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Hospital quality and medicare payment: A theoretical and empirical investigation

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DEDICATION

To my husband, Haiying Yu.

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CHAPTER 1

INTRODUCTION

Most Medicare spending for hospital care occurs under its Inpatient Prospective Payment System (IPPS) (MedPAC 2010). Under this system Medicare pays each hospital a fixed-price for each Medicare patient within a given diagnosis-related group (DRG). While the price for a given DRG can and does vary across hospitals, within a given hospital it is fixed for a year at a time. Medicare sets its price schedule prospectively for each hospital, so that at the start of a fiscal year, the hospital knows with certainty what Medicare will be paying during the upcoming year for each of the possible DRGs.

The rising costs of Medicare continue to dominate discussions about how to reform the program so that spending is better-controlled. The IPPS price schedule for hospitals is an important tool the Center for Medicare and Medicaid Services (CMS) has available to limit program spending. It is not clear, however, whether reductions in revenue due to lower Medicare fees might lead some hospitals to sacrifice care quality as they seek to lower costs. This is because there is little research on the nature of the relationship between what Medicare pays for a specific DRG and a hospital's quality of care for patients in that DRG.

At the same time, there is continued interest in improving the quality of care. A recent review of the research literature on the quality of U.S. healthcare suggests that healthcare in many hospitals frequently does not meet professional standards (Schuster et al. 2005). The Institute of Medicine (IOM) defines quality as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (Lohr 1990). Studies of the quality of acute care in the U.S. suggest that, on average, only about 70 percent of patients actually receive the recommended treatment. The other 30 percent receive contra-indicated care (Schuster et al. 2005). There is clearly room for improvement here.

CMS and the U.S. Department of Health and Human Services (HHS) have launched several initiatives in recent years aimed at improving care quality through provider accountability and through the public disclosure of information on the quality of care in hospitals. One of these initiatives, undertaken in conjunction with the Hospital Quality Alliance (HQA), was the development and launching of a user-friendly on-line tool, called "Hospital Compare" (www.hospitalcompare.hhs.gov), that provides consumers with information about patient care in their local area hospitals. The Hospital Compare website allows consumers to compare the quality of care, patient satisfaction, and the outcomes of care across particular hospitals in their area. Regarding quality, the website reports information on how often each hospital provides some of the recommended care to patients admitted for serious medical conditions, such as for a heart attack, heart failure, or pneumonia. For each condition, Hospital Compare reports the percentage of patients who received various treatment protocols that are widely-agreed to be appropriate for patients admitted with that condition. A hospital's rate of adherence to a range of treatment protocols for each medical condition determines its ranking vis-à-vis the other hospitals.

Hospital Compare was debuted in April 2005 at www.hospitalcompare.hhs.gov and at www.medicare.gov. Nearly all U.S. hospitals (95 percent) voluntarily submit data from patients' medical records for use in this quality reporting program (in part, because their Medicare PPS rates would be reduced if they chose not to participate).[1] Over time CMS has added more measures that consumers can compare across hospitals. In March 2008 CMS added data on what Medicare pays each hospital for different types of Medicare admissions, and data on how many patients each hospital treats in 44 high-prevalence DRGs.

The database being assembled through Hospital Compare is unique. For a large, nationwide sample of hospitals it contains both diagnosis-specific measures of care quality, along with diagnosis-specific Medicare payment rates. As such, it is well-suited for examining the nature of the relationship between Medicare payment and the quality of care provided to patients. There is widespread interest in whether quality responds to payment, and if so, in what ways.

This dissertation explores the relationship between the Medicare payment rate and the quality of hospital care using the Hospital Compare data. Specifically, we examine the effects of Medicare's hospital payment for

[1]Section 501(b) of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 stipulates that a hospital that does not submit performance data for Hospital Compare's ten quality measures will receive a 0.4 percentage point reduction in its annual payment update from CMS for FY2005, 2006 and 2007. The Deficit Reduction Act of 2005 increased that reduction to 2.0 percentage points. Thus, there have been strong financial incentives for hospitals to participate in the program.

pneumonia, heart failure and heart attacks admissions on the quality of care provided to pneumonia, heart failure and heart attacks patients, respectively.

This study contributes to the literature in a number of ways. First, it develops a theoretical model of a hospital's "quality" decision, which illustrates how quality responds to Medicare reimbursement. Unlike previous models of hospital behavior, it distinguishes between hospital quality and hospital inputs. With this distinction, it derives the prediction that higher reimbursement leads to higher quality. Second, using Hospital Compare data, it empirically estimates the payment/quality relationship for the case of pneumonia, heart failure, and heart attack individually. To my knowledge, this is the first study to implement the Hospital Compare data for this purpose. Finally, the analysis examines the effects of Medicare reimbursement on hospital- specific quality for patients with particular diagnoses, specifically, the diagnoses of pneumonia, heart failure, or heart attack.

The dissertation is organized as follows. The next chapter develops a simple model of hospital behavior under the assumption that a hospital maximizes an objective function that depends on both patient care and profit. The model then derives the testable hypothesis that quality is positively related to Medicare's payment rate. Chapter 3 briefly reviews the relevant prior literature on how the quality of care responds to Medicare payment rates. Following this, Chapter 4 describes the methods and data used for the empirical analyses. Chapter 5 reports the key findings. Finally, Chapter 6 concludes the dissertation with a qualitative summary of the broad findings that emerge from this work.

CHAPTER 2

THEORETICAL MODEL

The theoretical analysis concerned models a hospital's choice for quality of care, and derives whether and in what way, a hospital's optimal choice relates to Medicare's payment rate per admission. Following Dranove (1988), Hodgkin and McGuire (1994) and Dafny (2003, 2005), it is assumed that a hospital maximizes an objective function that depends on both hospital profit, π, and patients' health outcomes, H. There is one payer for hospital care, Medicare, that pays a fixed reimbursement (p) per admission, and all admissions are the same type, e.g., in the same DRG. The following are the basic equations of the model:

$$U = U(H, \pi) \qquad [1]$$

$$H = H(I, Q) \qquad [2]$$

$$\pi = R - TC \qquad [3]$$

$$R = p.X \qquad [4]$$

$$TC = c.X \qquad [5]$$

$$c = c(I, Q) \qquad where\ c_I = \frac{dc}{dI} > 0, c_Q = \frac{dc}{dQ} > 0 \qquad [6]$$

$$X = X(Q) \qquad where\ X' = \frac{dX}{dQ} > 0. \qquad [7]$$

Equation [1] is the hospital's objective function, $U(H, \pi)$, which depends on both the health outcomes of patients, $H,$ and hospital profit, $\pi.$ The hospital produces health outcomes using its resources (i.e., inputs), $I,$ and quality of care, Q, where increases in Q indicate a higher quality of care. Q is distinct from I in this model, and can be thought of as measuring the hospital's adherence to excellent standards of care. Two hospitals with identical resources may have different quality levels, depending on how they use those resources.

Profit, $\pi,$ equals total revenue, $R,$ minus total costs, $TC,$ and revenue depends on the number of admissions, $X,$ times the price received per case, $p,$ from Medicare. The hospital's costs per patient, $c,$ are an increasing function of its resources, $I,$ and the quality of care provided, Q. As indicated in [7], the volume of admissions is assumed to depend on the hospital's quality level, and higher quality attracts more patients. It envisions a monopolistically competitive market in which hospitals compete for patients on the basis of quality. Although physicians have no direct role here, one interpretation of Eq. [1] is that it reflects the objectives of the medical staff, who balance the hospital's interest in profit with their patients' interest in achieving the best health outcomes (Ellis and McGuire 1986).

Substituting Eqs. [4] through [7] into [3], profit takes the following form, with partial derivatives for I and Q given by:

$$\pi = p.X(Q) - c(I,Q).X(Q) \quad where \ \pi_I = -c_I.X < 0, \pi_Q = (p-c).X' - X.c_Q \qquad [8]$$

In order to derive the necessary conditions for utility maximization, the model assumes (following Dranove 1988), Dafny (2003) and Weisbrod (2004)) that the hospital's objective function can be approximated by a linear function with non-negative weights, α and (1-α), on patient care and profit, respectively. In this case, making use of [8] the objective function is written as:

$$U = \alpha H(I,Q) + (1-\alpha)[p.X(Q) - c(I,Q).X(Q)] \qquad [9]$$

Utility maximization with respect to resources and quality of care yields the following necessary first-order conditions for a solution:

$$U_I = \alpha H_I + (1-\alpha)(-c_I).X = 0 \qquad [10]$$

$$U_Q = \alpha H_Q + (1-\alpha)[p.X' - (c_Q.X + c.X')] = 0 \qquad [11]$$

For comparative static analysis, the model further assumes that the objective function is strictly concave and satisfies the sufficient second-order conditions, i.e., $U_{II} < 0$, $U_{QQ} < 0$, and $|H|^2 = U_{II}.U_{QQ} - (U_{IQ})^2 > 0$.

Let $I^*$and Q^* denote the solution to eqs. [10] and [11], i.e., the hospital's optimal levels for its resources and care quality. Since p enters eq. [11], $I^*$and Q^* depend on p: $I^* = I^*(p)$ and $Q^* = Q^*(p)$. A key result is the following:

Proposition: Higher Medicare payment per admission should increase a hospital's quality of care. That is, $\frac{dQ^*}{dp} > 0$.

Proof: From the first order conditions and the implicit function theorem, a matrix equation is written as follows:

$$\begin{bmatrix} U_{II} & U_{IQ} \\ U_{QI} & U_{QQ} \end{bmatrix} \begin{bmatrix} \frac{dI^*}{dp} \\ \frac{dQ^*}{dp} \end{bmatrix} = \begin{bmatrix} -U_{Ip} \\ -U_{QP} \end{bmatrix} \qquad where\ |H| = |J|^3 = \begin{vmatrix} U_{II} & U_{IQ} \\ U_{QI} & U_{QQ} \end{vmatrix} > 0 \qquad [12]$$

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[2] $|H|$ is Hessian determinant.

[3] $|J|$ is Jocobian determinant.

Using Cramer's Rule, it follows that

$$\frac{dQ^*}{dp} = \frac{\begin{vmatrix} U_{II} & -U_{Ip} \\ U_{QI} & -U_{QP} \end{vmatrix}}{|J|} > 0 \quad since\ U_{II} < 0, -U_{Qp} = (1-\alpha).X^{'} < 0, and\ U_{Ip} = 0 \qquad [13]$$

Thus, this model predicts that a higher Medicare payment per admission will lead a utility-maximizing hospital to raise its quality of care, while a lower Medicare payment per admission will have the opposite effect.

There is no similar result involving I^* in this model, i.e., the effect of an increase in p on the level of hospital resources, I^*, is ambiguous due to the tradeoff between hospital's two objectives, hospital profit and patients' health outcomes. Before turning to an empirical test of the proposition above, the following chapter reviews a number of relevant previous studies of the effects of Medicare payments on hospital behavior.

CHAPTER 3

LITERATURE REVIEW

This chapter briefly reviews prior theoretical work on the effects of Medicare payments on hospital behavior, and then summarizes the findings of empirical studies of the nature of the payment/quality relationship under Medicare. It is not aware that any prior theoretical work on the payment/quality relationship in hospitals. There has been work done, however, on the effects of third-party payments on a hospital's choice of "intensity." Hodgkin and McGuire (1994) developed a model of how intensity per admission and the number of admissions respond to a third-party payment system, such as Medicare. They loosely defined intensity to be either a hospital's input level or its technical sophistication. This is in keeping with ProPAC's[4] definition that intensity encompasses the number and complexity of patient care resources that are used in producing patient care (e.g., the size and composition of the nursing staff), or intermediate outputs in the hospital (such as the time patients spend in special care units, or the average length of stay).

Their model had three key assumptions: (1) a hospital's average cost per discharge varies only with its level of intensity, (2) consumer demand also varies only with intensity, and (3) the hospital maximizes utility, which depends on both intensity and profit. Insurer reimbursement in their model takes the general

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[4] ProPAC is the abbreviation of Prospective Payment Advisory Committee, which is now currently called Medicare Payment Advisory Committee (MedPAC).

form, $p = \alpha + \beta c,$ where α and β are nonnegative constants, and c is the hospital's average cost per discharge. This function encompasses a number of payment approaches as special cases, including PPS $(\alpha > 0, \beta = 0),$ cost-based reimbursement $(\alpha = 0, \beta = 1),$ and mixed arrangements $(\alpha > 0, \beta > 0)$, such as those that Medicare used when phasing in PPS program between 1984 and 1987. Hodgkin and McGuire showed that a hospital's utility-maximizing choice of intensity is positively related to $\alpha,$ and positively related to β, *ceteris paribus*.

Their model was extended by Dafney (2003) to allow for a mix of different DRGs among patients, where each DRG is paid a different rate. She allowed each hospital to select an intensity level, denoted by $\mathrm{I_{hd}}$, for each of its DRGs. Using comparative statics analysis Dafney showed that each chosen intensity level $(\mathrm{I_{hd}})$ is positively relate to its corresponding DRG payment $(\mathrm{P_{hd}})$.

