The Effect of Price Information on the Ordering of Images and Procedures

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abstract

BACKGROUND AND OBJECTIVES: Ordering rates for imaging studies and procedures may change if clinicians are shown the prices of those tests while they are ordering. We studied the effect of 2 forms of paid price information, single median price and paired internal/external median prices, on how often pediatric-focused and adult-oriented clinicians (most frequently general pediatricians and adult specialists caring for pediatric-aged patients, respectively) order imaging studies and procedures for 0- to 21-year-olds.

METHODS: In January 2014, we randomized 227 pediatric-focused and 279 adult-oriented clinicians to 1 of 3 study arms: Control (no price display), Single Median Price, or Paired Internal/External Median Prices (both with price display in the ordering screen of electronic health record). We used 1-way analysis of variance and paired *t* tests to examine how frequently clinicians (1) placed orders and (2) designated tests to be completed internally within an accountable care organization.

RESULTS: For pediatric-focused clinicians, there was no significant difference in the rates at which orders were placed or designated to be completed internally across the study arms. For adult-oriented clinicians caring for children and adolescents, however, those in the Single Price and Paired Price arms placed orders at significantly higher rates than those in the Control group (Control 3.2 [SD 4.8], Single Price 6.2 [SD 6.8], $P < .001$ and Paired Prices 5.2 [SD 7.9], $P = .04$). The rate at which adult-oriented clinicians designated tests to be completed internally was not significantly different across arms.

CONCLUSIONS: The effect of price information on ordering rates appears to depend on whether the clinician is pediatric-focused or adult-oriented.

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Dr Chien conceptualized and designed the study; acquired, analyzed, and interpreted the data; drafted and critically revised the manuscript; obtained funding; and provided administrative, technical, and material support; Ms Ganeshan, Dr Hatfield, and Mr Petty analyzed and interpreted the data and critically revised the manuscript; Drs Koplan, Lehmann, Schuster, and Sinaiko interpreted the data and critically revised the manuscript; Drs Rosenthal and Sequist conceptualized and designed the study, interpreted the data, critically revised the manuscript, and obtained funding; and all authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Previous controlled studies, adult and pediatric, have found that trainee physicians in hospital settings lower their test ordering rates in response to receiving price information in the form of charges ("list" prices).

WHAT THIS STUDY ADDS: This randomized controlled trial finds that pediatric-focused clinicians do not significantly alter their test ordering rates when shown paid prices for imaging studies and procedures, but adult-oriented clinicians caring for children and adolescents may increase those rates.

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Physicians have the expertise to discern whether medical spending is necessary or wasteful.[1,2] Consequently, physicians have been the target of price transparency interventions, that is, efforts to show physicians the prices of the services they are providing (eg, imaging tests and procedures). Numerous controlled studies, adult and pediatric, support the notion that when clinicians receive price information, they lower their test-ordering rates.[3–18]

Available evidence, however, has limitations. First, nearly all studies have presented physicians with price information in the form of charges.[3–18] Charges are used in contract negotiation and have been found to be up to 40-fold higher than paid price. Paid prices are the actual payments that providers receive from payers.[19] Therefore, presenting clinicians with charge information might exaggerate their response to prices, whereas providing more realistic paid prices might evoke more modest responses or even raise ordering rates if test prices are viewed to be inexpensive.[19] Second, most existing studies have focused on trainees rather than fully trained physicians.[3–18] Compared with trainees, fully trained clinicians may have a stronger sense of relative pricing (eg, that ultrasounds are cheaper than MRIs) and may be more experienced in combining relative price knowledge with clinical practice. Third, most studies were conducted >2 decades ago. More recent studies by members of our team suggest that clinicians can vary with respect to the degree to which they respond to price information.[16,20]

Additionally, almost all studies have been conducted in hospitals or emergency departments rather than in outpatient settings. Little is known about the effect of price information on physicians working in accountable care organizations (ACOs), a type of risk-bearing health care organization that benefits financially from lower overall spending.[16] ACOs are proliferating, and many can generate cost savings by shifting patients to lower cost alternatives (which frequently involves making sure care is delivered within the ACO as opposed to external to it).[21] As a result, ACOs may be interested in showing physicians paid prices as a single median figure, so physicians may focus on whether the test is "worth" the price they see. However, they may also be interested in how physicians respond to information that illustrates how prices differ if a test is performed internally or externally to the ACO.[22]

