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Physicians Treating Physicians: Information and Incentives in Childbirth†

By Erin M. Johnson and M. Marit Rehavi*

This paper provides new evidence on the interaction between patient information and physician financial incentives. Using rich microdata on childbirth, we compare the treatment of physicians when they are patients with that of comparable nonphysicians. We also exploit the presence of HMO-owned hospitals to determine how the treatment gap varies with providers' financial incentives. Consistent with induced demand, physicians are approximately 10 percent less likely to receive a C-section, with only a quarter of this effect attributable to differential sorting. While financial incentives affect the treatment of nonphysicians, physician-patients are largely unaffected. Physicians also have better health outcomes. (*JEL* D83, I11, J16, J44)

As much as $210 billion, or nearly 10 cents of every health dollar, may be spent on "medically unnecessary" treatment (IOM 2012, Table S-1). Childbirth is the most common reason for hospitalization in the United States and cesarean sections (C-sections) are the most common inpatient surgery. Four million babies are born each year, resulting in $50 billion in health care costs (Truven Health Analytics 2013). The nature of decision making in childbirth makes it particularly well-suited to testing for distortions to care. In addition, the large variation in C-section rates across time and place has led to concerns about their overuse. In 2013, C-section rates ranged from a low of 22.4 percent in Utah to a high of 38.9 percent in Louisiana, and much of this variation is unexplained.

Given concerns about overuse, a natural question is whether physician-mothers choose the same treatment for themselves and their patients. They do not. We find that physicians are less likely to get C-sections and have better health outcomes than

* Johnson: Massachusetts Institute of Technology Sloan School of Management, 77 Massachusetts Ave. E62-523, Cambridge, MA 02139 and National Bureau of Economic Research (NBER) (e-mail: erinmj@mit.edu); Rehavi: Vancouver School of Economics, University of British Columbia, 6000 Iona Drive, Vancouver, BC V6T 1Z1 and Canadian Institute for Advanced Research (e-mail: marit.rehavi@ubc.ca). We thank the anonymous referees for comments that greatly improved the paper. This paper has benefited from comments by: Doug Almond, Kate Baicker, Charlie Brown, David Card, Daniela Carusi, Joe Doyle, Randy Ellis, Amy Finkelstein, Josh Gottlieb, David Green, Jonathan Ketcham, Patrick Kline, Tom McGuire, Edward Norton, Jeff Smith, Heidi Williams, and participants at ASHEcon, BU/Harvard/MIT Health Seminar, University of Chicago Harris School of Public Policy Studies, University of Michigan, NBER Summer Institute, Ohio State University, RAND, Simon Fraiser University, University of British Columbia, and Yale University. We are grateful to Beate Danielsen for merging the confidential data and to Louise Hand and Betty Henderson-Sparks for their assistance in accessing the data. Rehavi gratefully acknowledges funding from the Hampton Fund and thanks the Robert Wood Johnson Foundation Scholars Program at the University of Michigan for financial support in the initial stages of this project.

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comparable nonphysicians. In addition, nonphysician-patients' treatment intensity covaries with their providers' financial incentives, while physician-patients appear unaffected. Our preferred explanation for these findings is that physician-patients are more informed about the appropriate level of care. Even among physicians, those in specialties with the more relevant medical knowledge receive the less intensive treatment.

This paper provides new evidence on the physician induced demand (PID) hypothesis and the role of patient information in treatment. PID posits that physicians can shift patient demand and move treatment quantity in the direction of their own interests because patients do not have the necessary medical knowledge to make independent decisions. Many studies document physicians' responses to financial incentives, but only a few have directly tested for PID (see McGuire 2000 and McClellan 2011 for reviews) and even fewer have measured health impacts.[1] We do both. We provide direct evidence on PID by measuring the difference in informed and uninformed patients' treatment across incentive environments and explore its consequences for patient health.

We present a simple model to illustrate the interaction between financial incentives and patient information in childbirth. Physicians can increase their income by recommending intensive treatment, but face a cost to patient satisfaction if they make an inappropriate recommendation to an informed patient. The model predicts OBs will recommend too many (few) C-sections when they are positively (negatively) reimbursed on the margin relative to vaginal deliveries. The model also predicts that the amount of overuse (or underuse) is decreasing in patient information.

To test these predictions, we use new micro-data on hospital births in California paired with confidential data from Texas. Together these states account for almost 25 percent of US births. First, we compare the C-section rate of physician-mothers with that of comparable nonphysicians. C-sections are typically more highly reimbursed than vaginal deliveries under fee-for-service (FFS), and physician-patients are more informed regarding their need for the procedure. Thus, in FFS the model predicts lower C-section rates for physician-mothers. We then examine how demand inducement differs across financial incentive environments. Specifically, we compare the gap in C-section rates between physician- and nonphysician-mothers inside and outside of a large system of HMO-owned hospitals in California. In contrast with FFS, in HMO-owned hospitals C-sections are less financially favorable to physicians and to the hospital, because the hospital internalizes the costs of care and incentivizes the physicians it employs accordingly. This directly tests whether the intersection of patient information and physician financial incentives is responsible for the treatment differences. Finally, we compare the health outcomes of physician-mothers and their infants with those of nonphysician-patients to ascertain whether they are consistent with receiving more optimal treatment.

We find that physician-mothers are 7–9 percent less likely to have a C-section than other highly educated patients. The C-section rate even varies among physician-patients with the relevance of their medical knowledge. Physician-patients

[1] Notable exceptions are Jacobson et al. (2013) and Clemens and Gottlieb (2014).

in specialties with the most relevant expertise have lower C-section rates. Physicians' lower C-section rates stem not from different preferences for attempting labor, but instead come from C-sections performed after an attempt at labor (herein "unscheduled C-sections"). Differential sorting of patients to hospitals or physicians can explain only 20 percent of the treatment gap. Finally, measures of treatment intensity suggest physician-patients are not achieving fewer C-sections by utilizing other forms of intensive treatment.

We also find a stark difference in the impact of the incentive environment. Nonphysicians have a higher C-section rate in hospitals where there is a financial incentive to perform C-sections. However, physician-patients appear to be unaffected by the financial environment (they have the same risk-adjusted C-section rate inside and outside of HMO-owned hospitals). These results suggest that, while financial incentives are an important determinant of treatment, patient information is an effective counterweight.

The consequences of these treatment differences are not only financial. Physician-mothers and their infants have lower morbidity than other patients. It also appears that physicians achieve these outcomes without using more hospital resources. Controlling for method of delivery, the hospital charges for physician-births are similar to those of nonphysicians.

Physicians and nonphysicians likely differ in many respects, including malpractice concerns, time costs, risk preferences, and selection of providers. Any of these might explain a single finding in isolation, but, as we discuss below, they do not fit the full pattern of results.

The remainder of the paper proceeds in five sections. Section I describes the clinical and institutional setting. In Section II, we summarize the existing literature and present the theoretical framework. Section III describes the data and empirical framework. Section IV presents the results, V discusses them, and VI concludes.

I. Clinical and Institutional Setting

C-section rates have increased from one in five births in 1996 to nearly one in three. The states we study, California and Texas, have C-section rates of 33.2 percent and 35.3 percent, respectively (Martin et al. 2013). Notable unexplained variation has been documented across hospitals and across physicians within geographic areas (Baicker, Buckles, and Chandra 2006; Epstein and Nicholson 2009; and Kozhimannil et al. 2013). While the optimal rate is unknown, many experts believe C-sections are overused. The United States Department of Health and Human Services repeatedly includes reducing C-section rates in its Healthy People goals. The 2020 goal is a 10 percent reduction. However, as the Chief OB for Sutter Health noted: "Cesarean birth ends up being a profit center in hospitals, so there's not a lot of incentive to reduce them" (Giron 2009).

Medical decision making during childbirth is especially well-suited to testing for inducement. Unlike most medical conditions, childbirth occurs for an unambiguous, predefined population (pregnant women) and treatment must occur within a narrow time frame. Thus, the scope for inducement exists only on the intensive margin. There is a well-documented payment wedge for C-sections relative to vaginal deliveries under FFS and an information asymmetry between OBs and patients. Less-informed patients typically cannot even reduce the asymmetry by seeking an independent second opinion during labor. Physician-patients, in contrast, are more likely to know which treatment is appropriate for them. They have direct medical knowledge of childbirth, as obstetric rotations are part of the core curriculum in US medical schools and residency programs. Physicians' medical training may also equip them to better understand and evaluate treatment options and their implications. Bronnenberg et al. (2015) document large asymmetries between experts and the average consumer in understanding even the basic fact that generic and brand name drugs are equivalent. Medical care in childbirth requires far more nuanced knowledge, suggesting asymmetries in this context are likely large. Moreover, unlike treatment for many acute conditions, patients are conscious during labor and thus their information has the potential to affect treatment.

