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Does Higher Price Transparency Imply Lower Prices and Less Price Dispersion in Healthcare Markets? An Empirical Analysis of the Effects of Compliance with the Hospital Price Transparency Final Rule in the Greater Los Angeles Area

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ABSTRACT

The Hospital Price Transparency Final Rule aims at reducing the cost of healthcare in the United States by making information about the prices of medical services more readily available to market participants. The economic rationale is that higher price transparency should reduce the level and the dispersion of prices by disincentivizing hospitals from charging higher prices than possible. Using data on 3789 prices for three diagnostic imaging procedures and on the compliance with the rule for 86 acute care hospitals in the Greater Los Angeles area, we test the hypothesis that price levels and price dispersion are lower among hospitals that are more compliant. We do not reject this hypothesis, although we do not observe strictly decreasing relationships in all analyses. Prices are lower at hospitals with high or medium compliance than at hospitals with low compliance, but there is not a clear difference between hospitals with high and hospitals with medium compliance. Prices are less dispersed among hospitals with high compliance than among hospitals with low compliance, but the evidence for hospitals with medium compliance is less clear. We conclude that high compliance with the Hospital Price Transparency Final Rule implies lower prices and less price dispersion among hospitals.

KEYWORDS

Healthcare; Price Transparency; Information Provision; Market Results; Empirical Study

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1. Introduction

The United States healthcare system is often considered an outlier in international comparisons: The cost of healthcare is among the highest in the world, but the outcomes of healthcare are not among the best (e.g., Comanor et al., 2006; Gunja et al., 2023). This problem has existed for decades, and the cost of healthcare is expected to rise even more (e.g., Centers for Medicare and Medicaid Services [CMS], 2023; Glied and Zhu, 2020; Telesford et al., 2023). Consequently, the United States legislature has passed a series of laws aimed at controlling the cost of healthcare. An example is the Hospital Price Transparency Final Rule, which came into effect on January 1, 2021 (CMS, 2019). This rule requires hospitals to make clear and accessible pricing information publicly available in two formats, as a comprehensive machine-readable file that covers all items and services that the hospital offers and as a consumer-friendly display that covers at least 300 “shoppable” services, i.e., services that can be scheduled in advance. The objective of the Hospital Price Transparency Final Rule is to render healthcare markets more competitive by increasing price transparency, thereby reducing the cost of healthcare.

Whether the rule can have the intended effect is far from clear, for three main reasons (see, e.g., A. Zhang et al., 2020). First, from the consumers’ perspective, price transparency can only be beneficial for shoppable services, and such services only account for a part of total healthcare expenditures. Second, usage of price information by consumers may be too low to have an effect if consumers lack an incentive to access and act on the information. Third, price transparency may not increase provider competition; it may even foster tacit collusion among hospitals by making it easier to monitor competitors’ prices. Empirical research is needed to determine whether such reasons outweigh the fundamental justification for the rule that higher price transparency should disincentivize hospitals from charging higher prices than possible.

Our study aims at exploring the effects of the Hospital Price Transparency Final Rule on the cost of healthcare by examining the rule's impact on two variables: price levels and price dispersion (see also, e.g., Brown, 2019). Analyzing price levels is a direct step in evaluating whether the rule can have its intended effect. Analyzing price dispersion is an indirect step, as it can be seen as a measure of “ignorance in the market” (Stigler, 1961, p. 214). While we would have wished to analyze price levels and price dispersion for the entire United States, for all available services, and using a longitudinal research design that would allow for better causal inference, we had to limit ourselves to a more modest approach because of the availability of data. Hence, we focus on acute care hospitals in the Greater Los Angeles area as an example of a relatively large healthcare market, on three diagnostic imaging procedures as examples of shoppable services, and on a cross-sectional design that is based on different levels of hospitals’ compliance with the Hospital Price Transparency Final Rule. The latter is possible because not all hospitals were immediately fully compliant (e.g., Gul et al., 2023; Jiang et al., 2022; Parente, 2023; and the studies cited therein). Our hypothesis is that price levels and price dispersion are lower among more compliant hospitals, and our data does not lead us to reject this hypothesis.

With this study, we contribute to the literature in four ways. First, since we evaluate a relatively recent policy change, there is a gap in the literature as to how effective the Hospital Price Transparency Final Rule is in terms of fostering competition in healthcare markets in the United States (see Jiang et al., 2023). Second, while previous research has covered state-level legislation (e.g., Tu and Gourevitch, 2014; Tu and Lauer, 2009), our analysis extends to a federal-level policy, hence to a different institutional setting. Third, from an international perspective, our findings hold potential value for legislators in other countries seeking insights into the impact of mandated price transparency on healthcare markets (see Araich et al., 2023). Fourth, our study contributes to the application of the economics of information (pioneered by Stigler, 1961), which should be relevant from an academic perspective.

In Section 2, we review extant literature and outline pertinent theoretical arguments from economics. In Section 3, we describe our data and methodological approach, with the results following in Section 4. We discuss our findings in Section 5, and Section 6 concludes.

2. Literature review

2.1. Potential reasons for positive effects of higher price transparency

On the one hand, the economic argument for positive effects of higher price transparency is straightforward. When the consumers' access to information about prices improves, they should become less likely to demand services from hospitals with relatively high prices, disincentivizing hospitals from charging higher prices than possible. More specifically, when the consumers' search costs in identifying prices in the healthcare market fall, hospitals should experience more price-elastic demand, which implies lower profit- and revenue-maximizing prices for the hospitals and greater pressure to eliminate inefficiencies. As prices should be pushed more towards the theoretical ideal of marginal cost at the optimal input combination, a remaining dispersion in prices would result from differences in circumstances, quality, or other sources of heterogeneity, no longer from attempts to extract consumer surplus from uninformed payers. In this sense, "price dispersion is a manifestation – and, indeed, it is the measure – of ignorance in the market" (Stigler, 1961, p. 214). Thus, higher price transparency should reduce both the level and the dispersion of prices, i.e., render healthcare markets more competitive (CMS, 2019). This reasoning does not imply that (all) prices will fall to marginal cost or that (all) price dispersion will be eliminated, as such perfect effects cannot be expected based on the research on the economics of information since Stigler's seminal paper (e.g., Baye et al., 2006). A case in point is that the decision where to source a service or procedure is influenced by three parties: patients, insurance providers, and referring physicians. Since all parties may not be completely flexible, e.g., because of prior experiences or contracts, there are rigidities that prevent price transparency from operating perfectly. Hence, our reasoning is directional: We hypothesize that price levels and price dispersion are lower among hospitals that are more compliant with the Hospital Price Transparency Final Rule.