Currently, there is a paucity of information on how those caring for children and adolescents, which includes both pediatric-focused and adult-oriented clinicians, respond to price information.[3–18] For imaging studies and procedures for pediatric patients, radiation exposure (eg, radiography, computed tomography) must be minimized, accompanying sedation may need to be arranged (eg, MRIs), or extra time for training may need to be provided (eg, pulmonary function tests).[23–27] Also, compared with that available with respect to adult care, there has been far less information on the degree to which there may be unnecessary variation in pediatric care. For example, although the *Dartmouth Atlas of Health Care* has illustrated substantial variation in adult health care across the United States for >20 years, it did not report the three to fivefold variation in pediatric test-ordering rates until 2013, and even then, it was only for New England.[28] Without a stronger sense of the degree to which wasteful testing on children and adolescents occurs, it may be difficult for clinicians caring for the pediatric-aged population to respond to price information in a clinically informed way.

We use a randomized-controlled trial to evaluate the effect of paid price information, shown as either a single median price or paired internal/external median prices, on how often pediatric-focused and adult-oriented clinicians caring for children and adolescents within an ACO place orders for imaging studies and procedures and how frequently they designate orders to be completed internally within the ACO.

METHODS

Study Setting

Atrius Health is a large multispecialty medical group consisting of >35 practice locations in eastern and central Massachusetts. When this study was conducted, 506 of Atrius' generalist and specialist clinicians delivered care to >160 000 pediatric-aged 0- to 21-year olds annually; 72% of this workforce were fully trained attending physicians (ie, MDs or DOs), and 28% were nurse practitioners or physician assistants. Sixty-seven percent of these patients were from white backgrounds, 19% were insured by Medicaid, and 76% were commercially insured. Approximately half of Atrius' health plan contracts (eg, commercial, Medicaid, and Medicare) are risk bearing. Boston Children's Hospital's Institutional Review Board approved this study, including a waiver of informed consent for clinicians.

Price Education Intervention

Atrius introduced the Price Education Initiative (PEI) to all eligible clinicians in January 2014. For each imaging study and procedure, Atrius calculated a single median paid price across all their risk-bearing contracts in the year before the PEI. Atrius also calculated a set of "internal" and "external" median paid prices that reflected the prices of tests if they were performed inside or outside of Atrius, respectively. Atrius prices were lower than non-Atrius prices in

Control

Name	Type
BRAIN MRI W/ CONTRAST	IMAGING
BRAIN MRI W/O + W /BRAIN MRA W/O / CAROTID MRA W/O CONTRAST	IMAGING
BRAIN MRI W/O + W /BRAIN MRA W/O / CAROTID MRA W/O + W CONTRAST (DISSECTION)	IMAGING
BRAIN MRI W/O + W/ CONTRAST	IMAGING

Single Median Price

Name	Type
BRAIN MRI W/ CONTRAST	IMAGING-Median: $778
BRAIN MRI W/O + W /BRAIN MRA W/O / CAROTID MRA W/O CONTRAST	IMAGING
BRAIN MRI W/O + W /BRAIN MRA W/O / CAROTID MRA W/O + W CONTRAST (DISSECTION)	IMAGING
BRAIN MRI W/O + W/ CONTRAST	IMAGING-Median: $778

Paired Internal/External Median Prices

Name	Type
BRAIN MRI W/ CONTRAST	IMAGING-Median: Int.: $636 vs Ext.: $949
BRAIN MRI W/O + W /BRAIN MRA W/O / CAROTID MRA W/O CONTRAST	IMAGING
BRAIN MRI W/O + W /BRAIN MRA W/O / CAROTID MRA W/O + W CONTRAST (DISSECTION)	IMAGING
BRAIN MRI W/O + W/ CONTRAST	IMAGING-Median: Int.: $636 vs Ext.: $949

FIGURE 1
Price display in clinicians' ordering screen.