In both the Hodgkin/McGuire model and in Dafney's model the *only* choice a hospital makes is choosing intensity. Intensity alone determines demand for admissions, and intensity alone determines cost per case. There are no inputs and there is no quality, per se. Rather, there is simply intensity.

This model (in the preceding Chapter) views a hospital differently. A hospital chooses *both* its inputs and a level for quality, and then combines them to produce patient health outcomes. Both inputs and the level of quality determine a hospital's cost per case. Quality refers to whether its inputs are applied towards patient care in ways that produce better outcomes. It is quality that matters to patients, not the level of inputs. There is no intensity in the model, and inputs are distinct from quality.

Most prior empirical studies of the effects of Medicare payments on hospitals have examined either the effects of switching from cost-based reimbursement to PPS in the mid 1980s, or the effects of more incremental changes in payment rates that have occurred since then. Studies of the transition to PPS investigated its effects on average length of stay, and the mortality rate of Medicare beneficiaries. Freiman et al. (1989) and Cutler (1990) provide evidence that average length of stay decreased with the decrease of Medicare reimbursement. However, the evidence regarding mortality is mixed. Rogers et al. (1990), Kahn et al. (1990), and Kosecoff et al. (1990) examined the effect of PPS on Medicare patients using a pre- and post- comparison. The studies found no increase in patient mortality rates (in-hospital, 30-day, and 180-day) subsequent to the switch to PPS, although there was an increase in the number of patients who were discharged in an unstable condition. Cutler (1995) found that the introduction of PPS had no long-run effects on the mortality of the elderly treated for severe illnesses. However, he found that decreases in average payments compressed the mortality distribution. That is, there was an increase in in-hospital mortality, a decrease in post-discharge mortality, and no change in 1-year mortality.

Studies by Staiger and Gaumer (1995), Shen (2003), Lindrooth et al (2007), and Kaestner and Guardado (2008) used plausibly exogenous variation in Medicare reimbursement that occurred under more recent program changes to examine the effects of changes in payment on treatment intensity, patient mortality, and the overall health outcomes of patients. Staiger and Gaumer

(1995) examined the effect of payment changes on the mortality of Medicare patients treated for urgent care. They found that changes in payment had mixed and unintuitive effects. On one hand, they found a reduction in Medicare reimbursement significantly increased mortality at 45 days, but this phenomenon occurred mostly in government hospitals, and to a lesser extent, in for-profit hospitals. On the other hand, in not-for-profit hospitals, reductions in Medicare reimbursement had no statistically significant effects on 1-year mortality.

Shen (2003) examined the effect of payment changes on the mortality of Medicare patients treated for heart attack. She found that a reduction in reimbursement for patients with acute myocardial infarction (AMI) increased their short-term mortality (measured at 7-, 30-, and 90-days), but left patients' 1-year mortality unchanged.

Lindrooth et al. (2007) studied how treatment intensity changed following changes in hospital reimbursement that occurred under the 1998 Balanced Budget Act (BBA), with special attention to how the responses varied between non-for-profit and for-profit hospitals. They found that following the slowdown in the "update factor" used to calculate Medicare DRG rates, not-for-profit hospitals significantly reduced the treatment intensity of patients in more generously-paid DRGs, whereas for-profit hospitals made few changes in treatment intensity. Kaestner and Guardado (2008) also examined treatment intensity, and focused on how it responded to changes in Medicare rates that arose from the geographical reclassifications of hospitals. They examined both hospital staffing and patient outcomes following reclassifications that occurred between 1994 and

2001. They found that changes in Medicare payments of roughly 10 percent had no meaningful effect on either staffing levels or patient outcomes.

A number of studies have examined the effects of Medicare payments on the quality of patient care provided by physicians. Generally speaking, studies find that physicians can and do respond to financial incentives by altering their treatment practices and the quality of care they provide to patients. Yip (1998) examined how physicians responded to a Medicare fee reduction in coronary artery bypass graft (CABG) surgeries, and found that physicians whose incomes were reduced the most by Medicare fee cuts performed higher volumes of CABGs. Hadley et al. (2003) studied how Medicare breast surgery fees affect the treatment received by older women with localized breast cancer. They found that Medicare's payment differential between mastectomy and breast conserving surgery (BCS) with radiation therapy significantly influenced a physician's choice between these two treatments. In areas where Medicare paid more for BCS, physicians were more likely to perform BCS rather than mastectomy, *ceteris paribus.* More recently, Brunt and Jensen (2010) found that over the period 2001-2003, lower Medicare reimbursement significantly reduced the perceived quality of physician visits for a wide range of quality measures, although the effects were small.

There are no studies, to my knowledge, that examine the link between Medicare payments and the technical processes for care within hospitals. Yet, this link is key to understanding the impact of a change in Medicare payment on health outcomes, since a hospital's first response to a decrease in Medicare payment may well entail altering its technical processes for care, which in turn influence patient outcomes.

The present study examines the relationship between Medicare payments and a number of technical aspects of treating pneumonia, heart failure and heart attacks. Specifically, the quality of pneumonia care, heart failure care and heart attacks care are measured by a hospital's frequency of adherence to widely-accepted treatment protocols for patients diagnosed with pneumonia, heart failure and heart attacks respectively. This approach has two advantages. First, changes in how patients are treated likely reflect a hospital's direct response to changes in reimbursement. Second, models of adherence to treatment protocols may be less vulnerable to bias arising from omitted patient severity of illness than health outcomes measures, such as mortality rates or hospital readmission rates.

CHAPTER 4

RESEARCH DESIGN AND METHODS

Using data on U.S. hospitals it examines how Medicare payment rates for pneumonia, heart failure, and heart attacks affect the quality of pneumonia, heart failure, and heart attack care, respectively. There are two objectives. First, it is to determine for each of these diagnoses whether there is a positive and significant relationship between the Medicare payment and the quality of hospital care for patients with that diagnosis – pneumonia, heart failure or heart attack. Second, it is to obtain estimates of the marginal effect of a change in Medicare reimbursement on the quality of care for each of these conditions. It assumes that within each hospital there is a common level of quality across all of the patients that share a particular primary diagnosis. (That is, the quality of pneumonia care is assumed to be the same for all patients with pneumonia, the quality of heart failure care is assumed to be the same for all heart failure patients, and the quality of heart attack care is assumed to be the same for all heart attack patients.)

Pneumonia is an inflammation of the lung commonly due to infection by bacteria, viruses, and sometimes by aspiration, fungi, or chemicals. It is the fifth leading cause of death among adults ages 65 and over. Among Medicare beneficiaries, pneumonia is the second most common cause of hospitalization (Myles Maxfield et al., 2004).

Heart failure is the inability of the heart to pump sufficient blood to the body. It is the most common cause of hospitalization among Medicare beneficiaries. Heart failure is also a chronic disease, for which appropriate outpatient management can reduce re-hospitalizations. Common risk factors for heart failure include previous heart attacks and high blood pressure. (Angela Merrill et al.,2003).

Heart attack is also called Acute Myocardial Infarction (AMI). It is a condition that occurs when the arteries leading to the heart become blocked and the blood supply is slowed or stopped. Each year, approximately 1.1 million people experience an acute myocardial infarction (AMI), or heart attack. One-third of those suffering an AMI die during the acute phase. Over 80 percent of all heart attack–related deaths occur in individuals age 65 or older. The average age of first heart attack is 66 for men and 70 for women (Robert Schmitz et al., 2003).

Heart failure, pneumonia, and heart attack rank among the ten most common diagnoses for Medicare inpatient care. The processes of care represented by quality measures for these three conditions are known to improve the quality of care patients receive during inpatient visits to the hospital (CMS,2009).

4.1 Data

Data for the analysis come from three sources. Hospital-specific data on the quality of pneumonia care, heart failure care and heart attack care are from October, 2006 to September, 2007, and Medicare's payment rate per pneumonia admission, per heart failure admission and per heart attack admission in that period come from the "Hospital Compare" website. Data on other characteristics of each hospital were obtained from the Prospective Payment System Impact (PPS Impact) files for Fiscal Year 2007 maintained by CMS, and data on each hospital's local area characteristics were obtained from the 2008 Area Resource file (ARF) of the Bureau of Health Professions.

The hospital sample consists of acute care U.S. hospitals observed in fiscal year 2007 (from October 1, 2006 to September 30, 2007) that meet the following criteria: (1) the hospital contracts with Medicare to provide acute inpatient care and agree to accept the program's predetermined payment rates as payment in full.[5] (2) it participates in the Hospital Compare data disclosure program, (3) it reported data on all of Hospital Compare's quality measures for pneumonia care, or heart failure care or heart attack care, and (4) Medicare payment data for the hospital were available at the Hospital Compare website. 3,012 acute care hospitals met these criteria and comprise the sample for the empirical analysis for pneumonia care; 3,078 acute care hospitals met these criteria and comprise the sample for the empirical analysis for heart failure care; 1,528 acute care hospitals met these criteria and comprise the sample for the empirical analysis for heart attack care.

4.2 Dependent Variables

For hospitals that participate in its data disclosure program, Hospital Compare reports information on different quality measures of inpatient care:

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[5] Medicare pays the approved amount minus any beneficiary liability, such as a deductible or copayment; the provider then collects the remaining amount from the beneficiary or a supplemental insurer (MedPAC 2010).

seven for pneumonia, four for heart failure and six for heart attacks. The measures describe the percentage of patients at the hospital who actually received the recommended treatment protocols that are widely agreed to be appropriate and vital to patients admitted with pneumonia, heart failure or heart attacks. Thus, they are quality measures consistent with the Institute of Medicine's definition for quality (Lohr et al., 1990).

4.2.1 Process-of-Care Measures of Quality for Pneumonia Care

In "Hospital Compare", data describing the quality of pneumonia care are tabulated from a hospital's actual medical records for its pneumonia patients. Specifically, the Hospital Compare database reports the percentage of pneumonia patients: (1) who were given an oxygenation assessment (this measure is called PN1), (2) who were given pneumococcal vaccination (PN2), (3) whose initial emergency room blood culture was performed prior to the administration of the first hospital dose of antibiotics (PN3), (4) who were given smoking cessation advice/counseling (PN4), (5) who were given initial antibiotics within 4 hours of arrival at the hospital (PN5), (6) who were given the most appropriate initial antibiotic(s) (PN6), and (7) who were assessed and given an influenza vaccination (PN7).[6]

A hospital's score on all seven of these measures is used to create a scalar index of its overall quality rating for pneumonia care. The index (PN) is

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[6] For details on the instruction of index, see "*Overview of Specifications of Measures Displayed on Hospital Compare as if December 14, 2006"* available online: http://www.cms.gov/HospitalQualityInits/18_HospitalProcessOfCareMeasures.asp#TopOfPage .

defined as the sum of a hospital's scores across the seven item-specific measures described above. Thus, the index ranges (in principle) from zero to 700. Our focus in the empirical work is estimating the relationship between Medicare's payment rate for a pneumonia stay and this overall quality index.

Table 1 reports statistics on the quality of pneumonia care across the 3,012 hospitals in the sample. The hospital's overall quality rating for pneumonia care, PN, averages 619 across the hospitals. The table reveals almost every pneumonia patient is given an oxygenation assessment (*M*=99.7), and the variation in this practice across hospitals is very slight. The average score for PN3, PN5 and PN6, are all about 90, and the variation across hospitals is moderate, with a standard deviation ranging from 6.3% to 7.3%. Average scores on the remaining three measures, PN2, PN4 and PN7, are varied and their variation across hospitals is substantial, with the standard deviation ranging from 14.2% to 19.7%.

Table 1

Variables: Hospital-Level Process of Care Quality Measures for Pneumonia (N=3012)

Variable	Description	Score (Percentage)		Patient Sample	
		Mean	SD	Mean	SD
PN	Overall quality index for pneumonia care (see text for definition)	618.99	53.30	856.98	577.92
PN1	% of pneumonia patients who were given oxygenation	99.71	1.44	215.35	143.01

	assessment				
PN2	% of pneumonia patients who were assessed and given pneumococcal vaccination	79.58	17.27	165.07	116.63
PN3	% of pneumonia patients whose initial emergency room blood culture was performed prior to the administration of their first hospital dose of antibiotics	90.22	7.30	154.80	112.53
PN4	% of pneumonia patients who were given smoking cessation advice /counseling	90.12	14.18	64.52	50.74
PN5	% of pneumonia patients who were given initial antibiotic(s) within 4 hours after arrival	93.52	6.25	75.53	51.10
PN6	% of pneumonia patients who were given the most appropriate initial antibiotic(s)	88.43	7.34	118.52	78.03
PN7	% of pneumonia patients who were assessed and given influenza vaccination	77.41	19.65	63.18	46.29

Notes: For the complete measure specifications see the *Specifications Manual for National Hospital Quality Measures* at www. qualitynet.org

4.2.2 Process-of-Care Measures of Quality for Heart Failure Care

Hospital Compare's information on the quality of heart failure care are tabulated analogously. That is, the data on care quality for heart failure care are computed from a hospital's actual medical records for its heart failure patients. Specifically, the database reports the percentage of heart failure patients: (1) who were given discharge instructions (this measure is called HF1), (2) who were given an evaluation of left ventricular systolic function (HF2), (3) who were given ACE inhibitor or ARB for left ventricular systolic dysfunction (HF3), and (4) who were given smoking cessation advice /counseling (HF4). [7]

A hospital's score on all four of these measures is used to create a scalar index of its overall quality rating for heart failure care. The index (HF) is defined as the sum of a hospital's scores across the four item-specific measures described above. Thus, the index ranges (in principle) from zero to 400. Our focus in the empirical work is estimating the relationship between the payment rate for a heart failure stay and this overall quality index.