Prior studies suggest that there is indeed potential for reducing price levels and price dispersion in the United States healthcare market. To mention a few examples, Newman et al. (2016) found that the average price of a knee replacement in Philadelphia, Pennsylvania, was $6,150 higher than the average price in Allentown, Pennsylvania, a town just one hour away; the average price in Dallas, Texas, was $16,819 higher than a few hours to the west in Lubbock, Texas. Geographic differences in the cost of living may partially account for the variation, but there are counterexamples. For instance, the average price in New Haven, Connecticut, was 11.4% higher than in Hartford, Connecticut, but the cost of living in New Haven was 0.2% lower than in Hartford (Council for Community and Economic Research, 2016; Newman et al., 2016). Further evidence on price dispersion not caused by differences in the cost of living is provided by Liss and Sumida (2021; see also Jiang et al., 2023), who studied the variation that exists within hospitals for the same procedure but for different patients' insurers. For instance, the price for a joint replacement at Northwestern Memorial Hospital in Chicago, Illinois, ranged from $4,613 to $50,680; at California Pacific Medical Center in San Francisco, the price ranged from $22,865 to $101,571. Since these differences exist within hospitals, they are not caused by geographic differences or costs associated with emergency care capabilities and regulatory requirements, which in general are higher for hospital-based providers than for non-hospital-based providers (Tu and Gourevitch, 2014; Tu and Lauer, 2009; Wu et al., 2014; X. Zhang et al., 2018). Another source of variation may be differences in quality and associated service offerings (Stigler, 1961), but price dispersion also exists among relatively homogeneous procedures. For example, diagnostic imaging procedures are performed largely by machines, unlike surgery, in which the surgeon's ability can more significantly affect the procedure's outcome (Araich et al., 2023; Cooper et al., 2019; Graboyes and McBirney, 2020; Whaley et al., 2019; X. Zhang et al., 2018). Nevertheless, Newman et al. (2016), for instance, found that the price of pregnancy ultrasound in Cleveland, Ohio, was $339 higher than the price in Canton, Ohio. More comprehensively and in summary, Cooper et al. (2019, p. 51 et passim) show that "prices vary substantially across regions, across hospitals within regions, and even within hospitals." They observed a substantial variation in prices across cases for the same procedure even when controlling for characteristics of the hospital, insurance plan, and patient. Based on this observation, they suggest that the market structure and, therefore, hospitals' leverage in negotiations with insurers have a strong influence on the level of prices and conclude "that patients and payers could save significant amounts of money if patients attended lower-priced providers" (Cooper et al., 2019, p. 103; see also Brown, 2019). Since mandated price transparency may result in a lower relative bargaining power for hospitals and in steering consumers towards hospitals with lower prices, it may be a partial solution to the high and rising cost of healthcare.

2.2. Potential reasons against positive effects of higher price transparency

On the other hand, three main arguments against positive effects of higher price transparency disfavor our hypothesis (for detailed arguments, see CMS, 2019). First, there are many non-shoppable services, such as emergency-related services, for which ex-ante information about prices is irrelevant (Araich et al., 2023; Babcock, 2019; Frost and Newman, 2016; Graboyes and McBirney, 2020; Han et al., 2022; Sinaiko and Rosenthal, 2016; A. Zhang et al., 2020). Shoppable services are for instance planned cesarean deliveries, diagnostic imaging procedures, and joint replacements. Higher price transparency is unlikely to have an impact on the prices of non-shoppable services if there are no spillover effects or externalities (see Brown, 2019; Whaley, 2019), and this raises the question whether spending on shoppable services is negligible. White and Eguchi (2014) studied private insurance claims data from 2011 for active and retired nonelderly autoworkers and their dependents and found that about 35% of total spending was attributable to shoppable services. Frost and Newman (2016) recreated the study using data on employer-sponsored insurance claims for individuals younger than 65, weighted to be nationally representative. They found that of the $524.4 billion spent, 43% related to shoppable services. (However, out-of-pocket spending by consumers on shoppable services was only 7%, which reduces the incentive to use price transparency tools; see the next paragraph.) Since these studies were conducted, expenditures have grown significantly, e.g., total healthcare spending rose from $2.7 trillion in 2011 to $4.3 trillion in 2021 (CMS, 2023). These estimates suggest that spending on shoppable services is not negligible, even if it may account for less than half of total healthcare spending (see also Parente, 2023).

Second, consumers' usage of price transparency tools may be too low to have an impact. In their literature review, A. Zhang et al. (2020; see also Chen and Miraldo, 2022) examined the effect of such tools on healthcare choices and outcomes and found that they had little overall impact due to low usage levels. More specifically, Sinaiko and Rosenthal (2016) studied nonelderly adults' use of Aetna's Member Payment Estimator, an online tool that provides price estimates. They found that 1.6% of the seven million subscribers who had access to the tool utilized it at least once during the first year of availability; in the second year, usage increased to 2.4%. Gourevitch et al. (2017) conducted a similar study for the Truven Treatment Cost Calculator, an online platform on which users can search for personalized cost estimates. The population consisted of the families of employees from two large companies, which "marketed the tool to their employees via communications during open enrollment including emails and paper mailings and used small prizes and lotteries to encourage employees to sign up for the tool" (Gourevitch et al., 2017, p. 1). Even with such marketing, of those eligible, only 11% utilized the tool at least once, and only 1% used it at least three times during a year. Similarly, Desai et al. (2017; see also Whaley et al., 2014) studied the use of Castlight Health as the California Public Employees' Retirement System's price transparency tool, using an intervention and a control group. Their study examined the association between access to the tool and spending as well as the association between conducting a price search and receiving lower-priced care. They found that the use of the price transparency tool did not lead to a significant decrease in spending on shoppable services, and attribute this to low usage of the tool, even though "it was heavily promoted" (Desai et al., 2017, p. 1402; see also Desai et al., 2021). Mehrotra et al. (2017) conducted a nationally representative survey of nonelderly adults who had received medical care in the previous twelve months. The survey found that 75% of the respondents did not know of a resource that would allow them to compare costs among providers, even though there was widespread availability of such resources (e.g., Whaley, 2019; A. Zhang et al., 2020). Apart from unawareness of price transparency tools, reasons for not using them (or for not becoming aware of them) include consumers assuming that price dispersion is negligible, exhibiting inertia, not wanting to endanger the relationship and rapport they have built up with specific providers, believing that lower prices imply lower quality, and lacking the incentive to save on healthcare costs because of the protection insurance offers, particularly for low-deductible health plans (Desai et al., 2021; Frost and Newman, 2016; Han et al., 2022; Mehrotra et al., 2017; Tu and Gourevitch, 2014; Wu et al., 2014; X. Zhang et al., 2018; A. Zhang et al., 2020). A solution to the last problem may be reference pricing, i.e., a maximum amount that insurers will reimburse, with the patients being financially responsible for the difference if they select a provider with higher charges (e.g., Chen and Miraldo, 2022; Desai et al., 2017; Graboyes and McBirney, 2020; White and Eguchi, 2014). Whaley et al. (2019) found that the availability of a price transparency tool alone did not change patients' behavior but combining price transparency with reference pricing led to significant shifts in the choice of provider and to lower average prices paid. These results suggest that higher price transparency will only have the desired effects if consumers are incentivized to make use of it (see also, e.g., Brown, 2019; Emanuel and Diana, 2021; Graboyes and McBirney, 2020; Han et al., 2022; Tu and Gourevitch, 2014; Tu and Lauer, 2009; X. Zhang et al., 2018). Nonetheless, even without demand-directed incentives, higher price transparency may lead to lower prices due to supply-side effects and managerial incentives, e.g., if it makes hospitals aware of lower prices, potentially caused by more efficient operations, at other hospitals and thereby enables them to identify opportunities to increase their competitiveness (Brown, 2019; Chen and Miraldo, 2022; Desai et al., 2021; Han et al., 2022; Rosko et al., 2020; Tu and Gourevitch, 2014; Whaley, 2019; Wu et al., 2014; A. Zhang et al., 2020). However, as the next paragraph outlines, the opposite is also possible.