92% of cases (mean difference $365 [SD $914]). Paper and electronic memos introduced the intent of the PEI, which was to provide price information without adjunctive clinical decision support or patient education materials. (Supplemental Table 4 lists the types of imaging studies and procedures for which price was displayed.)

Study Design

We randomized all clinicians who could independently place orders in Atrius' Epic-based electronic health record (EHR) to 1 of 3 study arms. We randomized all clinicians within a practice site before moving on to the next site. This was to ensure arm balance at practice locations because locations varied substantially in terms of size (5–50 providers), setting (urban, suburban), and patient population characteristics (eg, race/ethnicity, insurance).

We observed the ordering patterns of clinicians from January 26 to December 31, 2014. We called the clinicians randomized to receive a single median price display next to a test when placing that order in their EHR those in the Single Median Price arm; we referred to the clinicians randomized to have both internal and external median prices displayed those in the Paired Internal/External Median Price arm. Those in the Control arm did not see any price information in the EHR. (Fig 1 provides screenshots of what was displayed for the clinicians in the different study arms.) An accompanying qualitative study confirmed that clinicians viewed the price information being provided in ordering screens and that physicians were not comparing price information with one another across study arms.[29]

Data Source

Atrius' Epic Systems–based Stage 7 EHR records all clinicians' ordering actions (eg, orders placed, whether order was to be completed internally within Atrius) and served as the chief repository for research data.[30–33]

Pediatric-Focused and Adult-Oriented Clinicians

A priori we considered clinicians to be "pediatric focused" if more than half of their face-to-face encounters were with patients aged 0 to 21 years and "adult oriented" if they were not. Empirically, the 227 clinicians who qualified as pediatric-focused had a mean of 97% (SD 5%) of their encounters with 0- to 21-year-olds, whereas the 279 clinicians who were considered adult-oriented had a mean of 8% (SD 9%) of their encounters with that age group. Pediatric-focused clinicians cared for ~135 000 unique 0- to 21-year olds annually, whereas the adult-oriented

clinicians cared for about 25 000 unique 0- to 21-year olds annually. Among pediatric-focused clinicians, 95% were generalists (eg, had their specialty listed as general pediatrics), and 5% were specialists (eg, had their specialty listed as pediatric cardiology, allergy). Among adult-oriented clinicians, 49% were generalists (eg, internal medicine, family practice, obstetrics-gynecology), and 51% were specialists (eg orthopedics, dermatology).

Main Independent Variable

Our main independent variable was an indicator of whether the clinician was randomized to the Control, Single Median Price, or Paired Internal/External Median Prices study arm.

Outcome Variables

We specified the overall ordering rate as each clinician's total volume of price-displayed orders divided by his or her total volume of encounters (ie, all orders on price-displayed tests per 100 patient encounters). We defined orders as internally designated if clinicians indicated that an order for a price-displayed test should be completed within Atrius; this designation was not a mandatory field, so we could only measure if clinicians made an effort to schedule the test to be completed internally, not a ratio between internal and external orders.

Statistical Analysis

For our descriptive analyses, our unit of analysis was the unit of randomization, the clinician. We examined pediatric-focused clinicians separately from adult-oriented ones because these 2 groups differ substantially in their training and experiences caring for pediatric-aged patients. For each clinician type, we describe the total volume and composition of each clinician's patient panel: average age, percentage female, percentage white, percentage commercially or Medicaid insured, and number of chronic conditions per patient.[34] We then used 1-way analysis of variance (ANOVA) and pairwise *t* tests (if ANOVAs were significant) to describe and compare clinicians in the Control arm relative to those in the intervention arms because we verified that our arms were balanced at randomization. We used unweighted ANOVAs to assess the effect of the intervention on the average clinician; we used a weighted ANOVA (weighted on the volume of encounters) to assess the effect of the intervention on the average encounter.

We used postintervention (2014) data to measure the effect of the intervention because the preintervention (2013) data verified that study arms were balanced in our outcomes of interest before the intervention (Supplemental Tables 5 and 6 illustrate how arms were balanced in 2013).