Table 2 reports statistics on the quality of heart failure care across the 3,078 hospitals in the sample. The hospital's overall quality rating for heart failure care, HF, averages 343 across the hospitals. The table reveals that the average score for HF2, HF3 and HF4, are above 85, but the variation across hospitals is large, with a standard deviation ranging from 11.8% to 15.6%.

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[7] For details on the instruction of index, see "*Overview of Specifications of Measures Displayed on Hospital Compare as if December 14, 2006*" available online: http://www.cms.gov/HospitalQualityInits/18_HospitalProcessOfCareMeasures.asp#TopOfPage .

Average scores on the measure HF1 is the lowest, 72.5, with a substantial variation (*SD*=21.1%) across hospitals.

Table 2

Variables: Hospital-Level Process of Care Quality Measures for Heart Failure (N=3078)

Variable	Description	Score (Percentage)		Patient Sample	
		Mean	SD	Mean	SD
HF	Overall quality index for heart failure care (see text for definition)	342.55	46.64	606.26	535.61
HF1	% of heart failure patients who were given discharge instructions	72.54	21.13	210.31	185.64
HF2	% of heart failure patients who were given an evaluation of left ventricular systolic function	91.50	11.84	259.32	220.53
HF3	% of heart failure patients who were given ACE inhibitor or ARB for left ventricular systolic dysfunction	86.73	11.85	91.76	92.17
HF4	% of heart failure patients who were given smoking cessation advice /counseling	91.59	15.64	44.87	46.18

Notes: For the complete measure specifications see the *Specifications Manual for National Hospital Quality Measures* at www. qualitynet.org

4.2.3 Process-of-Care Measures of Quality for Heart Attack Care

In Hospital Compare the data on the quality of heart attack care are tabulated from a hospital's actual medical records for its heart attack patients. Specifically, the database reports the percentage of heart attack patients: (1) who were given aspirin at arrival (this measure is called AMI1), (2) who were given aspirin at discharge (AMI2), (3) who were given ACE inhibitor or ARB for left ventricular systolic dysfunction (AMI3), (4) who were given smoking cessation advice /counseling (AMI4), (5) who were given beta blocker at discharge (AMI5), and (6) who were given beta blocker at arrival (AMI6). [8]

Paralleling the approach to measuring overall quality for the other two diagnoses, a hospital's scores on all six of these measures is used to create a scalar index of its overall quality rating for heart attack care. The index (AMI) is defined as the sum of a hospital's scores across the six item-specific measures described above. Thus, the index ranges (in principle) from zero to 600. Our focus in the empirical work is estimating the relationship between the payment rate for a heart attack stay and this overall quality index.

Table 3 reports statistics on the quality of heart attack care across the 1,528 hospitals in the sample. The hospital's overall quality rating for heart attack care, AMI, averages 566 across the hospitals. The table reveals almost every heart attack patient is given aspirin at arrival (*M*=96.8), and the variation in this practice across hospitals is very slight. The average score for AMI2, AMI5

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[8] For details on the instruction of index, see "*Overview of Specifications of Measures Displayed on Hospital Compare as if December 14, 2006*" available online: http://www.cms.gov/HospitalQualityInits/18_HospitalProcessOfCareMeasures.asp#TopOfPage .

and AMI6, are all about 90, and the variation across hospitals is moderate, with a standard deviation ranging from 6.0% to 6.3%. The AMI4 scores 95.8 with a large variation (*SD*=11.36). The lowest score is AM3 (*M*=86.7) with substantial variation (*SD*=12.9).

Table 3

Variables: Hospital-Level Process of Care Quality Measures for Heart Attack (N=1528)

Variable	Description	Score (Percentage)		Patient Sample	
		Mean	SD	Mean	SD
AMI	Overall quality index for heart attack care (see text for definition)	566.45	31.66	814.55	699.26
AMI1	% of heart attack patients who were given aspirin at arrival	96.77	3.54	156.07	112.71
AMI2	% of heart attack patients who were given aspirin at discharge	95.43	6.31	202.89	198.38
AMI3	% of heart attack patients who were given ACE inhibitor or ARB for left ventricular systolic dysfunction	86.68	12.86	45.99	46.41
AMI4	% of heart attack patients who were given smoking cessation advice /counseling	95.84	11.36	74.42	81.61
AMI5	% of heart attack patients who were given beta blocker at discharge	95.87	6.03	208.48	202.77

AMI6	% of heart attack patients who were given beta blocker at arrival	93.87	6.31	126.71	92.26

Notes: For the complete measure specifications see the *Specifications Manual for National Hospital Quality Measures* at www. qualitynet.org

4.3 Independent Variables

4.3.1 Medicare DRG Payment

Medicare currently pays for acute inpatient services under the inpatient prospective payment system (IPPS). Under this system, Medicare sets per-discharge payment rates for Medicare severity diagnosis related groups (MS-DRGs), which group patients with similar clinical problems that are expected to require similar amounts of hospital resources.

Hospitals in principle are “price-takers” for their Medicare admissions. Medicare pays each hospital a flat price per stay for each beneficiary admitted in the DRG, and that price remains constant year-long, and does not vary with a patient’s length of stay or the intensity of services provided to a patient. Thus, within the same DRG a hospital receives the same amount for a short-stay, simple case and it does for a long-stay, complicated case.

It measures Medicare’s payment rate for a pneumonia admission as the amount the hospital received from Medicare in 2007 for each admission in DRG 89. DRG 89 describes admissions with a primary diagnosis of “simple pneumonia with comorbidities or complications.” DRG 89 is the fourth most commonly used DRG, representing 3.7 percent of all Medicare discharges (Office of Inspector General, 1989). DRG 89 is the most frequently assigned pneumonia-related DRG. Medicare's mean payment in 2007 for this DRG was $6,303 with a standard deviation of $1,341, revealing that Medicare's payment rate varied considerably across U.S. hospitals.

It measures Medicare's payment rate for a heart failure admission as the amount the hospital received from Medicare in 2007 for each admission in DRG 127. DRG 127 describes admissions with a primary diagnosis of "heart failure." In 2001, over one-half million beneficiaries were hospitalized at least once for heart failure, and Medicare spent over $4 billion on hospital care alone for heart failure (Angela Merrill et al., 2003). Medicare's mean payment in 2007 for this DRG was $6,381 with a standard deviation of $1,500, also revealing that Medicare's payment rate varied considerably across U.S. hospitals.

For heart attacks, Hospital Compare provides two DRG applying for heart attack admissions. One is DRG 121 describing admissions with a diagnosis of "heart attack with major complications"; the other one is DRG122 describing admissions with a diagnosis of "heart attack without complications". To measure the quality/payment for heart attack care appropriately, a price index is created to measure the payment rate for a heart attack admission by weighting the amount of the hospital received from Medicare in 2007 for each admission under DRG121 and each admission under DRG122[9]. So the weighted mean payment in 2007 for heart attacks was $8,519 with a standard deviation of

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[9] $$Price\ Index\ for\ heart\ attack = \frac{\text{admissions under DRG121}}{\text{total admissions under DRG121 and DRG122}} * \text{payment rate for DRG121} + \frac{\text{admissions under DRG121}}{\text{total admissions under DRG121 and DRG122}} * \text{payment rate for DRG122}$$

$2,103, revealing that Medicare's payment rate varied considerably across U.S. hospitals as well.

4.3.2 Other Independent Variables

The price Medicare pays for a same DRG admission, however, does vary from hospital to hospital. Medicare sets its price prospectively using a complicated formula that depends on a number of factors that can arguably be manipulated by a hospital, so in practice, there is some element of endogeneity in the price each receives. Under its IPPS, Medicare's price within a DRG is higher for: (1) hospitals in areas that face higher prices for medical care inputs, such as higher hourly wages for hospital employees, (2) hospitals that treat a disproportionate share (DSH) of very low-income patients, such as patients who rely on supplemental security income benefits or Medicaid patients, and (3) teaching hospitals that incur higher indirect costs of medical education (IME). They are also higher for admissions that are extraordinarily costly, called outliers .[10]

Specifically, Medicare's payment rate formula adjusts for five aspects of input costs, two aspects of a hospital's DSH-related expenses, and four aspects of its IME activities. Medicare calls these hospital-specific variables "adjustment factors." Prior to the start of the 2007 fiscal year Medicare set its payment rate

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[10] MedPAC Medicare Payment Basics: Hospital Acute Inpatient Services Payment System.

for the upcoming year in each of 579[11] severity-adjusted DRGs. Medicare draws its data for each hospital's adjustment factors from previous years, not the current year. So it is always a hospital's past choices (for those adjustment factors) that can influence its upcoming payment rates, not its current choices.

Medicare's reliance on historical data partially alleviates an endogeneity concern with the measure of its 2007 payment rate for a pneumonia admission, a heart failure admission or a heart attack admission. However, it does not eliminate the concern entirely. In particular, if some of those hospital characteristics, i.e., the adjustment factors, also affect care quality, but are omitted from an estimated quality regression, then their effects are arguably picked up by the regression's disturbance term. In this case the payment rate could be correlated with the disturbance, implying endogeneity, because those same adjustment factors are the known determinants of a hospital's rate. Following Hadley et al. (2003), to reduce the possibility of correlation between the payment rate and the disturbance, the regression models also control explicitly for the adjustment factors.

The identification assumption underlying estimation of the effects of payment is that by controlling for Medicare's adjustment factors directly in the quality model, the disturbance those hospital characteristics that are correlated with payment has been removed. With this strategy, there is likely be some correlation among explanatory variables in the model, but it should not be a problem provided it is not too large. This issue will be examined empirically.

[11] Now Medicare uses 745 DRGs.

Data on the adjustment factors used by Medicare are available from the CMS IPPS Impact File for 2007. There are 11 variables in this category, including the wage index applicable to the hospital's location (WI), the cost of living adjustment for operating PPS (COLA), the geographic adjustment factor for capital PPS (GAF), the ratio of Medicare operation costs to Medicare covered charge (OPPCR), the ratio of Medicare capital costs to Medicare covered charges (CPCCR), the resident-to-bed ratio used to calculate the IME adjustment to operating cost (RESBED), the ratio of residents-to-average-daily-census used to calculate the IME adjustment to capital cost (RDAY), the IME adjustment to operating costs (TCHOP), the IME adjustment to capital costs (TCHCP), the operating cost disproportionate share adjustment (DSHOPG), and the capital cost disproportionate share adjustment (DSHCPG).

Other hospital characteristics may also influence quality. The facility's ownership status, for example, may affect the relative importance it places on quality and profit (Sloan et al. 2001), or in terms of the model, its value for α in equation [10] above. The model therefore controls for whether a hospital is government-owned (OWNERG), non-profit (OWNERV), or for- profit (OWNERP). Because there are geographic variations in health care delivery that may involve quality (Wennberg, 1999,2002), the model also controls for a hospital's region (whether New England, Middle Atlantic, South Atlantic, East North Central, East South Central, West North Central, West South Central, Mountain, or the Pacific region), and whether a hospital is in an urban area (URBAN). It controls for a hospital's size using a series of dummy variables for its bed count (50 or fewer, 51-100, 101-150, 151-200, 201-300, or more than 300 beds) as well. Whether the hospital is a teaching facility (TEACH), its patient case-mix, as measured by the Medicare case-mix index (CMI), its average daily census (ADC), the total number of Medicare discharges at the hospital (BILLS), Medicare patients' share of total inpatient days (MCRPCT), and the percent of admissions meeting Medicare's disproportionate share criteria (DSHPCT) are also in each of the models.

Finally, the models control for a number of market-level characteristics, to gain insight into whether the structure of the market also affects the quality of hospital care. A measure of the concentration of hospitals is included in the facility's local area, specifically, a hospital Herfindahl index (HHI) measured at the county-level. The index is the sum of the squared market shares of all short-term general hospitals in the county. It takes positive values, with higher values signifying a greater concentration of hospitals, and it has a maximum value of 1 for any hospital that is the only short-term general hospital in its county. The absolute number of short-term general hospitals in the county (NHOS), and population density, as measured by individuals per square mile (POPSQ), are also included to capture additional aspects of the market. The data used to construct these variables are from the Area Resource File. Table 4, Table 5 and Table 6 report summary statistics on all of the independent variables in the quality models for pneumonia, heart failure and heart attack respectively.

4.4 Model Specification

The objective is to estimate the marginal effect of an increase in the Medicare payment rate on the quality of hospital care for pneumonia, heart failure, and heart attacks. Multivariate regression is used for this purpose, allowing for a possibly nonlinear relationship between payment and quality. Three separate sets of models is estimated. One set describes the determinants of the quality in pneumonia care, another set describes the quality of heart failure care, and a third set describes the quality of heart attack care.