The third reason why higher price transparency may fail to generate the desired effects is that it may not increase provider competition but foster tacit collusion in the form of conscious parallelism (see generally, e.g., Harrington, 2012). When hospitals gain access to pricing information, the higher-priced hospitals may not reduce their prices to match lower-priced competitors; instead, lower-priced hospitals may raise their prices towards those of higher-priced competitors. A well-known example from a different industry concerns the market for concrete in Denmark (Albæk et al., 1997). In 1993, the Danish antitrust authority decided to publish firms' prices for two grades of concrete. The intent of this legislation was to promote competition, as the antitrust authority believed that increasing the availability of pricing information would improve customers' ability to price shop and subsequently force firms to lower their prices. However, the opposite occurred: In the year following the publication, average prices rose by 15 to 20%. In addition, the level of price variation across firms fell from up to 30% to about 2 to 4% around the mean. Hence, in this case, the reduction of "ignorance in the market" did indeed lead to lower price dispersion, but at a higher level of prices – since the impact on the suppliers' ignorance outweighed the impact on the buyers' ignorance. This is the outcome that critics of healthcare price transparency fear (see, e.g., Brown, 2019; Chen and Miraldo, 2022; Graboyes and McBirney, 2020; Han et al., 2022; Tu and Lauer, 2009; Whaley, 2019; A. Zhang et al., 2020). Comparing the Danish market for concrete to the United States healthcare market may seem far-fetched, but there are economic similarities, i.e., high barriers to entry accompanied by a relatively high market concentration. In such a setting, tacit collusion is not unlikely.

3. Method

3.1. Response variable

The Hospital Price Transparency Final Rule requires hospitals to publish pricing information for all items and services offered as a machine-readable file and for a subset of at least 300 shoppable services as a consumer-friendly display (CMS, 2019). The machine-readable file must contain five standard charges for each item or service: gross charge, payer-specific negotiated charge, minimum negotiated charge, maximum negotiated charge, and discounted cash price. The consumer-friendly display must contain the last four standard charges. Gross charges are the prices that the hospital would charge without any discounts. Negotiated charges are the prices charged to third parties, i.e., healthcare insurance companies, which apply a discount or "contractual adjustment" to gross charges to determine their payment (e.g., Babcock, 2019). Discounted cash prices are charged to consumers who pay directly, i.e., without insurance. Hospitals determine these prices by applying a discount to gross charges; discounted cash prices tend to be higher than negotiated charges.

To analyze the prices charged by hospitals, we use a research dataset provided by Turquoise Health (2022), a firm that consolidates publicly available pricing information from machine-readable files to make it available on a centralized platform. The dataset contains prices in dollars published by providers for 14 services at 3900 hospitals across the United States. We cleansed the dataset by removing duplicate data points if they were identical and, in the case of conflicting price information, by using the respective hospital's machine-readable file for verification. If there was conflicting price information, then the different prices were either for different levels of care (i.e., inpatient or outpatient) and therefore valid according to the machine-readable file, or alternate prices were from an outdated version of the machine-readable file and therefore no longer valid. The dataset includes gross charges, negotiated charges, and discounted cash prices for each service. For our research, we exclude gross charges as they bear little resemblance to the prices that are actually relevant (Babcock, 2019; Tu and Gourevitch, 2014; Whaley, 2019). Negotiated charges and discounted cash prices are included because they cover the spectrum of prices that are in fact paid.

3.2. Explanatory variable

Based on a proprietary algorithm, the Turquoise Health (2022) dataset includes an ordinal "transparency score" for the hospitals covered. However, this score is based solely on hospitals' compliance with the machine-readable format. Consequently, Turquoise Health may classify hospitals that are not fully compliant with the rule as compliant (Jiang et al., 2022). In addition, some details of the algorithm are opaque, which makes the transparency score a problematic foundation for our research. To remedy these problems, we gathered data and constructed an ordinal variable to measure compliance with the Hospital Price Transparency Final Rule more comprehensively: A compliance level was assigned by visiting each hospital's website to verify whether pricing information had been published, in which formats (machine-readable file and consumer-friendly display), and to what level of completeness with respect to the required components. Compliance levels are categorized as follows: (1) low compliance: hospital has not published pricing information in both formats, (2) medium compliance: hospital has published pricing information in both formats, but the information is incomplete, and (3) high compliance: hospital has published pricing information in both formats, and the information is complete. To perform the categorization, we reviewed the machine-readable file and the consumer-friendly display (e.g., "cost estimator") for each of the hospitals in our sample (see Section 3.3). We classified the information as complete if it included billing codes and the required charges for the top five healthcare insurance companies in the United States (according to American Medical Association [AMA], 2021; verified ex post using AMA, 2022), otherwise as incomplete. More specifically for the consumer-friendly display, we verified that a search or filter by billing code and payer resulted in pricing information, as is required by the rule (CMS, 2019). If the combination of billing code and payer returned a price, we considered the information complete; if only one search or filter was possible or if the combination did not return a price, we considered the information incomplete.

