Steering Patients to Safer Hospitals? The Effect of a Tiered Hospital Network on Hospital Admissions

Dennis P. Scanlon, Richard C. Lindrooth, and Jon B. Christianson

Objective. To determine if a tiered hospital benefit and safety incentive shifted the distribution of admissions toward safer hospitals.

Data Sources/Study Setting. A large manufacturing company instituted the hospital safety incentive (HSI) for union employees. The HSI gave union patients a financial incentive to choose hospitals that met the Leapfrog Group's three patient safety "leaps." The analysis merges data from four sources: claims and enrollment data from the company, the American Hospital Association, the AHRQ HCUP-SID, and a state Office of the Insurance Commissioner.

Study Design. Changes in hospital admissions' patterns for union and nonunion employees using a difference-in-difference design. We estimate the probability of choosing a specific hospital from a set of available alternatives using conditional logistic regression.

Principal Findings. Patients affiliated with the engineers' union and admitted for a medical diagnosis were 2.92 times more likely to select a hospital designated as safer in the postperiod than in the preperiod, while salaried nonunion (SNU) patients (not subject to the financial incentive) were 0.64 times as likely to choose a compliant hospital in the post- versus preperiod. The difference-in-difference estimate, which is based on the predictions of the conditional logit model, is 0.20. However, the machinists' union was also exposed to the incentive and they were no more likely to choose a safer hospital than the SNU patients. The incentive did not have an effect on patients admitted for a surgical diagnosis, regardless of union status. All patients were averse to travel time, but those union patients selecting an incentive hospital were less averse to travel time.

Conclusions. Patient price incentives and quality/safety information may influence hospital selection decisions, particularly for medical admissions, though the optimal incentive level for financial return to the plan sponsor is not clear.

Key Words. Tiered hospital benefits, patient safety, Leapfrog Group, hospital choice, centers of excellence

Recent innovations in health insurance products and health financing mechanisms are attempting to address the escalation of health costs and the mounting evidence of problems with health care quality and safety in the United States. These innovations include (1) consumer-directed health insurance plans (CDHPs) (Parente, Feldman, and Christianson 2004a, b); (2) pay-for-performance (P4P) programs (Dudley 2005; Rosenthal et al. 2005; Christianson, Leatherman, and Sutherland 2007); (3) disease management (DM) programs (Beich et al. 2006; Mays, Au, and Claxton 2007); and (4) tiered pharmacy, hospital, and provider networks (Robinson 2003). Support for these innovations comes from the burgeoning industry of performance measurement in virtually all areas of health care, and the associated increase in the dissemination of health care “report cards” based on these measures (Pronovost, Berenholtz, and Goeschel 2008). Collectively, these innovations are attempting to increase value in the health care industry, where value is defined as the level of quality received for health care expenditures (Fraser and McNamara 2000; Scanlon, Chernew, and Doty 2002). Unfortunately there is little published evidence about the impact of these new approaches, and where evidence does exist, it often is anecdotal or unconvincing due to the possibility of bias resulting from nonrandom participation and program selection (Dudley 2005).

In this article, we examine the effect of a health benefits change on hospital choice at a large manufacturing company (the “firm”) headquartered in the Midwest. The firm enacted a “hospital safety incentive” (HSI) in its two major union populations, creating a financial incentive for union beneficiaries to use “safer” hospitals. The HSI is essentially a tiered hospital benefit where the “preferred” or safer hospitals require no coinsurance. Research by Steinbrook (2004), Robinson (2003), and Gabel et al. (2003) suggests that tiered hospital networks, though not commonplace, are growing in number. The emergence of tiered hospital networks has followed the widespread adoption and popularity of tiered copayments in pharmaceutical benefit design. While considerable research has addressed the impact of tiered pharmaceutical benefit design (e.g., Gibson, Ozminkowski, and Goetzel 2005;

Address correspondence to Dennis P. Scanlon, Ph.D., Associate Professor of Health Policy & Administration, The Pennsylvania State University, University Park, PA; e-mail: dpscanlon@psu.edu. Richard C. Lindrooth, Ph.D., is with the Department of Health Administration and Policy; Center for Health, Economics and Policy Studies, Medical University of South Carolina, Charleston, SC. Jon B. Christianson, Ph.D., is the James A. Hamilton Chair in Health Policy and Management, The University of Minnesota, Division of Health Policy and Management, Minneapolis, MN.

Goldman et al. 2005; Chernew et al. 2008), hospital care is conceptually different, and little is known about how tiered hospital networks function, or how they affect patients' choices (Robinson 2003).