Our 1-way ANOVA had 80% power to detect between-group variance of 0.5 orders per 100 encounters across the 3 arms while controlling for type I error at 5%. The pairwise *t* tests had 80% power to detect a difference of 0.9 orders per 100 encounters while controlling type 1 error at 5%.

RESULTS

Study Population

Across the study arms, pediatric-focused and adult-oriented clinicians were balanced with respect to the volume of unique patients they cared for within the year, the number of price-displayed imaging studies and procedures that they ordered, and the number of face-to-face encounters they had with 0- to 21-year-old patients in the study year (Table 1). The patient panels of pediatric-focused and adult-oriented clinicians were also comparable across the study arms with respect to their composition: age, percent female, percent white, number of chronic conditions, percent Medicaid, and percent commercially insured.

Pediatric-Focused Clinicians

The rate at which pediatric-focused clinicians placed orders for imaging studies and procedures and designated tests to be completed internally within the ACO did not differ across Control, Single Median Price, and Paired Internal/External Prices study arms (Tables 2 and 3). In the unweighted analysis, pediatric-focused clinicians in the Control arm ordered 2.5 (SD 2.2) imaging studies or procedures for every 100 face-to-face encounters, whereas those in the Single Median Price arm ordered 3.0 (SD 2.2, $P = .12$) tests, and those in the Paired Internal/External Median Prices arms ordered 3.2 (SD 5.0, $P = .23$). Pediatric-focused clinicians in the Control arm designated 0.04 (SD 0.1) orders to be completed internally within Atrius for every 100 face-to-face encounters, whereas those in the Single Median Price arm designated 0.3 (SD 1.3, $P = .07$) orders and those in the Paired Internal/External Median Prices arm designated 0.2 (SD 0.7, $P = .13$) orders to occur within Atrius. The nonsignificant relationship across study arms is consistent between the unweighted and weighted analyses, as are the levels of the ordering rates.

Adult-Oriented Clinicians

The significance and the levels of the overall ordering rate among adult-oriented clinicians differed between the unweighted (clinician oriented) analysis and the weighted (encounter oriented) analysis (Tables 2 and 3). In the unweighted analysis, adult-oriented clinicians in the Control arm ordered 3.2 (SD 4.8) imaging studies or procedures for every 100 face-to-face encounters, whereas those in the Single Median Price arm ordered 6.2 (SD 6.8, $P < .001$) tests, and those in

TABLE 1 Characteristics of Clinicians and Their Patient Panels, 2014

Type of Clinician	Control		Single Median Price		Paired Internal/External Median Prices		*P*[a]
	Mean	SD	Mean	SD	Mean	SD	
Pediatric-focused							
Total unique patients	1010	581	1047	492	1016	624	.91
Total orders	60	54	79	66	76	62	.11
Total encounters	2766	2090	2747	1685	2864	2073	.93
Characteristics of clinician's patient panels							
Mean age, y	7	2	7	2	7	2	.63
Percent female	50%	10%	50%	8%	49%	8%	.86
Percent white	65%	17%	62%	19%	63%	19%	.71
Mean number of chronic conditions[b]	0.13	0.13	0.13	0.12	0.11	0.07	.63
Percent Medicaid insured	19%	9%	21%	9%	19%	8%	.53
Percent commercially insured	76%	9%	75%	9%	77%	8%	.49
Adult-oriented							
Total unique patients	110	127	104	148	105	136	.95
Total orders	9	26	10	15	8	13	.70
Total encounters	222	263	208	276	212	260	.94
Characteristics of clinician's patient panels							
Mean age, y	16	4	16	4	16	4	.68
Percent female	67%	22%	66%	26%	64%	23%	.70
Percent white	68%	20%	71%	19%	72%	20%	.34
Mean number of chronic conditions[b]	0.26	0.31	0.25	0.23	0.26	0.25	.95
Percent Medicaid insured	19%	11%	18%	11%	18%	13%	.83
Percent commercially insured	76%	13%	78%	12%	76%	13%	.54

Pediatric-focused clinician $n = 87$ for Control, $n = 73$ for Single Median, and $n = 67$ for Paired Internal/External; adult-oriented clinician $n = 89$ for Control, $n = 86$ for Single Median, and $n = 104$ for Paired Internal/External.

