 [CI, 0.630–0.879]; stroke OR, 0.811 [CI, 0.680–0.942]; gastrointestinal hemorrhage OR, 0.821 [CI, 0.668–0.975]; hip fracture OR, 0.973 [CI, 0.758–1.188]; pneumonia OR, 0.729 [CI, 0.624–0.834]).	Positive
Saleh et al, 2012 (61)	48 574 pneumonia patients admitted to 189 New York hospitals (2005)	Standardized total average cost of care per discharge calculated from cost-to-charge ratios Type: accounting costs	Composite measure of successfully delivered process measures to opportunities to provide appropriate care Type: process	Multivariable regression models	Compared with hospitals in the top performance quartile, the ratios of average cost for hospitals in the 2nd, 3rd, and 4th quartiles were 1.05, 1.04, and 0.98, respectively.	Imprecise or indeterminate

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Schreyögg and Stargardt, 2010 (20)	35 279 patients treated for AMI at 115 VHA hospitals (2000–2006)	Costs incurred during index hospitalization, from cost accounting system Type: accounting costs	1-y mortality and readmission Type: outcome	Instrumental variables analysis	A $100 decrease in cost was associated with a 0.63% increase in the hazard of dying ($P < 0.001$) and a 1.24% increase in the hazard to be readmitted conditional on not dying ($P < 0.001$).	Positive
Silber et al, 2010 (62)	Medicare admissions to 3065 hospitals for general, orthopedic, and vascular surgery ($n = 4\ 558\ 215$ unique patients) (2000–2005)	EOL-EI Type: care intensity index	30-d mortality; in-hospital complications; failure-to-rescue Type: outcome	Multivariable regression model	The OR for complications in hospitals at the 75th percentile of aggressive treatment style compared with those at the 25th percentile (a U.S. $10 000 difference) was 1.01 ($P < 0.066$), whereas the OR for mortality was 0.94 ($P < 0.001$) and failure-to-rescue was 0.93 ($P < 0.001$).	Mixed-positive
Yasaitis et al, 2009 (14)	2712 U.S. hospitals reporting to Hospital Compare (2004–2007)	EOL-EI Type: care intensity index	Composite of 11 Hospital Compare process quality measures for AMI, pneumonia, and CHF Type: process	Multivariable regression model	Increase of $10 000 in end-of-life spending associated with change of –5.3 percentage points for overall quality ($P < 0.001$), –5.2 percentage points for AMI ($P < 0.001$), –9.2 percentage points for pneumonia ($P = 0.001$), and –0.3 percentage points for CHF ($P = 0.687$).	Negative
Zhang et al, 2009 (63)	316 deceased cancer patients at 7 treatment sites (2002–2007)	Per-capita spending for hospital stays and hospice care received in last week of life Type: expenditure	Caregiver rating of patient quality of death, mortality Type: outcome	Multivariable regression model	Patients with higher costs had lower quality of death in their final week (Pearson partial correlation coefficient = −0.17; $P = 0.006$).	Negative
Nursing homes						
Anderson et al, 1998 (64)	494 nursing homes in Texas (1990)	Total cost per resident day Type: accounting costs	Composite of 11 resident outcomes Type: outcome	Multivariable regression model	Nursing homes with the best outcomes had 7% higher cost per resident day than nursing homes with the lowest cost per day ($45.52 vs. $42.48; $P < 0.050$).	Positive
Cohen and Spector, 1996 (35)	658 Medicaid-certified nursing homes and 2663 residents (1987)	Medicaid nursing home payment rate per day Type: expenditure	Mortality; change in functional status; presence of bedsores Type: outcome	Multivariable regression model	The reimbursement rate was not significantly associated with outcomes (magnitude not presented).	Article-level: mixed This comparison: imprecise or indeterminate
Cohen and Spector, 1996 (35)	658 Medicaid-certified nursing homes and 2663 residents (1987)	Medicaid nursing home payment rate per day Type: expenditure	Number of RNs, LPNs, and total nursing staff per 100 facility residents Type: structure	Multivariable regression model	Additional dollar of Medicaid reimbursement per day associated with 0.16 more LPNs per 100 residents ($P < 0.050$), 0.003 more RNs per 100 residents ($P > 0.050$), and 0.061 more total staff per 100 residents ($P > 0.050$).	Mixed-positive
Grabowski, 2001 (36)	15 067 federally certified Medicaid and Medicare nursing homes (1995–1996)	Medicaid nursing home payment rate Type: expenditure	Medication error rate, use of urethral catheters, use of feeding tubes, use of physical restraints Type: process	Multipart multivariable regression models	No significant association between Medicaid reimbursement and 4 process measures (Medicaid rate of $105 vs. $65 associated with 0.62–percentage point decrease in medication errors, 0.23–percentage point decrease in use of feeding tubes, 0.07–percentage point decrease in use of catheters, and 0.80–percentage point decrease in use of physical restraints; all $P > 0.050$).	Imprecise or indeterminate

