Managed Care Incentives and Inpatient Complications

Philip A. Haile
University of Wisconsin—Madison
Madison, WI 53706
pahaile@facstaff.wisc.edu
and
NBER

Rebecca M. Stein
University of Pennsylvania
Philadelphia, PA 19104
rstein2@sssc.upenn.edu

Managed care organizations control costs through restrictions on patient access to specialized services, oversight of treatment protocols, and financial incentives for providers. We investigate possible effects of such practices on the care patients receive by studying frequencies of in-hospital complications. We find significant differences in complication rates between managed care and fee-for-service patients. We investigate the sources of this variation by comparing probabilities of complications among patients with different types of managed care coverage and patients treated in different hospitals. For several patient categories, the differences in outcomes we find appear to arise not from differential treatment of patients within hospitals or from heterogeneity in patients, but from variations in care across hospitals that tend to treat patients with different insurance types.

1. Introduction

In markets for credence goods, sellers are often experts who determine the types and quantities of goods needed by consumers, who

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may never learn the true quality of the recommendations or of the products themselves.[1] Consumers of auto repair services, for example, must rely on mechanics who stand to profit from recommending excessive repairs and from cutting corners in the work done—for example, by installing used rather than new parts. A similar problem arises in health care markets, where providers may have incentives to recommend more services than necessary or efficient[2] and to shirk on unobservable aspects of the treatment. Traditional indemnity (fee-for-service) health insurance can exacerbate these problems. Since insured patients typically do not bear the full cost of their treatment, they have incentives to overuse health services and little incentive to monitor doctors' recommendations (Arrow, 1963; Pauly, 1968), eliminating a potential disciplining force on providers. Managed care organizations have attempted to check some of these incentive problems with restrictions on patient access to specialized services, oversight of treatment practices, and financial incentives for providers to limit costs. One reason for the rising market shares of managed care organizations is their ability to control costs through such practices.

An obvious question is whether these practices reduce the quality of care patients receive. One might expect this to be so, since doctors and other health care providers are "common agents" (Bernheim and Whinston, 1986) for patients and insurers, whose objectives do not always coincide. However, managed care creates closer ties between decision making and financial responsibility for health care services and may, therefore, encourage providers to keep patients healthy in order to avoid future costs. The resulting emphasis on preventive care could result in better overall health under managed care. Nonetheless, one frequently hears claims by both doctors and patients that incentives to control costs result in compromised quality. Such a reduction could, of course, be efficient, since costs and quantities do matter and patients may have heterogeneous preferences for health care (Arrow, 1963). However, the effect of managed care incentives on the quality of patient care is an important issue on its own, and an assessment of this effect is a step toward a full welfare analysis.

We are not the first to consider this question. However, one limitation of previous research has been a paucity of useful measures of quality. An ideal measure would be sensitive to variations in care

1. The terminology was introduced by Darby and Karni (1973). Wolinsky (1993) and Taylor (1995) study models of such goods and cite evidence of opportunistic behavior by sellers in auto repair and health care markets. Arrow (1963) gives an early and insightful discussion of uncertainty and informational asymmetries in health care markets.

2. See, for example, Luft (1978), Dranove (1988), or Gruber and Owings (1996).

for a wide range of patient types at margins likely to be responsive to variations in incentives. We study outcomes among hospital patients using a measure that may satisfy these criteria better than alternatives (e.g., mortality rates) focused on elsewhere: frequencies of avoidable and potentially avoidable complications. Examples of such complications include postprocedure hemorrhage, postoperative stroke, reopening of a surgical site, postoperative infections, and a wide range of iatrogenic complications (complications directly caused by medical treatment).[3] We examine whether and how the frequencies of these complications differ across patients with managed care and fee-for-service (FFS) insurance.

Our empirical analysis is guided by an illustrative model in which a representative doctor chooses the treatment to provide based on a patient's health and the incentive structure under which the doctor works. We hypothesize three effects managed care might have on the doctor's incentives. First, managed care may reduce the doctor's financial return to providing additional treatment. Second, by forcing doctors to internalize some of the effects of current treatment on future health care costs, managed care may create greater incentives for providers to keep patients healthy through preventive care. Finally, heavy case loads and cost control pressures from managed care organizations may create incentives for rational *corner cutting* by doctors, tending to reduce the quality of care provided. Such an effect may also be created by managed care restrictions on patients' choice of doctors and/or hospitals, which may reduce providers' incentives to compete on quality. If managed care affects incentives in all of these ways, its net effect on the doctor's choices, and therefore on patient outcomes, is ambiguous. One objective of our empirical analysis is to measure this overall effect and to assess the relative importance of the component incentives.

Since we do find differences in outcomes across patients with different insurance types, a second objective of the paper is to identify more precisely the source of these differences. One question is whether outcomes differ across types of managed care organizations. Our data enable us to shed some light on this question by making a distinction between *preferred provider organizations* (PPOs) and *health maintenance organizations* (HMOs). PPOs typically have relatively weak relationships with providers and cover all of patients' costs only within a network of physicians who agree to reduced fees. HMOs vary considerably in structure, but typically place more stringent restrictions

3. The identification of complications from patient discharge data follows Iezzoni et al. (1992). We provide an overview in Section 5.

on patients' choices of providers, require preapprovals for many procedures, provide financial incentives for doctors to limit resource use, and may directly employ doctors. We might therefore expect the effects of HMO incentives on outcomes to be more pronounced. Our empirical results are consistent with this conjecture.

We also ask whether different care is given to patients with different insurance types in the same hospital. One might suspect that in many cases hospital-wide practices are adopted (formally or informally) in response to the "average" incentives created by the mix of insurance types served. Our analysis suggests that differences between managed care and FFS outcomes arise not from differential treatment of patients within hospitals, but from differences in care across hospitals. Hospitals with patient pools containing large shares of HMO patients tend to have more frequent complications. While our data set is not ideal for further investigation of the causes of this variation, our results strongly suggest differences in treatment received by HMO and FFS patients.

An obvious and important concern in our analysis is unobserved heterogeneity. If managed care patients are systematically different from other patients in ways that affect the likelihood of a complication, this could create misleading results. We are able to investigate this possibility from several angles and conclude that this is an unlikely explanation of our main results. However, while our focus is on the possible effects of managed care incentives on provider behavior, an alternative explanation of our empirical findings is that these result from endogenous matching of HMOs and the providers (e.g., hospitals, doctors) who serve their patients. In that case, the differences in outcomes we detect would still reflect policies and contracting practices of HMOs; however, the policy implications would be quite different. Regardless of the cause, however, our results suggest significant differences in the care being provided to different types of patients.

After a brief review of related literature in the next section, we present the model in Section 3. This is followed in Sections 4 and 5 by descriptions of our hospital discharge dataset and the complications measure of patient outcomes. We discuss the estimation approach and present the empirical results in Section 6. Section 7 is devoted to a discussion of unobserved heterogeneity. We conclude in Section 8.

2. Related Literature

Our work falls into a broad empirical literature evaluating outcomes in markets with asymmetric information and complex agency relationships. However, there have been many studies examining the more specific issue we focus on here, i.e., the effects of managed care on quality. Measuring quality is difficult, and several approaches have been tried. Many studies focus on inputs such as treatments, tests performed, lengths of stay, or follow-up visits (e.g., Retchin and Brown, 1990a, 1990b, 1991, or Retchin and Preston, 1991). The use of detailed clinical data makes it possible to consider many factors affecting each case and to detect fine variations in care, which may or may not result in variations in patient health. However, there are drawbacks to relying on these "input" criteria. Because detailed clinical reviews require a substantial amount of time spent on each patient record, construction of large data sets is prohibitively costly. Hence studies of inputs usually are limited to small samples unless one focuses on simple measures, such as length of stay, which have dubious relation to patient welfare. More important, while these studies take advantage of the expertise of practicing physicians in evaluating the care provided to each patient, the criteria used in such evaluations are necessarily subjective. Large variations in treatment practices across geographic areas, for example, suggest that there are not uniformly accepted standards among practicing physicians (e.g., Dartmouth Medical School, 1998). Beliefs about appropriate treatments may also be influenced by the incentive structures under which reviewers have operated in the past. For all of these reasons, focusing on input criteria as proxies for patient welfare may yield misleading results.

A natural alternative is to examine patient outcomes. This approach bypasses questions of how best to deliver care and focuses directly on results. A challenge to this literature, however, has been a dearth of useful outcome measures. Mortality rates are used in many studies, sometimes augmented with data on hospital readmissions (e.g., Riley et al., 1991; Cutler, 1995; and Kahn et al., 1990b). While deaths and readmissions are relatively frequent events for some types of patients, they are fairly crude measures of quality, particularly for younger patients. Recent work (e.g., Luft and Romano, 1993) has suggested that mortality is a useful measure only for a few types of patients.

For a few medical conditions, outcomes measures have been combined with input criteria. Carlisle et al. (1992) and Cutler et al. (2000) combine data on deaths and readmissions with data on treatments provided to HMO and FFS heart patients. Levinson and Ullman (1998) examine prenatal care and birth weights of babies born to Medicaid mothers where managed Medicaid has been implemented. Other studies have focused on treatments and outcomes for patients with hypertension (Murray et al., 1992; Udvarhelyi et al., 1991) and rheumatoid arthritis (Yelin et al., 1986). A different strand of this literature has relied on patient ratings of their own health and/or satisfaction with their health care services (Retchin et al., 1992; Safran et al. 1994; Haya et al., 1993; Ware et al., 1996).

The conclusions to be drawn from this literature (we do not attempt an exhaustive survey) are often unclear even for individual studies, and much less clear taken as a whole. While a few studies suggest better care for one group of patients or another, most find similar treatments and outcomes when similar patients are compared. Miller and Luft (1994), for example, conclude that HMO and FFS plans seem to provide roughly comparable levels of care quality. However, limitations of the quality criteria used in previous studies suggest that failures to detect differences should not be viewed as conclusive. A simple but important contribution of our paper is its focus on an alternative quality criterion—one based on patient outcomes that are less severe and more common than those used previously, and for which nearly all adult patients are at risk. We discuss this criterion in Section 5.

3. The Model

We consider a simple illustrative model in which a representative doctor observes a patient's health $h \in [0, 1]$ before deciding what treatment to provide.[4] The doctor chooses the number of procedures $p \in [0, \infty)$ to perform and the level of effort $e \in [\underline{e}, \bar{e}]$ to expend. Performing procedures may benefit the doctor directly through the resulting revenues and/or indirectly through their value to the patient. "Effort" refers to any activity that is beneficial to the patient but costly to the doctor. Additional effort may involve, for example, more thorough preparation for a surgical procedure, substitution of more expensive or sophisticated procedures for simpler ones, or more intensive patient monitoring. Costs of effort include direct disutility, opportunity costs, and direct costs net of any compensation for effort. Effort improves the patient's care and reduces the probability of a complication. Since the doctor may experience a loss when a complication occurs, there are benefits to effort that the doctor must weigh against its cost.[5]

4. We refer to the decision maker as the "doctor," although other agents face similar choices.

5. Kalish et al. (1995) demonstrate significant increases in costs associated with the occurrence of the complications we study. Controlling for other factors, they find that patients with complications have total charges 96.6 percent higher than those of patients without complications.

