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Are Health Care Services Shoppable? Evidence from the Consumption of Lower-Limb MRI Scans
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ABSTRACT

We study how privately insured individuals choose lower-limb MRI scan providers. Despite significant out-of-pocket costs and little variation in quality, patients often received care in high-priced locations when lower priced options were available. The choice of provider is such that, on average, patients bypassed 6 lower-priced providers between their homes and treatment locations. We show that referring physicians heavily influence where patients receive care. The influence of referring physicians is dramatically greater than the influence of patient cost-sharing or patients' home zip code fixed effects. Patients with vertically integrated referring physicians are also more likely to receive costlier hospital-based scans.

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1 Introduction

From 2000 to 2016, U.S. private health insurance premiums for family coverage increased 182 percent in real terms from \$6,438 to \$18,142 (Kaiser Family Foundation 2017). In an effort to slow premium growth, insurers have steadily increased beneficiaries' cost sharing and deductibles (Schoen et al. 2011; Kaiser Family Foundation 2015). Government policy encouraged these changes by establishing tax free health savings accounts (Bumiller 2016). The motivation underlying more demand side cost sharing is that increased cost exposure would both reduce moral hazard and encourage patients to become more active consumers of health care services – so-called shoppers (Baicker, Dow, and Wolfson 2006). As a result, at present in the United States (US), 46 percent of workers now have a deductible of \$1,000 or more, one in four are enrolled in a plan with a deductible of at least \$3,000, and average out-of-pocket costs in 2016 were \$714 (Kaiser Family Foundation 2017; JP Morgan Chase & Co. 2017). However, to date, the simple prediction from price theory – that increasing cost sharing and giving access to price transparency tools would induce patients to shop for care – has not been well supported by the empirical evidence on consumer behavior (Brot-Goldberg et al. 2017; Desai et al. 2017; Mehrotra et al. 2017). This paper studies whether and why the reality of shopping for health care services lags behind what price theory predicts.

Using data from a large commercial insurer, we study how individuals age 19 to 64 with private health insurance, high out-of-pocket cost exposure, and access to a price transparency tool consume lower-limb MRI scans. We focus, in particular, on the frequency that patients forgo receiving care at lower priced locations in lieu of receiving care at more expensive providers. Lower-limb MRI scans are among the least differentiated health care services, are relatively expensive, and can generally be scheduled in advance of care. They should, therefore, be one of the most easily shoppable health care services delivered to patients in the US. Our results show that patients do not shop for care effectively in this very simple clinical setting. We then take the next step of explaining why consumers behave as they do. We explore and describe the frictions that are preventing patients from accessing lower priced care and analyze the factors that are influencing patients' choices over where to receive treatment. We posit that given our evidence that patients struggle to shop effectively for lower-limb MRI scans, our evidence is suggestive that patients will also struggle to shop for more complex health care services.

In other contexts, economists generally believe that utility-maximizing consumers are capable of effectively shopping for simple goods and services (Samuelson 1948). Even for more complex goods like automobiles, there is evidence that consumers can capably observe and consider tradeoffs between complex characteristics, like fuel efficiency, horsepower, and cabin luxury (Berry, Levinsohn, and Pakes 1995). However, a literature has developed which questions the extent to which patients can effectively shop for health care services (see Arrow 1963; Volpp 2016; Brot-Goldberg et al. 2017). There are three factors that are often cited as impediments to individuals operating as effective health care consumers. The first is the presence of third-party insurance, which insulates individuals from the true prices of the services they consume. The second is that there remains very little accurate pricing information available for consumers to use to compare prices across providers (Mahomed et al. 2018). And lastly, quality in health care can be challenging to measure, especially for non-experts. As result, patients rely heavily on recommendations of the referring physician.

Within our data, the prices of lower-limb MRI providers vary extensively within region. For example, the MRI provider in the 80th percentile in the typical hospital referral region (HRR) is 1.73 times more expensive than the MRI provider in the 20th percentile. Much of this variation is a function of the type of facility where patients receive their imaging study: the average hospital-based lower-limb MRI scan in our data had a price of $1,474.35, while non-hospital-based lower-limb MRIs were, on average, priced at $642.82. Our analysis suggests that the clinical quality of MRI scans does not vary substantially across providers. A low quality scan would need to be repeated. However, of the 50,484 MRIs in our data, only 0.006 percent of scans (3 scans in total) were repeated within a 90-day window. We will return to the issue of the quality of reading the scans later in the paper.

Despite the variation in MRI scan prices across providers, patients often receive care in high-priced locations when lower priced options are available. Figure 1 is an example typical of the patterns we observe in our data. It shows the prices of MRI providers in a large urban HRR. Each column is a provider that delivered at least one lower-limb MRI in 2013. The dots (right vertical axis) show the number of cases treated at each provider. In this HRR, the provider in the 80th percentile of prices in the area is 2.2 times more expensive than the provider in the 20th percentile and the most expensive provider is 7.5 times as expensive as the lowest-cost provider. Notably, in this HRR, the highest priced provider has the highest volume of MRI scans. This result is present in HRRs across the county. When we analyze the entirety of our sample, ignoring capacity constraints and general equilibrium (GE) effects, we estimate that if patients went to the lowest priced provider within a 60-minute car drive from their homes, total MRI spending would be reduced by 55.12 percent, with insurer contributions decreasing by 61.22 percent ($333.39), and patient out-of-pocket costs decreasing by 44.23 percent ($135.13). We refer to this counterfactual as the 'maximum potential savings.'

When we explore the choices consumers make, we do not find that the usual features assumed to drive demand, such as the distance to potential providers, explain a significant amount of the variation in the prices of the MRI scans that patients receive. Indeed, a significant portion of the maximum potential savings is available without patients having to travel farther for care. For example, total spending on lower-limb MRI scans would be reduced by 35.81 percent if patients accessed the lowest priced provider available within the same drive time as they already were travelling (26-minutes on average). This result occurs because patients, on average, bypassed 6 lower-priced providers between their home and the location where they received their scan.

Previous research has posited that greater cost-sharing may be necessary to nudge consumers to shop more effectively for care (Lieber 2017). We do find that patients with higher out-of-pocket costs receive lower priced MRI scans. This is consistent with evidence that, when faced with substantial price exposure, a modest number of patients (fewer than 10 percent) will change their provider choice (Robinson, Whaley, and Brown 2016; Frank et al. 2015). However, despite significant cost-sharing, patients' out-of-pocket cost exposure only explains 2.4 percent of variance (4.2 percent of total explained variance) in the price of the locations where patients receive care.