The basic model within each diagnosis category takes the following form:

$$Q_i = \beta_0 + \beta_1 Pay_i + \beta_2 (Pay_i * Cases_i) + \beta_3 (Pay_i)^2 + \beta_4 AF_i + \beta_5 H_i + \beta_6 M_i + u_i \quad [14]$$

Here i indexes a hospital, Q is the quality measure for that diagnosis, Pay is Medicare's average payment to hospital i for that diagnosis, $Pay * Cases$, an interaction term, is the hospital's total revenue from Medicare payment and also controls for possible economies of scale in the provision of quality, $(Pay)^2$ is payment rate squared, AF is the vector of hospital-specific adjustment factors used by Medicare to determine the hospital's rate, H is the vector of hospital characteristics described above, M is the vector of market area characteristics, and u_i is a randomly distributed disturbance term with mean zero.

Given equation [14] the marginal effect of Medicare reimbursement on the diagnosis-specific quality of hospital care is:

$$\frac{dQ_i}{dPay_i} = \beta_1 + \beta_2 Cases_i + 2\beta_3 Pay_i \quad [15]$$

Thus, the marginal effect depends on the volume of patient cases and the Medicare payment rate. Equation [15] also illustrates how Medicare updates its annual base payment rates (known as standardized payment amounts). Medicare's payments are derived through a series of factor adjustments applied to these base payment rates. The base payment rates are updated annually, and absent other policy changes, the update raises all payment rates proportionately[12], affecting all fees across all hospitals paid under IPPS by exactly the same percentage. The update on the annual base payment rate is currently Medicare's primary policy tool for controlling spending for inpatient care.

4.5 Model Estimation

In the econometric analyses, the focus is on correcting for potential heteroskedasticity in the disturbances, and on checking whether there is still endogeneity in the Medicare payment rate after adjusting for hospital and geographic characteristics. Equation [14] is estimated first by ordinary least squares (OLS) with nonrobust standard errors (referred to as model 1) for pneumonia, heart failure and heart attacks. Then the possibility of heteroskedastcity for each of them is tested, using a Breusch-Pagan test (Breusch and Pagan 1979). The tests for each of them, pneumonia, heart failure and heart attacks, firmly reject an assumption of homoskedasticity ($p < 0.001$).

[12] MedPAC Medicare Payment Basics: Hospital Acute Inpatient Services Payment System.

Three different methods are used to correct for heteroskedasticity, and are referred as model 2, model 3, and model 4, respectively. In model 2, we calculate and report heteroskedasticity-robust standard errors for the OLS estimator. This approach is valid in large samples whether or not the errors have constant variance (White 1980). However, due to the presence of heteroskedasticity, an OLS estimator is no longer the best linear unbiased estimator. Therefore, equation [14] is also estimated using a Feasible Generalized Least Squares (FGLS) estimator (Wooldridge 2009), assuming the variance of the error is a function of the independent variables. Even though an FGLS estimator is no longer unbiased, it is consistent and asympototically more efficient than OLS. Model 3 is the FGLS estimator, without robust standard errors, assuming the variance of the error is a linear function of the independent variables. Finally, Model 4 reports an FGLS estimator with robust standard errors, assuming the variance of the error term is a nonlinear function of the independent variables.

A Hausman test (Hausman, 1978) is used to assess whether the estimated coefficients differ across these models for pneumonia, heart failure and heart attacks separately (Wooldridge, 2009, pp.286). In Hausman tests for all pneumonia, hear failure and heart attacks models, it fails to find significant differences between model 1 and model 3 ($p > 0.85$). It also test for whether model 2 and model 4 have different estimated coefficients, using the heteroskedasticity-robust version of a Hausman test (Wooldridge, 2002, pp. 118-123). In all these tests for pneumonia, heart failure and heart attack models, they still cannot reject the hypothesis of “no difference” between model 2 and model 4 ($p > 0.73$). The results of these Hausman tests suggest that the endogeneity is unobserved and the results of model 4 are likely highly reliable in each of the quality of care model, pneumonia, heart attack and heart failure.

CHAPTER 5

RESULTS

5.1 Results for Pneumonia Care

Table 7 reports the correlation coefficients for all seven quality measures for pneumonia care. As Table shows, the seven quality measures for pneumonia care are all positively correlated with one another. The correlation between PN2 and PN7 is particular strong, with a correlation coefficient of 0.79. All pair-wise correlations of the quality measures are statistically significant at the 1% level.

Table 8 reports the estimated models for the determinants of the quality of pneumonia care. The dependent variable is the index measure of hospital quality, PN. The first two columns display OLS regression parameters with and without robust standard errors, and the third and fourth column display FGLS regression parameters with and without robust standard errors. Because the FGLS estimates with robust standard errors are the most efficient estimates, given the presence of heteroskedasticity, the focus will be on the result of Model 4.

The interest centers on determining whether the Medicare reimbursement rate is positively related to quality. As Table 8 reveals, the relationship between payment and quality is nonlinear, with statistically significant first and second order terms. The first order term has a large, negative effect on quality, while the second order term and payment squared term have a small, positive effect on quality. This means that the marginal effect of payment on quality depends on the level of payment. It is negative over one range of payments, and positive over another range of payments.

Table 9 reports how the marginal effect of the payment rate varies over the full range of rates and pneumonia caseloads in this sample. It reports the marginal effect as a function of payment, when pneumonia caseload is held at the 1^{st}-, 5^{th}-, 10^{th}-, 25^{th}-, 50^{th}-, 75^{th}-, 90^{th}-, 95^{th}-, and 99^{th}-percentile, respectively. It also reports the marginal effect of payment as a function of caseload, when payment is held at the 1^{st}-, 5^{th}-, 10^{th}-, 25^{th}-, 50^{th}-, 75^{th}-, 90^{th}-, 95^{th}-, and 99^{th}-percentile, respectively. The standard error for each marginal effect in this table was calculated using the methods suggested by Wooldridge (2009, pp 198-199). Each entry in Table 9 reports the change in the quality index resulting from a $100 increase in payment, when payment and caseload are at the levels given in that row and column, respectively. For example, the number -0.287, which appears in the first row and column indicates that when payment is at $ 4,752 and the pneumonia caseload is at 17 cases per year, a $100 change in payment would lead to a decrease of 0.287 in the hospital's quality index. However, this change is statistically insignificant in view of the calculated standard error for this marginal effect.

As shown in Table 9, over much of the range for payment and caseload, the marginal effect of a $100 change in payment on quality is insignificant. However, for the most highly paid hospitals, and for hospitals with very high pneumonia caseloads, the marginal effect of a $100 change in payment on quality is positive and significant. This may be because with highly-paid and heavily case-loaded hospitals, the revenue from pneumonia DRG 89 occupies a relatively larger share of hospital total revenue and hospital profit. This would give these hospitals a greater incentive to improve the quality of their pneumonia care.

These findings suggest that unless a hospital is already highly paid for pneumonia cases, or treating a relatively high number of such cases, paying more for pneumonia cases is unlikely to improve the quality of pneumonia care. Alternatively, paying less for pneumonia cases has little impact on the quality of care.

There were a total of 433,531 cases under DRG 89 in 2007 for pneumonia care in the 3012 acute care hospitals in this sample. Based on these results, if Medicare paid $100 less per pneumonia case, only 58 hospitals (1.9 percent of the 3,012 hospitals in the sample) would experience a significant decrease in care quality, and in the affected hospitals, the overall quality index would decline by approximately 0.256 percent to 0.594 percent, which are both well under one percent. This means that care quality would not suffer much. Such a price reduction could save Medicare approximately 43 million dollars (1.6 percent of total Medicare spending in DRG 89 in 3012 acute hospitals) just for pneumonia care in DRG 89. Except for the 58 hospitals with significant effects on the reduction of Medicare payment, 2194 hospitals report insignificant negative effects and 760 hospitals report insignificant positive effects.

Table 10 reports the overall marginal effects of the payment rate on PN1 through PN7, respectively, calculated at the sample mean (payment= 6,300 and pneumonia cases=145). The table reveals that none of these seven individual processes are significantly related to the payment rate (p > .10), when calculated at the sample mean. The marginal effects of PN1, PN3 and PN4 are positive at the mean, in both the OLS and FGLS equations. The marginal effects of PN2, PN6 and PN7, however, are negative in both the OLS and FGLS equations. PN5 shows a mixed effect, which is positive in the OLS equations, but negative in the FGLS equations.

Turning to some of the other findings, a hospital's ownership status and location are also important determinants of its performance. Relative to government-owned hospitals (the reference group), non-profit and for-profit hospitals both provide significantly higher levels of quality for pneumonia patients.

Significant regional effects are also evident from the models estimated. Relative to the Pacific region (which encompasses CA, OR, WA, HI, and AK), hospitals in other areas exhibit higher quality care for pneumonia patients. The highest quality care occurs in hospitals in New England (CT, ME, MA, NH, RI, and VT) and the West North Central (IA, KS, MN, MO, NE, ND, and SD) region. Hospitals in the Mountain region (AI, CO, ID, MT, NV, NM, UT, and WY) perform slightly better than those in the Pacific region.

Interestingly, there is little effect of a hospital's size on its level of quality. Relative to hospitals with 50 or fewer beds, hospitals with 51-100 beds provide significantly higher quality. Larger hospitals, however, have comparable quality to relatively small hospitals.

5.2 Results for Heart Failure Care

The four quality measures for heart failure care are all positively correlated with one another. The correlation between HF1 and HF4 is strong, with a correlation coefficient of 0.54. All pair-wise correlations of the quality measures are statistically significant at the 1% level.

Table 10 reports the estimated models for the determinants of the quality of heart failure care. The dependent variable is the index measure of hospital quality, HF. The first two columns display OLS regression parameters with and without robust standard errors, and the third and fourth column display FGLS regression parameters with and without robust standard errors. Because the FGLS estimates with robust standard errors are the most efficient estimates, given the presence of heteroskedasticity, the focus is on the result of Model 4.

Our interest centers on determining whether the Medicare reimbursement rate is positively related to quality. As Table 10 reveals, the relationship between payment and quality is nonlinear, with statistically significant first and second order terms. The first order term has a large, negative effect on quality, while the second order term and payment squared term have a small, positive effect on quality. This means that the marginal effect of payment on quality depends on the level of payment. It will be negative over one range of payments, and positive over another range of payments.

Table 11 reports how the marginal effect of the payment rate varies over the full range of rates and heart failure caseloads in this sample. It reports the marginal effect as a function of payment, when heart failure caseload is held at the 1^{st}-, 5^{th}-, 10^{th}-, 25^{th}-, 50^{th}-, 75^{th}-, 90^{th}-, 95^{th}-, and 99^{th}-percentile, respectively. It also reports the marginal effect of payment as a function of caseload, when payment is held at the 1^{st}-, 5^{th}-, 10^{th}-, 25^{th}-, 50^{th}-, 75^{th}-, 90^{th}-, 95^{th}-, and 99^{th}-percentile, respectively. The standard error for each marginal effect in this table was calculated using the methods suggested by Wooldridge (2009, pp 198-199). Each entry in Table 11 reports the change in the quality index resulting from a $100 increase in payment, when payment and caseload are at the levels given in that row and column, respectively. For example, the number -0.130, which appears in the first row and column indicates that when payment is at $ 4,750 and the heart failure caseload is at 17 cases per year, a $100 change in payment would lead to a decrease of 0.130 in the hospital's quality index. However, this change is statistically insignificant in view of the calculated standard error for this marginal effect.

As shown in Table 11, over much of the range for payment and caseload, the marginal effect of a $100 change in payment on quality is insignificant. However, for the most highly paid hospitals, and for hospitals with very high heart failure caseloads, the marginal effect of a $100 change in payment on quality is positive and significant. This may be because with highly-paid and heavily case-loaded hospitals, the revenue from heart failure DRG 127 occupies a relatively larger share of hospital total revenue and hospital profit. This would give these hospitals a greater incentive to improve the quality of their heart failure care

These findings suggest that unless a hospital is already highly paid for heart failure cases, or treating a relatively high number of such cases, paying more for heart failure cases is unlikely to improve the quality of heart failure care. In other words, paying less for heart failure cases has little impact on the quality of care.

There were a total of 579,876 cases under DRG 127 in 2007 for heart failure care in the 3,078 acute care hospitals in this sample. Based on these results, if Medicare paid $100 less per heart failure case, only 134 hospitals (4.4 percent of the 3,078 hospitals in the sample) would experience a significant decrease in care quality, and in the affected hospitals, the overall quality index would decline by approximately 0.238 percent to 1.134 percent, which are both well under 1.5 percent. This means that care quality would not suffer much. Such a price reduction could save Medicare approximately 58 million dollars (1.5 percent of total Medicare spending in DRG 127 in 3078 acute hospitals) just for heart failure care in DRG 127. Except for the 134 hospitals with significant effects on the reduction of Medicare payment, 1215 hospitals report insignificant negative effects and 1729 hospitals report insignificant positive effects.