In childbirth, the primary treatment decision is whether to perform a vaginal delivery or a C-section. There are several clinical situations in which a C-section is clearly indicated, and the medical guidelines recommend scheduling a C-section before labor begins for many of them.[2] In California, 10 percent of first-time mothers have scheduled C-sections; the remaining 90 percent attempt vaginal delivery. An attempt at vaginal delivery begins with the natural onset of labor or medical induction of labor (15 percent of first births in California are induced). If at any point the OB believes the risks associated with continuing labor outweigh the benefits, she can recommend progressing to surgery. C-sections after a trial of labor are termed unscheduled C-sections. Some of these are emergency C-sections, in the sense that not immediately progressing to surgery would likely compromise health, but most unscheduled C-sections are not emergent.

C-sections clearly improve maternal and infant outcomes in some clinical situations (e.g., uterine rupture), but guidelines regarding the decision to leave the delivery room for the operating room are often ambiguous.[3] The benefit of the C-section must be weighed against the risks of maternal mortality and morbidity associated with major abdominal surgery. While maternal mortality rates are very low, they are estimated to be two to four times higher in C-sections than in vaginal delivery (Hall and Bewley 1999). Mothers are also more likely to be rehospitalized for infection, for cardiopulmonary and thromboembolitic conditions, and for surgical wound complications after a C-section (Lydon-Rochelle et al. 2000). In addition, recovery times and hospital stays are twice as long for cesarean deliveries, and C-sections may increase the risk of complications in future pregnancies as well as the ability to become pregnant (Ananth, Smulian, and Vintzileos 1997; Nielsen, Hagberg, and Ljungblad 1989; Alpay, Saed, and Diamond 2008; HCUP 2009; and Norberg and Pantano 2013). C-sections also carry risks for infants. For example, 1.1 percent of

[2] The American College of Obstetricians and Gynecologists (ACOG) recommends cesarean delivery before a trial of labor in first births for: breech or transverse lie, placenta previa, triplets and higher order multiples, uterine rupture, certain rare maternal cardiac or neurologic conditions, or a history of certain uterine surgeries.

[3] While guidelines for managing shoulder dystocia are quite clear, guidelines for cases when the first stage of labor fails to progress, or when the second stage of labor progresses past 1 or 2 hours are lacking. Even when guidelines are clear, as in cases of oxygen deprivation, monitoring typically provides only a noisy indicator of fetal distress (Prentice and Lind 1987).

infants delivered by cesarean are injured in the procedure (Alexander et al. 2006). However, these risks and costs must be weighed against the uncertain consequences of allowing labor to progress.

In FFS payment schemes, physicians are typically reimbursed more highly for C-sections than for vaginal delivery.[4] This difference in fees is not thought to be justified by increased costs incurred by the OB in a cesarean delivery. C-sections require surgical training and may be a more complex procedure, but they take less time on average, and the timing is more predictable.[5] Thus, the raw payment differential may even understate the difference in effective wage rates across the procedures.

In California, 15 percent of births take place in an HMO-owned hospital setting, where the HMO directly operates the hospital.[6] In this setting both physicians and hospitals have an incentive to perform vaginal deliveries in lieu of C-sections. According to the HMO, 95 percent of their physicians are paid by salary (as of 2006), and medical groups with costs under budget are eligible for additional compensation. Furthermore, since the hospital is owned by the insurance company, it internalizes the cost of care provided.

C-sections consume more hospital resources than vaginal deliveries. Average hospital charges are $6,000 higher for a C-section (Baicker, Buckles, and Chandra 2006).[7] Hospital costs associated with C-sections are estimated to be approximately $1,000 higher for uncomplicated deliveries and $3,000 higher for complicated deliveries (Podulka, Stranges, and Steiner 2011). These numbers are conservative (they only include direct medical costs), yet even they suggest reducing C-sections to their 1996 levels could save between $1 and $3 billion per year.

II. Literature and Theoretical Framework

A. *Literature*

The concept of induced demand is first attributed to Evans (1974). McGuire (2000) defines PID as: "when the physician influences a patient's demand for care against the physician's interpretation of the best interests of the patient" (McGuire 2000, 504). Physicians can effect such a shift because patients must rely on the physician to inform them of their treatment options and their expected risks and benefits.

In an ideal world, the econometrician would compare actual treatment quantity with the quantity the physician believes the patient would demand if she were perfectly informed. Because this is often not observable even ex post, empirical tests for

[4] Gruber, Kim, and Mayzlin (1999) report a difference of $500 on average. A more recent estimate from the Healthcare Blue Book is $380. This is close to the differential reported by Medicare (for patients eligible for SSDI): Medicare pays physicians $2,295 for a C-section versus $1,926 for a vaginal delivery on average.

[5] The Medicare Resource-Based Relative Value scale assigns a higher score to C-sections than to vaginal deliveries (49.26 versus 43.78), but there is some debate regarding whether this reflects the difference in true work or complexity between the two procedures. Source: www.physicianspractice.com/display/article/1462168/1589375.

[6] Another 37 percent of all births are to patients insured by an HMO, but delivering in a non-HMO-owned hospital.

[7] In California average charges for the mother are $8,472 higher. According to Truven Health Analytics, hospital and physician payments made by commercial insurers were $6,000 higher on average in California.

PID have followed one of two approaches. The first exploits variation in physicans' incentives to induce.[8] For example, Gruber and Owings (1996) exploit the shock to OB incomes resulting from the secular decline in fertility rates in the 1970s. They find that a 5 percent fall in incomes leads physicians to increase the C-section rate by 1 percentage point. A related test for inducement exploits changes in physician fees.[9] Physicians have been found to make up lost revenue by increasing volume (Nguyen and Derrick 1997; Yip 1998; Jacobson et al. 2010). In contrast, Gruber, Kim, and Mayzlin (1999) find C-sections increased by 0.7 percentage points in response to a $100 increase in the Medicaid fee differential. In both of the above approaches, identification comes from the reaction of physicians to a shock; they are not estimates of the overall level of PID.

The second broad approach to testing for PID uses variation in the information asymmetry necessary for physicians to induce demand. Studies have compared the treatment physicians choose (or would choose) for themselves with the treatment nonphysicians receive in general (Bunker and Brown 1973; Hay and Leahy 1982; Ubel, Angott, and Zikmund-Fisher 2011) and in childbirth (Chou et al 2006; Grytten, Skau, and Sørensen 2011). For example, in a Swiss survey, Domenigetti et al. (1993) find that physicians report receiving one of seven major surgical interventions one-third less often than nonphysicians. This empirical approach has also been employed more generally to test for agency problems when employing experts (Levitt and Syverson 2008). This paper merges the two broad approaches in the existing literature by jointly varying the ability and the incentive to induce demand.

The above studies highlight the role of physicians' financial incentives in treatment decisions. Financial remuneration, however, is unlikely to be the only factor in the physicians' calculation of the marginal costs and benefits of treatment choices. For example, malpractice risk has received considerable attention. However, in childbirth even the largest empirical estimates are relatively small (Avraham, Dafny, and Schanzenbach 2012). Dubay, Kaestner, and Waidmann (1999) and Sloan et al. (1997) find small increases, Kim (2007) finds no effect of malpractice risk on C-sections, and Currie and MacLeod (2008) finds malpractice pressure leads to sizable decreases in C-sections.

B. *Theoretical Framework*

In PID models, treatment quantities are determined in equilibrium by physicians equating the marginal cost of inducing demand with its marginal benefit (McGuire 2000). Models differ in how they incorporate the cost of inducement. Some incorporate the cost directly in the utility function (Ellis and McGuire 1986; McGuire and Pauly 1991; Gruber and Owings 1996), while others model patients' refusal of unwarranted care (Dranove 1988) or their future demand for that physician's services (Pauly 1980).

[8] Numerous authors have documented a positive cross-sectional correlation between physician supply and the use of surgery (Fuchs 1978; Rossiter and Wilensky 1983; and Cromwell and Mitchell 1986). Following Dranove and Wehner's (1994) critique, this empirical approach was superseded by studies exploiting exogenous shocks.

[9] The positive covariance of treatment with fees is consistent with PID, but it is also consistent with models without asymmetric information (McGuire 2000).