When no complication occurs, the doctor's utility from providing p procedures and effort level e to a patient of health h is given by

$$U(p, e, h, i), \tag{1}$$

where $i \in [0, 1]$ parametrizes the incentives faced by the doctor. Larger values of i correspond to "more managed" incentives. For example, i might depend on the patient's insurance type, with $i_{\text{HMO}} > i_{\text{PPO}} > i_{\text{FFS}}$. Alternatively, i could vary with the stringency of the cost control measures used by doctors' employers or the treatment practices adopted by different hospitals. The doctor's utility function (1) may reflect revenue and psychic benefits obtained from providing care, as well as the cost of effort. We assume $U(p, e, h, i)$ is twice continuously differentiable, strictly decreasing and strictly concave in e. Letting subscripts denote partial derivatives, we assume

$$\lim_{e \downarrow \underline{e}} U_2(p, e, h, i) = 0 \quad \text{and} \quad \lim_{e \uparrow \bar{e}} U_2(p, e, h, i) = -\infty. \tag{2}$$

We also assume that the doctor's benefit from performing additional procedures vanishes at sufficiently high levels:

$$\lim_{p \to \infty} U_1(p, e, h, i) \leq 0 \qquad \forall\, e, h, i. \tag{3}$$

Let $\pi(p, e, h)$ be the probability that a patient with health h experiences a complication when undergoing p procedures with effort e from the doctor. We assume $\pi(p, e, h)$ is twice continuously differentiable and strictly decreasing in e, with $\pi_{22}(p, e, h) \geq 0$. For simplicity we assume that for all p and h, $\pi(p, \underline{e}, h) = 1$ and $\pi(p, \bar{e}, h) = 0$. We assume that at sufficiently high levels, increases in p raise the likelihood of a complication:

$$\lim_{p \to \infty} \pi_1(p, e, h) > 0 \qquad \forall e, h. \tag{4}$$

Finally, $C(i)$ will denote the doctor's loss of utility when the patient experiences a complication. This cost may depend on i; for example, the doctor may bear a greater share of the financial burden of a complication under managed care.

After observing h and i, the doctor chooses p and e to maximize

$$U(p, e, h, i) - C(i)\pi(p, e, h).$$

This is equivalent to choosing p and π to maximize

$$U(p, e(\pi, p, h), h, i) - C(i)\pi,$$

where $e(\pi, p, h)$ is defined implicitly by the equation

$$\pi(p, e(\hat{\pi}, p, h), h) = \hat{\pi} \qquad \forall\, \hat{\pi} \in (0, 1) \tag{5}$$

and gives the effort level required to achieve a given probability π of a complication, given p and h.

The first-order conditions for this problem are

$$U_1(p, e(\pi, p, h), h, i) + U_2(p, e(\pi, p, h), h, i)e_2(\pi, p, h) = 0 \tag{6}$$

and

$$U_2(p, e(\pi, p, h), h, i)e_1(\pi, p, h) - C(i) = 0. \tag{7}$$

The definition (5) and the assumptions $\pi_2(p, e, h) < 0$ and $\pi_{22}(p, e, h) \geq 0$ imply that $e_{11}(\pi, p, h) \geq 0$. Hence

$$U_{22}(p, e(\pi, p, h), h, i)e_1(\pi, p, h)^2 + U_2(p, e(\pi, p, h), h, i)e_{11}(\pi, p, h) < 0, \tag{8}$$

ensuring that the doctor's problem is strictly concave in π. Choices of $\pi = 1$ and $\pi = 0$ are ruled out by (2). Since we consider only patients who have already been admitted to a hospital, we assume it is always optimal to provide at least one procedure. Assumptions (3) and (4) then imply existence of an interior optimum characterized by (6) and (7).

Our interest is in how changes in i affect the doctor's optimal solution $(p^*(h, i), \pi^*(h, i))$. We hypothesize three ways in which incentives may vary with i. First, the doctor's benefit from providing additional procedures may be reduced by managed care: $U_{14}(p, e, h, i) < 0$. In an HMO, for example, doctors often must expend resources to obtain preapproval for additional procedures and may face financial incentives discouraging treatment on the margin. We refer to this as an effect on the doctor's *returns to treatment*.

Second, the doctor's cost of effort may be higher under more managed care, i.e., $U_{24}(p, e, h, i) < 0$. For example, doctors serving managed care patients may face larger case loads, giving them higher opportunity costs of effort, and may work under more direct incentives to limit time (and other resources) spent on each patient. Managed care restrictions on the ability of patients to change providers may also reduce the incentive for doctors to provide high levels of effort to retain patients. With these incentives, doctors would engage in rational corner cutting (reductions in effort), and higher values of i will be associated with higher complication probabilities. The corner cutting and returns to treatment effects are similar: both involve a tendency for managed care to reduce the care provided, although changes in the returns to treatment affect the choice of p, while corner cutting affects the choice of e. The important distinctions are that an increase in p may not always benefit the patient but will be directly observable in our data. Increases in e unambiguously reduce the probability of a complication but are not directly observed.

Third, the cost borne by the doctor when a patient experiences a complication may be higher under managed care, i.e., $C'(i) > 0$. If managed care succeeds in forcing doctors to internalize more of the costs of a complication, doctors with more managed incentives will tend to choose a lower value of π [greater effort and a level of p closer to that which minimizes $\pi(p, e, h)$]. This *preventive care* effect leads unambiguously to a lower complication probability.

Our analysis focuses on the results of these three effects by observing the empirical relationships between measures of i, numbers of procedures performed, and complication frequencies. The potential for opposing incentives makes clear that the overall effect of managed care on complication rates is an empirical question. Estimating this overall effect is straightforward in principle. Assessing the presence and importance of each of the corner-cutting, preventive care, and returns-to-treatment effects is more difficult. The direct effects discussed above are complicated by interactions between the choices of p and e. An increase in p, for example, is likely to affect the marginal return to effort (more procedures may make effort more important, for example). Likewise, the doctor's marginal cost of effort may be affected by the number of procedures being performed. These interactions typically make the net effects of a change in i ambiguous, even when one knows which of the component effects is present. Consequently, simple comparisons of complication rates under different incentive regimes can reveal little about the presence of the component effects or the relative importance of variations in p versus e. Our data, however, allow us to control for the number of procedures performed on each patient. Exploiting this leads to clean results regarding the net effects of the opposing corner-cutting and preventive care effects on the doctor's choice of effort.

To see this, consider a doctor with incentives i who performs $\hat{p}$ procedures on a patient with health h.[6] The first-order condition determining the optimal choice of π [substituting $\hat{p}$ for p in (7)] is

$$U_2(\hat{p}, e(\pi, \hat{p}, h), h, i)\, e_1(\pi, \hat{p}, h) - C(i) = 0. \tag{9}$$

Let $\pi^*(h, i|\hat{p})$ denote the optimum. When the doctor is optimizing, $\hat{p}$ will equal $p^*(h, i)$. The derivative $\partial\pi^*(h, i)/\partial i$ can therefore be decomposed as

$$\frac{\partial\pi^*(h, i)}{\partial i} = \frac{\partial\pi^*(h, i|p^*)}{\partial i} + \frac{\partial\pi^*(h, i|p^*)}{\partial p^*}\frac{\partial p^*(h, i)}{\partial i}, \tag{10}$$

where $p^* = p^*(h, i)$.

Applying the implicit-function theorem to (9) shows that $\partial\pi^*\ (h, i|p^*)/\partial i$ is equal to

$$\frac{C'(i) - U_{24}(p^*, e(\pi^*, p^*, h), h, i)e_1(\pi^*, p^*, h)}{U_{22}(p^*, e(\pi^*, p^*, h), h, i)e_1(\pi^*, p^*, h)^2 + U_2(\hat{p}, e(\pi^*, p^*, h), h, i)e_{11}(\pi^*, p^*, h)}. \tag{11}$$

This expression has an ambiguous sign in general, due to the opposing corner-cutting and preventive care effects. The denominator is negative [by (8)]. Since (5) implies $e_1(\pi, p, h) = 1/\pi_2(p, e(\pi, p, h), h) < 0$, the numerator is also negative when

$$-C'(i)\pi_2(p^*, e(\pi^*, p^*, h), h) + U_{24}(p^*, e(\pi^*, p^*, h), h, i) < 0. \tag{12}$$

Note that $-C(i)\pi_2(p^*, e(\pi^*, p^*, h), h)$ is the marginal benefit of effort (holding p fixed), while $U_2(p^*, e(\pi^*, p^*, h), h, i)$ is the marginal cost of effort. Thus, (12) reflects the case in which the derivative with respect to i of the net marginal return to effort is negative. In this case the corner-cutting effect dominates the preventive care effect and, holding p fixed, patients will suffer more complications under more managed incentives. In the opposite case, the preventive care effect dominates and (11) is negative, i.e., patients with more managed insurance will have fewer complications conditional on p. These results are summarized in the following proposition.

Proposition 1: *$\partial\pi^*(h, i|p^*)/\partial i \gtrless 0$ iff $C'(i)\pi_2(p^*, e(\pi^*, p^*, h), h) \gtrless U_{24}(p^*, e(\pi^*, p^*, h), h, i)$.*

6. Here in particular we emphasize that we are holding constant the health of the patient, h. Because patients with identical health may undergo different numbers of procedures under different incentives, conditioning on the number of procedures may create differences in health across incentive regimes. We discuss our controls for patient health in the following section.

Proposition 1 shows that the effect of a change in the incentive structure on the likelihood of a complication *conditional on the number of procedures performed* reveals the net effect on effort of the competing corner-cutting and preventive care effects, at the doctor's optimal choice of p. When both $\partial\pi^*(h, i)/\partial i$ and $\partial\pi^*(h, i|p^*)/\partial i$ are known, the decomposition in (10) can be used to impute the value of $[\partial\pi^*(h, i|p^*)/\partial p^*]\partial p^*(h, i)/\partial i$, which captures the effect on complication rates of endogenous differences in the numbers of procedures provided to patients under different incentive structures. Hence, comparing complication rates across incentive regimes both conditional and unconditional on the number of procedures, we can measure the overall managed effect of managed care incentives, measure the net effect of the opposing corner-cutting and preventive care effects on effort, and determine whether differences in p or differences in e are predominantly responsible for differences (if any) in complication rates under different incentive structures.

4. California Hospital Discharge Data

Our empirical analysis of these effects uses a large sample of hospital patients with different types of insurance. Our base dataset is a census of discharges of California residents (the unit of observation is the discharged patient) from hospitals in the Sacramento and San Diego MSAs in 1995 and 1996. Sacramento and San Diego were selected as geographically self-contained markets with well-established managed care providers. Geographical self-containment minimizes the likelihood that patients select themselves out of the sample by going elsewhere for treatment. The data come from the California Office of Statewide Health Planning and Development (OSHPD), which collects discharge data for each patient released from California hospitals.