Table 12 reports the overall marginal effects of the payment rate on HF1 through HF4, respectively, calculated at the sample mean (payment= 6,381 and heart failure cases=188). The table reveals that most of these four individual processes are insignificantly related to the payment rate ($p > .10$), when calculated at the sample mean. The marginal effects of HF1and HF3 are positive at the mean, in both the OLS and FGLS equations. The marginal effects of HF4, however, are negative in both the OLS and FGLS equations. HF2 shows a mixed effect, which is positive in the OLS equations, but negative in the FGLS equations.

Turning to some of the other findings, a hospital's ownership status and location are also important determinants of its performance. Relative to government-owned hospitals (the reference group), non-profit and for-profit hospitals both provide significantly higher levels of quality for heart failure patients.

Significant regional effects are also evident from the models estimated. Relative to the Pacific region (which encompasses CA, OR, WA, HI, and AK), hospitals in other areas except for Mountain region all exhibit significantly much higher quality care for heart failure patients. The highest quality care occurs in hospitals in East North Central (IL, IN, MI, OH, and WI) and South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA and WV). Hospitals in the Mountain region (AI, CO, ID, MT, NV, NM, UT, and WY) perform slightly worse than those in the Pacific region but it is statistically insignificant.

There are significant effects of a hospital's size on its level of quality. Relative to hospitals with 50 or fewer beds, all other hospitals with more than 50 beds all provide significantly much higher quality than those with 50 or fewer beds. The highest quality care for heart failure patients occurs in hospitals with 201 - 300 beds and hospitals with more than 300 beds.

5.3 Results for Heart Attack Care

The six quality measures for heart attack care are all positively correlated with one another. The correlation between AMI2 and AMI5 is particular strong, with a correlation coefficient of 0.68. All pair-wise correlations of the quality measures are statistically significant at the 1% level.

Table 13 reports the estimated models for the determinants of the quality of heart attack care. The dependent variable is the index measure of hospital quality, AMI. The first two columns display OLS regression parameters with and without robust standard errors, and the third and fourth column display FGLS regression parameters with and without robust standard errors. Because the FGLS estimates with robust standard errors are the most efficient estimates, given the presence of heteroskedasticity, the focus on the result of Model 4.

Our interest centers on determining whether the Medicare reimbursement rate is positively related to quality. As Table 13 reveals, the relationship between payment and quality is nonlinear, with statistically significant second order term. The first order term has a negative and insignificant effect on quality, while the second order term and payment squared term, has a small, positive effect on quality. This means that the marginal effect of payment on quality depends on the level of payment. It will be negative over one range of payments, and positive over another range of payments.

Table 14 reports how the marginal effect of the payment rate varies over the full range of rates and heart attack caseloads in this sample. It reports the marginal effect as a function of payment, when heart attack caseload is held at the 1^{st}-, 5^{th}-, 10^{th}-, 25^{th}-, 50^{th}-, 75^{th}-, 90^{th}-, 95^{th}-, and 99^{th}-percentile, respectively. It also reports the marginal effect of payment as a function of caseload, when payment is held at the 1^{st}-, 5^{th}-, 10^{th}-, 25^{th}-, 50^{th}-, 75^{th}-, 90^{th}-, 95^{th}-, and 99^{th}-percentile, respectively. The standard error for each marginal effect in this table was calculated using the methods suggested by Wooldridge (2009, pp 198-199). Each entry in Table 14 reports the change in the quality index resulting from a $100 increase in payment, when payment and caseload are at the levels given in that row and column, respectively. For example, the number 0.028, which appears in the first row and column, indicates that when payment is at $ 5,372 and the heart attacks caseload is at 27 cases per year, a $100 change in payment would lead to a increase of 0.028 in the hospital's quality index. However, this change is statistically insignificant in view of the calculated standard error for this marginal effect.

As shown in Table 14, over all of the range for payment and caseload, the marginal effect of a $100 change in payment on quality is insignificant. These findings suggest that paying more for heart attack cases is unlikely to improve the quality of heart attack care. In other words, paying less for heart care cases has little impact on the quality of care.

There were a total of 134,158 cases under heart attack DRG 121 and DRG122 in 2007 for heart attack care in the 1528 acute care hospitals in this sample. Based on these results, if Medicare paid $100 less per heart attack case, care quality would not suffer much. Such a price reduction could save

Medicare approximately 13 million dollars (1.1 percent of total Medicare spending in DRG121 and DRG122 in 1028 acute hospitals) just for heart attack care in DRG 121 and DRG122.

Table 15 reports the overall marginal effects of the payment rate on AMI1 through AMI6, respectively, calculated at the sample mean (payment= 8,519 and heart attack cases=88). The table reveals that none of these six individual processes are significantly related to the payment rate ($p > .10$), when calculated at the sample mean. The marginal effects of AMI1 through AMI6 are all positive at the mean, in both the OLS and FGLS equations.

Turning to some of the other findings in the quality of heart attack care, compare to pneumonia and heart failure, a hospital's ownership status and location are not important determinants of its performance in heart attack care. Relative to government-owned hospitals (the reference group), non-profit hospitals provide higher level of quality for heart attack patients, but for-profit hospitals provide lower levels of quality for heart attack patients. However, both results are insignificant.

Significant regional effects are some evident from the models estimated. Relative to the Pacific region (which encompasses CA, OR, WA, HI, and AK), all hospitals in other areas exhibit higher quality care for heart attack patients. But only three regions, the New England (CT, ME, MA, NH, RI, and VT), the East North Central (IL, IN, MI, OH and WI) and the West North Central (IA, KS, MN, MO, NE, ND, and SD) present statistically significant higher quality of care.

There is significant effect of a hospital’s size on its level of quality. Relative to hospitals with 50 or fewer beds, except for hospitals with 51-100 beds, hospitals with more than 100 beds all provide significantly higher quality of heart attack care.

Overall, the results from heart attacks care do not show the significant impact of Medicare payment on the quality of heart attack care. This is distinct from the results from pneumonia and heart failure, which both show significant impact of Medicare payment on the care quality on high paid or high case-loaded hospitals.

CHAPTER 6

CONCLUSIONS

This study has examined the effects of Medicare reimbursement on the quality of hospital care, both theoretically and empirically. A model of quality determination in hospitals was developed, and used to derive the testable hypothesis the Medicare reimbursement rate and hospital quality should be positively related. Thus, it is expected that an increase in Medicare's payment for a given DRG should have a positive impact on a hospital's quality of care for that DRG. Newly available data on the quality of hospital care and Medicare payments for pneumonia, heart failure and heart attacks were then used to empirically test this hypothesis, controlling for hospital and market area characteristics, as well as for the adjustment factors used by Medicare in setting its hospital rates.

The study finds the relationship between Medicare payment and the quality of hospital care is qualitatively similar for pneumonia and heart failure care. In both cases the econometric model finds a significant nonlinear relationship between payment and quality. The first order term has a large, negative effect on quality, while the second order term and payment squared term have small, positive effects on quality. However, for heart attack care this nonlinear relationship is found to be insignificant.

For pneumonia care and heart failure care, the marginal effect of payment was found to depend on both the level of payment and the hospital's caseload for that DRG. Upon calculating the marginal effect of payment for different types of hospitals two findings emerged. On one hand, for the average hospital in the sample, the marginal effect on paying $100 dollar more on the quality of care is insignificant. On the other hand, for hospitals that are very highly paid for pneumonia patients or heart failure patients, or that treat large numbers of pneumonia cases or heart failure cases, there is a positive and significant marginal effect of payment on care quality. This finding is interpreted as partial support for the key hypothesis.

For hospitals in these categories, which likely derive substantial revenue from pneumonia care or heart failure care, an increase in Medicare payment for pneumonia care or heart failure care leads to a small and significant improvement in the quality of pneumonia care or heart failure care they provide. However, even for these hospitals, the size of the effects observed is quantitatively very small. (On the study heart attack care, the marginal effect on paying $100 dollar more on the quality of care is insignificant for all hospitals with very small scale as well.)

These findings suggest that under the current, resource-based purchasing model, it would likely be very hard to significantly improve hospital quality simply by paying hospitals a little more or a little less. To use financial incentives to encourage hospitals to improve quality of care, a value-based purchasing model should be designed.

These findings are good news for Medicare. If true for other DRGs, not just for pneumonia under DRG 89, heart failure under DRG 127 and heart attack under DRG 121 and DRG122, it suggests that if Medicare were to reduce payment rates to hospitals by one-to-two percent, there would likely be few negative repercussions on care quality.

Further research is needed to draw the whole picture of the payment/quality relationship. In the theoretical model, the hospital quality choice model should be extended to hospitals receiving different types of patients, (i.e different types of DRG) in the monopolistically competitive market. In the empirical study, other measures of quality should be applied to this study. Although quality indicators are widely accepted, they cannot fully contain the multi-dimensional nature of hospital quality. Moreover, these quality indicators focus on the technical aspects of care but do not capture the quality of life in the hospital, an important dimension of care quality. Third, panel approaches should be conducted to improve this study when the data are available because other factors, unobserved by the cross-sectional analysis, might affect the payment/quality relationship. In this study, geographic factors could impact both Medicare reimbursement and care quality.

APPENDIX

Table 4

Descriptive Statistics for the Explanatory Variables for Pneumonia Care (N=3012)

Variable	Description	Mean	SD
Payment [a]			
Pay	Medicare average payment (measured in thousands) for pneumonia DRG 89	6.30	1.34
Cases	Number of cases for pneumonia DRG 89	143.87	99.70
Pay*Cases	Total payment for pneumonia DRG 89	907.75	676.57
Hospital Characteristics			
Ownership			
OWNERG	1=Government; 0=others	0.19	0.39
OWNERV	1=Voluntary non-profit; 0=others	0.65	0.48
OWNERP	1=Profit; 0=others	0.17	0.37
Region			
New England	1=NEW ENGLAND;0=others	0.04	0.21
Middle Atlantic	1=MIDDLE ATLANTIC; 0=others	0.12	0.33
South Atlantic	1=SOUTH ATLANTIC; 0=others	0.18	0.39
East North Central	1=EAST NORTH CENTRAL; 0=others	0.15	0.36
East South Central	1=EAST SOUTH CENTRAL; 0=others	0.10	0.30

West North Central	1=WEST NORTH CENTRAL; 0=others	0.07	0.27
West South Central	1=WEST SOUTH CENTRAL; 0=others	0.14	0.35
Mountain	1=MOUNTAIN; 0=others	0.06	0.24
Pacific	1=PACIFIC; 0=others	0.11	0.32
BED			
Bed50	1 if beds<= 50; 0=others	0.13	0.34
Bed51_100	1 if 50<beds<=100; 0=others	0.19	0.40
Bed101_150	1 if 100<beds<=150; 0=others	0.19	0.40
Bed151_200	1 if 150<beds<=200; 0=others	0.12	0.33
Bed201_300	1 if 200<beds<=300; 0=others	0.16	0.37
Bed301	1 if beds>300; 0=others	0.19	0.39
URBAN	1 if geographic location is at the Urban, 0=rural	0.70	0.46
TEACH	1 if teaching hospital, 0=non-teaching hospital	0.33	0.47
CMI	Case mixed index	1.36	0.25
ADC	Average daily census	122.97	129.70
BILLS	Medicare cases measured in thousands	3.72	3.3
MCRPCT	Medicare days as a percent of total inpatient days	0.51	0.14
DSHPCT	Disproportionate share percent	0.27	0.16
Adjustment Factor			
WI	Wage Index applicable to the area where the	0.99	0.16

	hospital is located		
COLA	Cost of living adjustment for operating PPS. All hospitals except Alaska and Hawaii use 1.000	1.00	0.02
GAF	Geographic adjustment factor for Capital PPS	0.98	0.10
OPCCR	Ratio of Medicare operation costs to Medicare covered charge	0.38	0.15
CPCCR	Ratio of Medicare capital costs to Medicare covered charge	0.03	0.02
RESBED	Resident to bed ratio used to calculate the IME adjustment for operating PPS	0.06	0.16
RDAY	Resident to average daily census ratio used to calculate the IME adjusted for capital PPS	0.09	0.22
TCHOP	IME adjustment for operation PPS	0.03	0.07
TCHCP	IME adjustment for capital PPS	0.03	0.07
DSHOPG	Operating disproportionate share adjustment	0.11	0.12
DSHCPG	Capital disproportionate share adjustment	0.03	0.04
Market Characteristics[b]			
POPSQ	Population in thousands per square mile at the county level	1.56	5.65
NHOS	Number of short-term general hospitals at the county level	7.53	13.94
HHI	Herfindahl index at the county level	0.39	0.43

Notes: Data are from the PPS Impact File for FY 2007 unless otherwise noted

a: Data are from the “Hospital Compare” website.

b: Data are from the 2008 Area Resource File and reported at the county level (N=1526)

Table 5

Descriptive Statistics for the Explanatory Variables for Heart Failure Care (N=3078)