In the spirit of McGuire and Pauly (1991), we model the cost of inducement as a direct argument in the physician's utility function. Our model differs in that it explicitly incorporates patient information in order to illustrate the relationship between financial incentives, information, and demand inducement. Each patient's need for a C-section is denoted by the index z, which is distributed across patients according to $F(z)$. Let $\bar{z}$ be the clinically optimal threshold for performing a C-section (a C-section maximizes patient health for all patients with $z_i \geq \bar{z}$). For simplicity, assume that OBs perfectly observe z_i. Only a fraction of patients, p, observe z_i and the remainder of patients are uninformed.[10]

OBs are risk neutral and their utility functions equally weight profits and patient satisfaction as follows:[11]

$$u_i(c_i, r_i) = c_i\pi + \begin{cases} r_i(g(z_i - \bar{z})) + (1 - r_i)g(-(z_i - \bar{z})) & \text{informed} \\ 0 & \text{uninformed,} \end{cases}$$

where r_i and c_i are indicators equal to one when the OB recommends and performs a C-section, respectively. π is the profit differential between a C-section and a vaginal birth, and g is an increasing function that preserves origin symmetry. The second and third terms of the utility from treating an informed patient represent patient satisfaction with her OB's advice. Dissatisfaction with a clinically inappropriate recommendation is increasing in the patient's distance from the optimal threshold.[12]

An informed patient will only consent to clinically appropriate treatment, while an uninformed patient will defer to her OB:

$$c_i = \begin{cases} I[z_i \geq \bar{z}] & \text{informed} \\ r_i & \text{uninformed.} \end{cases}$$

When deciding whether to recommend treatment, the OB does not know whether an individual patient is informed. The OB observes the set of patient characteristics, x, and forms an expectation that the patient is informed based on those characteristics: $E(p_i | \mathbf{x}_i) = \hat{p}_i$. The OB then chooses r_i to maximize her expected utility:

$$\max_{r_i} \; (1 - \hat{p}_i)r_i\pi + \hat{p}_i\big[I[z_i \geq \bar{z}]\pi + r_i g(z_i - \bar{z}) + (1 - r_i)g(-(z_i - \bar{z}))\big]$$

The OB will recommend a C-section to patients with

$$z_i \geq \bar{z} + g^{-1}\left(\frac{-(1 - \hat{p}_i)\pi}{2\hat{p}_i}\right).$$

[10] We assume the probability a patient is informed is independent of the patient's health. The comparative statics are robust to assuming that OBs only have a noisy signal of z_i, as long as the precision of the signal is independent of whether the patient is informed. One could also consider a model in which all patients have imprecise signals of their health and update their beliefs based on physician advice. Dranove (1988) solves the strategic game that results from this set-up. While closed form solutions are not possible in the general case, the model makes similar predictions. Specifically, it predicts demand inducement will be decreasing in patient information.

[11] Neither is necessary for the predictions that follow.

[12] Patient satisfaction could enter the OB's utility function either due to reputation concerns or due to the disutility of interacting with a disgruntled patient. One could also imagine a more elaborate utility function in which an altruistic physician might also care about patient welfare. Allowing patient welfare to directly enter the physician's utility function affects the level of inducement, but does not affect the predictions that follow.

Let z_i^d denote the OB's cut-off for recommending a C-section to patient i: $z_i^d = \bar{z} + g^{-1}(\kappa_i)$ with $\kappa_i = \frac{-(1-\hat{p}_i)\pi}{2\hat{p}_i}$. The resulting C-section rate will negatively covary with z_i^d.[13]

The OB thus chooses the clinically optimal C-section threshold $\left(z_i^d = \bar{z}\right)$ in the case of no financial incentive $(\pi = 0)$ and perfectly informed patients $(\hat{p}_i = 1)$. Note that if there are other frictions in the market, the preferred C-section rate of perfectly informed patients may not be the clinical optimum, but the comparative statics will still hold. This model abstracts away from these factors to highlight the impact of information and financial incentives.

When π is greater (less) than 0, z_i^d is less (greater) than $\bar{z}$, and the OB performs too many (few) C-sections. The OB's treatment threshold also varies with $\hat{p}_i$, the expected probability the patient is informed:

$$(1) \qquad \frac{dz_i^d}{d\hat{p}_i} = \left(\frac{\partial}{\partial \kappa_i} g^{-1}(\kappa_i)\right)\left(\frac{1}{\hat{p}_i} + \frac{1-\hat{p}_i}{\hat{p}_i^2}\right)\frac{\pi}{2}.$$

The sign of π determines the sign of the derivative, as all other terms are positive. Thus, in FFS, where $\pi > 0$, z_i^d is increasing in $\hat{p}_i$, implying the C-section rate is decreasing in $\hat{p}_i$. The model's predictions reverse in HMO-owned hospitals, where vaginal births are incentivized $(\pi < 0)$. There z_i^d is decreasing in $\hat{p}_i$ and the resulting C-section rate is increasing in $\hat{p}_i$.

Figure 1 displays the OB's cutoff for recommending a C-section as a function of $\hat{p}_i$ for the case where $g(z_i - \bar{z})$ is simply $z_i - \bar{z}$. Note that even a modest probability that the patient is informed leads the OB to self-regulate and not recommend inappropriate care in the most clear-cut situations. Also note that OBs choose cut-offs that are further from the optimum when treating patients who are less likely to be informed. In FFS (HMO-owned hospitals), this results in a C-section rate that is higher (lower) for uninformed patients. The incentive environment does not affect the C-section rate of fully informed patients.

If clinical standards are chosen to maximize patient health, deviations from the clinical optimum will result in worse patient outcomes. Thus, the model also predicts that less informed patients should have higher morbidity.

III. Data and Methodology

A. *Data*

In order to test the above predictions, one needs to observe the treatments and outcomes of patients who differ in their likelihood of being informed about the appropriateness of treatment. Physicians' medical training makes them much more likely than the average person to have clinical knowledge, and their profession is visible to OBs. We therefore use being a physician as a proxy for the patient's probability of being informed. We identified physician-patients by merging the

[13] Informed patients have a C-section rate of $1 - F(\bar{z})$. Uninformed patients with $z_i > z_i^d$ receive a C-section. Thus, as long as there are some uninformed patients, the C-section rate rises as z_i^d falls.

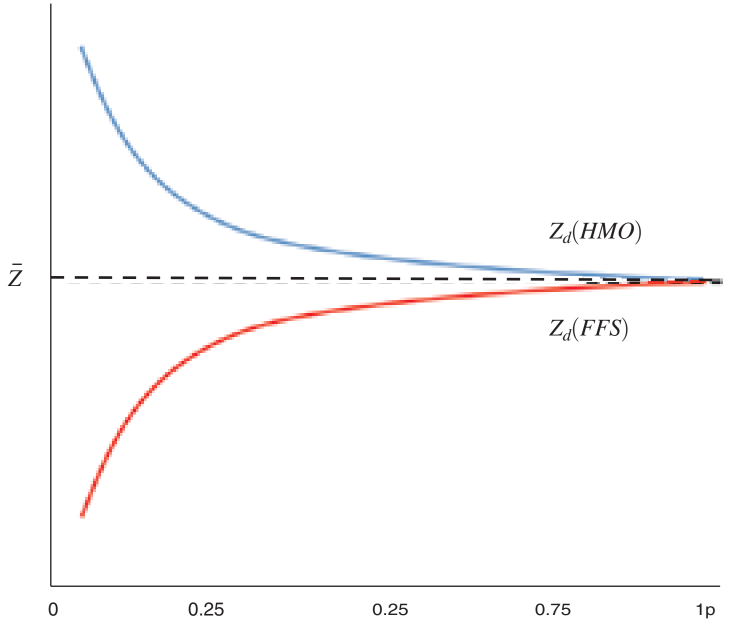

Figure 1. Physician Threshold and Presence of Informed Patients

confidential California Vital Statistics (VS) data with licensure data on physicians practicing in the state.[14] Specifically, we merge the California confidential Linked Patient Discharge Data-Birth Cohort File (PDD-Birth) with the California Medical Board database of all licensed physicians in the state. In addition to the full name, the mother's ZIP code, approximate age, and education were used in the merge process. A detailed description of the merge process is provided in the online Data Appendix.

The linked data include the VS record for every birth registered in California from 1996–2005. Births taking place in hospitals are linked to the mother and infant's hospital discharge records. The VS record includes maternal and paternal demographic information, maternal pregnancy history, pregnancy risk factors, and delivery complications. The data also has information on the birth, including method of delivery. The linked patient discharge data adds up to 24 diagnoses and 20 procedure codes for the mother and the infant. The data also include patient insurance type and hospital charges. See Table 1 for the full list of variables.

Due to the path dependence of treatment in second births, we focus on first births. There were 2,029,298 registered singleton first births over 20 weeks gestation in California hospitals in the sample period. Given the time needed to complete medical school, there are almost no physicians in their early twenties. We therefore restrict the sample to the 1,059,056 mothers between 24 and 45 years of age and exclude

[14] It was not possible to reliably identify physician-fathers in the VS data because the confidential PDD-Birth file does not include the father's first name.