These data offer two important advantages for this study and, more generally, for any outcomes research based on administrative records. First, the large amount of information collected regarding patient characteristics and treatment details makes it possible to minimize both type I and type II errors in identifying complications resulting from the quality of care provided. Each patient record may contain up to 24 secondary diagnoses and procedures, and the number of days between admission and each major surgery and procedure is included. The potential for recording many procedures and diagnoses helps prevent censoring of information that might either differentiate outcomes across patients or account for differences in outcomes. Information regarding the timing of various procedures is used in the complications screening algorithm to minimize false positives—an issue we discuss below. Second, OSHPD aggressively promotes standardization of administrative coding practices (Iezzoni et al., 1994a, 1994b).

Each record includes a number of patient characteristics (age, race, sex, ZIP code, payer type) as well as a detailed account of the patient's stay in the hospital, including date of admission, diagnosis-related group (DRG), major diagnostic category (MDC), length of stay, admission type (scheduled, unscheduled), admission source (home, residential care facility, ambulatory surgery, long-term care, acute inpatient hospital care, other inpatient care, other), total charges, codes for all diagnoses and procedures, patient disposition, and expected principal source of payment.[7] We include in our sample only patients whose payment source was HMO, PPO, private insurance company (not HMO or PPO), or Blue Cross/Blue Shield (not HMO or PPO). ZIP-code data were matched with census data to construct a proxy for patient income.[8] Table I provides summary statistics for our sample of patients. Tables II–VI then provide the same statistics for the subsamples of patients (risk pools) discussed below. Following the design of the complications screening algorithm (discussed below), we consider only patients aged 18–64 and exclude obstetric patients, psychiatric patients, and patients in psychiatric hospitals, long-term rehabilitation facilities, or substance-abuse facilities. Table VII lists summary statistics for our sample of hospitals.

5. Complications as an Outcome Measure

The complications screening program (CSP) we use to identify complications was developed by a team of medical researchers for use in evaluation of hospital quality. We provide an overview here. A more complete description of the algorithm and its development and validation is given in Iezzoni et al. (1992, 1994a, 1994b), Weingart et al. (2000), McCarthy et al. (2000), and Lawthers et al. (2000).[9]

7. Source-of-payment categories include Medicare, Medi-Cal, worker's compensation, county indigent programs, CHAMPUS/VA, other governmental, HMO, PPO, private insurance company (not HMO or PPO), Blue Cross/Blue Shield (not HMO or PPO), self-pay, charity care, no charge, and other nongovernmental. These categories are mutually exclusive, and in this time period all Medicare and Medi-Cal patients are indicated as such, even if their care is delivered through a managed care plan. Hence, our subsamples of HMO, PPO, and FFS patients exclude all Medicare and Medi-Cal patients.

8. For a few ZIP codes, income data are not publicly available. For the results below we have assigned these ZIP codes the median household income of the corresponding patient sample. Results are similar if patients from these ZIP codes are excluded from the sample.

9. See also the comments in Geraci (2000).

TABLE I.
DESCRIPTIVE STATISTICS: FULL SAMPLE

	FFS		PPO		HMO	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Patient characteristics:						
Age	46.1	12.4	46.0	11.9	46.3	11.8
Male	0.473		0.468		0.459	
Hispanic	0.074		0.088		0.088	
Black	0.030		0.032		0.070	
ZIP Median household income ($)	36,539	9,492	36,304	9,465	35,953	9,260
Admission source: acute	0.040		0.052		0.060	
Admission type: scheduled	0.388		0.475		0.382	
Number of ICD-9 diagnoses	4.02	2.86	4.08	2.94	4.17	2.94
Patient chronic conditions:						
Cancer with poor prognosis	0.019		0.021		0.017	
Metastatic cancer	0.043		0.054		0.047	
AIDS	0.005		0.006		0.007	
Chronic pulmonary disease	0.066		0.068		0.075	
Coronary artery disease	0.088		0.099		0.106	
Congestive heart failure	0.023		0.021		0.027	
Peripheral vascular disease	0.011		0.012		0.013	
Severe chronic liver disease	0.008		0.007		0.009	
Diabetes with end organ damage	0.018		0.017		0.024	
Chronic renal failure	0.010		0.010		0.012	
Nutritional deficiencies	0.011		0.012		0.009	
Functional impairment	0.020		0.023		0.022	
Dementia	0.002		0.002		0.002	
Number of chronic conditions	0.323	0.642	0.350	0.650	0.370	0.668
Hospital characteristics:						
Share of all patients in HMO	0.146	0.078	0.143	0.073	0.315	0.175
Teaching hospital[a]	0.621	0.862	0.922	0.926	1.22	0.841
High-tech index[a]	2.56	1.46	3.13	1.51	2.24	1.80
Treatment/outcome measures:						
Number of ICD-9 procedures	2.08	2.27	2.22	2.32	1.86	2.03
Any complication	0.058		0.068		0.066	
Number of observations	18,925		31,010		85,673	

[a] See text for definitions. Standard deviations omitted for binary variables.

TABLE II.
DESCRIPTIVE STATISTICS: MAJOR SURGERY

	FFS		PPO		HMO	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Patient characteristics:						
Age	45.3	11.9	45.2	11.3	45.4	11.4
Male	0.373		0.382		0.356	
Hispanic	0.069		0.082		0.087	
Black	0.021		0.028		0.058	
ZIP Median household income ($)	35,914	9,603	36,692	9,428	36,627	9,305
Admission source: acute	0.012		0.015		0.023	
Admission type: scheduled	0.727		0.794		0.752	
Number of ICD-9 diagnoses	3.41	2.61	3.37	2.58	3.41	2.55
Patient chronic conditions:						
Cancer with poor prognosis	0.004		0.003		0.004	
Metastatic cancer	0.029		0.037		0.039	
AIDS	0.001		0.001		0.001	
Chronic pulmonary disease	0.046		0.054		0.058	
Coronary artery disease	0.041		0.049		0.050	
Congestive heart failure	0.009		0.011		0.012	
Peripheral vascular disease	0.007		0.009		0.009	
Severe chronic liver disease	0.004		0.003		0.003	
Diabetes with end organ damage	0.005		0.005		0.007	
Chronic renal failure	0.002		0.002		0.004	
Nutritional deficiencies	0.002		0.003		0.002	
Functional impairment	0.008		0.009		0.010	
Dementia	0.000		0.000		0.000	
Number of chronic conditions	0.159	0.449	0.186	0.487	0.198	0.500
Hospital characteristics:						
Share of all patients in HMO	0.197	0.092	0.196	0.088	0.386	0.190
Teaching hospital[a]	0.622	0.862	0.960	0.926	1.21	0.838
High-tech index[a]	2.52	1.40	3.06	1.49	2.30	1.79
Treatment/outcome measures:						
Number of ICD-9 procedures	2.65	2.11	2.56	2.07	2.34	1.84
Length of stay	3.28	3.46	3.44	4.06	3.34	3.41
Any complication	0.109		0.11		0.12	
Number of observations	6,679		12,755		31,421	

[a] See text for definitions. Standard deviations omitted for binary variables.

TABLE III.
DESCRIPTIVE STATISTICS: MINOR SURGERY

	FFS		PPO		HMO	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Patient characteristics:						
Age	43.3	13.1	44.2	12.7	44.4	12.7
Male	0.526		0.534		0.496	
Hispanic	0.096		0.096		0.094	
Black	0.027		0.022		0.058	
ZIP Median household income ($)	36,916	9,284	36,222	9,417	36,158	9,469
Admission source: acute	0.009		0.016		0.015	
Admission type: scheduled	0.607		0.690		0.608	
Number of ICD-9 diagnoses	2.96	2.26	3.23	2.42	3.13	2.27
Patient chronic conditions:						
Cancer with poor prognosis	0.004		0.008		0.006	
Metastatic cancer	0.016		0.032		0.027	
AIDS	0.001		0.002		0.002	
Chronic pulmonary disease	0.036		0.055		0.046	
Coronary artery disease	0.021		0.034		0.034	
Congestive heart failure	0.006		0.009		0.010	
Peripheral vascular disease	0.016		0.016		0.022	
Severe chronic liver disease	0.004		0.001		0.003	
Diabetes with end organ damage	0.010		0.018		0.032	
Chronic renal failure	0.014		0.024		0.027	
Nutritional deficiencies	0.003		0.004		0.003	
Functional impairment	0.009		0.012		0.007	
Dementia	0.000		0.001		0.000	
Number of chronic conditions	0.140	0.453	0.215	0.530	0.219	0.544
Hospital characteristics:						
Share of all patients in HMO	0.149	0.076	0.154	0.077	0.405	0.232
Teaching hospital[a]	0.619	0.860	0.998	0.935	1.33	0.805
High-tech index[a]	2.49	1.54	3.03	1.62	2.16	1.79
Treatment/outcome measures:						
Number of ICD-9 procedures	2.45	1.84	2.57	2.03	2.22	1.59
Length of stay	2.09	2.66	2.60	7.06	2.39	2.87
Any complication	0.06		0.078		0.083	
Number of observations	1,398		2,249		5,846	

[a] See text for definitions. Standard deviations omitted for binary variables.

TABLE IV.
DESCRIPTIVE STATISTICS: CARDIAC

	FFS		PPO		HMO	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Patient characteristics:						
Age	52.7	9.1	52.7	8.8	52.0	9.4
Male	0.742		0.717		0.695	
Hispanic	0.067		0.054		0.057	
Black	0.028		0.024		0.041	
ZIP Median household income ($)	36,210	9,233	36,210	8,806	36,035	9,025
Admission source: acute	0.207		0.217		0.251	
Admission type: scheduled	0.304		0.346		0.270	
Number of ICD-9 diagnoses	5.10	2.90	4.93	2.81	5.09	2.92
Patient chronic conditions:						
Cancer with poor prognosis	0.005		0.006		0.004	
Metastatic cancer	0.006		0.016		0.008	
AIDS	0.001		0.000		0.001	
Chronic pulmonary disease	0.097		0.087		0.097	
Coronary artery disease	0.569		0.581		0.579	
Congestive heart failure	0.067		0.048		0.060	
Peripheral vascular disease	0.040		0.045		0.047	
Severe chronic liver disease	0.005		0.001		0.004	
Diabetes with end organ damage	0.027		0.019		0.024	
Chronic renal failure	0.014		0.012		0.010	
Nutritional deficiencies	0.002		0.002		0.002	
Functional impairment	0.015		0.014		0.017	
Dementia	0.000		0.000		0.000	
Number of chronic conditions	0.848	0.740	0.833	0.741	0.854	0.749
Hospital characteristics:						
Share of all patients in HMO	0.193	0.085	0.167	0.079	0.256	0.124
Teaching hospital[a]	1.08	0.937	0.905	0.932	1.22	0.853
High-tech index[a]	3.57	1.20	3.93	0.980	3.26	1.71
Treatment/outcome measures:						
Number of ICD-9 procedures	4.62	2.53	4.46	2.59	4.15	2.47
Length of stay	3.98	4.49	3.99	4.83	3.67	4.41
Any complication	0.128		0.132		0.100	
Number of observations	1,138		2,311		5,215	

[a] See text for definitions. Standard deviations omitted for binary variables.