Ultimately, we find that the factor that appears to limit patients' ability to price shop is a factor underdiscussed in the price transparency literature. In our analysis of variation in patients' MRI prices, we find that referring physicians heavily influence where patients receive care. Looking across the nation, referring physician fixed effects explain 51 percent of the variance (92.1 percent of explained variance) in the price of MRI scans that patients receive. Indeed, referrer fixed effects explain a significantly larger share of the variance in the price of patients' MRIs than patient zip code (ZCTA) fixed effects.

Further, we offer some of the first evidence on the behavior of referring physicians. We find that orthopedic surgeons tend to send their patients to a narrow group of imaging locations: the median referring orthopedic surgeon in our sample sends, on average, 79 percent of all her referrals to a single imaging provider. Likewise, the median referring orthopedic surgeon sends zero patients to the lowest cost provider within either 30- or

60-minutes from the patient's home. As a result, a crucial finding from our analysis is that in order to lower out-of-pocket costs and reduce total MRI spending, patients must diverge from their physicians' established referral pathways or insurers must somehow persuade physicians to refer patients to different locations. This pattern points to a role for insurers to educate or incentivize physicians to refer in a more cost-effective manner and generate price elasticity for MRI scans.

Decades of literature focusing on health care and other sectors has explored the agency relationship and found that agency is often imperfect (Hubbard 1998; Levitt and Syverson 2008). The referral decisions of physicians may be suboptimal for two reasons. First, referring physicians may lack information on the prices of the facilities where they are sending their patients, and second, physicians may be motivated to refer patients to specific providers for reasons other than quality or patient costs. Existing evidence suggests that physicians who are vertically-integrated with a hospital are more likely to refer patients to a hospital (Baker, Bundorf, and Kessler 2016). Consistent with this evidence, we find when a patient is referred by a vertically integrated referring physician, the price of their scan is 36.5 percent higher, they pay 31.9 percent higher out-of-pocket costs, and they are 27 percent more likely to receive a hospital-based scan.

Ultimately, our results have implications for the academic literature and for policy-makers. Existing models of patient choice use distance as the primary determinant of where patients receive care (Gowrisankaran, Nevo, and Town 2015; Capps, Dranove, and Satterthwaite 2003; Ho 2006). These results suggest that, particularly for planned care, economists should integrate the effect of physician agency into their choice models. Our results also suggest a mechanism behind findings in the literature showing that introducing deductibles lowered health spending by over 11 percent without inducing individuals to more actively price shop (Brot-Goldberg et al. 2017). While deductibles may reduce the probability of individuals accessing health care services, our results suggest that once patients touch the health system, where they receive ensuing care is strongly influenced by their referring physician.

On the policy front, our work highlights the limits of existing demand side cost sharing as a tool to improve patient shopping. Despite attractive predictions from price theory, these standard incentives do not perform well on real consumers in health care markets. Going forward, our work suggests that health care funders could more effectively steer patients towards high productivity providers by equipping physicians with information on the prices of potential locations for care and incentivizing them to make more cost-efficient referrals. These results are consistent with Ho and Pakes (2014), which find that insurers with more direct control over physician referrals are able to get lower priced secondary care and research on payment reform that suggests that when physicians are incented to make referrals to lower priced locations, they do so (Song et al. 2014; Carroll et al. 2018).

This paper is structured as follows. In Section 2, we describe our data and empirical approach. We present our results in Section 3. We offer a discussion of our results and conclude in Section 4. Appendix A includes additional background information on MRI scans, cost-sharing among the privately insured, and a brief discussion of agency relationships. Appendix B includes additional detail on how we identify MRI scans in our data, identify patients' referring physicians, construct price measures, and identify what patients and the insurer would have paid had patients received care at alternative locations.

2 Data, Identifying MRI Scans, Calculating Prices, and Building Patient Choice Sets

2.1 Primary and Secondary Data

Our primary data set is composed of insurance claims provided by a large national insurer that covers tens of millions of lives annually and is active in all 50 US states. Our main analysis uses data from 2013. We build an analytic sample of claims for the most common MRI scan in our data: lower extremity MRIs. Our goal is to identify shoppable, homogenous MRI scans (e.g. those that were not part of an emergency episode or that occurred during an inpatient stay). In Appendix B1, we describe how we identify lower-limb MRI scans and the sample restrictions we put in place so that the MRIs in our sample were ones where consumers could actively make decisions. Appendix B1 also illustrates how each restriction impacts our sample size.

As we describe in Appendix B2, we are also able to identify the physicians' who ordered patients' MRI scans. This allows us to link the referring physician ID to data from SK&A and infer whether referring physicians are part of vertically integrated organizations. The SK&A physician-level dataset identifies the group or hospital that owns a practice at which a given physician is employed. For our purposes, a physician is said to be in a "vertically integrated" practice if her practice is owned by a hospital. In the case of physicians practicing in multiple locations, we regard those physicians as being vertically integrated if any of the practices in which they work is hospital-owned.[1]

Our data contributor provides all their policy-holders with free access to a tool to search for providers and sort providers by distance and price. The tool links to claims data, so beneficiaries can observe their potential out-of-pocket payments at each location as a function of their plan design and year-to-date spending. We merge data on the use of this tool into our analysis. The transparency tool data includes a patient ID (which we use to link to the claims data), the date of the search, and information on what type of procedure the patient searched for. As a result, we can identify users who searched for MRI prices prior to receiving an MRI scan.

Our data include the amounts patients paid for the taking and reading of their MRIs via co-insurance, co-payments, and payments under their deductibles. Our data also include the prices our data our data contributor has negotiated with facilities and physicians for the taking and reading of MRIs. More specific information on how we construct price measures for lower-limb MRIs is described in Appendix B3.

2.2 Inferring MRI Quality

We assume that the taking and reading of MRIs is undifferentiated across providers. While the actual taking of the MRI scan is undifferentiated, there is evidence of differentiation in the reading of MRI scans across radiologists. For example, Briggs et al. (2008) found that in 13 percent of neurological MRI scans, there was a major difference in diagnosis when a specialist radiologist reviewed the findings of a general radiologist. However, most evidence on diagnostic radiology errors have been observed in the documentation of cancers (Brady 2017). We focus on analysis of lower-limb MRI scans following a referral by an orthopedic surgeon. As a result, radiologists in our sample are generally looking for structural anomalies (e.g. torn ligaments), not subtle evidence of a cancer. Moreover, 84 percent of patients in our sample had follow-up visits with

[1] We can link more than 95 percent of the referring physicians in our sample to the SK&A data. We assume physicians we cannot link to the SK&A data are not in vertically integrated practices. Our results are also robust to the alternative assumption that those physicians' practices are vertically integrated.

orthopedic surgeons in the six months after the taking of their MRI. Orthopedists tend to review MRI results themselves before they initiate surgery, and Kim et al. (2008) and Figueiredo et al. (2018) found no difference in the diagnoses made when scans were read by orthopedists versus radiologists. Recall that we limit our sample to patients who see an orthopedist within 3 months of their scan and whose scan is ordered by an orthopedist. Thus, the sample of patients we analyze will experience the "reading quality" of their orthopedist, not the facility where the scan is done. Therefore, we assume that the MRI scan service we study is undifferentiated with respect to clinical quality across providers.