Table 1—Summary Statistics: California

	Non-HMO hospitals				HMO hospitals			
	Physicians		Nonphysicians		Physicians		Nonphysicians	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Demographics:								
Age	32.55*	[3.92]	31.11*	[4.25]	32.60*	[4.07]	30.67*	[4.26]
Mother's education (%):								
Some college	0	[0]	11.81*	[32.27]	0	[0]	12.51*	[33.08]
College graduate	0	[0]	44.69*	[49.72]	0	[0]	42.23*	[49.39]
High education	100	[0]	38.38*	[48.63]	100	[0]	40.08*	[49.01]
Father's education (%):								
Some college	4.99*	[21.78]	13.00*	[33.63]	4.81*	[21.41]	16.98*	[37.55]
College graduate	16.59*	[37.21]	39.67*	[48.92]	19.42*	[39.60]	37.20*	[48.34]
High education	71.69*	[45.06]	37.62*	[48.44]	71.35*	[45.26]	34.16*	[47.42]
Mother's race (%):								
Black	3.47	[18.31]	2.99	[17.02]	5.77	[23.34]	6.17	[24.05]
Hispanic	6.11*	[23.96]	13.79*	[34.48]	7.31*	[26.05]	17.80*	[38.25]
Other (nonwhite)	38.76*	[48.73]	26.04*	[43.89]	47.31*	[49.98]	28.93*	[45.34]
ZIP code income ($)	34,567*	[15,538]	29,517*	[13,760]	33,882*	[13,914]	26,646*	[10,974]
Insurance (%):								
HMO	42.99	[49.51]	43.99	[49.64]	98.46	[12.32]	98.37	[12.65]
Government	3.58*	[18.58]	8.53*	[27.93]	0	[0]	0.31	[5.55]
Indigent	0	[0]	0.024	[1.55]	0	[0]	0.0035	[0.59]
Infant information (%):								
Female	48.34	[49.98]	48.57	[49.98]	50.00	[50.05]	48.74	[49.98]
Very early term (20–36 weeks)	8.10	[27.29]	7.71	[26.67]	9.62	[29.51]	8.59	[28.02]
Early term (37–39 weeks)	25.45*	[43.57]	21.78*	[41.28]	22.88	[42.05]	19.76	[39.82]
Post-dates (≥ 42 weeks)	5.82*	[23.42]	6.87*	[25.29]	5.77*	[23.34]	8.26*	[27.53]
Very low birth weight	0.90	[9.47]	1.01	[9.98]	0.96	[9.77]	1.24	[11.07]
Low birth weight	5.10	[22.00]	4.41	[20.53]	8.65*	[28.14]	5.00*	[21.80]
High birth weight	5.82*	[23.42]	8.97*	[28.58]	6.35*	[24.40]	9.77*	[29.68]
Prenatal care	99.71	[5.37]	99.78	[4.73]	100.00	[0]	99.73	[5.22]
Risk factors (%):								
Malpositioned fetus	4.38	[20.46]	4.57	[20.89]	3.85	[19.25]	4.11	[19.84]
Gestational diabetes	4.41	[20.54]	4.69	[21.14]	5.77	[23.34]	7.07	[25.62]
Eclampsia	0.036	[1.90]	0.081	[2.84]	0.39	[6.20]	0.19	[4.40]
Smoking/substance abuse	0.15	[3.80]	0.19	[4.31]	1.54	[12.32]	1.43	[11.88]
Hypertension /preeclampsia	5.53	[22.86]	5.78	[23.34]	7.31	[26.05]	7.54	[26.40]
Congenital anomaly	0.15	[3.80]	0.081	[2.84]	0	[0]	0.12	[3.39]
Rupture/hemorrhage	1.41	[11.79]	1.18	[10.82]	2.11*	[14.40]	1.16*	[10.70]
Ruptured membranes ≥ 24 hours	2.24	[14.81]	2.27	[14.88]	3.85	[19.25]	4.22	[20.10]
Isoimmunity	1.81	[13.33]	1.89	[13.61]	0.39	[6.20]	1.07	[10.27]
Oligohydramnios	3.80*	[19.10]	3.10*	[17.30]	5.77*	[23.30]	3.90*	[19.40]
Polyhydramnios	0.43	[6.57]	0.32	[5.63]	0.39	[6.20]	0.26	[5.11]
Growth restriction	2.82*	[16.56]	1.51*	[12.21]	2.69*	[16.20]	1.21*	[10.91]
Thyroid condition	2.39*	[15.26]	1.49*	[12.13]	2.12	[14.40]	1.85	[13.46]
Herpes	0.47	[6.84]	0.51	[7.15]	0.96	[9.78]	1.43	[11.85]
Asthma	1.27	[11.18]	0.94	[9.63]	2.89	[16.75]	2.87	[16.69]
Preexisting physical factors	1.95*	[13.84]	1.46*	[12.00]	2.69*	[16.20]	1.18*	[10.81]
Other preexisting conditions	1.45	[11.94]	1.11	[10.48]	1.73	[13.05]	0.98	[9.82]
Observations	2,766		494,077		520		85,165	

Notes: Table contains independent variables used in the main empirical analysis for the main estimation sample. Notably, the sample is limited to singleton first births to mothers who are at least 24 years of age in families with at least one college graduate parent. "Preexisting physical factors" includes previous uterine scar and maternal physical anomalies. "Other preexisting conditions" includes maternal heart disease, renal disease, and liver disease.

*Denotes differences in physician and nonphysician means that are significantly different from zero at the 5 percent level.

observations with missing maternal age, ZIP code, gestational age, or birthweight.[15] Finally, to reduce concerns about the comparability of physicians and nonphysicians our preferred sample is the 582,528 births to parents with at least 1 college degree between them, although this choice of comparison group is not essential for the results that follow. Of these, 3,286 mothers are identified as physicians in the probabilistic record linkage.

Table 1 summarizes the independent variables used in the analysis. In our sample, 15.8 percent of physician-patients and 14.7 percent of nonphysicians deliver in an HMO-owned hospital. The differences between physicians and nonphysicians are substantively similar in these two settings. Physicians are older, less likely to be hispanic, and live in ZIP codes with higher income per capita. By definition, physicians are all highly educated. The fathers of their children are also more highly educated than those of nonphysician-mothers.

Physicians give birth to infants with lower gestational ages and lower birth weights on average. In terms of clinical risk factors, physicians and nonphysicians are fairly similar.[16] Outside of HMO-owned hospitals, 4 of 17 physician/nonphysician differences are significant at the 5 percent level. Physicians have higher rates of oligohydramnios, growth restriction, thyroid conditions, and preexisting physical factors. Inside HMO-owned hospitals, differences are slightly larger and the significant differences are placental/uterine rupture and hemorrhage, oligohydramnios, growth-restriction, and preexisting maternal factors.

We complement the California data with VS data on all births in Texas from 1996–2003 and 2005–2007 (summarized in online Appendix Table A.1). 2004 is excluded because the hospital identifier was not available for that year. The Texas data come solely from the birth certificate and its associated survey. The data are less detailed and, most notably, it is not possible to reliably classify C-sections as scheduled or unscheduled. In addition, the following variables are unavailable: uterine rupture/hemorrhage; ruptured membranes over 24 hours; isoimmunity; oligohydramnios, polyhydramnios; growth restriction; thyroid condition; herpes, asthma, preexisting maternal physical factors; and other maternal preexisting conditions. However, the Texas data have some important variables that are unavailable in California. The name of the attending OB (after 2004) and the self-reported occupations of both parents are available in the confidential data. We identify 2,619 births to physician-mothers, 5,905 births to physician-fathers and 1,472 births in families with two physician-parents. We were also able to merge in the physician-patient's specialty for 77 percent of mothers and 75 percent of fathers. This allows us to further refine our proxy for patient information, as some specialties are more likely to be informed about the specifics of childbirth.

[15] There are 918,098 births to women under 24 and 142 births to women over 45.

[16] We exclude failure of the labor to progress, obstruction, and non-reassuring fetal heart rate. These are subjective and potentially endogenous to the treatment decision, particularly when physicians need to justify a C-section with a diagnosis code.

B. *Econometric Model*

We first estimate OLS regressions of a binary indicator for C-section on an indicator for whether the mother is a physician along with demographic and clinical controls. For the initial analysis, we focus on births occurring outside of HMO-owned hospitals. OLS regressions are of the following form:

$$(2) \qquad y_{iht} = \alpha + \beta D_{iht} + \mathbf{x}'_{iht}\gamma + \delta_t + \epsilon_{iht},$$

where y_{iht} is a dummy variable indicating whether patient i had a C-section in hospital h at time t. D_{iht} is a dummy indicating if the delivering mother is a physician, and x_{iht} is the set of all the variables listed in Table 1 including maternal demographics, infant information, and clinical risk factors. x_{iht} also includes interactions between ZIP code income and race and clinical risk factors interacted with age, race, and ZIP code.[17] δ_t is a vector of year-month fixed effects. Hospital fixed effects, ν_h, are included as indicated in tables. β is the coefficient of interest. It is the estimate of the difference in C-section rates for physicians and nonphysicians outside of HMO-owned hospitals. As discussed above, if physician-patients are more likely to be informed $(\hat{p}_{md} > \hat{p}_{non-md})$, the model predicts $\beta < 0$.[18]

The regressions above employ a fairly flexible functional form. However, there could be complex interactions between observed risk factors and demographics. For this reason, we also estimate nonparametric nearest neighbor matching regressions. This approach exploits the large size of the control group (nonphysicians) relative to the treatment group (physicians). Specifically, we estimate the average treatment-on-treated (TOT) effect by matching each physician with the closest comparable nonphysician on a rich vector of demographic and clinical variables. This vector includes a full set of 2-year age bins, education and race indicators, clinical risk factors, term length indicators, indicators for low and high birthweight, and 5-year time bins. The TOT estimator is calculated as the mean difference in C-section rates between treatment and control observations in the matched sample.[19]

To test whether physicians' treatment covaries with the treating physician's financial environment, we next turn to the full sample of patients (delivering inside and outside of HMO-owned hospitals). We estimate the following OLS regression:

$$(3) \quad y_{iat} = \alpha + \beta_1 D_{iat} + \beta_2 D_{iat} \times HMO_{iat} + \beta_3 HMO_{iat} + \mathbf{x}'_{iat}\gamma + \delta_t + \epsilon_{iat},$$

where HMO_{iat} is a variable indicating whether the birth for patient i in hospital service area (HSA) a at time t took place in an HMO-owned hospital. Where indicated, fixed effects for the patient's HSA are also included. HSAs are used in lieu of hospital fixed effects because the latter are collinear with the HMO-owned hospital

[17] The results are not dependent on including interactions in the regression.