BACKGROUND

The HSI

Published evidence on problems of quality, safety, and inefficiency in health care (e.g., the Institute of Medicine's reports, *To Err is Human* [IOM 2000] and *Crossing the Quality Chasm* [IOM 2001]), and the firm's leadership in organizations like the Leapfrog Group, helped to shape the design of the HSI.¹ In particular, evidence of poor safety and inefficient care in hospitals led the firm to work with two of its unions and its third-party administrator (TPA) to develop an incentive to encourage beneficiaries' use of safer hospitals. Under the HSI, the standard coinsurance was waived for union beneficiaries if they received care at hospitals designated to be safer according to national standards developed by the Leapfrog Group. The incentive was negotiated with the two unions (an engineers' union and a machinists' union) in 2002 to take effect July 1, 2004. Because the benefit did not apply to salaried nonunion (SNU) beneficiaries, we were able to use these individuals as a control group in our analysis. The company provided education and information about the HSI to the union population during the July 1, 2004–June 30, 2005 health benefits open enrollment period. Table 1 compares the inpatient benefits for SNU beneficiaries and union beneficiaries before and after the HSI went into effect. The average out-of-pocket cost per hospitalization in the postperiod for union beneficiaries who chose hospitals that did not meet the HSI safety standards was \$403.43 (SD = \$222.91, min. = \$75.76, max. = \$1,341.42), based on analysis of claims data.

CONCEPTUAL FRAMEWORK

Our research question is whether the HSI made a difference in the selection of hospitals. We assume that patients maximize expected utility, and that expected utility for hospital care is a function of multiple attributes including expected out-of-pocket costs and hospitals' quality, safety, amenities, and the distance/convenience of hospitals from patients' residences. Physicians' referrals/recommendations influence the choice of hospital through its influence on the weight patients assign to these different attributes. Recent

Table 1: Medical Plan Benefits Summary before and after Hospital Safety Incentive

	<i>Before (7/1/2004) Hospital Safety Incentive</i>		<i>After (7/1/2004) Hospital Safety Incentive</i>	
	<i>Salaried Nonunion (SNU) Employees</i>	<i>Union Hourly Employees</i>	<i>Salaried Nonunion (SNU) Employees</i>	<i>Union Hourly Employees</i>
Deductible (individual/ family)	\$200/ \$600	\$200/ \$600	\$200/ \$600	\$200/ \$600
Hospital coinsurance	0%	0%	0%	5% with option for 0% if “safe” hospital is used
Annual out-of-pocket maximum (individual/family)	\$5,000/ \$15,000	\$2,000/ \$4,000	\$5,000/ \$15,000	\$2,000/ \$4,000
Average out-of-pocket price (SD)	\$0	\$0	\$0	\$403.43 (\$222.91)

literature on the impact of health plan report cards influenced our conceptual framework and analytic approach; several studies utilize a Bayesian estimation framework to examine the degree to which individuals update their priors about quality attributes, and thus expected utility, based on the availability of “report card” information (Dranove and Satterthwaite 1992; Jin and Sorenson 2006; Chernew, Gowrisankaran, and Scanlon 2008).

We assume the consumerism campaign around the HSI acts similarly to the health plan reports cards in the Chernew et al. (2008) and Jin and Sorenson (2006) articles by providing union beneficiaries with information to update prior expectations about uncertain attributes, possibly leading to greater certainty about these attributes and/or greater or lesser weight applied to them. Interestingly, the introduction of the HSI increased union employees’ uncertainty about out-of-pocket hospital costs because it exposed them to coinsurance for hospital care for the first time in the post-period. Also, it was difficult for employees to estimate hospital prices for each hospital they might have chosen, and thus the total out-of-pocket dollar amount for which they would be liable.

STUDY DATA AND ANALYTIC SAMPLE

Data for this study came from four sources: (1) claims and enrollment data from the firm's TPA, (2) the 2004 American Hospital Association (AHA) Annual Survey data, (3) discharge data from the Hospital Cost and Utilization Project State Inpatient Database (HCUP-SID), and (4) hospital admissions and discount data from a state Office of the Insurance Commissioner.

Claims and Enrollment Data from the Firm

We received enrollment and hospital claims data from the firm's TPA for union and nonunion employees for the period July 2003 through April 2005. We limited our focus to employees and dependents residing in a single market (i.e., Metropolitan Statistical Area [MSA]) that was the major employment hub for the firm. Information from the claims and enrollment data includes the dollar amount of patient responsibility for hospital care; gender; age; whether the individual was an employee, early retiree, or spouse of an employee/early retiree; and union status. We also received the Diagnostic Related Group (DRG) and primary and secondary diagnosis codes associated with hospitalizations and the ICD-9-CM procedure codes. A third party deidentified the data per HIPAA requirements. To compute distances from patient residence to hospitals, we used residential zip code information (part of the HIPAA limited data set).