2.3 Constructing Patient Choice Sets and Estimating Payments at Alternate Providers

For each patient who underwent an MRI in our sample, we construct a choice set of MRI providers within a 60-minute drive of the patient's home. Details of how we construct this drive time-based choice set are described in Appendix B4. By using drive time instead of straight-line distance, we allow patients in rural areas to travel farther in the same amount of time than patients in densely populated cities.

The price of an MRI at each provider is calculated as the average of the prices of scans at that provider during our time period. The price we calculate includes the payments for the taking and reading of an MRI scan. Our combined price is the allowed amount captures the patient and insurer contributions to total payment for a scan. We then estimate what patients and our data contributor would pay for a lower-limb MRI scan at alternate, lower-priced providers. While we do not directly observe beneficiaries' plan characteristics, we can infer plan benefit designs from our data (see Appendix B4 for a detailed discussion of our strategy for identifying counterfactual payments).

For every case in our data, we identify the lowest priced alternative provider within a 60-minute drive from the patient's home zip code. This is a mechanical calculation that ignores capacity constraints and GE effects. We then calculate the "money left on the table" by patients and insurers. The "money left on the table" is the amount of money the patient and the insurer would have saved respectively had the patient received an MRI scan at this lowest-priced location.

3 Results

3.1 Descriptive Statistics

The mean total price of MRI scans in our data (i.e. sum of allowed amounts on both physician and facilities claims) is $850.07 (Panel A of Table 1). Twenty-five percent of MRIs in our sample were performed in hospitals. Hospital-based MRIs have an average price of $1,474.35; non-hospital-based scans have an average price of $642.82.

Patients in our data contribute $305.53, on average, to the cost of MRIs, while the insurer pays $544.54. 22 percent of patients in our data paid for the entirety of their MRI, 54 percent had non-zero cost-sharing but did not bear the full cost of their scan, and 24 percent had zero out-of-pocket costs. Of those individuals who had cost sharing, 31 percent had health care costs over $5,000 in the three months after the taking of the scan, 38 percent had health care costs over $5,000 in the six months after the taking of the scan, and 19 percent had health care costs over $10,000 in the six months after the taking of the scan.

As we illustrate in Panel A of Table 1, the median patient in our sample attends a provider that is approximately a 22-minute car ride from her home. We also find that the median patient had 16 MRI locations within 30-minutes of her home. In 20 percent of cases, the patient received an MRI on the same day she saw an orthopedist.

3.2 Within Market Variation in MRI Prices

There is significant variation in the price of MRI providers within HRRs. As we illustrate in Appendix Table A.1, the median HRR has 10 providers who delivered at least one scan to our sample population in 2013. Across the 302 HRRs in our sample, the median ratio between the 80th and 20th percentile provider prices is 1.73. In 89 percent of HRRs, the highest-priced provider within the HRR is a hospital. Notably, despite the fact that hospital-based MRIs tend to be approximately 2.3 times as expensive as MRIs performed outside of a hospital, in 25 percent of HRRs, the highest volume MRI provider is a hospital.

3.3 Maximum Potential Savings

We calculate how much a patient and her insurer could save if she received an MRI scan from the lowest priced provider within a 60-minute drive from her home instead of where she currently received care. While these estimates ignore GE effects and capacity constraints, they give a sense of the potential savings available if patients attended lower cost providers. We refer to these savings as the 'maximum potential savings.'

The maximum potential savings for patients and insurers that we observe are substantial (Panel A of Table 2). As we illustrate, if patients attended the lowest priced provider within an hour drive from their homes, there would be a mean savings per case of \$468.53 and a reduction in MRI spending of 55.12 percent. Under this counterfactual, patient out-of-pocket costs for the MRI would decrease, on average, by 44.23 percent from \$305.53 to \$170.40. Likewise, insurers would lower their average spending on each lower-limb MRI by 61.22 percent, from \$544.54 to \$211.15.

3.4 Association of MRI Prices with Quality, Distance, and Out-of-Pocket Costs

When economists write down choice models, the attributes of health care providers that patients are assumed to value typically include quality, distance from home, and price. We examine, in turn, the extent to which each of these factors may explain the patterns we observe.

Quality does not appear to vary across MRI providers. We assume that the reading of the MRI scan is done by the orthopedic surgeon who ordered the imaging study. The remaining measure of clinical quality is therefore whether MRI scan is correctly taken or needs to be repeated. However, as we illustrate in Appendix Table A.2, of the 50,484 MRI scans in our data, only three were repeated within 90 days.

Likewise, we find that patients can access lower-priced providers and obtain significant savings without travelling farther than they already went for care. In Panel B of Table 2, we test the share of the maximum potential savings that would be available if patients travelled no farther than they already went for care, 15-minutes minutes farther, 30-minutes farther, and 45-minutes farther. As we illustrate, if patients attended the lowest price provider reachable in the same time they traveled to reach their original providers, out-of-pocket costs could be reduced by 27 percent, insurance spending could be reduced by 41 percent, and total spending on lower-limb MRIs could be reduced by 36 percent. As a result, 65 percent of the maximum potential savings outlined in Panel B of Table 2 is available without forcing patients to travel farther than they already were travelling for care. Savings of this magnitude are possible without forcing patients to travel farther for care because, on average, patients travelled past six lower priced MRI providers between their home and the where they received an MRI scan.

In Appendix Table A.3, we observe, in our conditional correlates, that individuals with higher out-of-pocket costs receive cheaper lower-limb MRI scans. For example, we observe that relative to individuals who bore the full cost of their scan in out-of-pocket costs, individuals with zero price exposure had MRIs that were \$101 more expensive, left \$97 more dollars on the table, and were three percentage points more likely to receive a hospital-based scan. However, because of the structure of insurance plans, individuals may have spot prices (i.e. the price they pay when they access care) that differ markedly from their shadow prices (i.e. the expected true price given that some individuals will exceed their out-of-pocket maximum). Previous research has found that when faced with these non-linear contracts (e.g. commercial health insurance plans with high up front cost-sharing and out-of-pocket maximums), individuals tend to respond to the spot price, not the shadow price (Einav, Finkelstein, and Schrimpf 2015; Dalton, Gowrisankaran, and Town 2015; Brot-Goldberg et al. 2017).