[18] $\hat{p}_{non-md}$ need not be zero for these predictions to hold, and in fact highly educated families are likely to have some information regarding childbirth.

[19] The Mahlanobis measure is used to determine closeness. In cases of multiple exact matches, a weighted average of exact matches is used as the control observation. Analytical standard errors are calculated following Equation 14 of Abadie and Imbens (2006).

indicator.[20] As before, we expect lower C-section rates for physicians relative to nonphysicians outside of HMO-owned hospitals ($\beta_1 < 0$). We also expect lower C-section rates for nonphysicians in HMO-owned hospitals, where there is a financial incentive to do fewer C-sections on the margin, compared with nonphysicians delivering elsewhere ($\beta_3 < 0$). Because informed patients should be unaffected by the incentive environment, the model predicts more intense treatment for informed patients relative to less-informed patients inside of HMO-owned hospitals. If informed patients are unaffected by the incentive environment, then $\beta_2 + \beta_3 = 0$.

Finally, we examine how physicians' morbidity compares with that of nonphysicians. Because the patient morbidity measures we observe are rare and the linear probability model performs poorly with low frequency events, we estimate logit regressions of the form:

$$(4) \quad \text{logit}(I_{iat}) = \alpha + \beta_1 D_{iat} + \beta_2 D_{iat} \times HMO_{iat} + \beta_3 HMO_{iat} + \mathbf{x}'_{iat}\gamma + \delta_t,$$

where I_{iat} is an indicator variable for a maternal or infant morbid condition for patient i in HSA a at time t. The remaining variables are defined as in equation (3). Informed patients should have fewer adverse outcomes both in and outside of HMO-owned hospitals if inappropriate levels of care affect morbidity. If instead the marginal treatment is in the "flat of the curve," then there would not be differential morbidity for informed patients.

IV. Results

A. *Treatment Intensity*

Table 2 summarizes raw C-section rates of physician and nonphysician parents. Consistent with PID, physicians in California have lower C-section rates relative to nonphysicians outside of HMO-owned hospitals (1.7 ppts) and higher rates inside them (4.9 ppts). Overall C-section rates in Texas are higher, but physician-parents in Texas also have lower raw C-section rates compared with nonphysicians. Finally, in California nonphysicians inside HMO-owned hospitals have much lower C-section rates than those outside of HMO-owned hospitals (3 ppts).

These raw comparisons are in line with our model's predictions. Next, we turn to OLS regressions with the full set of controls for observed demographic and clinical factors described in Section III. In all specifications, the comparison group is nonphysicians between 24 and 45 years of age in families with at least 1 college-educated parent.

OLS estimates of equation (2) are in Table 3, panel A. Consistent with PID, physician-mothers have C-section rates that are 2.14 percentage points (7 percent) lower than educated nonphysicians. It is also clear that the reduced C-section rate is coming entirely from unscheduled C-sections: physicians have risk-adjusted

[20] An HSA is "a collection of Zip codes whose residents receive most of their hospitalizations from the hospitals within that area" (Dartmouth Atlas 2006). There are 3,436 HSAs in the US HSA fixed effects, while not a perfect proxy for the hospital, will control for the socioeconomic status of patients in the hospital's area.

TABLE 2—RAW C-SECTION RATES

	Non-HMO hospitals		HMO hospitals	
	Physicians	Nonphysicians	Physicians	Nonphysicians
Panel A. California				
Any C-section	27.4	29.1	31.0	26.1
	[44.6]	[45.4]	[46.3]	[43.9]
Scheduled C-section	10.9	10.0	12.5	8.1
	[31.1]	[30.0]	[33.1]	[27.3]
Unscheduled C-section	16.6	19.1	18.5	17.9
	[37.2]	[39.3]	[38.8]	[38.4]
Observations	2,766	494,077	520	85,165
	Physicians			
Panel B. Texas	Mothers	Fathers	Both parents	Nonphysicians
Any C-section	31.6	29.9	28.8	32.7
	[46.5]	[45.8]	[45.3]	[46.9]
Observations	2,619	5,905	1,472	362,349

Notes: Mean C-section rates for births to families in which at least one parent is a college graduate. Standard deviations are displayed in brackets.

Source: Authors' tabulations from California and Texas VS data

TABLE 3—C-SECTIONS AND PHYSICIAN-MOTHERS: CALIFORNIA

	Any C-section		Scheduled		Unscheduled	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. OLS						
Physician	−2.14***	−1.68**	0.016	0.028	−2.16***	−1.71**
	[0.79]	[0.70]	[0.60]	[0.55]	[0.66]	[0.67]
Hospital fixed effects?		Yes		Yes		Yes
Observations	496,843	496,843	496,843	496,843	496,843	496,843
Adjusted R^2	0.17	0.18	0.22	0.23	0.061	0.068
Panel B. Matching						
Physician	−2.18***	−1.81*	−0.19	0.34	−1.99***	−1.84***
	[0.87]	[0.99]	[0.56]	[0.68]	[0.78]	[0.90]
Hospital fixed effects?		Yes		Yes		Yes
Observations	94,360	16,916	94,360	16,916	94,360	16,916
Exact match rate	89%	53%	89%	53%	89%	53%

Notes: The sample is deliveries in non-HMO hospitals. Effects are displayed in percentage points with standard errors in brackets. Panel A regressions contain the controls summarized in Table 1, interactions as described in Section IIIB, and year × month effects. Standard errors are clustered by hospital. Panel B displays estimates from nearest neighbor matching regressions, with matching performed as described in Section IIIB. Abadie and Imbens (2006) analytical standard errors are in brackets. The number of observations in panel B refers to those receiving nonzero weights. The means of the dependent variables are 29.1 percent (any C-section), 10.0 percent (scheduled C-section), and 19.1 percent (unscheduled C-section).

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

unscheduled C-section rates that are 2.16 percentage points (11 percent) lower than nonphysicians. Thus, the effect is among mothers who have expressed a revealed preference for vaginal delivery by attempting labor. It is not the result of differences in maternal preferences for elective C-sections. Instead, the difference arises from decisions made in the delivery room regarding when to stop laboring and progress to surgical delivery.[21] This is consistent with the model. While clinical guidelines are clear for scheduled C-sections, they are less clear for unscheduled C-sections, and there is little time to gather additional information once labor has begun.

C-section rates vary substantially across hospitals within California. We next ask whether this treatment difference arises from physician-mothers choosing different hospitals or receiving differential treatment within the same hospital. After including hospital fixed effects, physicians' unscheduled C-section rates remain 9 percent below those of nonphysicians (Table 3, column 6). Thus, differential sorting does not appear to be the primary mechanism behind physicians' lower C-section rates.

The OLS regressions employ a fairly flexible functional form, however, there could still be complex interactions in the relationship between observed risk factors and C-sections To address this, we employ nearest neighbor matching estimators, which implicitly allow for complex interactions. Table 3, panel B presents TOT nearest neighbor matching estimates. Even matching on a rich set of covariates, the exact match rate is 89 percent in the main specification (Table 3, panel B, columns 1, 3, and 5). Regressions that also match on hospital achieve 53 percent exact match rates (columns 2, 4, and 6).[22] Both sets of results are strikingly similar to the OLS.

These findings are not unique to California. Table 4 presents OLS regression results for Texas. The Texas specifications include indicators for both physician-mothers and physician-fathers.[23] As in California, the comparison is to nonphysicians in families with at least one college degree. Columns 1 and 2 display results for all years and columns 3 and 4 for 2005–2007, the period in which the name of the attending physician is available. As in California, physician-mothers in Texas have significantly lower C-section rates. The difference is 2.79 percentage points overall, an 8.5 percent effect. Like in California, controlling for the hospital of delivery reduces the point estimate by 25 percent. Even after controlling for the attending OB, physician-mothers remain 6.5 percent less likely to receive a C-section.[24] This suggests the treatment gap arises from physician-patients receiving different treatment rather than selecting different OBs.

One potential concern is that physicians differ from nonphysicians on dimensions in addition to information. We therefore directly test whether treatment intensity varies with medical information. While all physicians are more likely than

[21] The difference in C-section rates does not appear to be driven by differences in medical judgment regarding how any single complication should be handled. Instead, it appears as if a different threshold is being applied to physician and nonphysician-patients across the board.

[22] Hospitals with fewer than 100 births are excluded due to low match rates (this excludes 0.12 percent of births and 1 physician-parent).

[23] They also include indicators for whether the parents are married and whether the mother and father each report an occupation other than homemaking (these are not available in California).

[24] Mothers treated by physicians delivering fewer than 20 babies are excluded from the attending fixed effect analysis. This specification does not include hospital fixed effects because the majority of attendings deliver at only one hospital.