TABLE V.
DESCRIPTIVE STATISTICS: ENDOSCOPY

	FFS		PPO		HMO	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Patient characteristics:						
Age	48.0	11.3	46.9	11.3	48.1	10.9
Male	0.529		0.525		0.567	
Hispanic	0.090		0.106		0.104	
Black	0.028		0.022		0.071	
ZIP Median household income ($)	36,051	9,463	35,729	8,681	35,964	9,054
Admission source: acute	0.019		0.035		0.040	
Admission type: scheduled	0.362		0.369		0.178	
Number of ICD-9 diagnoses	4.67	3.15	5.18	3.36	5.41	3.37
Patient chronic conditions:						
Cancer with poor prognosis	0.018		0.018		0.013	
Metastatic cancer	0.029		0.048		0.046	
AIDS	0.001		0.007		0.005	
Chronic pulmonary disease	0.050		0.072		0.071	
Coronary artery disease	0.043		0.077		0.074	
Congestive heart failure	0.022		0.033		0.044	
Peripheral vascular disease	0.003		0.010		0.010	
Severe chronic liver disease	0.047		0.044		0.065	
Diabetes with end organ damage	0.008		0.010		0.017	
Chronic renal failure	0.003		0.009		0.010	
Nutritional deficiencies	0.015		0.019		0.017	
Functional impairment	0.010		0.009		0.009	
Dementia	0.000		0.000		0.000	
Number of chronic conditions	0.248	0.570	0.357	0.666	0.382	0.655
Hospital characteristics:						
Share of all patients in HMO	0.121	0.082	0.125	0.080	0.289	0.157
Teaching hospital[a]	0.446	0.753	0.756	0.875	1.16	0.860
High-tech index[a]	2.22	1.40	2.99	1.52	2.25	1.76
Treatment/outcome measures:						
Number of ICD-9 procedures	2.89	2.55	3.48	2.99	3.12	2.58
Length of stay	3.72	4.93	4.26	8.46	4.23	4.79
Any complication	0.069		0.084		0.086	
Number of observations	726		1,058		2,684	

[a] See text for definitions. Standard deviations omitted for binary variables.

TABLE VI.
DESCRIPTIVE STATISTICS: MEDICAL

	FFS		PPO		HMO	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Patient characteristics:						
Age	46.5	12.7	46.2	12.2	46.8	12.0
Male	0.511		0.503		0.508	
Hispanic	0.074		0.095		0.088	
Black	0.039		0.038		0.085	
ZIP Median household income ($)	36,387	9,449	36,001	9,474	35,433	9,183
Admission source: acute	0.049		0.070		0.072	
Admission type: scheduled	0.137		0.175		0.100	
Number of ICD-9 diagnoses	4.32	2.74	4.53	2.88	4.63	2.94
Patient chronic conditions:						
Cancer with poor prognosis	0.033		0.041		0.029	
Metastatic cancer	0.057		0.076		0.056	
AIDS	0.009		0.011		0.012	
Chronic pulmonary disease	0.080		0.078		0.088	
Coronary artery disease	0.087		0.094		0.120	
Congestive heart failure	0.028		0.026		0.035	
Peripheral vascular disease	0.010		0.011		0.012	
Severe chronic liver disease	0.011		0.011		0.015	
Diabetes with end organ damage	0.024		0.024		0.033	
Chronic renal failure	0.013		0.013		0.014	
Nutritional deficiencies	0.016		0.019		0.014	
Functional impairment	0.029		0.038		0.032	
Dementia	0.004		0.004		0.003	
Number of chronic conditions	0.402	0.705	0.447	0.710	0.463	0.722
Hospital characteristics:						
Share of all patients in HMO	0.123	0.074	0.117	0.065	0.283	0.163
Teaching hospital[a]	0.581	0.845	0.863	0.921	1.20	0.843
High-tech index[a]	2.50	1.47	3.09	1.53	2.09	1.78
Treatment/outcome measures:						
Number of ICD-9 procedures	1.20	1.64	1.30	1.66	1.10	1.55
Length of stay	3.80	5.25	4.09	6.03	3.54	6.47
Any complication	0.010		0.011		0.012	
Number of observations	9,422		13,409		42,502	

[a] See text for definitions. Standard deviations omitted for binary variables.

TABLE VII.
Hospital Sample

	San Diego MSA	Sacramento MSA	Total
Number of hospitals[a]	23	16	39
Patients in sample per hospital:			
Median	3558	2099	2222
Lower quartile	1628	654	994
Upper quartile	5199	4534	5102
Share of sample patients in managed care (HMO, PPO):			
Median	0.846	0.826	0.833
Lower quartile	0.765	0.629	0.698
Upper quartile	0.933	0.902	0.912
Share of sample patients in HMOs:			
Median	0.590	0.489	0.516
Lower quartile	0.452	0.299	0.334
Upper quartile	0.642	0.565	0.612

[a] See text for discussion of hospitals and patients included in the sample.

The screening algorithm identifies complications based on the procedures and diagnoses in the hospital discharge record of each patient. A record is flagged when particular diagnoses, procedures, or combinations of these suggest that preventable or potentially preventable complications occurred during the patient's hospital stay. While there are specific diagnosis codes for some types of complications, the algorithm identifies many others. Complications identified by the algorithm are adverse events "that could be avoided or minimized by improving the process of care" (Iezzoni et al., 1994).[10] While not necessarily indicative of poor care at the individual case level, relatively high complication rates suggest potential quality-of-care problems (Iezzoni et al., 1992, 1994a, 1994b; Kalish et al., 1995). Examples of complications include aspiration pneumonia, reopening of a surgical site, postprocedure hemorrhage, and postoperative infections.

To reduce the probability of a false positive in screening the discharge data for complications, the algorithm incorporates a set of qualifying conditions for each complication considered. Patients are

10. The algorithm also identifies "sentinel events," which are adverse outcomes that always indicate an error in care. Examples include transfusion of incompatible blood type, brain damage from oxygen deprivation, or foreign body left in a patient during surgery. Because the occurrence of these events seems less likely to be affected by the incentives we focus on [we confirm this in Haile and Stein (1998)], we exclude them from our analysis.

assigned to *risk pools*—overlapping sets of patients at risk for each complication. Using diagnosis and procedure codes, six risk pools are defined: major surgery, minor surgery, cardiac,[11] endoscopy, medical (patients without major or minor surgery in a medical DRG), and all patients. Each of the 28 complication groups is assigned to one or more of the risk pools, and only patients in an appropriate risk pool can be flagged for a particular complication.[12] For example, reopening of a surgical site is assigned to both the major and minor surgery risk pools, while poisoning due to medication is assigned to all risk pools, including the all patients risk pool.

Before a complication will be flagged, explanations for the adverse event that are unrelated to the quality of care provided must be ruled out. For example, for a postoperative heart attack to be classified as a complication, the patient must have been in the major surgery, minor surgery, or endoscopy risk pool. In addition, the patient must not have been assigned to the MDC "diseases and disorders of the circulatory system" or to any cardiac DRG. For the complication "postoperative pneumonia," the patient must have had the principal surgery on the first or second day in the hospital (since surgery is unlikely to be performed on a patient who already has pneumonia) and the patient must not have (1) been assigned to the MDC "disease and disorders of the respiratory system," (2) been assigned to a DRG indicating immune system problems, or (3) had a diagnosis of AIDS, cancer, or compromised immune system. For many complications, the test for causes that may be unrelated to quality of care is even more extensive.

A complete list of the 28 groups of complications screened for and the corresponding complication rates in the sample is given in Table VIII. There we see that a large share of the complications address postoperative events. The most frequently occurring complication types are post-procedure hemorrhage/hematoma, mechanical complications (e.g., malfunction of or adverse reaction to a device or graft, excluding organ transplants), miscellaneous complications (including, for example, air embolism, infection following infusions/transfusions/

11. The cardiac risk pool is defined by the procedures performed—primarily diagnostic procedures such as cardiac catheterization or angiocardiogram. A few surgical treatments excluded from the major and minor surgery pools, such as partial ventriculectomy and angioplasty, are also included. Patients undergoing cardiac valve procedures, coronary bypass procedures, or other major chest/cardiothoracic/cardiovascular procedures are always in the major surgery risk pool but will be in the cardiac risk pool as well when the procedures defining the cardiac pool are also performed.

12. Hence the complication count for the all patients risk pool is not the sum of those in the other risk pools, but the number of occurrences of complications for which all patients are at risk.

TABLE VIII.
COMPLICATIONS, RISK POOLS, AND COMPLICATION RATES

Complication	Risk Pool(s)[a]	HMO Frequency	PPO Frequency	FFS Frequency
Postoperative stroke	A, B	0.00048	0.00067	0.00025
Postop. urinary-tract complications	A, B	0.00054	0.00087	0.00087
Postop. pulmonary compromise	A, B	0.00483	0.00653	0.00767
Postop. GI hemorrhage/ulceration	A, B	0.00086	0.00087	0.00087
Cellulitis/decubitus ulcer	A, B	0.00016	0.00040	0.00037
Septicemia	A, B	0.00048	0.00040	0.00025
Reopening of surgical site	A, B	0.00250	0.00253	0.00235
Aspiration pneumonia	A, B	0.00174	0.00180	0.00186
Postop. shock due to anesthesia	A, B	0.00000	0.00000	0.00000
Mechanical complications	A, B	0.00969	0.01146	0.01002
Miscellaneous complications	A, B	0.01457	0.01353	0.01225
Shock/cardiorespiratory arrest in hospital	B	0.00188	0.00133	0.00000
Postop. infections (not pneumonia, wound)	A, B, D	0.00191	0.00127	0.00104
Postop. nervous system complications	A, B, D	0.00051	0.00101	0.00058
Postop. myocardial infarction	A, B, D	0.00053	0.00051	0.00035
Other postop. cardiac abnormalities	A, B, D	0.00043	0.00051	0.00058
Procedure-related perforation/laceration	A, B, D	0.00343	0.00374	0.00288
Postop. phys./metab. derangements	A–D	0.00103	0.00085	0.00083
Postop. coma/stupor	A–D	0.00080	0.00045	0.00156
Postop. pneumonia	A–D	0.00446	0.00555	0.00448
Complic. due to anesthetic agents	A–D	0.00002	0.00000	0.00010
Venous thrombosis/pulmonary embolism	A–E	0.00072	0.00047	0.00083
Postprocedure hemorrhage/hematoma	A–F	0.01173	0.01100	0.00925
In-hospital hip fracture/fall	A–F	0.00022	0.00013	0.00058
Wound infection	A–F	0.00543	0.00584	0.00428
Iatrogenic complications	A–F	0.03741	0.03692	0.03144
Technical difficulty with medical care	A–F	0.00000	0.00000	0.00000
Poisoning due to medication	A–F	0.00051	0.00035	0.00042

[a] A = major surgery, B = minor surgery, C = cardiac, D = endoscopy, E = medical, F = all patients.

injections, etc., and conversion of a laparoscopic procedure to an open procedure) and iatrogenic complications (such as cardiac arrest resulting from a noncardiac procedure, aspiration pneumonia resulting from a procedure, or renal failure resulting from a procedure). By far the most common is the last of these groups, which comprises diagnoses unambiguously identified as complications resulting from medical care.