The TPA also provided information about hospitals' eligibility for the HSI. For 96 percent of patient admissions, hospitals had to meet both the Leapfrog Group's Computerized Physician Order Entry (CPOE) and Intensivist Patient Staffing (IPS) standards to be eligible for the patient to receive the HSI. If the hospital admission pertained to one of the six Leapfrog Group's *Evidence-Based Hospital Referrals* (EHR) standards, then the hospital had to meet the Leapfrog volume-related safety standard for that procedure rather than the CPOE and IPS standards.² Thus, eligibility for the HSI partly depended on the reason for the patient's admission and on the hospital's compliance with the relevant safety leaps. Hospital compliance was determined based on hospitals' responses to the Leapfrog Group's patient safety survey and could be updated each month if hospitals changed their compliance status. This happened only once in our study period; one hospital was noncompliant for the CPOE/IPS leap for the first 2 months of the postperiod (July and August of 2004), and then achieved compliance with these leaps as of September 2004. For each hospitalized patient in our data set, we used the DRG and ICD-9-CM procedure codes to determine if the admission was for an EHR procedure, and if

so determined the eligibility of each hospital in the patient's choice set for the HSI. If the admission was not for one of the six EHR procedures, we used the Leapfrog CPOE and IPS safety information to determine hospitals' eligibility for the HSI.

Hospital-Level Data

We used data from the 2004 AHA Annual Survey, a national survey of all specialty and general acute care hospitals in the United States, to specify characteristics of hospitals in our sample. The relevant characteristics for our analysis reflect patients' preferences for particular types of hospitals. These include the existence of specialty units (i.e., cardiac, obstetrics, Level 3 obstetrics, oncology, orthopedics [including sports medicine], trauma, and bariatric surgery); ownership status (public, for-profit, or nonprofit); teaching status; and number of hospital beds. We used the HCUP-SID data to calculate the average gross charge by DRG, regardless of the type of admission (e.g., routine or emergency) or discharge disposition (e.g., normal, transfer, death). We then deflated gross charges using the hospital-level average percent discount granted to private payers, which was available from the state Office of the Insurance Commissioner. We applied this discount to gross charges to calculate average net charges per discharge per DRG. We used this information to estimate the dollar value of 5 percent coinsurance that union participants in the firm's health benefits program would face if they selected a non-HSI hospital in the postperiod.

Analytic Sample

As part of our larger study, we administered a survey to understand awareness of the HSI; print- and Internet-based open enrollment materials; and the importance of various factors when selecting hospitals, physicians, and health plans. A contracted survey research center drew a random sample of 2,489 hospitalized beneficiaries admitted for 326 DRGs, including 1,420 union employees and 1,069 nonunion employees, with 51 percent of the hospitalizations occurring in the postperiod. We drew this sample from a population of 2,643 adult beneficiaries admitted to hospitals in a specific geographic area (i.e., MSA or market area) during the pre- and postperiods of our study. To allow for learning to occur after the incentive was put into place, and because one hospital changed its CPOE/IPS leap compliance status as of September 2004, we dropped admissions that began in July and August of the postperiod ($n = 313$). Next, we dropped individuals from our data set who were admitted

to the hospital via the ED ($n = 354$) on the assumption that the HSI would not be an important factor in their decision-making regarding choice of hospital. Likewise, we dropped patients who were admitted for nongeneral hospital services (e.g., substance abuse, trauma, rehabilitation, etc., $n = 87$). After dropping 13 patients who had a DRG for which we had incomplete hospital charge or discount data, we were left with an analytic sample of 1,722 patients with an admission for a medical or surgical diagnosis.

The hospital admission decision is typically different for medical and surgical procedures, as is the type of admitting physician. More hospitals are capable of treating medical conditions, as opposed to providing surgical procedures, which require specialized skills and equipment. As a result, we estimated separate models for medical and surgical diagnoses and the Chow test results ($p < .001$) supported the stratified sample.

Sample and Hospital Characteristics

Table 2 provides descriptive statistics for the two analytic samples: those patients admitted for a medical diagnosis ($n = 517$) and those admitted for a surgical diagnosis ($n = 1,205$), across the pre- and postperiods of our analysis. Note that the union employees represent two different populations: (1) engineers and their adult dependents and (2) machinists and their adult dependents. Because patients affiliated with these two unions differ on characteristics such as education ($p < .0001$) and income ($p < .0001$), we also control for type of union affiliation in the multivariate analyses by including a dummy variable for the engineers' union.

On average, about 27 hospitals were available to treat patients admitted for a medical diagnosis, while 24 were available to those admitted for a surgical procedure. Because not all hospitals are capable of treating every diagnosis, the number of alternatives varied by specific diagnosis. Table 2 also lists the common diagnoses for medical and surgical patients, and our multivariate models control for these diagnostic categories, because there are sometimes large differences between the union and nonunion groups in the frequency of these diagnoses.