3.3. Sample

Given the above-mentioned partly manual steps in data gathering and verification, we had to limit our research to three diagnostic imaging procedures at 86 acute care hospitals in the Greater Los Angeles area. This area, which consists of Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, was selected because it had the largest number of providers when compared to other metropolitan statistical areas and offered the most complete data relative to its size. (These may in general also be reasons for other studies' focus on California; see Cooper et al., 2019. Additionally, the market for healthcare in California is the largest in the United States; CMS, 2023.) Specialty hospitals such as children's, critical access, rehabilitation, psychiatric, and sole community hospitals were excluded because pricing structures differ from those at acute care hospitals due to the unique care setting in which the services are provided (see also Haque et al., 2022). Using Current Procedure Terminology (CPT) for identification, the three selected diagnostic imaging procedures are CPT 70553 ("Under Diagnostic Radiology (Diagnostic Imaging) Procedures of the Head and Neck"), CPT 72193 ("Under Diagnostic Radiology (Diagnostic Imaging) Procedures of the Spine and Pelvis"), and CPT 76700 ("Under Diagnostic Ultrasound Procedures of the Abdomen and Retroperitoneum"). Using descriptive terms, these are magnetic resonance imaging of the brain ("MRI" in the following text), computed tomography of the pelvis ("CT"), and ultrasound of the abdomen ("ultrasound"). We selected these procedures for three reasons: First, as they can be scheduled in advance, they are in principle shoppable, and their prices may thus be impacted by price transparency. Second, given the relatively homogeneous nature of these non-invasive procedures, quality does not differ as much between providers as it may for other procedures (Araich et al., 2023; Cooper et al., 2019; Graboyes and McBirney, 2020; Whaley et al., 2019; X. Zhang et al., 2018). Third, our dataset includes relatively many observations for these procedures (see Section 4.1), which shows that they are offered commonly and allows for a detailed analysis.

The data in our sample cover prices and compliance levels in April 2022. Given that the Hospital Price Transparency Final Rule became effective on January 1, 2021, hospitals had at least fifteen months to become compliant. This time frame should (and does, as our descriptive results in Section 4.1 suggest) result in a sufficient range of compliance for a meaningful test of our hypothesis. If all hospitals had the same level of compliance, as may happen over time, our method would not allow us to analyze the impact of compliance on prices (see generally Nunnally and Bernstein, 1994).

4. Results

4.1. Descriptive statistics

Our dataset covers 3789 prices, with 1196 pertaining to MRI, 1197 to CT, and 1396 to ultrasound. As to the compliance level, among the 86 hospitals in our sample, 10 have low compliance, 30 have medium compliance, and 46 have high compliance. (Jiang et al., 2022, identified a compliance of 44% in California, using a different operationalization. Our estimate of 46/86=53.5% for high compliance is in a similar area.) Summary statistics for the prices in dollars are shown in Table 1 and visualized in Figure 1.

4.2. Estimation results for the level of prices

Our research hypothesis is that prices are lower and less dispersed, the more compliant hospitals are. To test the hypothesis with respect to the level of prices, we estimate three regression models. Model L1 is a standard ordinary least squares (OLS) regression. Our reasoning for estimating two additional models is based on the shape

Table 1. Descriptive statistics for prices of procedures by hospitals' compliance levels.

Compliance level	n	Mean	Standard deviation	Coefficient of variation	Median	Inter-quartile range	Median absolute deviation
MRI							
Low	37	3119.84	3973.12	1.27	1004.09	4676.70	389.59
Medium	65	1883.78	2343.90	1.24	840.00	1401.00	499.06
High	1094	2811.95	3414.77	1.21	757.10	4119.01	409.88
Total	1196	2771.03	3388.69	1.22	811.04	3973.65	463.82
CT							
Low	38	1736.69	2786.85	1.60	475.61	2143.40	197.78
Medium	65	1173.09	1490.30	1.27	435.00	1282.70	238.59
High	1094	1464.80	1750.27	1.19	327.48	2375.29	146.48
Total	1197	1457.59	1779.23	1.22	381.84	2194.85	181.12
Ultrasound							
Low	50	880.69	1057.47	1.20	542.25	743.34	350.71
Medium	62	475.13	517.18	1.09	210.00	510.97	134.60
High	1284	621.00	731.56	1.18	182.50	844.55	99.50
Total	1396	623.82	739.29	1.19	204.14	795.05	121.79
Total							
Low	125	1803.70	2864.27	1.59	675.00	1212.78	329.09
Medium	192	1188.31	1732.13	1.46	541.48	1282.70	337.03
High	3472	1577.23	2378.46	1.51	448.70	1647.72	318.75
Total	3789	1564.99	2369.12	1.51	453.36	1647.72	323.41

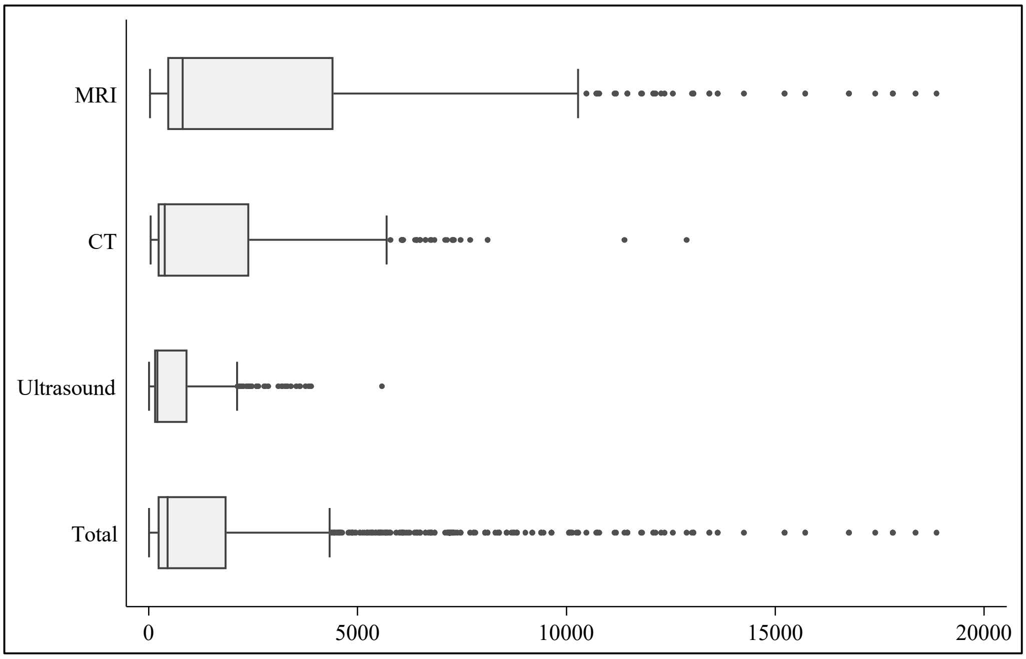

Figure 1. Boxplots for prices of procedures.