Variations in complication frequencies clearly cannot capture the effects of all variations in care that are important to patients' health. However, as an index of the overall quality of care received by patients, this criterion offers several advantages over common alternatives such as deaths, readmissions, lengths of stay, or tests performed. First, this measure captures many adverse outcomes in a single indicator.[13] Second, complications are identified directly from patient discharge records, making analysis of large samples feasible and avoiding potential biases from self-reporting or inconsistencies in the review of clinical records. Complications also occur sufficiently frequently among all adult patient populations for us to consider the effects of incentives on a much wider range of patients than is possible with measures such as death or readmission. For example, in our sample more than 10 percent of patients undergoing major surgery experience a complication. Finally, our complications criterion was designed specifically to provide a measure that is sensitive to the quality of care provided. *A priori*, this measure seems more likely than mortality to pick up variations in care that result from variations in provider incentives.[14] Recently, this measure has been used in the market by hospitals and hospital systems as a tool for monitoring and evaluating outcomes. It is included, for example, among the criteria for obtaining accreditation from the Joint Commission on Accreditation of Healthcare Organizations.

Table IX provides a preliminary look at complication frequencies among patients with different insurance types within each risk

13. Of course, this is also a limitation. Because each complication is still a fairly rare event and there are no established rankings of the different complications by severity, we will follow prior studies in treating all complications equally.

14. Rerunning the analysis below using death as our measure of an adverse outcome yields quite different results. In the major surgery and all patients risk pools, which demonstrate the most robust (positive) relation between managed care and complications rates, managed care insurance appears to have no significant relation to mortality rates (major surgery) or a negative relation (all patients). By contrast, we will see that an ordered model in which death is treated as a more severe adverse outcome than a complication gives results similar to those based on complications alone. A lack of correlation between mortality and complication rates is also found in Silber et al. (1995) and references therein. While this clearly suggests that the two criteria measure different things, which measure is more indicative of quality of care for various types of patients is an open question.

TABLE IX.
Raw Odds Ratios

	Odds Ratio	
Risk Pool	Managed Care[a]	HMO
Major surgery	1.093**	1.125***
Minor surgery	1.359***	1.386***
Cardiac	0.840*	0.757***
Endoscopy	1.260	1.267
Medical	1.237*	1.273**
All patients	1.202***	1.207***

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] HMO + PPO.

pool. Here we report odds ratios constructed from raw complication frequencies. Unconditional on any other patient characteristics, managed care patients are significantly more likely than FFS patients to experience complications in the major surgery, minor surgery, and all patients risk pools, but significantly less likely to experience a complication in the cardiac risk pool. Similar but slightly larger differences are found when comparing HMO and FFS patients.

6. Estimation and Results

6.1 Worse Outcomes Under Managed Care?

We compare frequencies of complications among managed care and FFS patients using a logistic regression for the model

$$y_{it} = 1\{\delta I_{it} + \mathbf{X}_{it}\beta + \epsilon_{it} > 0\}.$$

The dependent variable y_{it} is an indicator equal to one when patient i at hospital t experiences one or more complications.[15] Our primary interest is in δ, the parameter(s) on our indicator(s) of the incentive structure I_{it}, which may include dummy variables for patient i's insurance type, measures of the mix of insurance types served at hospital t, or both. We condition on a large set of controls for patient and hospital heterogeneity, $\mathbf{X}_{it}$, which includes the patient's race (dummies

15. Following Iezonni et al. (1994a, 1994b), we make no distinction between occurrence of single versus multiple complications in our baseline regressions. About 15 percent of patients who have at least one complication have more than one, suggesting an ordered model as a possible alternative specification, which we present below.

for black, Hispanic), age, admission source (acute inpatient), admission type (scheduled), and number of diagnoses. The number of diagnoses is an important (albeit noisy) control for patient i's health and also provides a control for any variations in coding practices across patients or hospitals. Due to high correlation between poverty and poor health (which might increase the likelihood of some complications), we include the median household income for the patient's ZIP code. We also include indicators for the presence of chronic conditions indicated by patients' secondary diagnoses.[16] Following Iezzoni et al. (1994a, 1994b), we include dummy variables for the patient's major diagnostic category (MDC), an indicator of the organ group being treated. In some specifications $\mathbf{X}_{it}$ also includes two hospital characteristics: an indicator for teaching hospitals and an index for the presence of high-tech equipment.[17]

We first estimate the logit model letting I_{it} be a dummy variable equal to one for patients with managed care insurance (HMO or PPO). Table X reports odds ratios based on the parameter estimates. Because validation studies of the CSP have focused on the major surgery risk pool,[18] we will also focus on the results for this risk pool, but will also report results for other risk pools. For the major surgery and all patients risk pools the estimate of δ is positive and significant, implying that a managed care patient is about 15 percent more likely to have a complication than a FFS patient, conditional on the patient's observable characteristics.[19] Coefficients on many but not all of the patient characteristics are significant as well.[20] In the minor-surgery

16. The complications screening algorithm was developed and validated using indicators for 13 chronic conditions as controls. In several of our regressions it was necessary to exclude one or more of these dummy variables due to the low frequency of the corresponding condition in the samples.

17. These hospital characteristics are taken from the American Hospital Association annual hospital survey of 1995. For the teaching hospital index, hospitals affiliated with a medical school received a rank of 2 and other hospitals with a residency program a rank of 1. The results are not changed by using other methods of combining these underlying indicators. The high-tech index is the sum of indicators for open-heart surgery, organ transplants, angioplasty, MRI equipment, and CT scan equipment. Where AHA data were incomplete, data were supplemented by contacting hospitals directly.

18. See Lawthers et al. (2000) and Weingart et al. (2000). These studies also considered the medical risk pool but found the CSP results less reliable for those patients.

19. These percentage differences apply to overall complication frequencies of 12 and 5 percent for the major surgery and all patients risk pools, respectively. While complications are important and costly events on their own, we view their frequency as an index of overall quality, not as the only outcome of interest. For this reason we emphasize odds ratios rather than the absolute magnitudes.

20. The significant negative coefficients on many of the chronic condition indicators requires explanation. Patients with chronic conditions are more likely to be to be severely ill and to present more difficult cases. Hence these patients tend to have

TABLE X.
Estimated Odds Ratios for Complication Probability[a]

	Major Surgery	Minor Surgery	Cardiac	Endoscopy	Medical	All Patients
Managed care	1.154***	1.248*	0.846	0.949	1.144	1.146***
Age	1.027	0.914	1.219	1.446	1.478*	0.983
Age squared	0.996	1.014	0.993	0.952	0.951**	1.000
Male	1.289***	0.854*	1.156*	0.928	0.769***	1.093***
Hispanic	1.088	0.881	1.323*	0.751	0.973	1.046
Black	1.194**	0.982	0.873	0.671	0.784	0.913
Median HH income (ZIP)	1.036**	1.022	0.969	0.956	1.085**	1.033**
Admission source: acute	0.771***	0.672	1.066	1.737**	2.594***	1.195***
Admission type: scheduled	1.175***	1.104	1.391***	2.464***	1.430***	3.823***
Cancer with poor prognosis	0.525***	0.313*	0.198	1.045	0.857	0.305***
Metastatic cancer	0.690***	0.914	0.513	1.653**	0.632***	0.705***
AIDS	0.325**				0.251***	0.097***
Chronic pulmonary disease	0.526***	0.672**	0.612***	0.878	0.513***	0.663***
Coronary artery disease	0.344***	0.540***	0.678***	0.582**	0.979	0.887***
Congestive heart failure	0.573***		0.805	1.050	0.916	0.737***
Peripheral vascular disease	0.356***	0.476***	0.564***		0.709	0.659***
Severe chronic liver disease	0.186***			0.331***	0.415***	0.126***
Diabetes with EOD	0.224***		0.326***	0.487	0.368***	0.227***
Chronic renal failure	0.485***	0.667*	0.996			0.563***
Nutritional deficiencies	0.687	0.802	0.549	0.510*		0.296***
Functional impairment	0.548***	0.419**	0.902	0.576	0.602***	0.313***
Number of ICD-9 diagnoses	1.711***	1.582***	1.530***	1.376***	1.271***	1.437***
Patients with a complication	5,924	748	974	280	766	6,821
Number of patients	50,855	9,493	8,664	3,410	65,333	135,608
Complication rate	0.116	0.079	0.112	0.082	0.012	0.050

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Also included: indicators for major diagnostic category (MDC).

risk pool we obtain an even larger estimated odds ratio, although the underlying estimate of δ is statistically different from zero only at a 10 percent level of significance. In the cardiac risk pool our results suggest that managed care patients are almost 20 percent *less* likely to experience a complication, although the result is significant only at the 12 percent level. In the other risk pools, we find no significant differences in complication frequencies between managed care and FFS patients.

Table XI presents odds ratios based on results from the same regressions run with separate dummy variables for PPO and HMO patients. The PPO dummy has no statistically significant coefficient in any of the risk pools. By contrast, the estimated HMO odds ratios are similar to those for the managed care indicators in the previous regressions, but farther from 1 and with smaller standard errors. In the major surgery, minor surgery, and all patients risk pools, HMO patients are significantly more likely to experience a complication than other patients—20 percent more likely in major surgery, 32 percent more likely in minor surgery, and 18 percent more likely in the all patients pool. In the cardiac risk pool, however, HMO patients are nearly 30 percent less likely to have a complication than other patients.

Interpreting these results in the framework of our model suggests that the overall differences in outcomes detected in these regressions are composed of several different effects acting on the two choice variables, procedures and effort. As suggested by Proposition 1, we run the same regressions conditioning on the number of procedures performed on each patient in order to focus on the effects of managed care incentives on effort. The resulting odds ratio estimates are presented in Table XII. In every risk pool the estimated effect of an additional procedure on the probability of a complication is positive and significant, with estimated odds ratios between 1.08 and 1.24. This may reflect (1) greater opportunity for a complication to occur when a patient undergoes more procedures, (2) the fact that some complications are identified from procedures performed, or (3) performance of

more diagnoses indicating the severity of the patient case, as well as more complications. If the numbers of procedures and diagnoses are omitted from the analysis, the chronic-condition dummies proxy for this effect and significant positive coefficients on the chronic condition dummies are obtained, as we might expect. However, when the number of diagnoses is included in the regression, we pick up this effect directly, so including the chronic condition indicators results in a sort of double counting. More precisely, the *additional* diagnoses recorded to indicate the presence of a chronic condition should be given an interpretation different from that given the average diagnosis in the diagnosis count for patients without chronic conditions. If the number of diagnoses provides a good control for the underlying health of the patient, the negative coefficients on the chronic condition dummies are then expected as a correction for this difference.