Consistent with previous findings, individuals in our sample do not appear to effectively differentiate between spot and shadow prices. While we are unable to identify when individuals are over their deductible, we can observe individuals' health spending in the three, six, and 12 months after the taking of their MRI scan. In Appendix Table A.4, we further subdivide those patients some cost with some or total cost exposure into those who have health care costs above and below \$5,000 in the six months after they received care. A threshold of \$5,000 was chosen as most plans from our insurer have out-of-pocket maximums of \$5,000.[2] For many individuals, health care costs over \$5,000 in the six months after a scan would mean they faced a shadow price of zero for their MRI scan, depending on when their deductible reset. When we differentiate between individuals who bore the full cost of their MRI with low future spending (e.g. those with a spot price that matches their shadow price) and those who likely bore the full cost of their MRI but had high future spending (e.g. those who had a shadow price that is considerably lower than their spot price), we find that there is no statistically significant difference between the prices of their MRIs. This result is robust when we split those with cost sharing into groups with other levels of spending and shorter and longer windows in which we measure spending (see Appendix Tables A.5 to A.8).

3.5 Use of Price Transparency Tools

Of note, as we illustrate in Appendix Table A.9, very few individuals searched for the price of an MRI scan before receiving a scan. Of the 50,484 lower-limb MRI scans in our sample, patients used the price transparency tool supplied by the insurer to search for the price of MRI providers prior to receiving care in only 374 of cases (0.74 percent). This result is consistent with previous analysis from Desai et al. (2017), which also found that few privately insured individuals use price transparency tools before accessing care.

3.6 Drivers of Money Left on the Table

To better understand the factors that explain the variance in lower-limb MRI scan prices, total amount of money left on the table, and whether an MRI scan is performed in a hospital, we perform an ANOVA and include controls for patients' out-of-pocket price exposure, patient demographic characteristics (year of birth,

[2] We use this strategy because we cannot observe when individuals' deductibles reset each year and the reset dates differ across plans in our data.

Charlson comorbidity score, race, and sex), fixed-effects for patients' home HRR, and fixed-effects for patients' referring physicians.

Our results indicate that referring physicians heavily influence where patients receive care. As we illustrate in Table 3, referrer fixed-effects explain the largest share of the variance in the price of MRIs, money left on the table, and whether or not a patient received a hospital-based MRI scan. Indeed, referrer fixed effects explain 51.47, 50.38, and 54.39 percent of the variance in each variable, respectively. As we illustrate in Appendix Table A.10, this result remains robust when we substitute fixed effects for the zip code where the patient lives for fixed effects for the HRR where the patient lives. These results are also robust to excluding the 20 percent of MRI cases that were delivered on the same day a patient saw an orthopedic surgeon. Likewise, in Appendix Table A.11, we carry out a similar decomposition using an alternative approach, where we use the price of a patient's MRI as the dependent variable, and identify the R2 statistic for a series of regressions including various combinations of covariates (e.g. zip code fixed effects, patient characteristics, referrer fixed effects) in each regression. Our results using this alternative approach remain qualitatively unchanged.

3.7 Referring Physicians, Prices, and Money Left on the Table

Orthopedists tend to refer their patients to a narrow group of MRI providers. In our data, the average referring orthopedic surgeon made 10 referrals for lower-limb MRIs in 2013 (Panel B of Table 1). The median orthopedic surgeon sent patients to 2.5 locations and the median referring physician's modal referral location received 79 percent of her referrals.

As we illustrate in Panel C of Table 2, one consequence of this is that, in order for patients and insurers to save money, patients need to diverge from referring physicians' established referral patterns. Indeed, if each patient received an MRI from the modal location where his or her orthopedist referred patients, it would result in only a 10.72 percent reduction in MRI spending and achieve only 19.65 percent of the maximum potential savings.

3.8 Vertical Integration and MRI Costs

The ownership structure of the practices where referring physicians work also influences where patients receive care. As we describe in Panel B of Table 1, 14 percent of orthopedic surgeons in our sample worked in hospital-owned practices. Appendix Figure A.1 shows for each orthopedic surgeon in our data, the share of the surgeon's patients she sent from her practice to a hospital to receive a lower-limb MRI scan. Vertically integrated physicians are more likely to send patients for hospital-based scans. Among non-vertically-integrated referring physicians, the mean orthopedic surgeon sent 19 percent of her patients for a hospital-based scan. By contrast, the mean vertically-integrated referring physician sent 52 percent of her patients for a hospital-based MRI.

Table 4 presents results from a regression in which each observation is an MRI scan and the dependent variable is either the total price of an MRI, the patient contribution, the insurer contribution, the money left on the table, an indicator for whether a patient had a hospital-based scan, or an indicator for whether an MRI scan was repeated. In addition to controlling for patient characteristics and the patient's HRR, we include an indicator for whether a patient's referring physician is part of a hospital-owned practice. We observe that patients with a vertically integrated referring physician were 27 percentage points more likely to receive a hospital-based MRI and had scans that were $277.19 more expensive. This results in an additional $89.68 in out-of-pocket costs, $187.51 more spending by insurers, and another $270.20 left on the table.[3]

4 Discussion and Conclusions

We explore the extent to which patients currently shop for health care by examining how individuals with private health insurance currently consume pre-planned lower-limb MRI scans. Lower-limb MRI scans are a useful procedure to study for this analysis because they are plausibly homogenous and can be planned in advance by patients. We posit that if patients do not effectively choose an imaging provider, they are likely to struggle when they make even more complicated health care consumption decisions.

We find that, on average, patients travel past six lower-priced providers in route to where they received care. Indeed, we find that if patients had attended the lowest cost provider within the distance they already travelled, they could have reduced their out-of-pocket costs by $83.93 (27.47 percent) and insurer spending by $220.52 (40.50 percent). Patients' out-of-pocket cost exposure explained only 2.37 percent of the variance in MRI price prices and 2.29 percent of the money left on the table (these represent 4.24 percent and 4.19 percent, respectively, of the explained variance). Moreover, despite mean out-of-pocket costs of over $300.00 per scan, less than 1 percent of individuals in our sample searched for the price of lower-limb MRI scans before accessing care.