of the price distribution: Since prices are in general bounded from below but, in principle, not bounded from above, the prices in our dataset are expectedly skewed and contain outliers to the right (which can be seen in Figure 1 and by comparing means to medians in Table 1; see also Stigler, 1961). Since outliers may be informative data points, we do not discard or replace them. Instead, in Model L2, we use log-transformed prices as the response variable. The log transformation reduces the skewness of the price distribution from 2.68 to 0.36. Model L3 is a quantile regression model, with which we estimate the conditional median rather than the conditional mean of prices to use an approach that is more robust against outliers. For all models, the explanatory variables are (1) dummy variables for the three ordinal levels of compliance, (2) dummy variables for the three procedures, and (3) dummy variables for the five counties in Greater Los Angeles to control for potential differences in the cost of living and other subregional fixed effects. Estimation results are shown in Table 2.

Table 2. Results of regression analyses for the level of prices.

Model	L1 (OLS)	L2 (OLS)	L3 (Quantile regression)
Response variable	Price	Log-transformed price	Price
Compliance level			
Low	Base	Base	Base
Medium	-973.79	-0.563	-156.94
	(0.000)	(0.000)	(0.002)
High	-850.48	-0.664	-296.94
	(0.000)	(0.000)	(0.000)
Procedure			
MRI	Base	Base	Base
CT	-1309.80	-0.658	-412.27
	(0.000)	(0.000)	(0.000)
Ultrasound	-2096.26	-1.387	-556.31
	(0.000)	(0.000)	(0.000)
County			
Los Angeles	Base	Base	Base
Orange	-560.98	-0.346	-13.74
	(0.000)	(0.000)	(0.779)
Riverside	1568.73	0.993	1715.31
	(0.000)	(0.000)	(0.000)
San Bernardino	412.50	0.032	-13.74
	(0.001)	(0.600)	(0.663)
Ventura	2899.70	1.436	1882.77
	(0.000)	(0.000)	(0.000)
Model constant	3158.76	7.579	996.94
	(0.000)	(0.000)	(0.000)
n	3789	3789	3789
R^2 (Pseudo-R^2 for L3)	0.278	0.338	0.132

Notes: P-values for coefficients, based on robust standard errors, are shown in parentheses. For the three sets of dummy variables, the first category serves as the base level; the coefficients for the other categories show estimated differences to the base level, controlling for the other explanatory variables.

The results in Table 2 show that for all three models, hospitals with medium or high compliance charge significantly lower prices than hospitals with low compliance. Moreover, for log-transformed and median prices, there is a strictly decreasing relationship: The higher the compliance level, the lower are the prices (Models L2 and L3). This does not hold true for mean prices, as hospitals with medium compliance charge lower prices than hospitals with high compliance (Model L1). These patterns are visualized in Figure 2.

While the confidence intervals shown in Figure 2 give an impression as to how precise the point estimates are, they are partly uninformative in judging the significance of differences between the estimates (Schenker and Gentleman, 2001). Furthermore, the results in Table 2 do not show the significance of the difference in prices between medium and high levels of compliance. Therefore, we summarize the results of F-tests for all differences in Table 3.

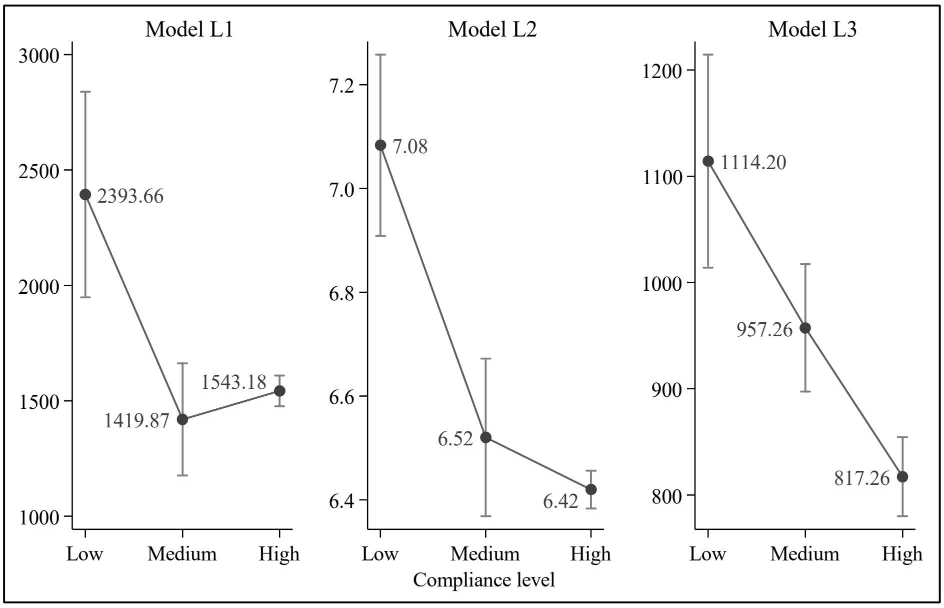

Figure 2. Main results of regression analyses for the level of prices.

Notes: Point estimates and 95% confidence intervals for the conditional mean of prices (Model L1), the conditional mean of log-transformed prices (Model L2), and the conditional median of prices (Model L3).

We also include the percentage difference in prices between levels of compliance to assess economic significance in addition to statistical significance. The percentage difference does not have descriptive relevance, since it is based on ceteris-paribus estimations, but still gives an insight into the magnitude of the effect of higher compliance.

Table 3. Summary of pairwise comparisons for the level of prices.