Variable	Description	Mean	SD
Payment [a]			
Pay	Medicare average payment (measured in thousands) for heart failure DRG 127	6.38	1.50
Cases	Number of cases for heart failure DRG 127	188.39	153.98
Pay*Cases	Total payment for heart failure DRG 127	1228.91	1106.52
Hospital Characteristics			
Ownership			
OWNERG	1=Government; 0=others	0.19	0.39
OWNERV	1=Voluntary non-profit; 0=others	0.64	0.48
OWNERP	1=Profit; 0=others	0.17	0.38
Region			
New England	1=NEW ENGLAND;0=others	0.04	0.21
Middle Atlantic	1=MIDDLE ATLANTIC; 0=others	0.12	0.33
South Atlantic	1=SOUTH ATLANTIC; 0=others	0.18	0.39
East North Central	1=EAST NORTH CENTRAL; 0=others	0.15	0.36
East South Central	1=EAST SOUTH CENTRAL; 0=others	0.10	0.30

West North Central	1=WEST NORTH CENTRAL; 0=others	0.07	0.27
West South Central	1=WEST SOUTH CENTRAL; 0=others	0.14	0.35
Mountain	1=MOUNTAIN; 0=others	0.06	0.24
Pacific	1=PACIFIC; 0=others	0.12	0.32
BED			
Bed50	1 if beds<= 50; 0=others	0.13	0.34
Bed51_100	1 if 50<beds<=100; 0=others	0.20	0.40
Bed101_150	1 if 100<beds<=150; 0=others	0.20	0.40
Bed151_200	1 if 150<beds<=200; 0=others	0.12	0.33
Bed201_300	1 if 200<beds<=300; 0=others	0.16	0.37
Bed301	1 if beds>300; 0=others	0.19	0.39
URBAN	1 if geographic location is at the Urban, 0=rural	0.71	0.45
TEACH	1 if teaching hospital, 0=non-teaching hospital	0.33	0.47
CMI	Case mixed index	1.36	0.26
ADC	Average daily census	122.02	128.92
BILLS	Medicare cases measured in thousands	3.69	3.24
MCRPCT	Medicare days as a percent of total inpatient days	0.50	0.14
DSHPCT	Disproportionate share percent	0.27	0.17
Adjustment Factor			
WI	Wage Index applicable to the area	0.99	0.16

	where the hospital is located		
COLA	Cost of living adjustment for operating PPS. All hospitals except Alaska and Hawaii use 1.000	1.00	0.02
GAF	Geographic adjustment factor for Capital PPS	0.99	0.10
OPCCR	Ratio of Medicare operation costs to Medicare covered charge	0.38	0.15
CPCCR	Ratio of Medicare capital costs to Medicare covered charge	0.03	0.02
RESBED	Resident to bed ratio used to calculate the IME adjustment for operating PPS	0.06	0.16
RDAY	Resident to average daily census ratio used to calculate the IME adjusted for capital PPS	0.09	0.22
TCHOP	IME adjustment for operation PPS	0.03	0.07
TCHCP	IME adjustment for capital PPS	0.03	0.07
DSHOPG	Operating disproportionate share adjustment	0.11	0.12
DSHCPG	Capital disproportionate share adjustment	0.03	0.04
Market Characteristics[b]			
POPSQ	Population in thousands per square mile at the county level	1.56	5.60

NHOS	Number of short-term general hospitals at the county level	7.90	14.76
HHI	Herfindahl index at the county level	0.39	0.43

Notes: Data are from the PPS Impact File for FY 2007 unless otherwise noted

a: Data are from the “Hospital Compare” website.

b: Data are from the 2008 Area Resource File and reported at the county level

(N=1526)

Table 6

Descriptive Statistics for the Explanatory Variables for Heart Attack Care (N=1528)

Variable	Description	Mean	SD
Payment [a]			
Pay	Medicare payment index (measured in thousands) for heart attack (see text for definition)	8.51	2.10
Cases	Number of cases for heart attack under DRG 121 and DRG 122	87.80	52.46
Pay*Cases	Weighted Total payment for heart attack under DRG 121 and DRG 122	764.76	534.78
Hospital Characteristics			
Ownership			
OWNERG	1=Government; 0=others	0.14	0.32
OWNERV	1=Voluntary non-profit; 0=others	0.72	0.45
OWNERP	1=Profit; 0=others	0.14	0.35
Region			
New England	1=NEW ENGLAND;0=others	0.06	0.23
Middle Atlantic	1=MIDDLE ATLANTIC; 0=others	0.17	0.37
South Atlantic	1=SOUTH ATLANTIC; 0=others	0.23	0.42
East North Central	1=EAST NORTH CENTRAL; 0=others	0.16	0.37

East South Central	1=EAST SOUTH CENTRAL; 0=others	0.08	0.27
West North Central	1=WEST NORTH CENTRAL; 0=others	0.07	0.25
West South Central	1=WEST SOUTH CENTRAL; 0=others	0.10	0.30
Mountain	1=MOUNTAIN; 0=others	0.04	0.19
Pacific	1=PACIFIC; 0=others	0.10	0.30
BED			
Bed50	1 if beds<= 50; 0=others	0.01	0.12
Bed51_100	1 if 50<beds<=100; 0=others	0.09	0.29
Bed101_150	1 if 100<beds<=150; 0=others	0.18	0.38
Bed151_200	1 if 150<beds<=200; 0=others	0.16	0.37
Bed201_300	1 if 200<beds<=300; 0=others	0.24	0.42
Bed301	1 if beds>300; 0=others	0.31	0.46
URBAN	1 if geographic location is at the Urban, 0=rural	0.81	0.39
TEACH	1 if teaching hospital, 0=non-teaching hospital	0.44	0.50
CMI	Case mixed index	1.47	0.24
ADC	Average daily census	178.3	146.67
BILLS	Medicare cases measured in thousands	5.47	3.56
MCRPCT	Medicare days as a percent of total inpatient days	0.51	0.12
DSHPCT	Disproportionate share percent	0.25	0.15

Adjustment Factor			
WI	Wage Index applicable to the area where the hospital is located	1.01	0.15
COLA	Cost of living adjustment for operating PPS. All hospitals except Alaska and Hawaii use 1.000	1.00	0.02
GAF	Geographic adjustment factor for Capital PPS	1.00	0.10
OPCCR	Ratio of Medicare operation costs to Medicare covered charge	0.36	0.14
CPCCR	Ratio of Medicare capital costs to Medicare covered charge	0.03	0.01
RESBED	Resident to bed ratio used to calculate the IME adjustment for operating PPS	0.08	0.17
RDAY	Resident to average daily census ratio used to calculate the IME adjusted for capital PPS	0.11	0.23
TCHOP	IME adjustment for operation PPS	0.04	0.08
TCHCP	IME adjustment for capital PPS	0.03	0.07
DSHOPG	Operating disproportionate share adjustment	0.10	0.11
DSHCPG	Capital disproportionate share adjustment	0.04	0.04
Market Characteristics[b]			
POPSQ	Population in thousands per square mile	1.92	6.42

	at the county level		
NHOS	Number of short-term general hospitals at the county level	7.54	12.70
HHI	Herfindahl index at the county level	0.34	0.40

Notes: Data are from the PPS Impact File for FY 2007 unless otherwise noted

a: Data are from the “Hospital Compare” website.

b: Data are from the 2008 Area Resource File and reported at the county level (N=1526)

Table 7

Correlation of Process of Care Quality Measures for Pneumonia (N=3012)

	PN1	PN2	PN3	PN4	PN5	PN6	PN7
PN1	1.000						
PN2	0.243	1.000					
PN3	0.097	0.338	1.000				
PN4	0.213	0.503	0.173	1.000			
PN5	0.176	0.403	0.355	0.197	1.000		
PN6	0.282	0.326	0.184	0.251	0.309	1.000	
PN7	0.204	0.794	0.315	0.430	0.346	0.291	1.000

Note: All pair-wise correlations are statistically significant at the 1% level.

Table 8

Estimated Linear Regression Models for the Overall Quality (PN) of Pneumonia Care

	Hospital Quality			
	OLS Estimates		FGLS Estimates	
	With Standard Errors	With Robust Standard Errors	With Standard Errors	With Robust Standard Errors
Independent Variables	Model 1	Model 2	Model 3	Model 4
Pay	-9.344 *	-9.344 *	-7.536 *	-7.536 *
	(5.176)	(5.011)	(4.493)	(4. 12)
Pay * Cases	0.004	0.004	0.005**	0.005**
	(0.003)	(0.002)	(0.002)	(0.002)
$(Pay)^2$	0.638 **	0.638 **	0.501*	0.501**
	(0.298)	(0.287)	(0.256)	(0.237)
Ownership	9.117***	9.117***	8.888***	8.888***
Non-profit	(2.510)	(2.684)	(2.386)	(2.381)
Profit	8.533***	8.533**	8.735***	8.735***
	(3.256)	(3.584)	(3.164)	(3.117)
REGION				
New England	30.039***	30.039***	28.350***	28.350***
	(5.602)	(5.100)	(4.136)	(4.506)
Middle	22.192***	22.192***	22.676***	22.676***
Atlantic	(4.652)	(4.742)	(3.900)	(4.375)
South	13.144***	13.144***	17.401***	17.401***

Atlantic	(4.676)	(5.027)	(4.186)	(4.489)
East North	22.338***	22.338***	24.857***	24.857***
Central	(4.507)	(4.977)	(3.949)	(4.345)
East South	18.833***	18.833***	22.301***	22.301***
Central	(5.381)	(5.718)	(4.757)	(4.987)
West North	23.532***	23.532***	28.377***	28.377***
Central	(5.207)	(5.248)	(4.403)	(4.549)
West South	17.148***	17.148***	19.679***	19.679***
Central	(4.841)	(5.118)	(4.249)	(4.493)
Mountain	4.832	4.832	8.339**	8.339*
	(5.072)	(4.965)	(4.347)	(4.463)
BEDS				
BED51_100	11.501***	11.501***	8.614**	8.614**
	(3.389)	(3.916)	(3.851)	(3.641)
BED101_150	7.305*	7.305*	6.699	6.699*
	(4.217)	(4.373)	(4.236)	(4.070)
BED151_200	5.936	5.936	5.991	5.991
	(4.977)	(5.071)	(4.697)	(4.510)
BED201_300	0.936	0.936	0.209	0.209
	(5.459)	(5.524)	(5.054)	(4.924)
BED301	3.170	3.170	0.146	0.146
	(6.689)	(6.417)	(5.850)	(5.712)
URBAN	-2.091	-2.091	-3.480	-3.480
	(3.317)	(3.521)	(3.051)	(2.883)
TEACHING	1.687	1.687	0.293	0.293

		(3.057)	(3.024)	(2.329)	(2.585)
	CMI	20.332***	20.332***	19.314***	19.314***
		(5.794)	(6.206)	(4.714)	(5.477)
	ADC	-0.038	-0.038	-0.005	-0.005
		(0.024)	(0.024)	(0.020)	(0.020)
	BILLS	-0.805	-0.805	-0.907	-0.907
		(0.989)	(0.938)	(0.764)	(0.793)
	MCRPCT	-33.458***	-33.458***	-23.933**	-23.933**
		(11.236)	(12.369)	(9.906)	(10.213)
	DSHPCT	-99.398***	-99.398***	-78.328***	-78.328***
		(17.279)	(22.513)	(19.573)	(17.395)
Adjustment Factors					
	WI	41.981	41.981	78.073**	78.073***
		(37.774)	(32.675)	(33.486)	(29.332)
	COLA	-92.591**	-92.591**	-75.430***	-75.430**
		(47.163)	(48.846)	(28.551)	(35.416)
	GAF	-24.851	-24.851	-66.356	-66.356
		(56.429)	(48.064)	(49.956)	(44.209)
	OPCCR	-40.579***	-40.579***	-28.875***	-28.875***
		(8.388)	(9.544)	(7.676)	(7.290)
	CPCCR	134.284**	134.284	117.656**	117.656**
		(70.225)	(82.535)	(58.849)	(60.459)
	RESBED	317.232	317.232	311.125	311.125
		(288.923)	(348.452)	(262.723)	(311.853)
	RDAY	356.535	356.535	498.211**	498.211

	(251.997)	(325.855)	(245.587)	(307.299)
TCHOP	-740.360	-740.360	-810.952	-810.952
	(686.721)	(814.584)	(625.338)	(738.419)
TCHCP	-1193.063	-1193.063	-1549.566**	-1549.566*
	(728.127)	(957.989)	(709.016)	(897.483)
DSHOPG	87.724***	87.724**	73.389**	73.389**
	(31.654)	(36.233)	(31.190)	(30.015)
DSHCPG	-81.818	-81.818	-57.220	-57.220
	(68.011)	(68.462)	(58.437)	(58.739)
Market Characteristics				
POPPS	-0.006	-0.006	-0.321	-0.321
	(0.216)	(0.282)	(0.224)	(0.272)
NHOS	-0.412***	-0.412***	-0.170*	-0.170*
	(0.079)	(0.110)	(0.098)	(0.092)
HHI	-0.767	-0.767	0.586	0.586
	(2.951)	(2.947)	(2.576)	(2.658)
Constant	706.463	706.463	680.776	680.776
	(56.150)	(57.026)	(38.526)	(44.800)
R-squared	0.191	0.191	0.147	0.147

Notes: * Indicates a statistically significant difference (0.05<p<.10); **Indicates a statistically significant difference (0.01<p<.05); *** Indicates a statistically significant difference p<.01.