Table 4—C-Sections and Physician Parents: Texas

	Any C-section			
	(1)	(2)	(3)	(4)
Panel A				
Physician-mother	−2.79***	−2.09***	−3.10**	−2.53*
	[0.84]	[0.62]	[1.58]	[1.53]
Physician-father	−0.38	0.40	−0.27	0.70
	[0.72]	[0.53]	[1.21]	[1.20]
Hospital fixed effects?		Yes		
Attending fixed effects?				Yes
Observations	372,691	372,691	101,839	101,839
Adjusted R^2	0.12	0.14	0.09	0.16
Panel B				
Physician-mother	−4.13***	−3.26***	−4.65**	−4.18**
	[1.06]	[0.91]	[1.96]	[1.99]
Less informed physician-mother	3.07**	2.89*	3.82	4.12
	[1.50]	[1.50]	[3.13]	[3.12]
Physician-father	−1.92**	−1.39**	−1.90	−0.99
	[0.75]	[0.64]	[1.54]	[1.53]
Less informed physician-father	3.94***	4.07***	4.31	4.76
	[1.27]	[1.22]	[2.94]	[2.90]
Hospital fixed effects?		Yes		
Attending fixed effects?				Yes
Observations	372,345	372,345	101,702	101,702
Adjusted R^2	0.12	0.14	0.09	0.16

Notes: Columns 1 and 2 are for the full sample; columns 3 and 4 are for the subsample with attending names (years 2005–2007). All regressions include maternal demographic controls, infant information, and clinical risk factors and year × month effects (see Table A.1). Panel B includes all the covariates in panel A and flags for being unable to identify physician specialty. Effects are displayed in percentage points. The mean of the dependent variable is 32.6 percent (columns 1 and 2) and 38.8 percent (columns 3 and 4). Standard errors, clustered by hospital in columns 1 and 2 and by attending in columns 3 and 4, are in brackets.

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

nonphysicians to be informed, there is variance in information even among physicians. For example, gerentologists are less likely to have recent relevant clinical experience. The model predicts less informed physicians will have C-section rates further from the clinical optimum. In panel B of Table 4, we interact the physician indicator with an indicator for whether the physician-patient specializes in an area of medicine without direct relevance to childbirth.[25] All else equal, physician-patients with the most relevant medical knowledge have the lowest C-section rates. The most informed physician-mothers have C-section rates that are around 4 percentage points lower than nonphysicians (Table 4, panel B, row 1); mothers

[25] Physician-patients are classified as less informed if their specialty does not involve surgery (a C-section is abdominal surgery with all of the attendant risks and post-operative recovery) or anesthesiology, and if it plays no direct role in treating mothers or infants during or immediately after childbirth (OBs, pediatricians, and family medicine would therefore not be classified as less informed).

in other specialties have C-section rates that are only slightly lower than nonphysicians (Table 4, panel B, sum of coefficients from rows 1 and 2).[26] This provides direct evidence on the impact of information and medical knowledge on treatment. It suggests that it is the relevance of the medical knowledge to childbirth, not general medical knowledge, that leads to lower C-section rates. Moreover, it is not consistent with the results being driven by differential treatment due to physicians' status in hospitals.

The analysis thus far has focused on physician-mothers. In Texas, we are able to identify most births to physician-fathers (the father's occupation is missing in 15 percent of births). The mothers of physician-fathers' babies do not have lower C-section rates on average (Table 4, panel A). However, this is at least partly due to the gender mix of medical specialties. Physician-fathers with the most relevant medical knowledge are less likely to have babies delivered via C-section (Table 4, panel B, row 3), although the magnitude is smaller than for physician-mothers. Even among the group of more informed physicians, physician-mothers could be overrepresented in the most informed specialties, such as obstetrics and gynecology.

B. *Financial Incentives*

Physician financial incentives are thought to be the primary impetus behind PID. We now directly test whether the gap between physician and nonphysician-patients varies with their providers' financial incentives. Table 5 displays estimates of the coefficients in equation (3). As discussed above, we expect HMO-owned hospitals to have lower C-section rates than non-HMO-owned hospitals. The model also predicts physician-patients will be less affected by the incentive environment because they are more likely to be informed about appropriate treatment.

As expected, the coefficient on the HMO-owned hospital indicator is negative. Nonphysician-mothers delivering at HMO-owned hospitals have C-section rates that are almost 5 percentage points lower than nonphysicians delivering elsewhere (columns 1 and 2). Roughly half the difference comes from lower scheduled and unscheduled C-sections, respectively. The coefficient on HMO-owned hospital (β_3) and the coefficient on the interaction between HMO-owned hospital and physician-patient (β_2) are close in magnitude and of opposite sign.[27] Thus, unlike other patients, physicians appear to be unaffected by the contract environment of their providers. They have the same risk-adjusted C-section rates in and outside of HMO-owned hospitals. This is exactly what the model predicts. When broken out into scheduled and unscheduled C-sections the same pattern holds, although the estimates are less precise.

Enrolling in an HMO that operates its own hospitals is a choice. One potential concern is that physicians and nonphysicians could differentially sort into these

[26] Nurses are another natural group to study. They have more medical knowledge than the average person, but less than physicians. All else equal, mothers who are nurses have a marginally significant 1 percentage point lower C-section rate even after controlling for the attending physician. There is likely enormous variation in the medical knowledge of those who self-identify as nurses.

[27] p-values from the test of the null that $\beta_2 + \beta_3 = 0$ are 0.79 and 0.92 for the regressions displayed in columns 1 and 2, respectively. For the regressions in columns 5 and 6, they are 0.90 and 0.80.

Table 5—C-Sections and Physician-Mothers—HMO and Non-HMO Hospitals

	Any C-section		Scheduled		Unscheduled	
	(1)	(2)	(3)	(4)	(5)	(6)
Physician	−2.04**	−1.89**	0.12	0.12	−2.16***	−2.01**
	[0.80]	[0.77]	[0.50]	[0.48]	[0.76]	[0.78]
HMOHosp × physician	5.53**	4.75**	2.88*	2.44*	2.64	2.31
	[2.29]	[2.23]	[1.47]	[1.44]	[1.86]	[1.86]
HMOHosp	−4.94***	−4.58***	−2.05***	−1.74***	−2.89***	−2.84***
	[0.43]	[0.49]	[0.26]	[0.26]	[0.35]	[0.41]
HSA fixed effects?		Yes		Yes		Yes
Observations	580,719	580,719	580,719	580,719	580,719	580,719
Adjusted R^2	0.16	0.17	0.21	0.22	0.064	0.066

Notes: Regressions include controls as in panel A of Table 3, with the exception of HMO patient, which is excluded. Physician is an indicator that the mother is a physician and HMOHosp is an indicator that the birth took place in an HMO-owned hospital. Effects are displayed in percentage points. Standard errors, clustered by maternal HSA, are in parentheses.

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

hospitals.[28] Results are robust to restricting the comparison group to families with highly educated mothers, who may be more similar to physicians (Table 6, columns 1 and 2). To further investigate socioeconomic differences, Table 6, columns 3 and 4, provide estimates with maternal ZIP code fixed effects in place of HSA fixed effects. If differential sorting based on socioeconomic status is driving results, one would expect the effect size to be diminished by this change. Estimates are virtually identical to those in Table 5. For the pattern of results above to be due to sorting, the differences between physician- and nonphysician-patients would have to reverse across the financial incentive environment. Additionally, if physicians and nonphysicians are differentially sorted, this would likely be reflected in the rates at which they choose to deliver at the closest hospital to their home and the distance they are willing to travel to their hospital of choice. Physician-patients and nonphysician-patients both in and outside of HMO-owned hospitals are equally likely to deliver at the closest hospital and travel comparable distances to their delivery hospital (Table A.1 in the online Data Appendix). In addition, we get the same pattern of results for patients who chose to deliver at their closest hospital (Table 6, columns 5 and 6) and patients who bypassed the closest facility to get to their delivery hospital (Table 6, columns 7 and 8). Of course we cannot rule out that physician- and nonphysician-patients differentially sort into HMO-owned hospitals based on factors that are not reflected in hospital location. If these factors are not absorbed by observed factors, bias could result.

[28] Results are robust to including hospital fixed effects in lieu of the HMO-owned hospital indicator (see Supplementary Table A.3 in the online Appendix). This suggests they are not due to physicians differentially sorting to hospitals within the HMO system.

Table 6—Unscheduled C-Sections—Additional Estimates

	High education moms		ZIP code fixed effects		Deliver at closest hospital		Deliver at other hospital	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Physician	−2.20***	−2.06***	−2.18***	−1.94***	−3.08*	−2.67	−1.87**	−1.78**
	[0.78]	[0.79]	[0.68]	[0.69]	[1.57]	[1.64]	[0.88]	[0.89]
HMOHosp × physician	2.85	2.49	2.66	2.28	3.93	3.17	2.32	2.02
	[1.93]	[1.93]	[1.80]	[1.80]	[4.80]	[4.71]	[2.03]	[2.03]
HMOHosp	−3.03***	−2.86***	−2.89***	−2.87***	−3.60***	−3.30***	−2.71***	−2.65***
	[0.34]	[0.37]	[0.17]	[0.18]	[0.59]	[1.02]	[0.35]	[0.39]
Fixed effects?		HSA		ZIP		HSA		HSA
Observations	226,323	226,323	582,528	582,528	129,188	129,188	451,531	451,531
Adjusted R^2	0.063	0.065	0.064	0.066	0.062	0.068	0.064	0.066

Notes: Regressions include controls as in panel A of Table 3, with the exception of HMO patient, which is excluded. Physician is an indicator that the mother is a physician and HMOHosp is an indicator that the birth took place in an HMO-owned hospital. Effects are displayed in percentage points. Standard errors, clustered by HSA (columns 1–2 and 5–8) and ZIP code (columns 3–4) are in parentheses.