Table 2 illustrates that the CPOE/IPS standards were used to determine HSI eligibility for all medical admissions and for 91–95 percent of the surgical admissions. When the CPOE/IPS standards did not apply to surgical patients, the other HSI standards applied based on the patient's particular diagnosis; for example, the PCI standard applied in 4–7 percent of surgical admissions.

Table 2: Descriptive Statistics for Hospitalized Patients

Variable	Medical Admission (n = 517)				Surgical Admission (n = 1,205)			
	Union (n = 308)		Nonunion (n = 209)		Union (n = 650)		Nonunion (n = 555)	
	Pre (n = 160)	Post (n = 148)	Pre (n = 128)	Post (n = 81)	Pre (n = 371)	Post (n = 279)	Pre (n = 322)	Post (n = 233)
Patient characteristics								
Engineering union	0.300 (0.460)	0.311 (0.464)	0.000 (0.000)	0.000 (0.000)	0.329 (0.470)	0.434 (0.496)	0.000 (0.000)	0.000 (0.000)
Age	52.463 (9.093)	50.149 (10.445)	48.664 (11.983)	50.210 (10.793)	51.792 (8.967)	52.505 (8.842)	51.053 (9.499)	51.704 (9.625)
Gender (0 = female, 1 = male)	0.425 (0.495)	0.391 (0.489)	0.335 (0.474)	0.419 (0.496)	0.398 (0.490)	0.422 (0.494)	0.338 (0.473)	0.339 (0.474)
Years on firm health benefits	17.273 (10.615)	21.667 (22.120)	13.400 (10.966)	19.091 (12.012)	21.769 (13.457)	23.196 (12.003)	20.716 (11.351)	24.430 (14.462)
Choice variables								
Number of hospitals in choice set	26.781 (2.913)	26.601 (2.864)	26.859 (1.747)	26.877 (2.164)	24.270 (4.301)	24.108 (4.082)	24.786 (4.241)	24.339 (4.331)
Average price for choice set hospitals	0.000 (0.000)	236.494 (87.684)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	477.205 (190.177)	0.000 (0.000)	0.000 (0.000)
Drive time (in minutes) to selected hospital	24.781 (22.847)	23.291 (22.159)	24.445 (23.710)	21.617 (17.582)	27.377 (23.971)	28.168 (24.676)	27.652 (25.762)	24.944 (20.690)
Patient diagnosis								
Cardiac diagnosis	0.238 (0.427)	0.196 (0.398)	0.195 (0.398)	0.136 (0.345)	0.089 (0.285)	0.118 (0.324)	0.093 (0.291)	0.112 (0.316)
Oncology diagnosis	0.038 (0.191)	0.034 (0.181)	0.016 (0.125)	0.049 (0.218)	0.011 (0.103)	0.036 (0.186)	0.022 (0.146)	0.021 (0.145)
Normal pregnancy DRG	0.044 (0.205)	0.122 (0.328)	0.141 (0.349)	0.123 (0.331)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Complicated pregnancy DRG	0.063	0.047	0.078	0.049	0.054	0.025	0.093	0.090

Orthopedic DRG	(0.243)	(0.213)	(0.269)	(0.218)	(0.226)	(0.157)	(0.291)	(0.287)
	0.050	0.014	0.031	0.000	0.296	0.348	0.295	0.288
	(0.219)	(0.116)	(0.175)	(0.000)	(0.457)	(0.477)	(0.457)	(0.454)
Bariatric DRG	0.000	0.000	0.000	0.000	0.151	0.086	0.084	0.077
	(0.000)	(0.000)	(0.000)	(0.000)	(0.358)	(0.281)	(0.278)	(0.268)
Leapfrog safety standard								
Abdominal aortic aneurism admission	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.056)	(0.000)
CABG admission	0.000	0.000	0.000	0.000	0.008	0.011	0.006	0.004
	(0.000)	(0.000)	(0.000)	(0.000)	(0.090)	(0.103)	(0.079)	(0.066)
CPOE/IPS admission	1.000	1.000	1.000	1.000	0.946	0.935	0.913	0.923
	(0.000)	(0.000)	(0.000)	(0.000)	(0.226)	(0.246)	(0.282)	(0.268)
Esophagectomy admission	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Neonatal intensive care admission	0.000	0.000	0.000	0.000	0.003	0.004	0.012	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.052)	(0.060)	(0.111)	(0.000)
Pancreatic resection admission	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.066)
PCI admission	0.000	0.000	0.000	0.000	0.043	0.050	0.065	0.069
	(0.000)	(0.000)	(0.000)	(0.000)	(0.203)	(0.219)	(0.247)	(0.253)

Note: Mean and SD in parentheses.

DRG, diagnostic related group; CABG, coronary artery bypass graft.