[a] One-way ANOVA.

[b] Agency for Healthcare Research and Quality's Chronic Condition Indicator.34

TABLE 2 Ordering Rates by Arm and Order Type, 2014: Clinician-Oriented Analysis

Clinicians	Control		Single Median Price		Pairwise *t* Test[a]	Paired Internal/External Median Prices		Pairwise *t* Test[b]	Unweighted ANOVA
	Mean	SD	Mean	SD	*P*	Mean	SD	*P*	*P*
Pediatric-focused									
Overall order rate	2.5	2.2	3.0	2.2	NA	3.2	5.0	NA	.35
Internal designation rate	0.04	0.1	0.3	1.3	NA	0.2	0.7	NA	.16
Adult-oriented									
Overall order rate	3.2	4.8	6.2	6.8	<.001	5.2	7.9	.04	.01
Internal designation rate	1.1	2.5	1.7	3.2	NA	1.6	3.5	NA	.31

Pediatric-focused clinician $n = 87$ for Control, $n = 73$ for Single Median, and $n = 67$ for Paired Internal/External; adult-oriented clinician $n = 89$ for Control, $n = 86$ for Single Median, and $n = 104$ for Paired Internal/External. NA, not applicable.

[a] Single Median Price versus Control.

[b] Paired Internal/External Median Price versus Control.

TABLE 3 Ordering Rates by Arm and Order Type, 2014: Encounter-Oriented Analysis

Clinicians	Control		Single Median Price		Pairwise *t* Test[a]	Paired Internal/External Median Prices		Pairwise *t* Test[b]	Weighted ANOVA
	Mean	SD	Mean	SD	*P*	Mean	SD	*P*	*P*
Pediatric-focused									
Overall order rate	2.2	2.2	2.9	2.2	NA	2.7	2.2	NA	.12
Internal designation rate	0.06	0.4	0.1	0.4	NA	0.1	0.4	NA	.52
Adult-oriented									
Overall order rate	4.2	5.0	4.6	5.2	NA	3.6	5.1	NA	.37
Internal designation rate	1.1	2.1	1.3	2.2	NA	1.2	2.2	NA	.78

Pediatric-focused clinician $n = 87$ for Control, $n = 73$ for Single Median, and $n = 67$ for Paired Internal/External; adult-oriented clinician $n = 89$ for Control, $n = 86$ for Single Median, and $n = 104$ for Paired Internal/External. NA, not applicable.

[a] Single Median Price versus Control.

[b] Paired Internal/External Median Price versus Control.

the Paired Internal/External Median Prices arms ordered 5.2 (SD 7.9, P = .04). In the weighted analysis, adult-oriented clinicians in the Control arm ordered 4.2 (SD 5.0) imaging studies or procedures for every 100 face-to-face encounters, whereas those in the Single Median Price arm ordered 4.6 (SD 5.2, P = .37) tests, and those in the Paired Internal/External Median Prices arms ordered 3.6 (SD 5.1, P = .78), suggesting that higher volume clinicians in the intervention arms were less likely to order, while their counterparts in the Control arm were more likely to do so.

However, adult-oriented clinicians across the study arms were similar to one another with respect to the rate at which they designated tests to be done internally in both the unweighted and weighted analyses. As for designating studies and procedures to be completed internally, those in the Control arm designated test to be completed internally 1.1 (SD 2.5) times for every 100 face-to-face encounters, whereas those in the Single Median Price and Paired Internal/External Median Prices arms designated those tests to be completed internally at a rate of 1.7 (SD 3.2, P = .11) and 1.6 (SD 3.5, P = .25), respectively. The nonsignificant relationship across study arms is consistent between the unweighted and weighted analyses, as are the levels of the ordering rates.