TABLE XI.
ESTIMATED ODDS RATIOS FOR COMPLICATION PROBABILITY: SEPARATE PPO AND HMO DUMMIES[a]

	Major Surgery	Minor Surgery	Cardiac	Endoscopy	Medical	All Patients
PPO	1.051	1.093	1.146	0.846	1.017	1.056
HMO	1.198***	1.315**	0.725***	1.003	1.188	1.182***
Age	1.024	0.905	1.205	1.438	1.473*	0.979
Age squared	0.996	1.014	0.993	0.952	0.951**	1
Male	1.293***	0.859*	1.155*	0.926	0.769***	1.094***
Hispanic	1.085	0.876	1.324*	0.751	0.974	1.046
Black	1.176**	0.952	0.904	0.656	0.769*	0.900*
Median HH income (ZIP)	1.036**	1.024	0.965	0.955	1.087**	1.034**
Admission source: acute	0.763***	0.671	1.099	1.738**	2.565***	1.191***
Admission type: scheduled	1.180***	1.116	1.350***	2.534***	1.460***	3.854***
Cancer with poor prognosis	0.520***	0.310*	0.210	1.046	0.859	0.306***
Metastatic cancer	0.689***	0.913	0.485	1.644**	0.632***	0.705***
AIDS	0.332**				0.250***	0.097***
Chronic pulmonary disease	0.526***	0.672**	0.614***	0.881	0.513***	0.662***
Coronary artery disease	0.344***	0.536***	0.674***	0.589**	0.977	0.887***
Congestive heart failure	0.571***		0.817	1.038	0.913	0.735***
Peripheral vascular disease	0.355***	0.467***	0.574***		0.710	0.658***
Severe chronic liver disease	0.186***			0.330***	0.412***	0.125***
Diabetes with EOD	0.222***		0.334***	0.483	0.366***	0.226***
Chronic renal failure	0.481***	0.670*	0.959			0.564***
Nutritional deficiencies	0.694	0.803	0.568	0.512*		0.298***
Functional impairment	0.548***	0.424**	0.911	0.577	0.606***	0.313***
Number of ICD-9 diagnoses	1.712***	1.585***	1.534***	1.376***	1.272***	1.438***
Patients with a complication	5,924	748	974	280	766	6,821
Observations	50,855	9,493	8,664	3,410	65,333	135,608
Complication rate	0.116	0.079	0.112	0.082	0.012	0.050

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Also included: indicators for major diagnostic category (MDC).

additional procedures in response to a complication.[21] Regardless of the interpretation, however, the estimated HMO effects are changed very little by this conditioning.[22] For the major surgery, minor surgery, and all patients risk pools, the estimated HMO coefficients are positive and significant. Interpreting these results in the framework of our model, the net effect of the competing corner-cutting and preventive care incentives on doctors' effort appears to be negative for these risk pools.[23]

For every risk pool the estimated HMO odds ratio in Table XII is larger than that obtained unconditional on the number of procedures (Table XI). Hence, except in the cardiac risk pool, controlling for the number of procedures magnifies the differences in complication rates between HMO and FFS patients. However, the differences between the estimates of δ in Tables XI and XII are small, suggesting [through the decomposition in (10)] that the overall differences in HMO and FFS outcomes result primarily from variations in doctors' effort. This may not be surprising given the broad definition of effort here; however, it does provide valuable evidence that the differences in complication frequencies found above are not the result of differences in the degree to which the *quantity* of treatment (as measured by the number of procedures) puts patients at risk of a complication.

While small in magnitude, the signs of the differences between results in Tables XI and XII are consistent with response to a reduction in doctors' returns to treatment under managed care. More direct evidence is given in Table XIII, which reports the results of Poisson regressions of the number of procedures performed on the same set of covariates considered above. In every risk pool except endoscopy, HMO patients undergo significantly fewer procedures, as should be the case if HMOs are reducing doctors' returns from providing additional treatment.

6.2 Differences Within or Between Hospitals?

In the previous section we took each patient's insurance type as an indicator of the incentives faced by the doctor caring for him. Patients' insurance types may be highly correlated with the hospitals they use.

21. A natural concern is that the number of procedures could be correlated with unobserved factors affecting the likelihood of a complication. We attempt to minimize this possibility by conditioning on the number of diagnoses and other patient characteristics.

22. Very similar results are obtained if we substitute the patient's length of stay for the number of procedures.

23. The results for the cardiac risk pool are again different. We examine this risk pool more closely in the following section.

TABLE XII.
Estimated Odds Ratios for Complication Probability, Controlling for Number of Procedures[a]

	Major Surgery	Minor Surgery	Cardiac	Endoscopy	Medical	All Patients
PPO	1.056	1.076	1.151	0.795	1.014	1.052
HMO	1.236***	1.383**	0.788***	1.045	1.222*	1.274***
Age	1.058	0.931	1.754	1.430	1.511*	1.084
Age squared	0.994	1.014	0.961	0.956	0.950**	0.993
Male	1.270***	0.849*	1.067	0.931	0.758***	1.050*
Hispanic	1.080	0.872	1.163	0.767	0.952	1.011
Black	1.196**	0.972	0.911	0.721	0.775	0.966
Median HH income (ZIP)	1.036**	1.021	0.946	0.951	1.090**	1.030**
Admission source: acute	0.755***	0.623	1.144	1.309	2.720***	1.277***
Admission type: scheduled	1.230***	1.156	1.406***	2.102***	1.487***	3.578***
Cancer with poor prognosis	0.526***	0.348*	0.224	1.251	0.828	0.328***
Metastatic cancer	0.651***	0.860	0.408*	1.407	0.638***	0.689***
AIDS	0.367*				0.258***	0.123***
Chronic pulmonary disease	0.547***	0.730*	0.651***	1.026	0.537***	0.722***
Coronary artery disease	0.356***	0.600***	0.701***	0.597**	1.003	0.900**
Congestive heart failure	0.569***		0.741**	1.059	0.889	0.705***
Peripheral vascular disease	0.376***	0.452***	0.607***		0.745	0.693***
Severe chronic liver disease	0.176***			0.282***	0.396***	0.126***
Diabetes with EOD	0.245***		0.454***	0.765	0.417***	0.307***
Chronic renal failure	0.484***	0.727	0.880			0.557***
Nutritional deficiencies	0.637	0.729	0.448	0.486*		0.262***
Functional impairment	0.543***	0.453**	0.909	0.829	0.660**	0.391***
Number of ICD-9 diagnoses	1.667***	1.514***	1.402***	1.272***	1.236***	1.350***
Number of ICD-9 procedures	1.080***	1.124***	1.237***	1.223***	1.115***	1.175***
Patients with a complication	5,924	748	974	280	766	6,821
Observations	50,855	9,493	8,664	3,410	65,333	135,608
Complication rate	0.116	0.079	0.112	0.082	0.012	0.050

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Also included: indicators for major diagnostic category (MDC).

TABLE XIII.

POISSON REGRESSION COEFFICIENTS: NUMBER OF PROCEDURES PERFORMED[a]

	Major Surgery	Minor Surgery	Cardiac	Endoscopy	Medical	All Patients
PPO	−0.027***	0.016	−0.050	0.063**	0.049***	0.020***
HMO	−0.122***	−0.104***	−0.437***	0.019	−0.137***	−0.127***
Median HH income (ZIP)[b]	−0.222	0.398	7.713***	0.847	0.745*	0.761***
Age	0.000	−0.002	−0.078***	−0.001	0.007***	0.001
Age squared	0.000	0.000	0.001***	0.000	0.000***	0.000***
Male	0.061***	0.035**	0.297***	−0.052***	0.100***	0.062***
Hispanic	0.011	0.048**	0.393***	0.035	0.124***	0.070***
Black	−0.061***	−0.026	−0.069	−0.041	0.047***	−0.076***
Admission source: acute	0.026	0.159***	−0.305***	0.253***	−0.298***	−0.049***
Admission type: scheduled	−0.085***	−0.078***	−0.225***	0.223***	0.153***	0.370***
Cancer with poor prognosis	−0.057	−0.120	−0.898***	−0.120*	0.116***	−0.202***
Metastatic cancer	0.181***	0.107***	−0.004	0.267***	0.040**	0.022**
AIDS	−0.289***				0.026	−0.298***
Chronic pulmonary disease	−0.173***	−0.155***	−0.350***	−0.103***	−0.155***	−0.148***
Coronary artery disease	−0.131***	−0.264***	−0.092*	−0.026	0.097***	0.139***
Congestive heart failure	−0.103***		0.412***	−0.052	0.073***	0.005
Peripheral vascular disease	−0.216***	0.020	−0.340***		−0.176***	−0.105***
Severe chronic liver disease	0.127***			0.096***	0.097***	−0.080***
Diabetes with EOD	−0.383***		−1.278***	−0.405***	−0.435***	−0.504***
Chronic renal failure	−0.034	−0.137***	0.405*			0.046***
Nutritional deficiencies	0.038	0.043	1.959***	−0.009		−0.025
Functional impairment	−0.037	−0.170***	0.284		−0.283***	−0.316***
Dementia	−0.214					
Number of ICD-9 diagnoses	0.112***	0.126***	0.449***	0.087***	0.119***	0.123***
Observations	50,855	9,493	8,664	4,468	65,333	135,608

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Also included: indicators for major diagnostic category (MDC).
[b] Coefficients scaled up by 10^6.

As seen in Table VII, there is considerable heterogeneity in the types of patients served by different hospitals, including cases in which a hospital has virtually no FFS or no managed care patients. Indeed, one striking feature in Table I is the mix of patients at the hospitals treating patients with different types of insurance. HMO patients are treated in hospitals in which HMO patients account for about 30 percent of all patients,[24] while FFS and PPO patients are treated in hospitals with HMO shares of around 15 percent. Hence, it is natural to ask whether the differences in complication frequencies detected above reflect differences in outcomes for HMO and FFS patients in the same hospitals or differences across hospitals. This question can be addressed directly by adding hospital fixed effects to the specifications above. Interpreting differences in outcomes as reflecting differences in incentives, this specification enables us to ask whether managed care incentives act primarily at the individual patient level or through variations in hospital-wide treatment practices. [25]

Odds ratios from these regressions are provided in Table XIV. Including the hospital fixed effects eliminates the HMO effect in all but the cardiac risk pool, where an odds ratio of 0.797 is significant at the 5.1 percent level. With this exception, these results indicate that variations in care across patient types suggested above are generated primarily by differences in practices across hospitals rather than by differential treatment of patients within hospitals. Combined with the preceding results, this implies that hospitals treating larger numbers of HMO patients tend to have higher complication frequencies. While these results may suggest support for a hypothesis that practice patterns are adjusted at the hospital level to reflect the incentives created by the mix of patients (insurance types) being served, a thorough investigation of inter-hospital differences requires a larger cross section of hospitals than that available in our sample.