Table 3 provides summary statistics for the hospitals in our sample. We included all hospitals that treated patients in the sample rather than restricting the choice set using an arbitrary market definition. We separately list information about the number of hospitals eligible for each of the HSI categories based on the Leapfrog Group's patient safety standards. Five hospitals qualified for the HSI based on the CPOE/IPS standards, while the number of hospitals meeting the HSI for other conditions varied from zero (abdominal aortic aneurism) to two (CABG surgery, neonatal intensive care, pancreatic resection, and esophagectomy).

MODELING APPROACH

We selected a modeling strategy that allowed us to answer the following question: Did the HSI make a difference in the specific hospital chosen from the set of available alternatives and thus shift the distribution of hospitals used in the union population?

Conditional Logistic Regression Choice Model

The standard approach employed in the economics literature for studying choice among alternatives is to model an individual's (e.g., individual i) utility for each possible alternative (e.g., hospital j) in a given time period (e.g., time period t), as a function of observed characteristics of the choices, the chooser, or both (Garnick et al. 1989; Wan-Tzu, Porell, and Adams 2004). Utility is assumed to be stochastic and most models assume an independent and identically distributed error term, such as from the Type I extreme value distribution (Mc Fadden 1973). Under this framework, the assumption is that individuals are utility maximizers, and therefore individual i chooses alternative j if $U_{ij} > U_{ik}$ for all $i \neq k$. We specify the utility that patient i derives from being admitted for care at hospital j in time t as follows:

$$U_{ijt}(I_{ij}, T, U_i, H_j, H_j^S, P_i^D, D_{ij}) = \beta_1 I_{ij} + \beta_2 I_{ij} T + \beta_3 I_{ij} U_i + \beta_4 I_{ij} U_i T + \beta_5 H_j + \beta_6 H_j^S P_i^D + \beta_7 D_{ij} + \beta_8 D_{ij} H_j + \varepsilon_{ijt} \quad (1)$$

where I_{ij} indicates whether hospital j was eligible for the safety incentive based on patient i 's procedure, T is a time dummy that takes on a value of 1 in the postperiod and zero in the preperiod, U_i is patient i 's union status (and also whether the patient was a member of the engineers' union). H_j is a column vector of hospital j 's characteristics; H_j^S is a column vector of hospital j 's

Table 3: Descriptive Statistics for Choice Set Hospitals ($n = 28$) Means

<i>Variable</i>	<i>CPOE/IPS</i>		<i>PCI</i>		<i>CABG</i>	
	<i>Compliant (n = 5)</i>	<i>Noncompliant (n = 23)</i>	<i>Compliant (n = 1)</i>	<i>Noncompliant (n = 27)</i>	<i>Compliant (n = 2)</i>	<i>Noncompliant (n = 26)</i>
Trauma center at hospital	0.400	0.652	0.000	0.630	0.500	0.615
Transplant at hospital	0.400	0.130	1.000	0.148	0.500	0.154
Public hospital	0.600	0.261	0.000	0.333	0.000	0.346
Bed size (> 300 beds)	0.600	0.217	1.000	0.259	1.000	0.231
For-profit hospital	0.000	0.087	0.000	0.074	0.000	0.077
Teaching hospital	0.400	0.000	0.000	0.074	0.000	0.077
Cardiac services	0.600	0.696	1.000	0.667	1.000	0.654
Oncology services	0.800	0.870	1.000	0.852	1.000	0.846
Obstetrics services	0.600	0.870	0.000	0.852	0.500	0.846

<i>Variable</i>	<i>Esophagectomy/Pancreatic Resection</i>		<i>Neonatal Intensive Care</i>		<i>Abdominal Aortic Aneurism</i>	
	<i>Compliant (n = 2)</i>	<i>Noncompliant (n = 26)</i>	<i>Compliant (n = 2)</i>	<i>Noncompliant (n = 26)</i>	<i>Compliant (n = 0)</i>	<i>Noncompliant (n = 28)</i>
Trauma center at hospital	0.000	0.653	0.500	0.615	NA	0.607
Transplant at hospital	1.000	0.115	0.500	0.153	NA	0.178
Public hospital	0.500	0.307	0.500	0.307	NA	0.321
Bed size (> 300 beds)	1.000	0.230	1.000	0.230	NA	0.285
For-profit hospital	0.000	0.076	0.000	0.076	NA	0.071
Teaching hospital	0.500	0.038	0.500	0.038	NA	0.071
Cardiac services	1.000	0.653	1.000	0.653	NA	0.678
Oncology services	1.000	0.846	1.000	0.846	NA	0.857
Obstetrics services	0.500	0.846	1.000	0.807	NA	0.821

specialty service offerings; P_i^D is a column vector of patient i 's diagnosis type; D_{ij} is the driving time from the patient's residential zip code to each of the j hospitals in the choice set. We used *Mapquest.com* software to compute travel times between patients' zip codes and the street address of each hospital in the choice set.