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Grabowski, 2001 (36)	15 067 federally certified Medicaid and Medicare nursing homes (1995–1996)	Medicaid nursing home payment rate Type: expenditure	Number of facility deficiencies assigned in Medicaid certification process, including 175 measures of structure, process, and outcome. Type: composite measure	Multipart multivariable regression models	No significant association between Medicaid reimbursement and number of deficiencies (Medicaid rate of $105 vs. $65 associated with 0.62 fewer deficiencies [5.66 vs. 6.28 {95% CI for difference, −4.07 to 20.42}]).	Imprecise or indeterminate
Grabowski, 2001 (36)	15 067 federally certified Medicaid and Medicare nursing homes (1995–1996)	Medicaid nursing home payment rate Type: expenditure	Number of RNs, LPNs, and nurses' assistants per 100 facility residents Type: structure	Multipart multivariable regression model	Medicaid rate of $105 vs. $65 associated with 1.44 (22%) more RNs per 100 residents ($P < 0.050$). For LPN and nurses' assistant measures, there was a positive but not significant effect (Medicaid rate of $105 vs. $65 associated with increase of 13% and 11%, respectively; both $P < 0.050$).	Mixed-positive
Grabowski, 2001 (37)	15 643 federally certified Medicare and Medicaid nursing homes (1996)	Medicaid nursing home payment rate Type: expenditure	Proportion of residents with pressure sores Type: outcome	Multivariable regression model	An increase in Medicaid reimbursement of $1 was associated with a 0.9969 (1996 national sample, $P < 0.010$) and a 0.9983 (1996 New York sample, $P < 0.050$) lower likelihood of a resident acquiring a pressure sore.	Mixed-positive
Grabowski, 2001 (37)	15 643 federally certified Medicare and Medicaid nursing homes (1996)	Medicaid nursing home payment rate Type: expenditure	Number of RNs Type: structure	Multivariable regression model	An increase in the Medicaid rate of $1 was associated with an additional 0.14 RNs per nursing home ($P < 0.001$) in a 1981 national sample; 0.13 in a 1996 New York sample ($P < 0.010$); but no significant association in a 1996 national sample.	Mixed-positive
Hicks et al, 2004 (43)	446 non–hospital-based nursing homes in Missouri (1999)	Variable costs for patient care, ancillary services, and administration from cost reports Type: accounting costs	ADL decrease; pressure ulcers; weight loss; initiation of psychotropic drugs Type: outcome	Multivariable regression model	Negative, cubic association between variable costs and decrease in ADLs ($P < 0.050$), weight loss ($P < 0.050$), pressure ulcer incidence ($P = 0.106$), and psychotropic drug use ($P = 0.71$).	Mixed-negative
Mukamel and Spector, 2000 (65)	525 public and private freestanding nursing homes in New York (1991)	Facility variable costs. Type: accounting costs	ADL decrease; pressure ulcers; 6-mo mortality Type: outcome	Multivariable regression model	Regression result shows inverted U-shaped association between quality and costs (interpretation of magnitudes not presented; ADL decrease, $P < 0.050$ for linear term and $P < 0.100$ for quadratic term; pressure ulcers, $P < 0.100$ for linear term and $P < 0.050$ for quadratic term; mortality, $P < 0.100$ for linear term and $P < 0.050$ for quadratic term).	Mixed
Weech-Maldonado et al, 2006 (66)	749 nursing homes in New York, Kansas, Vermont, Maine, and South Dakota (1996)	Total patient care costs (direct, ancillary, and indirect costs) per resident day Type: accounting costs	Pressure ulcers worsening; mood decline Type: outcome	Instrumental variables analysis	Pressure ulcers had a significant inverted U-shaped association with quality, with increasing costs at the lower range of quality but decreasing costs associated with higher quality after a threshold. Mood decline exhibited the opposite pattern, with a relatively flat curve at the lower range of quality but increasing costs after a threshold.	Mixed
Weech-Maldonado et al, 2003 (67)	781 nursing homes in New York, Kansas, Vermont, Maine, and South Dakota (1996)	Total patient care costs (direct, ancillary, and indirect costs) per resident day Type: accounting costs	Use of physical restraints; prevalence of urethral catheters Type: process	Structural equation modeling	Process quality did not have a significant direct effect on costs (magnitude not reported).	Article-level: mixed This comparison: imprecise or indeterminate