Table 9

Marginal Effect of the Payment Rate on the Quality Index for Different Levels of Payment and Caseload of Pneumonia Care

(Change in Quality with a $100 Change in the Medicare Payment Rate, i.e. Δpay=0.1)

Payment	Caseload (Percentile and Cases)								
(Percentile	1%	5%	10%	25%	50%	75%	90%	95%	99%
and Pay)	Case=17	Case=32	Case=47	Case=76	Case=121	Case186	Case=271	Case=329	Cases=470
1%	-0.287	-0.280	-0.272	-0.257	-0.235	-0.202	-0.159	-0.129	-0.058
Pay=4.752	(0.216)	(0.215)	(0.215)	(0.215)	(0.215)	(0.215)	(0.217)	(0.220)	(0.227)
5%	-0.261	-0.253	-0.246	-0.231	-0.208	-0.175	-0.132	-0.103	-0.032
Pay=5.023	(0.206)	(0.205)	(0.205)	(0.205)	(0.205)	(0.205)	(0.208)	(0.210)	(0.218)
10%	-0.247	-0.239	-0.232	-0.217	-0.194	-0.161	-0.118	-0.089	-0.018
Pay=5.170	(0.200)	(0.200)	(0.200)	(0.200)	(0.200)	(0.200)	(0.202)	(0.205)	(0.213)
25%	-0.221	-0.212	-0.205	-0.191	-0.168	-0.135	-0.092	-0.063	0.008
Pay=5.443	(0.191)	(0.190)	(0.190)	(0.190)	(0.190)	(0.191)	(0.193)	(0.195)	(0.204)
50%	-0.175	-0.168	-0.160	-0.145	-0.123	-0.090	-0.047	-0.017	0.054
Pay=5.913	(0.175)	(0.175)	(0.175)	(0.174)	(0.174)	(0.175)	(0.178)	(0.180)	(0.190)
75%	-0.099	-0.091	-0.083	-0.069	-0.046	-0.013	0.030	0.059	0.131

Pay=6.709	(0.152)	(0.152)	(0.151)	(0.151)	(0.151)	(0.152)	(0.155)	(0.158)	(0.169)
90%	0.027	0.035	0.042	0.057	0.080	0.113	0.156	0.185	**0.256***
Pay=8.014	(0.128)	(0.127)	(0.127)	(0.127)	(0.127)	(0.129)	(0.133)	(0.136)	**(0.149)**
95%	0.119	0.126	0.134	0.148	0.171	**0.208***	**0.247***	**0.276***	**0.348****
Pay=8.961	(0.126)	(0.126)	(0.125)	(0.125)	(0.126)	**(0.126)**	**(0.131)**	**(0.135)**	**(0.149)**
99%	**0.365***	**0.373****	**0.380****	**0.395****	**0.418****	**0.451****	**0.494*****	**0.523*****	**0.594*****
Pay=11.520	**(0.182)**	**(0.182)**	**(0.182)**	**(0.182)**	**(0.183)**	**(0.184)**	**(0.187)**	**(0.190)**	**(0.201)**

Notes: In these calculations, caseload ranges from its lowest to highest value; and payment ranges from its lowest to highest value.

These results are calculated on model (4): FGLS estimates with robust standard errors.

Statistically significant marginal effects are highlighted in bold.

* Indicates a statistically significant difference (0.05<p<.10); **Indicates a statistically significant difference (0.01<p<.05); *** Indicates a statistically significant difference (p<.01).

Table 10

Marginal Effect of a $100 change on the Medicare Payment Rate on PN, and PN1 through PN7, Calculated at the Sample Mean for Pneumonia care (Pay=6.3 and Cases=145)

Variable	Description	Based on OLS Estimates	Based on FGLS Estimates
		With Robust Standard Errors	With Robust Standard Errors
		Model(2)	Model(4)
PN	Overall quality index for pneumonia care (see text for definition)	-0.725	-0.498
PN1	% of pneumonia patients who were given oxygenation assessment	0.073	0.027
PN2	% of pneumonia patients who were assessed and given pneumococcal vaccination	-0.076	-0.323
PN3	% of pneumonia patients whose initial emergency room blood culture was performed prior to the administration of their first hospital dose of antibiotics	0.449	0.224
PN4	% of pneumonia patients who were given smoking cessation advice /counseling	0.142	0.527
PN5	% of pneumonia patients who were	0.042	-0.061

	given initial antibiotic(s) within 4 hours after arrival		
PN6	% of pneumonia patients who were given the most appropriate initial antibiotic(s)	-0.653	-0.573
PN7	% of pneumonia patients who were assessed and given influenza vaccination	-0.788	-0.631

Notes: None of these marginal effects of the payment rate are statistically significant at the 10 percent level or better.

Table 11

Correlation of Process of Care Quality Measures for Heart Failure (N=3078)

	HF1	HF2	HF3	HF4
HF1	1.000			
HF2	0.476	1.000		
HF3	0.403	0.433	1.000	
HF4	0.545	0.477	0.287	1.000

Note: All pair-wise correlations are statistically significant at the 1% level.

Table 12

Estimated Linear Regression Models for the Overall Quality (HF) of Heart Failure Care

	Hospital Quality			
	OLS Estimates		FGLS Estimates	
	With Standard Errors	With Robust Standard Errors	With Standard Errors	With Robust Standard Errors
Independent Variables	Model 1	Model 2	Model 3	Model 4
Pay	-0.336	-0.336*	-0.997*	-0.997**
	(0.263)	(0.201)	(0.59)	(0.46)
Pay * Cases	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
$(Pay)^2$	0.046*	0.046*	0.062	0.062*
	(0.027)	(0.024)	(0.041)	(0.035)
Ownership Non-profit	5.353**	5.353**	4.623**	4.623**
	(2.556)	(2.335)	(1.810)	(1.829)
Profit	2.741	2.741	5.215**	5.215**
	(3.256)	(2.941)	(2.421)	(2.358)
REGION				
New England	16.052***	16.052***	8.848***	8.848**
	(4.773)	(4.390)	(3.442)	(3.844)
Middle Atlantic	12.394***	12.394***	11.245***	11.245***
	(3.972)	(3.912)	(2.911)	(3.219)
South Atlantic	16.916***	16.916***	12.590***	12.590***
	(3.934)	(3.949)	(3.020)	(3.272)

East North	19.861***	19.861***	17.356***	17.356***
Central	(3.839)	(3.792)	(2.919)	(3.203)
East South	13.470***	13.470***	9.502***	9.502**
Central	(4.533)	(4.615)	(3.551)	(3.800)
West North	12.955***	12.955***	15.193***	15.193***
Central	(4.391)	(4.469)	(3.377)	(3.384)
West South	14.070***	14.070***	12.843***	12.843***
Central	(4.098)	(4.167)	(3.167)	(3.302)
Mountain	-4.217	-4.217	1.342	1.342
	(4.291)	(4.358)	(3.585)	(3.417)
BEDS				
BED51_100	26.474***	26.474***	25.419***	25.419***
	(2.793)	(3.752)	(3.687)	(3.772)
BED101_150	31.376***	31.376***	29.777***	29.777***
	(3.356)	(3.968)	(3.933)	(3.979)
BED151_200	31.850***	31.850***	32.167***	32.167***
	(3.889)	(4.159)	(4.011)	(4.059)
BED201_300	33.654***	33.654***	32.088***	32.088***
	(4.152)	(4.366)	(4.151)	(4.203)
BED301	32.902***	32.902***	31.562***	31.562***
	(5.197)	(4.844)	(4.575)	(4.489)
URBAN	2.170	2.170	2.610	2.610
	(2.787)	(3.297)	(2.658)	(2.728)
TEACHING	0.376	0.376	-0.015	-0.015
	(2.595)	(2.177)	(1.850)	(1.931)

CMI	34.594***	34.594***	22.407***	22.407***
	(4.477)	(4.278)	(2.991)	(3.058)
ADC	-0.037*	-0.037**	-.001	-.001
	(0.020)	(0.014)	(0.013)	(0.012)
BILLS	0.253	0.253	0.304	0.304
	(0.858)	(0.703)	(0.561)	(0.543)
MCRPCT	-35.480***	-35.480***	-22.243***	-22.243***
	(9.414)	(10.271)	(7.757)	(8.185)
DSHPCT	-69.150***	-69.150***	-53.657***	-53.657***
	(14.112)	(21.220)	(16.498)	(16.315)
Adjustment Factors				
WI	20.265	20.265	65.367**	65.367**
	(32.209)	(41.467)	(28.711)	(26.610)
COLA	1.753	1.753	-43.275	-43.275
	(41.885)	(46.311)	(46.053)	(33.127)
GAF	19.234	19.234	-53.539	-53.539
	(48.233)	(61.838)	(43.119)	(40.145)
OPCCR	-27.666***	-27.666***	-17.690***	-17.690***
	(7.083)	(7.614)	(5.836)	(5.876)
CPCCR	14.163	14.163	28.360	28.360
	(60.697)	(77.270)	(47.786)	(50.353)
RESBED	353.815	353.815*	242.416	242.416
	(244.574)	(187.719)	(180.152)	(183.059)
RDAY	302.116	302.116*	208.999	208.999
	(212.857)	(171.559)	(177.323)	(180.271)

TCHOP	-722.563	-722.563*	-491.542	-491.542
	(580.713)	(443.435)	(429.763)	(437.911)
TCHCP	-989.580	-989.580**	-690.678	-690.678
	(615.620)	(500.267)	(518.832)	(523.641)
DSHOPG	94.481***	94.481***	71.909***	71.909***
	(26.353)	(34.078)	(25.262)	(26.309)
DSHCPG	-67.639	-67.639	-27.830	-27.830
	(57.397)	(59.681)	(48.160)	(51.274)
Market Characteristics				
POPPS	-0.181	-0.181	-0.587***	-0.587***
	(0.174)	(0.218)	(0.144)	(0.193)
NHOS	-0.192***	-0.192***	-0.100*	-0.100**
	(0.063)	(0.066)	(0.053)	(0.049)
HHI	-1.373	-1.373	-1.181	-1.181
	(2.480)	(2.664)	(2.094)	(2.124)
Constant	271.095	271.095	336.444	336.444
	(47.984)	(53.969)	(50.009)	(38.228)
R-squared	0.223	0.223	0.150	0.150

Notes: * Indicates a statistically significant difference (0.05<p<.10); **Indicates a statistically significant difference (0.01<p<.05); *** Indicates a statistically significant difference p<.01.

Table 13

Marginal Effect of the Payment Rate on the Quality Index for Different Levels of Payment and Caseload of Heart Failure Care

(Change in Quality with a $100 Change in the Medicare Payment Rate, i.e. Δpay=0.1)

Payment	Caseload (Percentile and Cases)								
(Percentile and	1%	5%	10%	25%	50%	75%	90%	95%	99%
Pay)	Case=17	Case=34	Case=47	Case=79	Case=147	Case=250	Case=380	Case=499	Case=709
1%	-0.130	-0.129	-0.120	-0.115	-0.102	-0.086	-0.072	-0.064	-0.027
Pay=4.750	(0.130)	(0.129)	(0.129)	(0.127)	(0.125)	(0.126)	(0.126)	(0.127)	(0.132)
5%	-0.112	-0.111	-0.111	-0.110	-0.099	-0.074	-0.068	-0.057	-0.018
Pay=5.032	(0.122)	(0.121)	(0.121)	(0.120)	(0.120)	(0.125)	(0.128)	(0.129)	(0.130)
10%	-0.098	-0.095	-0.091	-0.082	-0.066	-0.060	-0.048	-0.039	0.012
Pay=5.182	(0.118)	(0.118)	(0.117)	(0.117)	(0.117)	(0.120)	(0.120)	(0.122)	(0.125)
25%	-0.083	-0.076	-0.063	-0.049	-0.037	-0.022	-0.017	-0.008	0.046
Pay=5.449	(0.110)	(0.109)	(0.109)	(0.109)	(0.109)	(0.111)	(0.113)	(0.115)	(0.119)
50%	-0.051	-0.046	-0.035	-0.024	-0.012	-0.007	-0.001	0.001	0.060
Pay=5.929	(0.102)	(0.102)	(0.102)	(0.101)	(0.101)	(0.101)	(0.104)	(0.105)	(0.108)
75%	-0.022	-0.013	-0.008	0.003	0.010	0.037	0.045	0.056	0.093

Pay=6.791	(0.068)	(0.067)	(0.067)	(0.066)	(0.066)	(0.067)	(0.071)	(0.075)	(0.083)
90%	0.043	0.061	0.073	0.092	0.118	0.149	0.173	**0.238***	**0.328****
Pay=8.266	(0.125)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.130)	**(0.139)**	**(0.145)**
95%	0.222	0.236	0.240	**0.262***	**0.286***	**0.357****	**0.364****	**0.397****	**0.493*****
Pay=9.254	(0.156)	(0.156)	(0.156)	**(0.155)**	**(0.155)**	**(0.156)**	**(0.160)**	**(0.166)**	**(0.183)**
99%	**0.648****	**0.679****	**0.712****	**0.745*****	**0.803*****	**0.845*****	**0.897*****	**0.945*****	**1.134*****
Pay=11.579	**(0.275)**	**(0.275)**	**(0.277)**	**(0.280)**	**(0.282)**	**(0.286)**	**(0.291)**	**(0.301)**	**(0.341)**

Notes: In these calculations, caseload ranges from its lowest to highest value; and payment ranges from its lowest to highest value.