The service matches, denoted $P_i^D \times H_j^S$, match the patient's diagnosis to hospitals that offer the relevant specialized services. Recall that H_j^S is a set of S dummy variables that equals one if the hospital offers: oncology, Level 1 obstetrics, Level 2–3 obstetrics, cardiac care, bariatric, or orthopedics. P_i^D indicates whether the patients had a diagnosis specific to the set of specialized hospital services. Thus, the value of $P_i^D \times H_j^S$ for a patient with an oncology diagnosis would equal one if the hospital in the choice set offers oncology services and zero otherwise.

The final term in Equation (1), ε_{ij} , represents the personal and idiosyncratic component of patient i 's evaluation of hospital j . Note that uninteracted patient characteristics are subsumed in the patient fixed effect in conditional logit models. We interacted several of the terms in order to gauge whether there was a differential impact on the probability of hospital choice. For example, we estimated whether all patients were more likely to choose an HSI hospital in the postperiod relative to the preperiod and whether this was more likely for union employees relative to nonunion employees, and for the different types of union employees. We also report specifications using hospital fixed effects. In this specification, we exclude all hospital variables that do not vary across patients or over time. This specification is particularly important in the models that include price because it is possible that hospitals with a high average price are of higher quality, safer, or offer other amenities that are attractive to the patient. The hospital fixed effect will control for such time invariant unobserved characteristics. We also estimated a variant of Equation (1) where we replace the $I_{ij} \times U_i \times T$ interactions with $I_{ij} \times U_i \times T \times OOP_j$ where OOP_j is the out-of-pocket price faced by union employees if admitted to noncompliant hospitals. The last row of Table 1 shows that OOP_j is equal to zero for all nonunion admissions in either period; all union admissions in the preperiod; and all union admissions to compliant hospitals in the postperiod.³

RESULTS

We present the results from the conditional logistic regression in Table 4. The top set of results is based on the specification that uses dummy variables to

Table 4: Conditional Logistic Regression of the Probability of Choosing a Hospital from Set of Available Hospitals

<i>Variable Specification</i>	<i>Medical Admissions (n = 517)</i>		<i>Surgical Admissions (n = 1,205)</i>	
	<i>Primary</i>	<i>Hospital Fixed Effects</i>	<i>Primary</i>	<i>Hospital Fixed Effects</i>
Dummy variable specification				
Drive time	-0.12*** [0.01]	-0.12*** [0.01]	-0.09*** [0.01]	-0.09*** [0.01]
HSI eligibility	-1.95*** [0.51]	-0.21 [1.32]	-1.62*** [0.34]	-1.48*** [0.51]
HSI eligibility × post	-0.45 [0.38]	-0.44 [0.40]	-0.24 [0.29]	-0.15 [0.30]
HSI eligibility × union	-0.21 [0.38]	-0.33 [0.40]	0.12 [0.24]	0.06 [0.26]
HSI eligibility × union × engineers' union	-0.42 [0.49]	-0.31 [0.49]	0.15 [0.28]	0.26 [0.30]
HSI eligibility × union × post	-0.24 [0.66]	-0.30 [0.71]	0.16 [0.39]	0.10 [0.41]
HSI eligibility × union × engineers' union × post	1.76*** [0.65]	1.79*** [0.70]	-0.05 [0.46]	-0.08 [0.49]
HSI eligibility × drive time	0.08*** [0.01]	0.06*** [0.01]	0.05*** [0.01]	0.04*** [0.01]
Price specification				
Drive time	-0.12*** [0.01]	-0.12*** [0.01]	-0.09*** [0.01]	-0.09*** [0.01]
Out-of-pocket price (/1,000) × union	3.48*** [1.48]	1.63 [1.78]	0.40 [0.52]	-0.05 [0.51]
Out-of-pocket price (/1,000) × union × engineers' union	-6.78*** [2.39]	-7.13*** [2.47]	0.44 [0.78]	0.66 [0.79]
HSI eligibility	-2.11*** [0.49]	-0.25 [1.32]	-1.71*** [0.34]	-1.52*** [0.51]
HSI eligibility × post	-0.05 [0.29]	-0.35 [0.32]	0.00 [0.23]	-0.05 [0.24]
HSI eligibility × union	0.01 [0.31]	-0.29 [0.34]	0.26 [0.23]	0.10 [0.25]
HSI eligibility × union × engineers' union	-0.24 [0.37]	-0.22 [0.42]	0.23 [0.25]	0.37 [0.27]
HSI eligibility × drive time	0.08*** [0.01]	0.06*** [0.01]	0.05*** [0.01]	0.04*** [0.01]

* $p = .1$; ** $p = .05$; *** $p = .01$.

Robust SE with zip code clustering are in brackets. Primary specification includes hospital characteristics; hospital characteristics interacted with drive time; and service match interactions. Fixed effect specification includes service match interactions. Full results are available upon request.