Ultimately, we find that a patient's referring physician is the strongest determinant of the cost of the MRI scan that a patient receives, the money that they leave on the table, and whether or not they receive a hospital-based MRI scan. In our decomposition, referring physician fixed effects explain 51.47 percent of the variance in price of an MRI a patient received (92.08 percent of the explained variance). Our results speak to the importance of the agency relationship in determining where patients receive care. We observe that the median referring physician (orthopedic surgeons in our sample) refers patients to three MRI providers, while the modal location where they send their patients captures 79 percent of their referrals. As a result, in order to attend a cheaper MRI provider, patients need to be diverted from their physicians' pre-established referral pathways. These results indicate that in order to lower MRI spending, insurers could work with physicians themselves to influence where they sent their patients, narrow provider networks, or introduce such strong incentives to patients that they request different referrals or seek out different referring physicians.

However, modifying referral patterns is complicated because physicians' referrals are linked to the ownership structure of their medical practices. Patients who were treated by an orthopedic surgeon working in a hospital-owned practice received more expensive MRI scans, left more money on the table, and were 27 percent more likely to receive a hospital-based scan.

Our evidence suggests that, at present, patients in our sample do not 'shop' for care. This is in spite of significant out-of-pocket costs, ready access to a price transparency tool, and the opportunity to reduce their spot price without traveling longer distances. Going forward, our findings suggest that because of the weight patients appear to place on the advice of their referring physicians, it is unlikely that a significant number of patients will use information from an app or from a pricing webpage to diverge from where their physicians typically send patients for imaging studies. Given that we observe these results for patients consuming lower-limb MRI scans, it is even less likely that patients will actively price shop for more complex and differentiated services.

[3]One argument in favor of vertical integration between physicians and hospitals is that it could increase care coordination between providers (Baicker and Levy 2013). While this is a possibility we cannot exclude, because the cases we examine are not emergencies, there is time to get the scan to the orthopedist without any adverse impact on the health of the patient.

Our work has direct implications for the study of health care markets and for public policy. Most models of how patients choose where to receive care do not explicitly model the role of referring physicians and often find that the distance between patients and providers is the primary determinant of where patients receive care. While the distance from a patient's home to her hospital may be an important predictor of where she receives care in an emergency, our work suggests that for care where individuals rely on the advice of their referring physicians, referring physicians' preferences may dominate the effects of cost-sharing and distance in determining where patients receive care. Our work therefore suggests that economists should integrate the impact of agency into models of patient choice, particularly in non-emergent settings.

On the policy front, over the last 20 years, much of the focus for insurers has been on determining how to use demand side cost sharing to drive patients to consume health care more efficiently. Our results, consistent with Brot-Goldberg et al. (2017), suggest that blunt tools such as high deductibles are not very effective at influencing patients' choices. Our results indicate that while demand side cost sharing may reduce the rates that individuals access care (with uncertain impacts on welfare), once individuals meet with their physician, they rely heavily on their physician's advice in deciding where to receive subsequent care. This suggests that insurers should work to steer their beneficiaries towards lower priced providers and towards referring physicians that make lower-priced referrals, and that policy-makers and insurers should work to incentivize physicians to make more efficient referrals. In short, price conscious referring physicians are likely to be crucial for raising the price elasticity of MRI scans.

References

Afendulis, Christopher C and Daniel P Kessler (2007). "Tradeoffs from Integrating Diagnosis and Treatment in Markets for Health Care". In: *American Economic Review* 97 (3), pp. 1013–1020. URL: `https://doi.org/10.1257/aer.97.3.1013`.

Akın, Ş Nuray and Brennan C Platt (2014). "Insurance, Consumer Search, and Equilibrium Price Distributions". In: *Journal of Risk and Insurance* 81 (2), pp. 397–429. URL: `https://doi.org/10.1111/j.1539-6975.2013.01515.x`.

Arrow, Kenneth J (1963). "Uncertainty and the Welfare Economics of Medical Care". In: *American Economic Review* 53 (5), pp. 941–973. URL: `http://www.jstor.org/stable/1812044`.

Baicker, Katherine, William H Dow, and Jonathan Wolfson (2006). "Health Savings Accounts: Implications for Health Spending". In: *National Tax Journal*, pp. 463–475. URL: `https://www.ntanet.org/NTJ/59/3/ntj-v59n03p463-75-health-savings-accounts-implications.html`.

Baicker, Katherine and Helen Levy (2013). "Coordination Versus Competition in Health Care Reform". In: *New England Journal of Medicine* 369 (9), pp. 789–791. URL: `https://doi.org/10.1056/NEJMp1306268`.

Baker, Laurence C, M Kate Bundorf, and Daniel P Kessler (2014). "Vertical Integration: Hospital Ownership of Physician Practices is Associated with Higher Prices and Spending". In: *Health Affairs* 33 (5), pp. 756–763. URL: `https://doi.org/10.1377/hlthaff.2013.1279`.

— (2016). "The Effect of Hospital/Physician Integration on Hospital Choice". In: *Journal of Health Economics* 50, pp. 1–8. URL: `https://doi.org/10.1016/j.jhealeco.2016.08.006`.

Berry, Steven, James Levinsohn, and Ariel Pakes (1995). "Automobile Prices in Market Equilibrium". In: *Econometrica* 63 (4), pp. 841–890. URL: `http://www.jstor.org/stable/2171802`.

Brady, Adrian P (2017). "Error and discrepancy in radiology: inevitable or avoidable?" In: *Insights into imaging* 8 (1), pp. 171–182. URL: `https://doi.org/10.1007/s13244-016-0534-1`.

Briggs, GM et al. (2008). "The Role of Specialist Neuroradiology Second Opinion Reporting: Is There Added Value?" In: *Clinical Radiology* 63 (7), pp. 791–795. URL: `https://doi.org/10.1016/j.crad.2007.12.002`.

Brot-Goldberg, Zarek C et al. (2017). "What Does a Deductible Do? The Impact of Cost-Sharing on Health Care Prices, Quantities, and Spending Dynamics". In: *Quarterly Journal of Economics* 132 (3), pp. 1261–1318. URL: `https://doi.org/10.1093/qje/qjx013`.

Brown, Zach (2016). *Equilibrium Effects of Health Care Price Information*. (Revised March 2018) Available at `http://www-personal.umich.edu/~zachb/zbrown_eqm_effects_price_transparency.pdf`.