These results are calculated on model (4): FGLS estimates with robust standard errors.

Statistically significant marginal effects are highlighted in bold.

* Indicates a statistically significant difference (0.05<p<.10); **Indicates a statistically significant difference (0.01<p<.05); *** Indicates a statistically significant difference (p<.01).

Table 14

Marginal Effect of a $100 Change in the Medicare Payment Rate on HF, and HF1 through HF4, Calculated at the Sample Mean for Heart Failure Care(Pay=6.38 and Cases=188)

Variable	Description	Based on OLS Estimates With Robust Standard Errors Model(2)	Based on FGLS Estimates With Robust Standard Errors Model(4)
HF	Overall quality index for heart failure care (see text for definition)	0.025	0.017
HF1	% of heart failure patients who were given discharge instructions	0.045	0.068
HF2	% of heart failure patients who were given an evaluation of left ventricular systolic function	0.124	-0.013
HF3	% of heart failure patients who were given ACE inhibitor or ARB for left ventricular systolic dysfunction	0.489	0.056
HF4	% of heart failure patients who were given smoking cessation advice /counseling	-0.015	-0.071*
Notes	* Indicates a statistically significant difference (0.05<p<.10).		

Table 15

Correlation of Process of Care Quality Measures for Heart Attack (N=1528)

	AMI1	AMI2	AMI3	AMI4	AMI5	AMI6
AMI1	1.000					
AMI2	0.532	1.000				
AMI3	0.348	0.391	1.000			
AMI4	0.219	0.209	0.125	1.000		
AMI5	0.480	0.679	0.471	0.231	1.000	
AMI6	0.602	0.465	0.383	0.174	0.637	1.000

Note: All pair-wise correlations are statistically significant at the 1% level.

Table 16

Estimated Linear Regression Models for the Overall Quality of Heart Attack Care

	Hospital Quality			
	OLS Estimates		FGLS Estimates	
	With Standard Errors	With Robust Standard Errors	With Standard Errors	With Robust Standard Errors
Independent Variables	Model 1	Model 2	Model 3	Model 4
Pay	-0.028	-0.028	-0.345	-0.345
	(1.778)	(1.774)	(1.144)	(1.090)
Pay * Cases	-0.002	-0.002	0.004***	0.004**
	(0.003)	(0.002)	(0.001)	(0.002)
$(Pay)^2$	0.016	0.016	0.026	0.026
	(0.059)	(0.045)	(0.029)	(0.024)
Ownership	2.190	2.190	1.840	1.840
Non-profit	(2.281)	(2.170)	(1.492)	(1.582)
Profit	-0.120	-0.120	-0.268	-0.268
	(2.969)	(2.296)	(2.258)	(2.315)
REGION				
New	10.702**	10.702**	3.676	3.676
England	(4.495)	(4.478)	(3.047)	(3.032)
Middle Atlantic	3.111	3.111	3.227	3.227
	(3.812)	(4.497)	(2.484)	(2.830)
South Atlantic	3.915	3.915	1.874	1.874
	(3.773)	(3.976)	(2.551)	(2.758)

East North	7.245*	7.245*	4.563*	4.563*
Central	(3.783)	(3.800)	(2.444)	(2.612)
East South	1.414	1.414	1.352	1.352
Central	(4.547)	(4.667)	(2.858)	(3.062)
West North	11.830***	11.830***	9.065***	9.065***
Central	(4.423)	(3.376)	(2.689)	(2.811)
West South	3.996	3.996	0.501	0.501
Central	(4.121)	(4.240)	(2.866)	(2.997)
Mountain	4.723	4.723	2.656	2.656
	(4.834)	(4.546)	(3.010)	(3.026)
BEDS				
BED51_100	6.414	6.414	3.591	3.591
	(6.630)	(12.519)	(9.173)	(8.009)
BED101_150	13.465**	13.465	9.617	9.617
	(6.583)	(12.360)	(9.012)	(7.890)
BED151_200	16.962**	16.962	11.065	11.065
	(6.694)	(12.190)	(8.987)	(7.858)
BED201_300	15.337**	15.337**	11.042	11.042
	(6.884)	(12.203)	(9.040)	(7.901)
BED301	14.940**	14.940	11.307	11.307
	(7.423)	(12.373)	(9.210)	(8.027)
URBAN	-2.250	-2.250	-1.138	-1.138
	(3.577)	(4.500)	(3.361)	(2.922)
TEACHING	0.726	0.726	-0.545	-0.545
	(2.276)	(2.195)	(1.485)	(1.452)

CMI	15.7395***	15.7395***	10.158***	10.158***
	(4.861)	(4.504)	(2.978)	(2.921)
ADC	-0.026	-0.026**	-0.012	-0.012
	(0.017)	(0.013)	(0.010)	(0.008)
BILLS	-0.653	-0.653	-0.329	-0.329
	(0.730)	(0.557)	(0.428)	(0.382)
MCRPCT	-30.709***	-30.709***	-21.090***	-21.090***
	(11.409)	(12.033)	(8.194)	(7.843)
DSHPCT	-56.026**	-56.026*	-32.649	-32.649
	(22.455)	(30.720)	(23.943)	(20.867)
Adjustment Factors				
WI	30.788	30.788	29.429	29.429
	(27.979)	(27.161)	(18.417)	(25.258)
COLA	-1.291	-1.291	1.590	1.590
	(39.602)	(37.018)	(19.604)	(19.735)
GAF	-5.942	-5.942	-14.046	-14.046
	(41.799)	(40.748)	(27.485)	(37.981)
OPCCR	-5.608	-5.608	-4.776	-4.776
	(7.429)	(7.707)	(5.669)	(5.084)
CPCCR	-22.896	-22.896	-0.773	-0.773
	(68.112)	(74.141)	(56.688)	(51.012)
RESBED	300.252	300.252*	196.463	196.463
	(247.726)	(167.630)	(134.138)	(140.577)
RDAY	266.599	266.599	159.595	159.595
	(239.682)	(168.304)	(136.262)	(149.957)

TCHOP	-698.295	-698.295*	-470.260	-470.260
	(602.879)	(413.890)	(332.234)	(347.548)
TCHCP	-775.009	-775.009	-436.895	-436.895
	(679.854)	(474.578)	(384.043)	(425.870)
DSHOPG	38.347	38.347	8.124	8.124
	(32.694)	(41.541)	(30.199)	(27.350)
DSHCPG	29.883	29.883	48.704	48.704
	(64.442)	(80.075)	(61.518)	(56.927)
Market Characteristics				
POPPS	-0.285*	-0.285*	-0.312**	-0.312**
	(0.151)	(0.165)	(0.150)	(0.137)
NHOS	-0.118*	-0.118*	-0.002	-0.002
	(0.069)	(0.077)	(0.052)	(0.052)
HHI	-0.332	-0.332	1.404	1.404
	(2.571)	(2.726)	(1.991)	(1.846)
Constant	581.565	581.565	534.882	534.882
	(46.320)	(48.706)	(26.490)	(28.833)
R-squared	0.22	0.22	0.21	0.21

Notes: * Indicates a statistically significant difference (0.05<p<.10); **Indicates a statistically significant difference (0.01<p<.05); *** Indicates a statistically significant difference p<.01.

Table 17 – Heart Attack

Marginal Effect of the Payment Rate on the Quality Index for Different Levels of Payment and Caseload of Heart Attack Care

(Change in Quality with a $100 Change in the Medicare Payment Rate, i.e. Δpay=0.1)

Payment	Caseload (Percentile and Cases)								
(Percentile	1%	5%	10%	25%	50%	75%	90%	95%	99%
and Pay)	Cases=27	Case=34	Case=40	Case=53	Case=73	Case=108	Case=150	Case=189	Case=290
1%	0.028	0.171	0.223	0.285	0.335	0.363	0.382	0.390	0.400
Pay=5.372	(0.888)	(0.844)	(0.836)	(0.829)	(0.829)	(0.831)	(0.832)	(0.833)	(0.834)
5%	0.033	0.176	0.228	0.290	0.340	0.368	0.387	0.395	0.405
Pay=6.110	(0.856)	(0.810)	(0.801)	(0.795)	(0.794)	(0.795)	(0.797)	(0.798)	(0.799)
10%	0.035	0.178	0.231	0.293	0.342	0.371	0.389	0.397	0.410
Pay=6.521	(0.839)	(0.792)	(0.782)	(0.775)	(0.775)	(0.776)	(0.777)	(0.778)	(0.779)
25%	0.040	0.183	0.235	0.298	0.347	0.376	0.394	0.403	0.412
Pay=7.227	(0.809)	(0.760)	(0.749)	(0.742)	(0.741)	(0.742)	(0.743)	(0.744)	(0.745)
50%	0.050	0.189	0.241	0.303	0.353	0.381	0.400	0.408	0.418
Pay=8.068	(0.775)	(0.722)	(0.710)	(0.702)	(0.701)	(0.702)	(0.703)	(0.704)	(0.705)
75%	0.054	0.197	0.249	0.312	0.361	0.389	0.408	0.416	0.426

Pay=9.259	(0.727)	(0.669)	(0.656)	(0.647)	(0.644)	(0.645)	(0.646)	(0.647)	(0.648)
90%	0.066	0.209	0.262	0.324	0.374	0.402	0.420	0.429	0.439
Pay=11.116	(0.656)	(0.589)	(0.573)	(0.561)	(0.557)	(0.557)	(0.559)	(0.559)	(0.560)
95%	0.076	0.219	0.271	0.334	0.384	0.412	0.430	0.439	0.449
Pay=12.610	(0.603)	(0.526)	(0.507)	(0.493)	(0.488)	(0.488)	(0.489)	(0.489)	(0.490)
99%	0.097	0.240	0.292	0.355	0.404	0.433	0.451	0.459	0.469
Pay=15.652	(0.510)	(0.410)	(0.384)	(0.361)	(0.352)	(0.350)	(0.350)	(0.351)	(0.352)

Notes: In these calculations, caseload ranges from its lowest to highest value; and payment ranges from its lowest to highest value.

These results are calculated on model (4): FGLS estimates with robust standard errors.

Statistically significant marginal effects are highlighted in bold.

* Indicates a statistically significant difference (0.05<p<.10); **Indicates a statistically significant difference (0.01<p<.05); *** Indicates a statistically significant difference (p<.01).

Table 18

Marginal Effect of a $100 Change in the Medicare Payment Rate on AMI, and AMI1 through AMI6, Calculated at the Sample Mean for Heart Attack Care (Pay=8.51 and Cases=87.80)

Variable	Description	Based on OLS Estimates	Based on FGLS Estimates
		With Robust Standard Errors	With Robust Standard Errors
		Model(2)	Model(4)
AMI	Overall quality index for heart attack care (see text for definition)	0.039	0.045
AMI1	% of heart attack patients who were given aspirin at arrival	0.663	0.501
AMI2	% of heart attack patients who were given aspirin at discharge	0.703	0.816
AMI3	% of heart attack patients who were given ACE inhibitor or ARB for left ventricular systolic dysfunction	0.315	0.476
AMI4	% of heart attack patients who were given smoking cessation advice /counseling	0.078	0.492
AMI5	% of heart attack patients who were given beta blocker at discharge	0.181	0.933

AMI6	% of heart attack patients who were given beta blocker at arrival	0.738	0.112

Notes: None of these marginal effects of the payment rate are statistically significant at the 10 percent level or better.

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ABSTRACT

HOSPITAL QUALITY AND MEDICARE PAYMENT: A THEORETICAL AND EMPIRICAL INVESTIGATION

by

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Advisor: Gail Summers

Major: Economics

Degree: Doctor of Philosophy

Does Medicare's payment rate for a hospital stay influence the quality of care received by a patient? This question is examined, theoretically and empirically. First, a model is developed which generates the key hypothesis -- that Medicare's payment rate per admission should be positively related to care quality. This hypothesis is tested by estimating the relationship between Medicare's DRG payment for pneumonia, heart failure and heart attacks and care quality, using clinically-recognized measures of the quality of pneumonia care, heart failure care and heart attack care. Newly available data on acute hospitals in 2007 from "Hospital Compare" (maintained by CMS) are analyzed. Similar results are provided from pneumonia care and heart failure care. It is found that a significant positive relationship between Medicare's payment rate and care quality for some hospitals in both pneumonia care and heart failure care, but not for others, and where it is

significant, the effect on quality is small in magnitude in both cares. For a hospital with average characteristics, the effect of payment on quality is insignificant. However, for hospitals that are very highly paid for pneumonia or heart failure and hospitals that treat large numbers of pneumonia cases or heart failure cases, a positive significant relationship is found. For such hospitals, which likely derive substantial revenue from pneumonia care or heart failure care, an increase in Medicare's payment rate leads to a very small improvement in the quality of care provided.

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