Coefficients and SE (in brackets).

identify the effect. The bottom set of results is based on the specification that included the estimated hospital specific DRG out-of-pocket price. We include both a primary and a fixed effect specification for the medical and surgical samples. The primary specification controls for hospital type (public, teaching, for-profit, size, trauma); hospital type interacted with drive time; and the hospital–patient service matches. The fixed effect specification includes the patient–hospital service match variables but not the hospital type variables.

The conditional logit results indicate that the HSI had an effect for patients with a medical diagnosis who are affiliated with the engineers' union. The HSI eligibility $\times$ union $\times$ engineers' union $\times$ postinteraction illustrates this effect. Unconditional probabilities computed from the coefficients suggest that this group used an HSI eligible hospital in the postperiod 2.92 times more often than in the preperiod, whereas the SNU control group was only 0.64 times as likely. The increase in the likelihood that members of the engineers' union pick an HSI eligible hospital in the postperiod relative to the preperiod was about 4.6 times greater than the equivalent relative likelihood for the nonunion controls. In contrast, the hospital choices of patients affiliated with the machinists' union (i.e., the use of HSI eligible hospitals in the postperiod compared with the preperiod) were not significantly different than the SNU control group. This result is robust to the fixed effects specification. Patients in both unions were unresponsive to the incentive if they had a surgical diagnosis. One should use caution when interpreting the coefficient on the HSI eligibility variable because it must be interpreted in the context of its interactions.

Perhaps a more intuitive way to consider the impact of the HSI is to examine the pre–post difference (i.e., “the difference-in-difference”) in the predicted probabilities that the three groups of patients (engineers' union, machinists' union, and SNU) would select one of the hospitals eligible for the HSI. Unlike the odds presented above, these predicted probabilities are computed from the coefficient estimates and are based on the average patient characteristics across the sample in the pre- and postperiods. The predicted probabilities indicate a large and significant change in the probability that patients affiliated with the engineers' union would select an HSI hospital, with the probability moving from 0.12 in the preperiod to 0.26 in the postperiod, a difference of 0.14. The comparable probabilities for the machinists' and SNU beneficiaries were 0.16–0.10 and 0.19–0.14, respectively. This represents a “difference-in-difference” of about 0.20 for the engineers' union patients relative to the SNU patients, a meaningful effect size due to the HSI. In contrast, the difference between the machinists' and nonunion patients was negligible.

Furthermore there was not a significant difference among any of the groups for surgical diagnoses.

Results from the price regressions in Table 4 tell a similar story as the dummy variable specification. In the medical sample, members of the engineer's union were significantly less likely to be admitted to a hospital that had a positive price. This result was consistent across the primary and fixed effects specifications, though the union coefficient loses significance in the fixed effects specification. This is possibly because the out-of-pocket price is endogenous if attractive hospitals can negotiate higher prices. Hospital attributes like reputation and amenities are likely to be fixed in the short-run and thus controlled for in the hospital fixed effects, leading to a smaller and insignificant coefficient. Note that price varies within hospital across DRGs, and identification requires that reputation and amenities do not vary across DRGs, which is unlikely in practice.

Robustness

We examined the robustness of our results to a number of variations, including the analysis sample, the model specification used in the conditional logit, and an alternative estimation approach to the conditional logit model. For the sample, we examined the sensitivity of the results to our decision to drop patients admitted (a) via the Emergency Department, (b) for nongeneral hospital services, and (c) in the first 2 months (July/August) of the postperiod. The results were highly robust to these sample exclusions.

Within each sample, we estimated various specifications of the model, with each differing from the specification reported in Table 4 by dropping or adding sets of covariates. The most parsimonious specification included only the HSI eligibility variable and union variables and their interactions. The most complete specification included interactions between patient-level variables (e.g., age, gender) and drive time. Finally, we examined whether the conditional logit results were sensitive to the choice set definition. The results using a more restrictive definition (e.g., only hospitals within 100 minutes of patients' residences) are comparable. However, if we further narrow the choice set, the number of admissions in the sample becomes smaller and an overly narrow definition, say only hospitals within 60 minutes, leads to insignificant but qualitatively similar results.

In summary, our main finding, that the HSI influenced hospital selection for medical patients affiliated with the engineering union (but not the machinists' union) relative to SNU patients, was generally robust to differences in

sample and model specification. The lack of a finding for surgical patients was highly robust to changes in sample and specification.

We also examined an alternative estimation approach to the conditional logit, estimating instead a simple logistic regression where the dependent variable in both the pre- and postperiods took on a value of one if the hospitalized patient chose a hospital that qualified for the HSI in the postperiod, and zero if the patient chose one of the hospitals that did not qualify for the HSI in the postperiod. In essence the simple logistic regression model is a different specification of the conditional logit model that uses less information, and also requires more assumptions in the specification of the model covariates. For example, to include distance as a covariate, we had to compute a differential distance variable, defined as the difference in distance from patients' residences to the closest HSI and non-HSI hospitals. The results from this simple logit were not robust in terms of statistical significance, though the direction of the coefficients was similar. As mentioned above, we believe the conditional logit model is superior because it uses the full set of information including the relative differences in attributes between every hospital in the choice set.