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Weech-Maldonado et al, 2003 (67)	781 nursing homes in New York, Kansas, Vermont, Maine, and South Dakota (1996)	Total patient care costs (direct, ancillary, and indirect costs) per resident day Type: accounting costs	Cognitive decline; mood decline; pressure ulcer prevalence and incidence Type: outcome	Structural equation modeling	Better outcomes quality was associated with lower costs (magnitude not reported, $P < 0.010$).	Negative
Weech-Maldonado et al, 2003 (67)	781 nursing homes in New York, Kansas, Vermont, Maine, and South Dakota (1996)	Total patient care costs (direct, ancillary, and indirect costs) per resident day Type: accounting costs	Staffing mix Type: outcome	Structural equation modeling	Greater RN staffing was associated with higher costs (magnitude not reported, $P < 0.100$).	Positive
Physician						
Bradbury et al, 2000 (68)	175 249 adult medical service admissions to 100 hospitals in 25 states for 26 DRGs (1993–1994)	Total charges, ancillary charges, and LOS Type: charges	In-hospital mortality and morbidity, defined as continued clinical instability determined by presence of MedisGroups key clinical findings Type: outcome	Multivariable regression model	Total charges showed a positive, significant ($P < 0.010$) association with mortality and morbidity; insufficient information presented to abstract magnitude of associations.	Negative
Rosenthal et al, 2008 (38)	Commercially-insured beneficiaries of 6 Massachusetts health plans treated by 496 Bridges to Excellence–recognized physicians and 5120 nonrecognized physicians (2003–2006)	Price-standardized payments per episode of care Type: expenditure	Bridges to Excellence Physician Office Link recognition based on a composite of structure measures Type: structure	Multivariable regression model	Physician Office Link–recognized physicians had significantly fewer episodes per patient (2.09 vs. 2.22, $P < 0.050$) and lower average resource use per episode ($570 vs. $700, $P < 0.050$) than nonrecognized physicians.	Article-level: mixed This comparison: negative
Rosenthal et al, 2008 (38)	Commercially-insured beneficiaries of 6 Massachusetts health plans treated by 496 Bridges to Excellence–recognized physicians and 5120 nonrecognized physicians (2003–2006)	Price-standardized payments per episode of care Type: expenditure	Bridges to Excellence Diabetes Care Link recognition based on a composite of process measures Type: process	Multivariable regression model	Diabetes Care Link–recognized PCPs had more episodes per patient (2.61 vs. 2.44, $P < 0.050$) and lower average resource use per episode ($623 vs. $649, $P < 0.050$) compared with nonrecognized PCPs. Diabetes Care Link–recognized endocrinologists had more episodes per patient (1.66 vs. 1.58; $P < 0.050$) and higher average resource use per episode ($2671 vs. $2534; $P < 0.050$) compared with nonrecognized endocrinologists.	Mixed-positive
Starfield et al, 1994 (69)	2024 Medicaid patients aged >65 y treated by 135 Maryland physicians for diabetes, hypertension, asthma, well-child care, or otitis media (1988)	Annual total Medicaid payments per capita Type: expenditure	Emergency care visits and ambulatory care-sensitive hospitalizations Type: access	Risk adjustment of payments variable	No significant association between access and cost (magnitude not reported)	Article-level: mixed This comparison: imprecise or indeterminate
Starfield et al, 1994 (69)	2024 Medicaid patients aged >65 y treated by 135 Maryland physicians for diabetes, hypertension, asthma, well-child care, or otitis media (1988)	Annual total Medicaid payments per capita Type: expenditure	Condition-specific composites of multiple process quality measures Type: process	Risk adjustment of payments variable	No consistent association between process measures and cost, although patients of low-cost providers had the highest (worst) scores for diabetes, hypertension, and well-adult care (magnitude not reported).	Mixed-positive
Starfield et al, 1994 (69)	2024 Medicaid patients aged >65 y treated by 135 Maryland physicians for diabetes, hypertension, asthma, well-child care, or otitis media (1988)	Annual total Medicaid payments per capita Type: expenditure	Diabetes outcome (specific measure not reported) Type: outcome	Risk adjustment of payments variable	No significant association between outcomes and cost (magnitude not reported).	Imprecise or indeterminate

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Appendix Table 2—**Continued**

Study, Year (Reference), by Provider Level	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Provider groups						
Kralewski et al, 2011 (70)	36 medical groups in Minnesota that care for at least 300 patients (2007–2008)	Risk-adjusted sum of average allowed amount paid for each service, procedure, and prescription PMPY Type: expenditure	6 process measures from Minnesota Community Measurement database Type: process	None	Spearman correlation coefficients between cost and process quality measures were negative for 6 of 7 quality measures, ranging from −0.19 to 0.04; statistical significance not reported.	Imprecise or indeterminate
Solberg et al, 2002 (71)	110 000–150 000 employees and dependents of member companies of an employer coalition in Minnesota receiving care from 18 provider groups (1996–1998)	Price-standardized payments per patient-year as reported in employer coalition claims database Type: expenditure	Multiple process quality measures for depression; adult and child asthma; diabetes; and preventive services Type: process	Multivariable regression model	No significant association between cost and 13 quality measures (low-cost tercile vs. middle tercile: OR, 0.85–1.1.38; high-cost tercile vs. middle tercile: OR, 0.82–1.62; all $P > 0.050$). Low-cost tercile associated with higher quality compared with middle tercile for 4 quality measures (OR, 1.34–1.85; $P < 0.050$) and lower quality for 1 quality measure (OR, 0.49; $P < 0.010$). High-cost tercile associated higher quality compared with middle tercile for 3 quality measures (OR, 1.14–1.51; $P < 0.050$).	Mixed