To obtain some suggestive results, however, we consider a parsimonious empirical specification that excludes the hospital fixed effects but includes, in addition to the PPO and HMO dummies, a small set of hospital characteristics, including the share of patients in the hospital who are in an HMO.[26] These results are presented in Table XV. Neither the PPO nor the HMO dummy variable has a statistically

24. Recall that Medicare and Medi-Cal patients (among others) are not classified as HMO, PPO, or FFS.

25. For one risk pool, endoscopy, hospital dummies could not be included due to the small number of hospitals with significant numbers of complications among both managed care and FFS patients.

26. Results are similar if one uses the number of patients in our sample at each hospital as the denominator for this share. Similar but slightly noisier results are obtained using the share of managed care (HMO + PPO) patients.

TABLE XIV.
Estimated Odds Ratios for Complication Probability with Hospital Fixed Effects[a]

	Major Surgery	Minor Surgery	Cardiac	Medical	All Patients
PPO	1.062	1.083	1.131	0.964	1.022
HMO	0.984	1.160	0.797*	1.097	0.993
Age	1.032	0.942	1.279	1.502*	1.006
Age squared	0.993	1.009	0.988	0.949**	0.997
Male	1.284***	0.876	1.140	0.775***	1.087***
Hispanic	1.038	0.812	1.356*	0.945	1.034
Black	1.121	0.902	0.935	0.776	0.891*
Median HH income (ZIP)	1.045**	1.034	0.991	1.095**	1.055***
Admission source: acute	0.743***	0.625	0.876	2.449***	1.004
Admission type: scheduled	1.221***	1.197*	1.217**	1.448***	3.749***
Cancer with poor prognosis	0.496***	0.306*		0.872	0.303***
Metastatic cancer	0.644***	0.847		0.591***	0.671***
AIDS	0.296**			0.266**	0.090***
Chronic pulmonary disease	0.523***	0.676**	0.584***	0.519***	0.649***
Coronary artery disease	0.337***	0.559***	0.683***	0.951	0.842***
Congestive heart failure	0.547***		0.830	0.910	0.715***
Peripheral vascular disease	0.361***	0.494***	0.575***	0.699	0.654***
Severe chronic liver disease	0.167***			0.419***	0.125***
Diabetes with EOD	0.209***		0.374***	0.371***	0.240***
Chronic renal failure	0.422***	0.680*			0.541***
Nutritional deficiencies	0.638	0.746			0.303***
Functional impairment	0.543***	0.430**		0.609***	0.327***
Number of ICD-9 diagnoses	1.766***	1.598***	1.534***	1.275***	1.441***
Patients with a complication	5,924	748	974	766	6,821
Observations	50,855	9,493	8,664	65,333	135,608
Complication rate	0.116	0.079	0.112	0.012	0.050

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Also included: indicators for major diagnostic category (MDC) and hospital fixed effects.

significant coefficient in this specification, except in the cardiac risk pool. However, the coefficient on the HMO share is significant in all but the minor surgery risk pool, where the estimate of δ is significant at the 12-percent level.[27] The results suggest that patients in the cardiac risk pool are significantly less likely to experience a complication in a hospital serving predominantly HMO patients. Patients in the major surgery, endoscopy, medical, and all patients risk pools are significantly more likely to have a complication in a hospital more specialized in treatment of HMO patients than in a hospital more specialized in treatment of FFS (or PPO) patients. In the major surgery risk pool, for example, the odds ratio of 2.27 on the HMO share suggests that for the average patient, going to a hospital with a 10 percent higher share of HMO patients would increase the likelihood of a complication by about 8.5 percent.

Finally, to evaluate the robustness of the results, we consider an ordered model that accounts for the fact that the occurrence of multiple complications may indicate a more severe adverse outcome than a single complication. We estimate an ordered logit model with the dependent variable equal to 1 if a single complication occurs, 2 if two or more complications occur, 3 if the patient dies (regardless of the number of complications), and 0 otherwise. The results, reported in Table XVI, are very similar to those reported above.[28]

7. Unobserved Heterogeneity

Endogenous matching of patients, doctors, insurance types, and hospitals is a serious concern in any analysis comparing outcomes across patients or hospitals. Our model ignores these issues by assuming a representative doctor in a single hospital and holding fixed the health of the patient. In practice, patients and/or their employers choose the type of health insurance to purchase, based at least in part on costs and on the quality and quantity of services available. Doctors also choose (or are chosen) to treat greater or lesser shares of managed care patients, based in part on the match between managed care practice and compensation structures and on doctors' own preferences. Similarly, HMOs generally choose the hospitals at which their patients are treated and may restrict access to hospital treatment. We discuss each of these issues and the implications for the interpretation of our results.

27. These claims are subject to the caveat that unobserved heterogeneity in quality across hospitals could induce a more complicated error structure than we have assumed.

28. If we omit the share of HMO patients and focus only on the HMO and PPO indicators, the results are also similar to those in Table XIII.

TABLE XV. ESTIMATED ODDS RATIOS FOR COMPLICATION PROBABILITY[a]

	Major Surgery	Minor Surgery	Cardiac	Endoscopy	Medical	All Patients
PPO	1.060	1.090	1.104	0.810	0.995	1.023
HMO	1.006	1.158	0.793**	0.881	1.142	1.026
HMO share	2.270***	1.600	0.214**	7.413***	1.978*	3.009***
Age	1.031	0.911	1.251	1.422	1.479*	0.990
Age squared	0.994	1.013	0.990	0.953	0.951**	0.999
Male	1.292***	0.869	1.145	0.910	0.768***	1.091***
Hispanic	1.094	0.860	1.270	0.746	0.959	1.033
Black	1.110	0.920	0.923	0.647	0.774	0.870**
Median HH income (ZIP)	1.041**	1.026	0.964	0.945	1.079*	1.029*
Admission source: acute	0.760***	0.678	1.058	1.799**	2.571***	1.197***
Admission type: scheduled	1.174***	1.118	1.259**	2.658***	1.467***	3.839***
Cancer with poor prognosis	0.531***	0.315*	0.220	1.010	0.854	0.310***
Metastatic cancer	0.690***	0.904	0.450	1.620*	0.622***	0.699***
AIDS	0.324**				0.249***	0.094***
Chronic pulmonary disease	0.521***	0.672**	0.612***	0.855	0.516***	0.666***
Coronary artery disease	0.343***	0.539***	0.679***	0.569***	0.981	0.881***
Congestive heart failure	0.572***		0.808	1.022	0.913	0.736***
Peripheral vascular disease	0.352***	0.467***	0.572***		0.706	0.658***
Severe chronic liver disease	0.188***			0.324***	0.414***	0.123***
Diabetes with EOD	0.216***		0.347***	0.471*	0.374***	0.227***
Chronic renal failure	0.496***	0.669*			0.935	0.565***
Nutritional deficiencies	0.692	0.828	0.519	0.506*		0.296***
Functional impairment	0.546***	0.425**	0.894	0.546	0.593***	0.310***
Teaching hospital	1.027	1.028	1.104	0.771**	0.951	1.000
High-tech index	0.990	0.998	1.072*	1.131**	1.072**	1.077***
Number of ICD-9 diagnoses	1.716***	1.591***	1.541***	1.380***	1.271***	1.437***
Patients with a complication	5,924	748	974	280	766	6,821
Observations	50,855	9,493	8,664	3,410	65,333	135,608
Complication rate	0.116	0.079	0.112	0.082	0.012	0.050

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Also included: indicators for major diagnostic category (MDC).

TABLE XVI.
ORDERED LOGIT COEFFICIENT ESTIMATES

	Major Surgery	Minor Surgery	Cardiac	All Patients
PPO	0.062	0.084	−0.079	0.001
HMO	0.016	0.150	−0.342***	0.022
HMOSHT	0.781***	0.550**	−1.480***	0.410***
Median HH income (ZIP)	0.036**	0.017	−0.002	0.029**
Age	−0.002	−0.011	0.223	−0.005
Age squared	0.000	0.000	−0.006	0.000
Male	0.251***	−0.162*	0.160*	0.138***
Hispanic	0.095*	−0.195	0.232	0.024
Black	0.114*	−0.130	−0.198	−0.098*
Admission source: acute	−0.292***	−0.227	0.130	0.215***
Admission type: scheduled	0.020	0.023	0.235***	0.792***
Cancer with poor prognosis	−0.376*	−0.834*	−0.309	−0.161**
Metastatic cancer	−0.355***	−0.011	−0.853**	0.393***
AIDS	−0.709*			0.135
Chronic pulmonary disease	−0.663***	−0.294*	−0.520***	−0.390***
Coronary artery disease	−1.088***	−0.688***	−0.443***	−0.269***
Congestive heart failure	−0.534***		−0.184	−0.022
Peripheral vascular disease	−1.015***	−0.870***	−0.577***	−0.394***
Severe chronic liver disease	−0.919***			−0.528***
Diabetes with EOD	−1.442***		−1.017***	−1.385***
Chronic renal failure	−0.448**	−0.561***	0.133	0.009
Nutritional deficiencies	−0.184	0.211	−1.049*	−0.455***
Functional impairment	−0.426***	−0.867**	−0.112	−0.734***
Number of ICD-9 diagnoses	0.521***	0.477***	0.428***	0.333***
Observations	50,855	9,493	8,664	135,608

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.