Conclusions and Limitations

The results from our analyses suggest the HSI influenced the particular hospital chosen for those patients affiliated with the engineers' union and admitted for a medical diagnosis, with the "difference-in-difference" estimated to be 0.20 for the engineers' union relative to the SNU group. Unlike those patients affiliated with the engineers' union, those affiliated with the machinists' union were no more likely than SNU beneficiaries to select an HSI compliant hospital in the postperiod. Members of the engineers' union are more highly educated than members of the machinists' union and may have been better able to learn about and take advantage of the incentive during the relatively short follow-up period.

There are a number of limitations, however. First, patients affiliated with the machinists' union may have learned about the HSI eventually (e.g., the firm could have provided more education and outreach to the machinist population) and reacted similarly to patients affiliated with the engineers' union; the relatively short follow-up period would not have picked up such a lag. Second, although we had a sizeable number of hospitalized patients, we may have had limited power to detect an effect in the surgical sample. We did, however, estimate a large and statistically significant effect for the medical diagnosis sample, which includes a smaller number of patients.

Third, only about 18 percent of hospitals in the market were eligible for the HSI for most admissions. Given the likely importance of the admitting physician in the hospital selection decision, and the fact that most physicians have limited hospital staff privileges, it seems likely that if more hospitals had met the safety criteria, the incentive may have had a larger effect. On the contrary, if most hospitals qualified, the choice set would differ little from the choices available before the HSI, and the HSI would not likely affect the distribution of patients across hospitals.

Fourth, while our results suggest that the HSI influenced some patients' decisions, the design of HSI does not allow us to comment on the size of the incentive needed to change behavior, because there was no variation in the coinsurance rate in the treatment group.

Fifth, we did not estimate the financial return of the HSI to the plan sponsor (i.e., the firm), though when deciding to implement the tiered hospital network, the firm believed, as the Leapfrog Group does, that safer hospitals are ultimately less costly due to shorter lengths of stay and fewer complications. If true, this would suggest that coinsurance reductions could yield value for the plan sponsor if patients choose safer hospitals as a result. Interestingly, after we collected data, the engineers' union contract dropped the HSI (an outcome of 2006 labor negotiations between the firm and the engineers' union), eliminating the tiered hospital benefit design from the very group in which we estimated its significant impact. This loss underscores the challenge in assessing the effectiveness of benefit innovations that typically require a learning period on the part of employees, when these innovations are "on the table" during regular wage and benefit negotiations.

Sixth, we specifically focused on a tiered hospital network designed to provide consumers with an incentive to use safer hospitals. While there are alternative ways to improve hospital safety, including direct supply side incentives (e.g., P4P), accreditation, or regulation, our study did not consider the relative cost-benefit of these diverse approaches.

In summary, our results suggest that the HSI resulted in a shift among hospitals of patients with medical admissions in a specific union group and employer. Our findings could reflect, to a considerable degree, the unique characteristics of this employer and the community in which the patients were located, and the particular benefit design offered by the employer. It seems likely that innovations in benefit designs, payment strategies, and cost-sharing arrangements will continue to grow in number, as employers and their health plan agents seek greater value for their health care dollars. Many of these innovations will be nonstandardized and locally developed, providing additional opportunities for research. By building on and extending the analysis

reported in this paper, researchers can create a stronger foundation for future decisions of public and private payers regarding the value of these approaches. In particular, it will be important for researchers to address the net financial benefits of different health benefit innovations.

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NOTES

1. The Leapfrog Group is a national coalition of private and public purchasers focused on hospital patient safety and health care value (see <http://www.leapfroggroup.org> for more information).
2. More information about the six EHR procedures can be found at http://www.leapfroggroup.org/media/file/Leapfrog-Evidence-based_Hospital. Information about CPOE can be found at http://www.leapfroggroup.org/for_hospitals/leapfrog_safety_practices/cope and http://www.leapfroggroup.org/media/file/Leapfrog-Evidence-based_Hospital. Information about CPOE can be found at http://www.leapfroggroup.org/for_hospitals/leapfrog_safety_practices/cope. Information about IPS can be found at http://www.leapfroggroup.org/for_hospitals/leapfrog_hospital_survey_copy/leapfrog_safety_practices/icu_physician_staffing.
3. We estimated an alternative specification with both $I_{ij} \times U_i \times T$ and $I_{ij} \times U_i \times T \times \text{OPP}_j$ but the two terms are highly collinear and, especially given our small sample, it was not possible to separately identify a price effect and a program effect.

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Appendix SA1. Author Matrix.

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