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

C. *Maternal and Infant Morbidity*

The estimates above demonstrate that physician-mothers receive different treatment in birth than comparable nonphysicians. However, are physicians receiving better care or just different care? Are they using their medical knowledge to get more clinically appropriate treatment or are they being permitted to choose higher risk treatment plans? The model predicts nonphysicians' treatment will deviate from the clinical optimum, and they will therefore have higher morbidity. If, alternatively, physician-mothers were pursuing high risk treatment paths or placing more weight on their own health relative to their infants', one would expect them or their infants to have higher morbidity rates. They do not.

Infant and maternal death in childbirth are incredibly rare in the United States. The overall maternal death rate in California is only 8 per 100,000 college-educated women, and no physician-mothers died in our sample. Infant and maternal complications during and immediately following childbirth are more common. Table 7 includes the conditions we observe in at least 1 percent of births and their means (See Table A.1 for more detail). Almost 9 percent of mothers have third or fourth degree perineal lacerations, which are serious tears sustained during labor. Post-partum hemorrhage, a more severe complication, is less common (3 percent) as is maternal infection (4.5 percent). For infants, we observe the presence of meconium (4.1 percent), respiratory conditions, infection (2.0 percent), and delivery trauma (1.2 percent). We split respiratory conditions into the less serious conditions that require oxygen therapy or mechanical ventilation (2.7 percent) and the more severe cases that require intubation (2.5 percent).

Because even these conditions are relatively infrequent, we estimate logit regressions as in equation (4). Table 7 displays the average marginal effects (AMEs).

Table 7—Maternal and Infant Outcomes—Average Marginal Effects

	Maternal morbidity			Infant morbidity				
	Laceration (1)	Hemorrhage (2)	Infection (3)	Meconium (4)	Respiratory assistance (5)	Intubation (6)	Infection (7)	Trauma (8)
Physician[a]	−1.15***	−0.020	−1.17***	−0.65*	−0.041	−0.42*	−0.28	−0.31*
	[0.43]	[0.35]	[0.42]	[0.39]	[0.30]	[0.22]	[0.24]	[0.17]
HMOHosp × physician	0.22	−1.74*	1.78*	−0.70	−0.75	−0.77	−0.25	−0.063
	[1.48]	[0.89]	[1.02]	[0.78]	[0.99]	[0.57]	[0.39]	[0.41]
HMOHosp[b]	3.37***	1.77***	0.32	−0.89*	1.60***	−0.023	−1.03***	−0.26***
	[0.54]	[0.43]	[0.45]	[0.52]	[0.53]	[0.29]	[0.11]	[0.088]
HSA fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	580,690	580,614	580,212	580,399	579,557	580,188	580,080	578,579
Pseudo R^2	0.038	0.037	0.038	0.072	0.14	0.16	0.11	0.050
Mean of dependent variable	8.9	3.1	4.5	4.1	2.7	2.5	2.0	1.2

Notes: Average marginal effects from logit regressions including controls as detailed in Table 5 are displayed in percentage points. The construction of the morbidity measures is described in Section IVC. Sample sizes vary across columns when one or more HSAs is dropped during logit estimation. Standard errors, clustered by HSA, are in brackets.

[a] HMOHosp is set to zero in the AME integration.

[b] Physician is set to zero in the AME integration.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Overall, physician-mothers have better outcomes. Outside of HMO-owned hospitals, physician-mothers have significantly lower rates of laceration (1.15 ppts) and infection (1.17 ppts) compared with nonphysicians. These suggest that the marginal vaginal delivery does not require extended or difficult active labors. The laceration result is striking given physician-mothers' higher rates of vaginal delivery. Lacerations result from vaginal deliveries, while infection and maternal hemorrhage can arise in women delivering vaginally or by C-section. Thus, the reduced rate of infection could arise from physicians having fewer C-sections and associated surgical wounds at risk for infection or they could have lower infection rates even within delivery method categories. Additionally, while physician-mothers are unlikely to be able to reduce their rates of laceration or hemorrhage through self-care, they may be able to reduce their risk of infection after delivery.[29]

Infants born to physician-mothers have lower rates of meconium (0.65 ppts), trauma (0.31 ppts), and intubation (0.42 ppts). While other effects are less precisely estimated, they are all negative, suggesting that physician-mothers are not achieving their lower C-Section rates by persisting in more perilous labors, nor are they improving their own morbidity by risking the health of their infants.[30] Moreover, the results suggest overuse outside of HMO-owned hospitals adversely impacts patients.

[29] Readmission to the hospital is even more subject to the physician self-care concern. That said, physician-mothers and their babies are also less likely to be readmitted in the 14 days after delivery.

[30] The Texas VS data includes 1 and 5-minute APGAR scores. While estimates are imprecise, we find no evidence of differential APGAR scores (see Supplementary Table A.4).

Inside HMO-owned hospitals the health consequences of reduced C-sections are less clear cut. Nonphysician-mothers delivering in this setting experience significantly higher rates of laceration and post-partum hemorrhage (3.37 ppts and 1.77 ppts, respectively). However, mothers in this setting are avoiding major abdominal surgery (C-sections), and they may prefer an increased risk of complications to a guaranteed surgical incision. Physician-mothers appear to be able to avoid some but not all of the increased morbidity in HMO-owned hospitals. They are entirely able to avoid the increase in the most severe maternal complication, hemorrhage (the AMEs of the HMO-owned hospital indicator and interaction term are nearly equal and offsetting). Results for infants in the HMO-owned hospital setting are mixed. They have lower rates of meconium, infection, and trauma, but higher rates of respiratory assistance. Being an informed patient offsets approximately half of the respiratory assistance effect.

The above suggests that informed patients are not simply receiving different care. Informed patients' and their infants' health outcomes suggest they are receiving better care, as the model predicts.

D. *Additional Treatment Margins*

The estimates above strongly suggest that physician-patients are able to mitigate demand inducement on the C-section margin. However, there are several other key treatment decisions in childbirth. A question is whether the difference in C-section rates arises from differences on these other margins that then make a C-section less necessary. Two such margins are labor induction and the use of epidural anesthesia. Finally, as the second stage of labor progresses, the attending can attempt to aid in the delivery through the use of forceps or a vacuum extractor.

Table 8 presents estimates of equation (3) using indicators for induction, forceps, and vacuum as dependent variables. Physician-mothers are significantly more likely to be induced, thus physicians are not avoiding C-sections through lower rates of induction (Table 8, column 1). They are also not substituting forceps or vacuum extractions for C-sections. Physician-mothers are significantly less likely to be delivered by vacuum extraction, and there is no measurable difference in the use of forceps. The use of epidural anesthesia is available on the Texas birth certificate after 2004. We find physician-parents are more likely to get epidurals, suggesting differential use of epidurals is not driving their lower C-section rate and that physicians are not opposed to medical interventions in birth more generally (see Supplementary Table A.4).

The treatment decisions investigated above constitute the major medical interventions in childbirth, but are not the only treatments provided. Moreover, while the average vaginal birth is cheaper than a C-section, safely performing the marginal vaginal birth could require more resources both during the birth and to treat any complications that arise. If either physicians or their infants have adverse outcomes on margins not cataloged in the discharge data, one would expect them to require additional medical care. Hospital charges provide a summary measure of total treatment provided. Though payers typically receive a large discount on

Table 8—Ancillary Procedures and Hospital Charges and Physician-Mothers

	Ancillary procedures			(log) Hospital charges		
	Labor induction (1)	Vacuum extraction (2)	Forceps (3)	(4)	(5)	(6)
Physician	1.67**	−1.31*	0.086	−3.93**	−2.57***	−1.55*
	[0.67]	[0.71]	[0.25]	[1.69]	[0.94]	[0.82]
HMOHosp × physician	3.39**	2.49	−0.055			
	[1.62]	[1.63]	[0.57]			
HMOHosp	−1.04	−4.92***	−1.04***			
	[0.73]	[0.54]	[0.30]			
Scheduled C-section						0.53***
						[0.097]
Unscheduled C-section						0.62***
						[0.0084]
Fixed effects?	HSA	HSA	HSA		Hospital	Hospital
Observations	580,719	580,719	580,719	482,333	482,333	482,333
Adjusted R^2	0.060	0.029	0.013	0.40	0.57	0.68
Mean of dependent variable	15.8	16.0	2.0		19,124	

Notes: Regressions include the full set of controls described in Table 3, panel A. In columns 1–3 the sample includes all hospitals, and these regressions exclude the HMO insurance variable; in columns 4–6 the sample is all non-HMO-owned hospitals. Standard errors, clustered by HSA in columns 1–3 and by hospital in columns 4–6, are in parentheses.