DISCUSSION

In contrast to the previous literature on price transparency,[3–18] this study finds that showing the paid price of imaging studies and procedures to clinicians does not necessarily lower test ordering rates. This finding is consistent with our study adult-oriented clinicians caring for adults.[20] It is possible that an accountable care organization that has been involved in risk-bearing contracts for decades created a cost-conscious clinical environment with little waste to remove.[16,29] It is also distinctive that clinicians received paid price information, not charges, so prices may have been lower than clinicians may have expected ex ante. Finally, paid prices may have affected the clinical encounter in ways that were not reflected by ordering data (eg, sparked cost of care conversations that may have allowed clinicians and patients to substitute medical management or laboratory testing for imaging studies or procedures)[29]; this would not have been reflected in overall ordering rates.

Our finding that adult-oriented clinicians caring for children can increase their ordering rates in response to price information is intriguing and worth further study in future investigations.[3–18] The fact that the same price information with the same adult-oriented clinicians yields different ordering results when the patient population is pediatric rather than adult raises questions about the role price expectations may play in price transparency interventions. It is possible that price displays may have caused adult-oriented clinicians to become accustomed to seeing prices for adult procedures (eg, colonoscopies), which are typically more expensive than the types of imaging studies and procedures commonly ordered for children (eg, ultrasounds, radiography). As a result, tests for children or adolescents may seem affordable relative to adults. Although Internal Designation rates are quite different relative to the Overall rate, we caution the reader against presuming that a lack of designation is equivalent to tests being performed externally. Many orders without an internal designation in the EHR are performed internally per other clinical workflow patterns. Also, we did not directly compare ordering rates between pediatric-focused and adult-oriented clinicians because this difference was not the focus of the comparison and so could not conclude the lack of statistical difference was simply due to low power.

ACOs like that studied here are important from a pediatric perspective. Up to 42% of the clinicians within ACOs can be pediatric focused,[35] and this study illustrates that adult-oriented clinicians can care for a sizeable number of pediatric patients within a year even if the pace at which they see pediatric patients is relatively infrequent. ACOs face strong incentives to reduce waste, so they may be motivated to display paid prices through their EHR in an effort to reduce waste and promote health care value, and it should be recognized that the effect of such efforts may affect adults and children differently.

Although this is the largest randomized control trial of prospectively presenting fully trained clinicians caring for children and adolescents with paid prices at the point of care, our study has limitations.[3–18] Control group contamination can be a concern,[36] but a qualitative study we previously conducted found that clinicians did not discuss price data with their colleagues.[29] Also hospital-based price transparency interventions have not found evidence of control group contamination to be present even when trainees worked in teams, cross-covered, and regularly signed out to one another.[3–18] Next, our study was conducted at a single ACO, so findings may be different in other types of health care organizations or organizational cultures. Third, we were not able to evaluate the effect of price information on pediatric test ordering rates related to care appropriateness or quality as we did for our adult evaluation.[20] Lastly, our ability to identify some orders as ones that should be completed internally within the organization, although novel, is still rudimentary; findings may differ if designation

was required as a part of ordering. We do not include a comparison of internal order rates between adult-oriented and pediatric-focused clinicians because the large variance of the small adult sample precludes commenting on whether these rates are different despite the large apparent difference in the means.

Clinicians are increasingly expected to act as good stewards of health care resources.[37–40] To assist clinicians in value-conscious ordering practices, organizations (especially risk-bearing ones like ACOs) may want to consider including price displays in their EHRs. Those with a particular interest in removing waste from the health care system may want to consider strategies to accompany physician-targeted price transparency efforts or veer toward more targeted educational campaigns such as Choosing Wisely lists, which highlight when care does not match evidence-based practice.[29,41] Physician-targeted price transparency efforts may also have other benefits that warrant further exploration, such as the ability to improve patient and provider shared decision-making when patients face out-of-pocket costs.

CONCLUSIONS

In summary, this study shows that simply presenting clinicians with price information does not ensure lower ordering rates. The effect of price information may depend on the context, the type of clinician, the patient population being cared for, or a combination of these. Understanding the effect of providing clinicians with price information may be a far more complex activity than previously appreciated.

ABBREVIATIONS

ACO: Accountable Care Organization
ANOVA: analysis of variance
EHR: electronic health record
PEI: Price Education Initiative

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