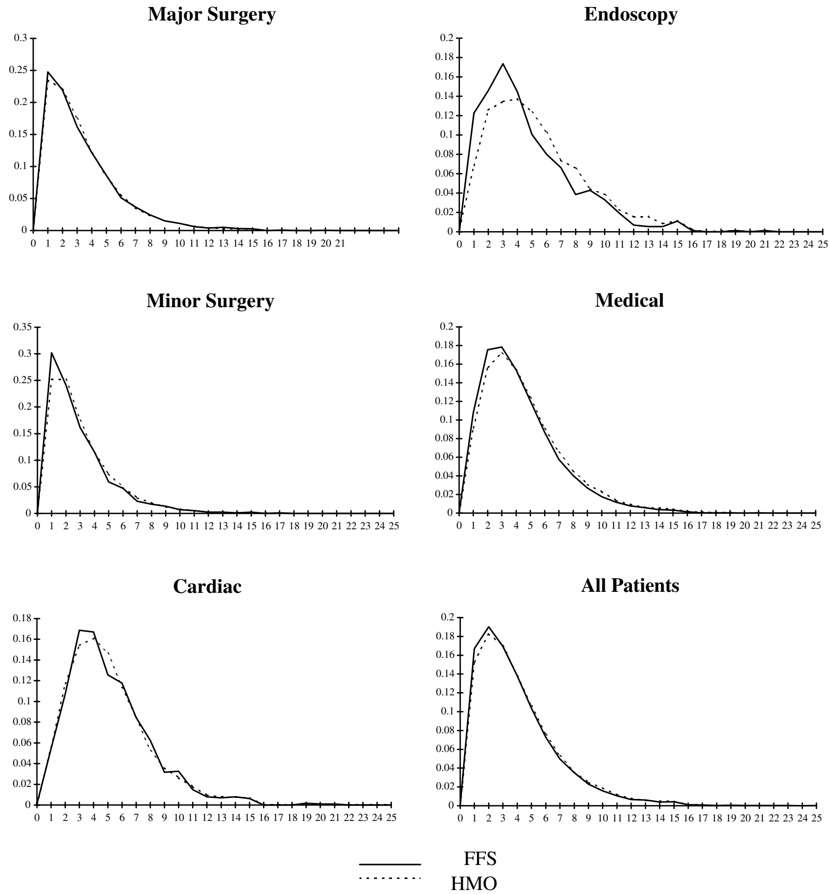
7.1 PATIENT SELECTION

Self-selection by patients is the most serious concern, since this could result in biased estimates of differences in outcomes across types of patients. The direction of the potential bias is unclear *a priori*. Managed care organizations are widely believed to target younger, healthier patients. If patient health is a significant factor determining the likelihood of a complication, this could lead to fewer complications among managed care patients even if the care they receive is identical to that given FFS patients. Correcting for such selection bias would, of course, only reinforce our findings for the risk pools in which we find HMO patients to have higher complication rates. However, managed care organizations also restrict the use of services, including hospital services, and have been in the forefront of shifting treatments to ambulatory care settings or outpatient clinics. Therefore, even if managed care patients tend to be younger and healthier than their counterparts with FFS insurance, they could be in worse health conditional on admission. If this were the case and complication probabilities were significantly affected by unobserved patient health, we could find managed care patients having more complications than observably similar FFS patients when given identical care. Hence selection bias is certainly a concern here.

However, several factors suggest that this is an unlikely explanation of our results, at least in the major surgery and all patients risk pools we emphasize. First, as revealed by Tables I–VI, managed care and FFS patients in our sample are actually quite similar in observable characteristics. Broadly speaking, although there are differences, those that are not small are primarily for variables that either (1) have no consistent significant effect on the probability of a complication in the regressions suggesting an adverse HMO effect or (2) have effects, but in the direction that would suggest *lower* complication rates for HMO patients.[29] Some differences in patients are suggested in the minor surgery and endoscopy risk pools, where the numbers of diagnoses, numbers of procedures, and lengths of stay suggest that, conditional on admission, HMO patients may involve more severe cases. This is what one would expect if HMOs are successful in shifting minor surgical and endoscopic procedures to an outpatient setting in less severe cases, but provide few barriers to inpatient treatment for patients in need of more serious treatments. By contrast, based on these measures, there appears to be little difference in the health of HMO and FFS patients in the major surgery and all patients risk pools. Figure 1 provides additional supporting evidence, showing the full empirical densities of the number of diagnoses in each patient pool.

These are, of course, only arguments that HMO and FFS patients do not differ dramatically in *observable* characteristics, at least in the major surgery and all patients risk pools. We do control for these observables in the regression analysis. The real issue is what, if anything, we can infer about the importance of *unobserved* heterogeneity. Table XVII provides a comparison of odds ratios both conditional and unconditional on observable patient characteristics. For the major surgery, cardiac, and all patients risk pools, for which we have found

29. One large difference is in the racial mix, with significantly larger shares of black patients in HMOs. We experimented with interactions between this dummy, the HMO dummies, and HMO shares, but found no evidence that race has a significant effect.



Numbers of diagnoses on horizontal axes. Share of patients on vertical axes.

FIGURE 1. EMPIRICAL FREQUENCIES OF DIAGNOSIS COUNTS

robust HMO effects above, accounting for observable patient heterogeneity *magnifies* the differences in HMO and FFS outcomes. In none of the risk pools is there a significant weakening of the estimated HMO effect, and all changes are small. While we cannot rule out the possibility that omission of relevant health measures biases our estimates to some degree, only if the net effect of omitted health measures on outcomes is larger than that of all the observable measures would our qualitative results be overturned.

Finally, some fairly strong evidence against patient selection as an explanation of our results has already been seen in Table XIV,

TABLE XVII.
HMO ODDS RATIOS, UNCONDITIONAL AND CONDITIONAL ON PATIENT CHARACTERISTICS

Risk Pool	Odds Ratio: Unconditional[a]	Odds Ratio: Conditional[b]
Major surgery	1.114***	1.159***
Minor surgery	1.179**	1.241**
Cardiac	0.741***	0.662***
Endoscopy	1.109	1.114
Medical	1.201*	1.158
All patients	1.080***	1.141***

* Significant at 10-percent level.
** Significant at 5-percent level.
*** Significant at 1-percent level.
[a] Based on logit specification including only an intercept and HMO dummy.
[b] Based on a logit specification identical to that in Table XI without the PPO dummy.

where coefficients on HMO and PPO dummies are insignificant when the hospital fixed effects are included. If HMO patients were systematically different from FFS patients in ways that affected complication probabilities, the HMO odds ratios should be significantly different from one, which they generally are not.[30]

The possible exception is the cardiac risk pool, which deserves additional comment in any case. In Table XIV, the HMO dummy has a coefficient significant at the 10 percent level for cardiac patients. While all patients in this risk pool undergo one of the (primarily diagnostic) procedures defining the pool, a substantial number of these patients also undergo surgical procedures in the same hospital visit. However, the share differs significantly across the insurance types: 63.6 percent of HMO cardiac patients are in a surgical diagnosis group, compared to 71.5 percent of FFS patients. Similarly, 12.4 percent of HMO patients in the cardiac risk pool are also in the major surgery risk pool, compared to 18.0 percent of FFS patients. This does not necessarily mean

30. Taking this a step further, we considered separate regressions for FFS and HMO patients. For the major surgery and all patients risk pools, a significant positive relationship betwen a hospital's HMO patient share and its complication frequency is found in both subsamples. This reinforces the results above, suggesting that any unobserved characteristics that differ systematically across HMO and FFS patients have no significant effect on the likelihood of a complication. In the other risk pools the results are less clear, although these involve very small samples of hospitals. Implicit in this and the preceding argument is an assumption that the composition of the patient pool at the hospital providing treatment is not correlated with unobserved *patient* characteristics that affect the likelihood of a complication. For example, if FFS patients receiving treatment in a hospital with a high HMO share tend to be sicker or more prone to complications in other unobservable dimensions than FFS patients treated in a hospitals with smaller HMO shares, this could lead us to incorrectly infer differences in the quality of treatment at the different hospitals.

that FFS patients are more likely to receive surgery conditional on undergoing a cardiac procedure—since our data do not enable us to follow patients across multiple admissions, it is possible that diagnostic and surgical procedures are more likely to be performed in separate hospital visits for HMO patients, or that diagnostic treatments are more likely to occur on an outpatient basis.

Indeed, treatment practices for cardiac patients have changed considerably since the design of the CSP. Hospitalization for a catheterization procedure, for example, is now rare, and HMO's have been on the cutting edge of shifting this and other procedures to an outpatient setting where possible. Hence, we may expect differences in the HMO and FFS cardiac patient pools. Table IV may offer some additional support for this possibility, showing that HMO cardiac patients have somewhat shorter lengths of stay on average and undergo slightly fewer procedures. Given the greater risk of a complication for surgical patients (particularly with the focus on postoperative complications in the screening algorithm), these differences between HMO and FFS patients in the cardiac risk pool may have significant effects on our results. This needn't rule out the possibility that our results indicate real differences in care for cardiac patients, with superior treatment under managed care.[31] However, at a minimum, one must interpret the results for the cardiac risk pool with additional caution.

7.2 Provider Selection

A second concern is that the apparent effects of managed care incentives result from matching of doctors and hospitals to insurer types rather than changes in care in response to variations in incentives. It is important to emphasize that this would not affect the conclusion that HMO patients appear to receive different treatment. However, this would have important implications for the interpretation of the results and any policy conclusions one might draw. As an extreme example, suppose that "good" doctors choose to serve FFS patients while "bad" doctors serve HMO patients. The existence of managed care incentives need not have any effect on patient treatment by a given doctor, nor on the supply of good and bad doctors, for managed care patients to receive worse treatment in this case. Yet this could lead to the kinds of results we find for the major surgery and

31. For example, one possibility is that HMOs are particularly good at improving cardiac treatment. This might occur, for example, if cardiac care is particularly well suited to standardized practices and monitoring aimed at reducing costly complications or if cardiac outcomes are more easily monitored by the market, resulting in demand-side incentives for high-quality care.

all patients risk pools. Of course, almost all California doctors have at least one managed care contract, but less extreme sorting could have similar effects.

A similar concern regarding interpretation of the results arises from the possibility that HMOs contract with hospitals that are systematically different. For example, HMOs might tend to contract with hospitals that for exogenous reasons have lower staffing ratios, worse treatment practices, or less skilled doctors, any of which might also reduce costs. We can offer little evidence regarding such possibilities. Suggestive evidence comes from the fact that the significance of the HMO-share variables remains when other observable differences in hospitals are taken into account. Nonetheless, because our analysis focuses on a large sample of patients in a relatively small set of hospitals, it is well suited for assessing intra-hospital variation in outcomes but can offer only limited evidence regarding the source of inter-hospital differences. Our hope is that future work focusing on these differences in a larger sample of hospitals incorporating a richer set of hospital characteristics will shed light on this question.

8. Conclusion

We have undertaken an analysis of the effects of managed care incentives on the quality of care provided to hospital patients, using in-hospital complications as an outcome criterion that can be applied to a wide range of patient types. This is only one measure of the quality of care, and quality is only one measure of the desirability of outcomes in this market, even from the perspective of patients alone. However, understanding the effects of managed care on quality is clearly important on its own and as a component of a complete normative analysis.

We obtain two main results. First, we find evidence of significantly worse outcomes for HMO patients. Our most robust and important results concern major surgery patients, who constitute a large share of our sample, have relatively high frequencies of the complications we study, and for whom the complications screening program has been shown to give reliable indications of in-hospital complications that may result from substandard care. The differences we identify do not appear to result from unobserved heterogeneity in patients that is associated with their insurance types. Interpreting these differences as the result of managed care incentives, they suggest that any positive effects of preventive care incentives created by managed care are more than outweighed by accompanying corner-cutting incentives. Even without this causal interpretation, our results indicate significant differences in the care being provided to different types of patients.

Second, the differences in care arise at the hospital level. HMO and FFS patients are treated similarly within a given hospital, but there are significant differences in care across hospitals that are associated with a hospital's mix of insurance types. This may reflect differences in choices regarding hospitals with which different insurers contract, differences in the types of doctors serving HMO and FFS patients, or hospital-wide responses to the incentives created by the mix of insurance types being served.

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