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

hospital charges, multiplicative discount factors will be absorbed by hospital fixed effects.[31]

Hospital charges are only available for births outside HMO-owned hospitals. Columns 4–6 of Table 8 therefore display estimates from regressions of the form of equation (1) with log hospital charges as the dependent variable. Charges of physician-mothers and their infants are nearly 2.6 percent lower than those of nonphysician-mothers delivering in the same hospitals (column 5). If this reduction could be achieved in the broader US population, hospital charges would be reduced by $2 billion per year.[32] Over a third of these savings are attributable to the difference in delivery method in the two groups. However, even after accounting for differences in the use of C-Sections, physician-mothers and their infants have hospital charges that are 1.6 percent lower than other comparable patients, a difference of $497 per birth.

[31] It is also important to note that hospital charges do not include physician charges or unbilled care, such as the amount of time a physician spends with the patient.

[32] This may overestimate the amount of hospital costs avoided. Percentages may be more informative, as costs paid are typically a fixed fraction of charges. On the other hand, this estimate does not include any cost savings associated with reduced readmissions due to complications from C-sections.

V. Discussion

We have shown that physician-patients receive different treatment in childbirth, appear to be more immune to their treating OB's financial incentives, and that they and their infants have better health outcomes. Our preferred explanation of these findings is that there is less of an information asymmetry between physician-patients and their OBs and that this makes them less susceptible to PID. Below we consider alternatives to patient information. Each may explain any one of our findings in isolation, but the full pattern of results suggests patient information is the key factor.

We observe treatments, but not the OB's recommendations. It is therefore possible that OBs recommend the same treatments to all their patients, but that physician-patients' preferences for C-sections differ from nonphysicians' for reasons unrelated to their clinical knowledge. For example, even among highly educated women, physicians are relatively highly compensated and often work either as sole proprietors or in group practices where maternity leave is costly. The most informed physician-mothers could be choosing a higher clinical threshold for C-sections due to their high cost of time away from work (although this would not explain why the babies of the most informed physician-fathers are also less likely to be delivered by C-section). If this were driving results, one would expect women who are self-employed to also have lower C-section rates. However, self-employed women and business owners have C-section rates that are similar to other educated women (Supplementary Table A.5). Furthermore, we have shown that physician-patients do not appear to be opposed to medical intervention in general or even to interventions that may increase the need for a C-section. They are more likely to get epidural anesthesia and inductions. Moreover, for differences in preferences to explain the results, the difference would have to reverse with the financial incentive environment. This might be possible if physicians and nonphysicians differentially sorted into HMO-owned hospitals. However, we have shown that physicians and nonphysicians are equally likely to deliver at the closest hospital to their homes; and they drive similar distances to get to their delivery hospital.

Physician-patients could also differ in their risk preferences or in their ability to make decisions under uncertainty. To explain our pattern of results, one would need the relative processing deficiencies or risk preferences to shift across financial incentive environments and across physician specialties. Even if you exclude surgeons, who may have more experience with high stakes decision-making, from the analysis, the most informed specialties still have lower C-section rates. In addition, if physicians were taking on more risk, one would expect them to experience more adverse outcomes or to require more treatment. Neither appears to be the case.

Even if physician-patients have the same preferences for risk, their OBs may be less risk-averse when treating them. Fear of malpractice lawsuits is often cited as a potential driver of C-sections. If OBs believe physician-patients will be less likely to sue in the event of a bad outcome, they might perform fewer C-sections on them. However, to explain the above results, OBs would need to believe that the risk of a lawsuit varies with patients' medical specialties. Moreover, we find similar results in California and Texas, states with very different malpractice environments. If anything, there is a larger effect in Texas, where the malpractice environment is more favorable to OBs. Finally, if the results were due to OBs being less risk-averse in their treatment of physician-patients, we would expect their infants to have equal or worse outcomes than nonphysicians' infants. That is not the case.

An alternative to PID that we cannot entirely rule out is OBs treating physician-patients differently out of professional courtesy.[33] One might be concerned that the better outcomes of physician-patients and their infants are due not to the intensity of their treatment, but to differences in the unobserved quality or quantity of care they receive. However, if such a phenomenon were to exist, it would have to be driven entirely by a difference in attention and uncompensated effort, as charges and ancillary treatments are, if anything, lower for physician-patients. Results are also similar when teaching hospitals are excluded, further suggesting differential attention from attendings and residents in teaching hospitals is not driving results.

Finally, the effects we document may not be solely due to the treating of OB's financial incentives. Physician and hospital incentives likely covary. HMO-owned hospitals internalize the costs of care and face an incentive to reduce C-sections. Non-HMO-owned hospitals are likely reimbursed more for C-sections than their higher costs justify. The physician ultimately makes treatment recommendations, but hospitals may be able to influence physicians in the direction of their interests. To the extent the hospital does incentivize physicians, it would still be a form of PID. If the hospital affects treatment directly through policies that constrain physician choice, then our estimates would encompass the effects of both physician and hospital incentives. However, the lower C-section rates do not appear to result from differential treatment of any single condition. Also, it is not clear how much leverage non-HMO-owned hospitals have over OBs with privileges.

VI. Conclusion

This paper presents an induced demand model, highlighting the interaction between patient information and provider financial incentives and tests its predictions using data on childbirth. Consistent with the model, physician-mothers are 7.5 percent less likely to have a C-section, and physician-mothers with the most relevant medical knowledge are 12.7 percent less likely to have a C-section. Outside of HMO-owned hospitals, the difference in C-section rates comes entirely from unscheduled C-sections; it arises from treatment decisions among mothers who chose to attempt labor. Sorting across hospitals and attendings explains only 20 percent of this difference. It also appears informed patients are able to avoid the impact of their provider's financial incentives. While patients in HMO-owned hospitals have significantly lower C-section rates (5 percentage points), physician-patients have similar C-section rates inside and outside of HMO-owned hospitals.

Physician-mothers are not avoiding C-sections by substituting other forms of resource-intensive care. Physicians have lower hospital charges and are less likely to have vacuum extractions. It appears physicians are able to achieve at least as

[33] If professional courtesy arises from the fact that a physician-patient will know if anything less than optimal care is provided or any related reputational concerns, then it is a manifestation of PID.

good or better health outcomes while receiving less intensive treatment. This is consistent with our induced demand model—informed patients are able to prevent being moved away from their optimum. While the results taken together are strongly suggestive of PID as the primary driver, we of course cannot rule out that the true cause is some other unobserved dimension on which physician-patients differ.

Outside of HMO-owned hospitals, PID clearly lowers social welfare. C-section rates, morbidity, and hospital costs are higher for the marginal patient, and the higher C-section rate means longer recovery times for mothers. The socially optimal C-section rate may be even lower than the rate of physician-patients. Physician-patients are likely targeting a private optimum, and, like all patients with insurance, they do not face the full marginal cost of their care. Inside HMO-owned hospitals the impact of PID on social welfare is less clear. OBs provide fewer C-sections, but there appear to be some tradeoffs in morbidity. The socially optimal level of risk is not zero, therefore lower C-section rates with higher morbidity could be welfare-improving. Considering only the financial costs borne by the hospital (and thus the HMO), this trade-off appears to pass cost-benefit analysis: the increase in hospital costs associated with the higher morbidity is substantially lower than our estimates of direct savings due to eliminated C-sections.[34] This exercise, of course, does not take into account any non-hospital costs or benefits, including impacts on patient welfare.

This paper demonstrates that approximately 10 percent of C-sections represent overuse of healthcare and that this overuse is not only costly but may adversely impact patients. This study also provides suggestive evidence that efforts to improve patient knowledge and information could improve outcomes while reducing health costs. Information interventions will not provide patients with the same level of information that physicians have. However, if all patients could be treated the way physicians are treated, hospital and physician charges could be reduced by 3 percent or nearly $2 billion,[35] and we would nearly achieve the US Government's Healthy People 2020 goal of reducing primary C-sections by 2.6 percentage points. If all patients could be treated like the most informed physician-patients, then the Healthy People 2020 goal would be exceeded. Over the period we study, the C-section rate increased from 20 to 32 percent. Changes in patient information or physician financial incentives are unlikely to have been large enough to explain this dramatic increase. Future research will need to disentangle the other factors clearly at work. One candidate is hospital policies and standards of care. Even a physician-patient is limited in how far she can deviate from standard practice and norms.

[34] We regress hospital charges on indicators for observed morbidities using the specification of column 5 in Table 8 (coefficients are in Supplementary Table A.6). We then multiply these charges by estimates of the increase in morbidity for each measure (from Table 7). While the conditions are expensive to treat, they are so rare that, summing across all measures, the expected costs arising from differential morbidity is only $25 for the average patient ($155 if one ignores margins with improved morbidity). These are well below the cost of a C-section.

[35] Calculations are based on the California estimates. Back-of-the-envelope calculations suggest inducement on the C-section margin represents only approximately $30 million in physician fees (1 percent of physician incomes). Physician fees average $1,926 for vaginal deliveries and $2,295 for C-sections (Medicare). Inducing demand increases OB's income from the average patient by 0.02 ($2,295–$1,926). This is compared with average fees of $0.292 \times 2{,}295 + (1 - 0.292) \times 1{,}926$.

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