Model	L1	L2	L3
Estimated difference in level of prices between compliance levels			
Medium vs. low	-973.79	-0.563	-156.94
	[-40.7%]	[-8.0%]	[-14.1%]
	(0.000)	(0.000)	(0.002)
High vs. medium	123.31	-0.100	-140.00
	[8.7%]	[-1.5%]	[-14.6%]
	(0.335)	(0.208)	(0.000)
High vs. low	-850.48	-0.664	-296.94
	[-35.5%]	[-9.4%]	[-26.7%]
	(0.000)	(0.000)	(0.000)

Notes: Percentage differences are shown in brackets. P-values for differences, based on robust standard errors, are shown in parentheses.

The comparisons in Table 3 are the foundation for our conclusions with respect to the level of prices. We observe the clearest result for the conditional median of prices (Model L3): The higher a hospital's compliance level, the lower is the median. For the conditional mean of prices (Model L1) and the conditional mean of log-transformed prices (Model L2), there is a significant difference between hospitals with medium or high compliance and hospitals with low compliance, but there is no significant difference between hospitals with medium and hospitals with high compliance. To pick a result in terms of economic significance, the percentage difference in median prices between hospitals with high and hospitals with low compliance is 26.7%; for mean prices, the difference is 35.5%. We may thus conclude that hospitals with low compliance charge higher prices on average than hospitals with medium or high compliance. Whether there is a difference between hospitals with medium and hospitals with high compliance is less clear.

4.3. Estimation results for the dispersion of prices

There are several options to measure price dispersion (e.g., Baye et al., 2006). Therefore, and in line with our approach to the level of prices, we estimate three regression models with different response variables. In Model D1, the response variable is the standard deviation (SD) as a common measure of dispersion. The other two models relate to measures that are more robust against outliers: In Model D2, the response variable is the interquartile range (IQR), and in Model D3, the response variable is the median absolute deviation from the median (MAD). We do not use the coefficient of variation, because for this measure, lower values can be caused by higher means. It would therefore be uninformative to compare coefficients of variation between compliance levels for the same procedure, although their patterns tend to favor our hypothesis (Table 1). For all models, the explanatory variables are the same three sets of dummy variables as for the level of prices (Section 4.2). Since these sets cover three compliance levels, three procedures, and five counties, there are in principle 45 combinations for which we could estimate measures of dispersion. For seven combinations, our dataset includes fewer than two prices, which is the minimum needed for measures of dispersion; the estimations are therefore based on 38 combinations. Results are shown in Table 4, visualized in Figure 3, and summarized in Table 5.

Table 4. Results of regression analyses for the dispersion of prices.

Model	D1 (OLS)	D2 (OLS)	D3 (OLS)
Response variable	SD of prices	IQR of prices	MAD of prices
Compliance level			
Low	Base	Base	Base
Medium	-1856.45	-3125.40	-1357.14
	(0.061)	(0.045)	(0.083)
High	-1830.50	-2671.69	-1925.85
	(0.050)	(0.042)	(0.013)
Procedure			
MRI	Base	Base	Base
CT	-1565.15	-1905.56	-706.41
	(0.055)	(0.112)	(0.275)
Ultrasound	-2749.48	-3097.04	-1092.38
	(0.001)	(0.008)	(0.069)
County			
Los Angeles	Base	Base	Base
Orange	-936.52	-593.04	-13.99
	(0.178)	(0.540)	(0.977)
Riverside	2154.85	4025.02	1798.07
	(0.039)	(0.016)	(0.046)
San Bernardino	990.41	1788.65	839.11
	(0.042)	(0.022)	(0.052)
Ventura	1647.75	3133.17	2171.23
	(0.056)	(0.011)	(0.002)
Model constant	4281.69	4672.09	1919.10
	(0.001)	(0.005)	(0.032)
n	38	38	38
R^2	0.590	0.569	0.517

Notes: P-values for coefficients, based on robust standard errors, are shown in parentheses. For the three sets of dummy variables, the first category serves as the base level; the coefficients for the other categories show estimated differences to the base level, controlling for the other explanatory variables.

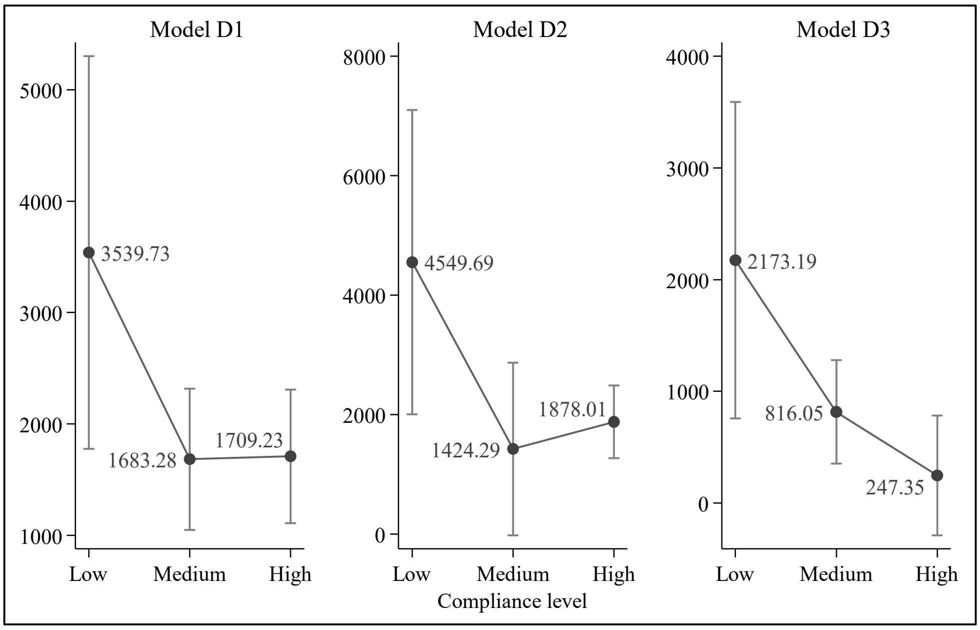

Figure 3. Main results of regression analyses for the dispersion of prices.

Notes: Point estimates and 95% confidence intervals for the conditional SD of prices (Model D1), the conditional IQR of prices (Model D2), and the conditional MAD of prices (Model D3).

Table 5. Summary of pairwise comparisons for the dispersion of prices.