— (2017). *An Empirical Model of Price Transparency and Markups in Health Care*. (Revised January 2018) Available at `http://www-personal.umich.edu/~zachb/zbrown_empirical_model_price_transparency.pdf`.

Bumiller, Elisabeth (2016). *Bush Promotes Health Accounts at Wendy's*. The New York Times. URL: `https://www.nytimes.com/2006/02/16/politics/bush-promotes-health-accounts-at-wendys.html`.

Capps, Cory, David Dranove, and Mark Satterthwaite (2003). "Competition and Market Power in Option Demand Markets". In: *RAND Journal of Economics* 34, pp. 737–763. URL: `https://www.jstor.org/stable/1593786`.

Carroll, Caitlin et al. (2018). "Effects of Episode-Based Payment On Health Care Spending and Utilization: Evidence from Perinatal Care in Arkansas". In: *Journal of Health Economics* 61 (September), pp. 47–62. URL: `https://doi.org/10.1016/j.jhealeco.2018.06.010`.

Chandra, Amitabh et al. (2016). "Health Care Exceptionalism? Performance and Allocation in the US Health Care Sector". In: *American Economic Review* 106 (8), pp. 2110–44. URL: `https://doi.org/10.1257/aer.20151080`.

Cooper, Zack et al. (2018). *The Price Ain't Right? Hospital Prices and Health Spending on the Privately Insured*. Working Paper 2018. (Revised May 2018). National Bureau of Economic Research. URL: `http://www.nber.org/papers/w21815`.

Dalton, Christina M, Gautam Gowrisankaran, and Robert Town (2015). *Salience, Myopia, and Complex Dynamic Incentives: Evidence from Medicare Part D*. Working Paper 21104. (Revised May 2018). National Bureau of Economic Research. URL: `http://www.nber.org/papers/w21104`.

Desai, Sunita et al. (2017). "Offering a Price Transparency Tool Did Not Reduce Overall Spending Among California Public Employees and Retirees". In: *Health Affairs* 36 (8), pp. 1401–1407. URL: `https://doi.org/10.1377/hlthaff.2016.1636`.

Dionne, Georges and Louis Eeckhoudt (1984). "Insurance and Saving: Some Further Results". In: *Insurance: Mathematics and Economics* 3 (2), pp. 101–110. URL: `https://doi.org/10.1016/0167-6687(84)90048-9`.

Einav, Liran, Amy Finkelstein, and Paul Schrimpf (2015). "The Response of Drug Expenditure to Nonlinear Contract Design: Evidence from Medicare Part D". In: *Quarterly Journal of Economics* 130 (2), pp. 841–899. URL: `https://doi.org/10.1093/qje/qjv005`.

Figueiredo, Sergio et al. (2018). "Use of MRI by Radiologists and Orthopaedic Surgeons to Detect Intra-articular Injuries of the Knee". In: *Revista Brasileira de Ortopedia (English Edition)* 53 (1), pp. 28–32. URL: `https://doi.org/10.1016/j.rboe.2016.12.013`.

Frank, Matthew et al. (2015). "The Impact of Tiered Network of Hospital Choice". In: *Health Services Research* 50 (5), pp. 1628–1648. URL: `https://doi.org/10.1111/1475-6773.12291`.

Frost, Amanda and David Newman (2016). *Spending on Shoppable Services in Health Care*. Brief 11. Available at http://www.healthcostinstitute.org/files/Shoppable%20Services%20IB%203.2.16_0.pdf. Health Care Cost Institute Issue.

Gowrisankaran, Gautam, Aviv Nevo, and Robert Town (2015). "Mergers when Prices are Negotiated: Evidence from the Hospital Industry". In: *American Economic Review* 105 (1), pp. 172–203. URL: https://doi.org/10.1257/aer.20130223.

Gruber, Jonathan and Maria Owings (1996). "Physician Financial Incentives and Cesarean Section Delivery". In: *RAND Journal of Economics* 27, p. 99. URL: https://www.jstor.org/stable/2555794.

Harris, Katherine M (2003). "How Do Patients Choose Physicians? Evidence from a National Survey of Enrollees in Employment-Related Health Plans". In: *Health Services Research* 38 (2), pp. 711–732. URL: https://doi.org/10.1111/1475-6773.00141.

Ho, Katherine (2006). "The welfare effects of restricted hospital choice in the US medical care market". In: *Journal of Applied Econometrics* 21 (7), pp. 1039–1079. URL: https://doi.org/10.1002/jae.896.

Ho, Katherine and Ariel Pakes (2014). "Hospital Choices, Hospital Prices, and Financial Incentives to Physicians". In: *American Economic Review* 104 (12), pp. 3841–84. URL: https://doi.org/10.1257/aer.104.12.3841.

Hubbard, Thomas N (1998). "An Empirical Examination of Moral Hazard in the Vehicle Inspection Market". In: *RAND Journal of Economics* 29 (2), pp. 406–426. URL: http://www.jstor.org/stable/2555895.

Iglehart, John K (2009). "Health Insurers and Medical-Imaging Policy — A Work in Progress". In: *New England Journal of Medicine* 360 (10), pp. 1030–1037. URL: https://doi.org/10.1056/NEJMhpr0808703.

JP Morgan Chase & Co. (2017). *Paying Out-of-Pocket: The Healthcare Spending of 2 Million US Famililies*. JP Morgan Chase & Co. Institute. New York, NY. URL: https://www.jpmorganchase.com/corporate/institute/report-affording-healthcare.htm.

Kaiser Family Foundation (2015). *Employer Health Benefits Annual Survey: 2015*. Menlo Park, CA: The Henry J. Kaiser Family Foundation. Accessed June 2018. URL: http://files.kff.org/attachment/report-2015-employer-health-benefits-survey.

— (2017). *Employer Health Benefits Annual Survey: 2017*. Menlo Park, CA: The Henry J. Kaiser Family Foundation. Accessed June 2018. URL: http://files.kff.org/attachment/Report-Employer-Health-Benefits-Annual-Survey-2017.

Kim, Allis et al. (2008). "Effect of Specialty and Experience on the Interpretation of Knee MRI Scans". In: *Bulletin of the NYU Hospital for Joint Diseases* 66, p. 272. URL: https://pdfs.semanticscholar.org/fa42/f3b9fde191aaf4191d73ceb0d3f9fb0af9b0.pdf.

Kocher, Robert and Nikhil R Sahni (2011). "Hospitals' Race to Employ Physicians – The Logic behind a Money-Losing Proposition". In: *New England Journal of Medicine* 364 (19), pp. 1790–1793. URL: https://doi.org/10.1056/NEJMp1101959.