ACE = angiotensin-converting enzyme; ADL = activity of daily living; AHA = American Hospital Association; AMI = acute myocardial infarction; CHF = congestive heart failure; CMS = Centers for Medicare & Medicaid Services; DRG = diagnosis-related group; EOL-EI = End-Of-Life Expenditure Index; FFS = fee-for-service; HCUP NIS = Healthcare Cost and Utilization Project National Inpatient Sample; HQA = Hospital Quality Alliance; HRR = hospital referral region; ICU = intensive care unit; LDL = low-density lipoprotein; LOS = length of stay; LPN = licensed practical nurse; OR = odds ratio; PCP = primary care physician; PMPY = per member per year; PPD = predicted probability of dying; RN = registered nurse; VA = Veterans Affairs; VHA = Veterans Health Administration.

Appendix Table 3. **Characteristics and Findings of Reviewed Studies on the Association Between Health Care Cost and Quality for Patient-Level Analyses**

Study, Year (Reference)	Participants (Years of Data Collection)	Cost Measure Description and Type	Quality Measure and Type	Methods to Control Confounding	Findings of Association Between Cost and Quality	Association Type
Cunningham, 2009 (72)	32 210 adults sampled from 60 Community Tracking Study sites in 2003 reporting they have a physician usual source of care	High medical cost burden, defined as out-of-pocket medical spending: insurance premiums ratio Type: expenditure	Patient trust in their physician, patient assessment of quality of care from physician Type: patient experience	Multivariable regression model	Persons with high medical cost burdens had greater odds of lacking trust in their physician to put their needs first (OR, 1.40 [95% CI, 1.15–1.70]), and 2 other measures of mistrust of their physician. High medical cost burden was also associated with negative assessments of the thoroughness of care they receive (OR, 1.26 [CI, 1.02–1.56]) and 2 other measures of perceived quality.	Negative
Doyle et al, 2012 (73)	667 143 Medicare FFS beneficiaries hospitalized through ED; secondary analysis with 637 813 patients in New York within 5 miles of an ambulance referral boundary (2002–2008)	Hospital costs per discharge, estimated using charges and cost-to-charge ratios Type: accounting costs	Mortality within 30 d or 1 y of discharge Type: outcome	Instrumental variables analysis	10% higher cost associated with 1.44 percentage points lower 1-y mortality rate ($P < 0.010$); second empirical strategy finds that 10% higher cost associated with 0.47–0.54 percentage points lower 1-y mortality rate ($P < 0.050$), varying by sample.	Positive
Fenton et al, 2012 (74)	51 946 adult respondents to MEPS (2000–2007)	Total annual health spending per capita Type: expenditure	Patient satisfaction with physician communication Type: patient experience	Multivariable regression models	Compared with patients in the lowest quartile of patient satisfaction, patients in the highest quartile had 8.8% higher (95% CI, 2.3%–16.4%) total health spending.	Positive
Fu and Wang, 2008 (19)	A nationally representative sample of 13 980 adults (aged ≥18 y) in the MEPS (2003)	Annual per-capita total health spending, including private insurance, public payers, and other sources Type: expenditure	Patient self-rating of health care for all physicians and providers encountered Type: patient experience	Multivariable regression model	No significant association between patient satisfaction and annual per-capita total health expenditure (coefficient = 0.004, no other information on magnitude presented, $P = 0.60$).	Imprecise or indeterminate
Hadley et al, 2011 (25)	17 438 beneficiaries aged >64 y entering MCBS (1991–1999)	Total health spending per-capita, total Medicare spending per capita Type: expenditure	Mortality after 3 y; HALex Type: outcome	Instrumental variables analysis	10% greater medical spending over previous 3 y was associated with a 1.5% greater survival probability ($P = 0.039$; range, 1.2–1.7, depending on spending measure) and a 1.9% larger HALex value ($P = 0.45$; range, 1.2–2.2).	Positive

ED = emergency department; FFS = fee-for-service; HALex = Health and Activity Limitations Index; MCBS = Medicare Current Beneficiary Survey; MEPS = Medical Expenditure Panel Survey; OR = odds ratio.