Model	D1	D2	D3
Estimated difference in dispersion of prices between compliance levels			
Medium vs. low	-1856.45	-3125.40	-1357.14
	[-52.4%]	[-68.7%]	[-62.4%]
	(0.061)	(0.045)	(0.083)
High vs. medium	25.95	453.71	-568.71
	[1.5%]	[31.9%]	[-69.7%]
	(0.952)	(0.556)	(0.121)
High vs. low	-1830.50	-2671.69	-1925.85
	[-51.7%]	[-58.7%]	[-88.6%]
	(0.050)	(0.042)	(0.013)

Notes: Percentage differences are shown in brackets. P-values for differences, based on robust standard errors, are shown in parentheses.

The results show that there is a significantly negative difference in price dispersion between hospitals with high and hospitals with low compliance. A particularly strong difference pertains to the median absolute deviation of prices, which is 88.6% lower among hospitals with high compliance (Model D3). However, all three models show that there is no significant difference between hospitals with high and hospitals with medium compliance. The differences between hospitals with medium and hospitals with low compliance are in the hypothesized direction, but they are not significantly different from zero, except for the interquartile range of prices (Model D2). We may thus conclude that prices are more dispersed among hospitals with low compliance than among hospitals with high compliance. For hospitals with medium compliance, we do not obtain such a clear result.

4.4. Robustness checks

4.4.1. Response variable

Our dataset covers negotiated charges and cash prices (see Section 3.1). To evaluate the robustness of our findings, we separate these two categories, essentially isolating the interests of insurance companies from those of consumers who pay directly. We perform this analysis for the level of prices, which is of prime interest, by estimating the same three regression models as in Section 4.2, but separately for the categories of prices. For the dispersion of prices, the separate models would be based on sparsely populated combinations (see Section 4.3), leading to unreliable estimates and partly insignificant models. Estimation results for the level of prices are shown in Table 6.

Table 6. Results of regression analyses for the level of prices with negotiated charges separated from cash prices.

Model	L1 NC	L1 CP	L2 NC	L2 CP	L3 NC	L3 CP
Response variable	Negotiated charge	Cash price	Log-trans-formed negotiated charge	Log-trans-formed cash price	Negotiated charge	Cash price
Compliance level						
Low	Base	Base	Base	Base	Base	Base
Medium	-876.31	-3264.45	-0.977	-0.665	-276.26	-1789.71
	(0.000)	(0.001)	(0.000)	(0.004)	(0.000)	(0.165)
High	-360.04	-2749.19	-0.533	-0.941	-257.63	-1795.50
	(0.013)	(0.006)	(0.000)	(0.000)	(0.001)	(0.164)
Model constant	2611.99	6464.61	7.439	8.456	941.71	3817.50
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)
n	3591	198	3591	198	3591	198
R^2 (Pseudo-R^2 for L3)	0.285	0.330	0.351	0.328	0.136	0.136

Notes: P-values for coefficients, based on robust standard errors, are shown in parentheses. Control variables, not shown here, are the type of procedure and the county, as in Table 2.

The results of the robustness check largely support our main findings. Pertinently, the results for the conditional means of negotiated charges and cash prices each show the same pattern as for prices overall (Models L1 NC and L1 CP). For log-transformed and median negotiated charges, we do not observe the strictly decreasing relationships as for prices overall (Models L2 NC and L3 NC), but hospitals with medium or high compliance nevertheless set lower charges than hospitals with low compliance. For log-transformed and median cash prices, we observe strictly decreasing relationships, although the coefficients for median cash prices are statistically (but not economically) insignificant (Models L2 CP and L3 CP).

4.4.2. Explanatory variable

To assess the robustness of our results against a different operationalization of hospitals' compliance with the Hospital Price Transparency Final Rule, we use the "transparency score" by Turquoise Health (2022; see Section 3.2). Although this score pertains solely to the hospitals' machine-readable files, it may serve as a proxy for the hospitals' overall compliance. Moreover, since the score is generated algorithmically, it offers an approach to measure compliance that differs from our main, manual measurement.

For the robustness check, we compare prices at hospitals with machine-readable files labeled "complete" by Turquoise Health (i.e., the highest score of 5; 32 hospitals) to prices at other hospitals (scores less than 5; 54 hospitals). We estimate the same six regression models as in Sections 4.2 and 4.3, with the ordinal compliance level replaced by a binary variable that takes on the value 1 for a complete machine-readable file and 0 otherwise (see also Jiang et al., 2022). The coefficients for this variable are shown in Table 7.

Table 7. Results of regression analyses for the level and dispersion of prices using the transparency score by Turquoise Health.

Model	L1 TH	L2 TH	L3 TH	D1 TH	D2 TH	D3 TH
Response variable	Price	Log-transformed price	Price	SD of prices	IQR of prices	MAD of prices
Complete machine-readable file	-1525.05 (0.000)	-0.997 (0.000)	-818.00 (0.000)	-954.97 (0.024)	-1854.46 (0.017)	-930.40 (0.009)
Model constant	3425.43 (0.000)	7.663 (0.000)	1401.32 (0.000)	3374.96 (0.000)	3699.45 (0.000)	1357.22 (0.003)
n	3789	3789	3789	29	29	29
R^2 (Pseudo-R^2 for L3)	0.359	0.443	0.167	0.722	0.618	0.685

Notes: P-values for coefficients, based on robust standard errors, are shown in parentheses. Control variables, not shown here, are the type of procedure and the county, as in Tables 2 and 4.

The results of the robustness check support our main findings. For instance, the conditional mean and standard deviation of prices are significantly lower among hospitals with a complete machine-readable file than among other hospitals (Models L1 TH and D1 TH). However, in a more fine-grained analysis than reported here, we do not observe strictly decreasing relationships for all individual values of the transparency score. For example, hospitals with a "mostly complete" machine-readable file (score of 4) charge significantly higher mean prices and have a significantly higher standard deviation of prices than hospitals with only a "partially complete" machine-readable file (score of 2). Since our main estimations also do not always show strictly decreasing relationships (e.g., Figures 2 and 3), the robustness check corroborates the results.

5. Discussion

5.1. Summary

The Hospital Price Transparency Final Rule aims at reducing the cost of healthcare in the United States by making information about the prices of medical procedures more readily available to the public, i.e., patients, employers, clinicians, insurers, legislators, analysts, and other third parties (CMS, 2019). The economic rationale is that higher price transparency should reduce both the level and the dispersion of prices by disincentivizing hospitals from charging prices higher than marginal cost and by incentivizing them to eliminate inefficiencies. Theoretical and conceptual arguments and extant empirical evidence both support and contradict this rationale. Our research therefore aims at testing the hypothesis that price levels and price dispersion are lower among hospitals that are more compliant with the Hospital Price Transparency Final Rule than among other hospitals. For our sample of three diagnostic imaging procedures at 86 acute care hospitals in the Greater Los Angeles area, we do not reject this hypothesis, although we do not observe strictly decreasing relationships in all analyses. Prices are lower at hospitals with high or medium compliance than at hospitals with low compliance, but there is not a clear difference between hospitals with high and hospitals with medium compliance. Prices are less dispersed among hospitals with high compliance than among hospitals with low compliance, but the evidence for hospitals with medium compliance is less clear. Focusing only on the intersection of these results, we conclude that high compliance with the Hospital Price Transparency Final Rule implies lower prices and less price dispersion among hospitals.