Lee, David W and Frank Levy (2012). "The Sharp Slowdown In Growth Of Medical Imaging: An Early Analysis Suggests Combination Of Policies Was The Cause". In: *Health Affairs* 31 (8), pp. 1876–1884. URL: https://doi.org/10.1377/hlthaff.2011.1034.

Levitt, Steven D and Chad Syverson (2008). "Market Distortions When Agents Are Better Informed: The Value of Information in Real Estate Transactions". In: *Review of Economics and Statistics* 90 (4), pp. 599–611. URL: https://doi.org/10.1162/rest.90.4.599.

Lieber, Ethan M J (2017). "Does It Pay to Know Prices in Health Care?" In: *American Economic Journal: Economic Policy* 9 (1), pp. 154–79. URL: https://doi.org/10.1257/pol.20150124.

Litkowski, Patricia E (2016). "Curbing the Urge to Image". In: *American Journal of Medicine* 129, pp. 1131–1135. URL: https://doi.org/10.1016/j.amjmed.2016.06.020.

Mahomed, Safiyyah et al. (2018). "Changes in Ability of Hospitals to Provide Pricing for Total Hip Arthroplasty from 2012 to 2016". In: *JAMA Internal Medicine* 178 (8), pp. 1132–1133. URL: http://dx.doi.org/10.1001/jamainternmed.2018.1473.

Mehrotra, Ateev et al. (2017). "Americans Support Price Shopping For Health Care, But Few Actually Seek Out Price Information". In: *Health Affairs* 36 (8), pp. 1392–1400. URL: https://doi.org/10.1377/hlthaff.2016.1471.

Pope, Devin G (2009). "Reacting to rankings: Evidence from "America's Best Hospitals"". In: *Journal of Health Economics* 28 (6), pp. 1154–1165. URL: http://www.sciencedirect.com/science/article/pii/S0167629609000873.

Robinson, James, Christopher Whaley, and Timothy Brown (2016). "Association of reference pricing for diagnostic laboratory testing with changes in patient choices, prices, and total spending for diagnostic tests". In: *JAMA Internal Medicine* 176 (9), pp. 1353–1359. URL: http://dx.doi.org/10.1001/jamainternmed.2016.2492.

Romley, John A and Dana P Goldman (2011). "How Costly is Hospital Quality? A Revealed-Preference Approach". In: *Journal of Industrial Economics* 59 (4), pp. 578–608. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-6451.2011.00468.x.

Samuelson, Paul A (1948). *Economics: The Original 1948 Edition*. McGraw-Hill Education.

Schoen, Cathy et al. (2011). *State Trends in Premiums and Deductibles, 2003-2010: The Need for Action to Address Rising Costs*. Brief 26. Available at http://europepmc.org/abstract/MED/22097393. Commonwealth Fund Issue, pp. 1–38.

Song, Zirui et al. (2014). "Changes in Health Care Spending and Quality 4 Years into Global Payment". In: *New England Journal of Medicine* 371 (18), pp. 1704–1714. URL: http://dx.doi.org/10.1056/NEJMsa1404026.

Volpp, Kevin G (2016). "Price Transparency: Not a Panacea for High Health Care Costs". In: *JAMA* 315 (17), pp. 1842–1843. URL: http://dx.doi.org/10.1001/jama.2016.4325.

Whaley, Christopher, Jennifer Schneider Chafen, and Sophie Pinkard (2014). "Association Between Availability of Health Service Prices and Payments for These Services". In: *JAMA* 312 (16), pp. 1670–1676. URL: http://dx.doi.org/10.1001/jama.2014.13373.

White, Chapin and Megan Eguchi (2014). *Reference Pricing: A Small Piece of the Health Care Price and Quality Puzzle*. National Institute for Health Care Reform. Available at http://nihcr.org/wp-content/uploads/2016/07/Research_Brief_No._18.pdf.

Zhang, Xinke et al. (2018). "Does Enrollment in High-Deductible Health Plans Encourage Price Shopping?" In: *Health Services Research* 53 (S1), pp. 2718–2734. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/1475-6773.12784.

Table 1: Descriptive Statistics for MRI Scans and Referring Physicians

Panel A: MRI Descriptive Statistics on MRI Scans

	Mean	S.D.	P25	Median	P75	N
Total amount paid (all MRIs)	850.07	535.48	474.88	647.82	1,049.75	50,484
Total amount paid (hospital-based MRIs)	1,474.35	559.82	1,049.59	1,427.50	1,839.97	12,583
Total amount paid (non-hospital-based MRIs)	642.82	324.89	451.05	546.65	746.53	37,901
Amount paid by patient	305.53	365.20	20.32	178.35	471.96	50,484
Proportion of MRIs performed in hospitals	0.25					50,484
Travel time to provider (min.)	26	18	14	22	33	50,484
No. of providers within 30-minutes	21	21	6	16	30	50,484
No. of providers within 60-minutes	69	59	28	52	85	50,484
No. of providers closer to patient than one attended	13	23	1	5	15	50,484
Share of patients with zero cost-sharing	0.24					50,484
Share of patients who bore the full cost of their MRIs	0.22					50,484

Panel B: Descriptive Statistics on Orthopedists' MRI Referral Patterns

	Mean	S.D.	P25	Median	P75	N
No. of referrals by orthopedists	10	7	6	8	12	3,442
Proportion of hospital-owned orthopedists	0.14					3,299
No. locations where patients received MRIs	2.8	1.7	2.0	2.5	4.0	3,442
Proportion of cases sent to modal MRI location	0.73	0.23	0.56	0.79	0.93	3,442
Share of patients sent to a hospital	0.24	0.34	0.00	0.04	0.40	3,442
Share of patients sent to cost-minimizing location within 30-min drive	0.13	0.23	0.00	0.00	0.18	3,442

Notes: In panel A, each observation is a single lower-extremity MRI that occurred in 2013. A observation in Panel B is an orthopedist that made 5 or more referrals in 2013. 1Of the 3,442 referring orthopedist NPIs in our sample, 143 did not appear in the SK&A data; this is why we are only able to calculate the proportion of hospital-owned referrers across 3,299 orthopedists in our sample