5.2. Limitations

Our study suffers from five limitations that restrict its implications and entail directions for future research.

First, our sample is limited with respect to the geographic area, the type of hospital, and the type of procedure. Given that our sampling choices were not based on statistical randomization (e.g., we did not select the Greater Los Angeles Area at random but because it is a relatively large healthcare market), we have no evidence that our results carry over to other samples. Second, our operationalization of compliance, as described in Section 3.2, is imperfect, as we could not check every single payer and billing code combination but had to limit ourselves to the insurance companies with the highest market shares. In addition, we scaled compliance ordinally in three categories, which implies that especially for medium compliance, the underlying ratio-scaled compliance (the degree of the completeness of pricing information, e.g., as a percentage) may exhibit substantial within-category variation. This may be a measurement-related explanation for our unclear findings with respect to medium compliance. As we cannot rule out other explanations, we do not focus on medium compliance in our conclusions. Furthermore, we measured compliance manually, and while we checked our categorization to ensure validity, reliability, and objectivity, we cannot rule out measurement errors. In a study on a larger scale, it would be possible to improve upon our operationalization and measurement. Third, prices at hospitals that are less compliant with the Hospital Price Transparency Final Rule are underrepresented in our data, as such hospitals are by definition likely to publish fewer prices in their machine-readable files than more compliant hospitals. Hence, we observe more prices, the more compliant providers are. An indication of this underrepresentation is that in our data, the ratio between hospitals with high and hospitals with low compliance is 46/10=4.6, but the ratio between their prices is 3472/125=27.8. Our estimations for hospitals with low compliance are therefore less precise than those for hospitals with high compliance (as the wider confidence intervals in Figures 2 and 3 show). At the extreme, our data does not include prices from hospitals that are completely non-compliant and have therefore not published any prices in machine-readable files gathered by Turquoise Health (2022). Thus, we cannot assess the full range of the impact of price transparency on prices. If we could extrapolate the differences between hospitals with high compliance and hospitals with low compliance to the differences between hospitals with low compliance and unobserved hospitals with no compliance, then the impact of price transparency would be even higher. However, since we do not always observe strictly decreasing relationships, we do not have an empirical foundation for such an extrapolation. Nevertheless, it seems warranted to at least surmise that non-compliant hospitals tend to charge higher prices than other hospitals, because this may be a factor contributing to their non-compliance (for more general factors, see Araich et al., 2023; Haque et al., 2022; Jiang et al., 2022). Fourth, our cross-sectional research design does not allow for causal inference. Most importantly, it cannot be ruled out that more-compliant hospitals had lower prices than less-compliant hospitals before the Hospital Price Transparency Final Rule went into effect: Prices may not fall because of compliance, but compliance may be higher because of lower prices. A longitudinal research design would be needed to shed more light on the existence of a causal relationship (see also Jiang et al., 2023). More specifically, a design based on panel data with hospitals as units and compliance and prices over time as observations would allow to model unobserved heterogeneity (thereby controlling for potential third-variable confounds) and to include a lag to account for the time it may take for the Rule to take effect (thereby establishing temporal precedence of the cause over the effect; see generally, e.g., Shadish et al., 2002). Fifth, our research is partial in the sense that it only pertains to the effects of price transparency on prices. We cannot comment on the compliance cost of legally mandated price transparency for hospitals and, ultimately, society. The additional regulation imposes a bureaucracy burden on hospitals, and while this burden might be relatively low (for hospitals that have the necessary infrastructure in place, see Jiang et al., 2022 and 2023, and when compared to more intrusive government interventions such as price controls, see Babcock, 2019), it may still tilt decisions by healthcare providers towards less investment in the United States. Moreover, if higher price transparency results in lower prices and if hospitals do not react by increasing efficiency, profits may fall to an extent that endangers hospitals' capacity "to respond to the ever-changing healthcare environment" (Rosko et al., 2020, p. 360).

Uncovering such potential welfare-reducing effects would constitute a long-term research project.

5.3. Implications

Although we cannot infer causality and cannot generalize our results, our study suggests that higher price transparency implies lower prices and less price dispersion in healthcare markets. This conclusion supports the rationale of the Hospital Price Transparency Final Rule, as consumers can save on healthcare costs by receiving care at hospitals fully in compliance with the rule. At the least, we offer some empirical evidence against the fear that higher price transparency may have opposite effects, e.g., by fostering tacit collusion. Since both the level and the dispersion of prices, and not only the latter, are lower among hospitals with high compliance, the reduction of "ignorance in the market" does not seem to favor suppliers more than buyers (in contrast to the case of the Danish market for concrete mentioned in Section 2.2). Higher price transparency can thus be helpful in pushing prices towards marginal cost, i.e., in rendering healthcare markets more competitive.

This policy implication is reinforced, even without a causal interpretation of our results, by understanding high compliance with the Hospital Price Transparency Final Rule by a provider as a signal or as a form of advertising to buyers of healthcare services (see generally Nelson, 1974; Spence, 1973): Since providers with lower prices are more likely to be highly compliant than providers with higher prices, compliance in itself is informative and in general less costly to ascertain ex ante than prices themselves. (Medium compliance may also be sufficient to serve as a signal of lower prices, but given our unclear findings in this regard, this implication is less pronounced.) Consumers, insurers, and employers can therefore rely on compliance as an indicator of more competitive prices, and if they do, compliant hospitals will experience rising sales.

6. Conclusion

It is probably unfortunate for buyers but fortunate for research that not all hospitals were immediately fully compliant with the Hospital Price Transparency Final Rule – our study makes use of this fact. We find that high compliance entails lower prices and less price dispersion among hospitals in our sample, which supports the rationale of the policy. In light of these results, we conclude that higher price transparency can contribute to reducing the cost of healthcare.

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Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Author contributions

All the authors contributed to all research steps. The idea for the paper originated in the second author's unpublished master's thesis.

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