Table 2: Maximum Potential Savings If Patients Went to Alternative Providers

	Total Savings			**Patient Savings**			**Insurer Savings**		
Panel A. Maximum Potential Savings if Patient Went to the Lowest Priced Provider within a 60-minute Drive from their Home									
	Mean Payment	Mean Savings	Perc. Reducing in Spending	Mean Payment	Mean Savings	Perc. Reducing in Spending	Mean Payment	Mean Savings	Perc. Reducing in Spending
	\$850.04	\$468.53	55.12%	\$305.53	\$135.13	44.23%	\$544.54	\$333.39	61.22%
Panel B. The Share of the 'Maximum Potential Savings' That is Achievable by Driving Distance									
	% max savings	% reduc. of total spend	Savings per case (\$)	% max savings	% reduc. of total spend	Savings per case (\$)	% max savings	% reduc. of total spend	Savings per case (\$)
No Farther	64.98%	35.81%	304.45	62.11%	27.47%	83.93	66.14%	40.50%	220.52
+15 Mins	88.44%	48.74%	414.36	86.75%	38.37%	117.23	89.12%	54.57%	297.13
+30 Mins	96.28%	53.07%	451.11	95.49%	42.23%	129.04	96.61%	59.15%	322.07
+45 Mins	99.48%	54.83%	466.07	99.37%	43.95%	134.28	99.52%	60.93%	331.79
Panel C. Savings If Patients Attended the Lowest Priced Location within Referring Physicians' Established Referral Networks									
	% max savings	% reduc. of total spend	Savings per case (\$)	% max savings	% reduc. of total spend	Savings per case (\$)	% max savings	% reduc. of total spend	Savings per case (\$)
	19.65%	10.72%	85.90	16.61%	7.30%	21.49	20.93%	12.71%	64.42

Notes: The Mean Payment columns show what the total, patient, and insurer average payment were for a lower-extremity MRI in our sample of patients. The Mean Savings columns show what the total, patient, and insurer savings would have been had the patient gone to an alternative location. In Panel A, it is the cheapest location within a 60-minute drive from the patient's home. In Panel B, it is savings by travel distance from where they actually received care. In Panel C, it is the savings if patients went to the lowest price provider where their orthopedist referred patients.

Table 3: ANOVA of MRI Price, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan

	Total amount paid		**Money left on the table**		**Probability of hospital-based MRI**	
	(1)	(2)	(3)	(4)	(3)	(4)
	Partial R^2	P-Value	Partial R^2	P-Value	Partial R^2	P-Value
Patient cost sharing F.E.	0.0237	0.0000	0.0229	0.0000	0.0191	0.0000
Patient Charlson score	0.0006	0.0050	0.0005	0.0083	0.0002	0.3844
Patient sex	0.0000	0.4159	0.0000	0.4985	0.0000	0.4691
Patient year of birth	0.0005	0.0642	0.0004	0.1517	0.0005	0.0496
Patient race	0.0001	0.3867	0.0001	0.2934	0.0002	0.1742
Patient HRR F.E.	0.0194	0.0000	0.0188	0.0000	0.0187	0.0000
Referring orthopedist F.E.	0.5147	0.0000	0.5038	0.0000	0.5439	0.0000
Obs.	35,852		35,852		35,852	

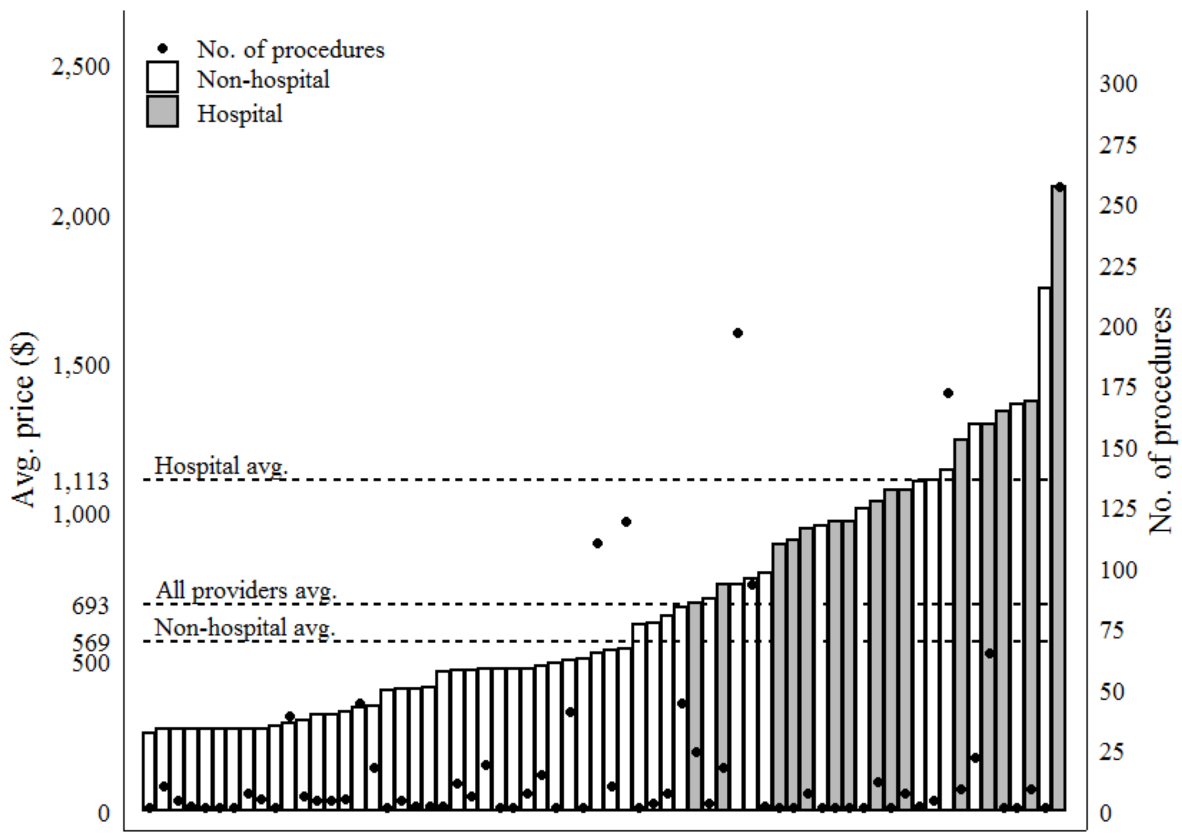
Notes: This table presents the partial R^2s from an analysis of variance (ANOVA) of factors in explaining MRI prices, the amount of money patients could save themselves and their insurer had the patient gone to the minimum cost provider within 60-minutes' driving time of their homes, and the probability that a patient received a hospital-based MRI. This table relies on the same sample of patients described in Table 1. We additionally limit the analysis to patients whose referring orthopedists made at least 5 referrals in 2013. This reduces the number of referring orthopedists in the sample from 10,921 to 3,442 and reduces the sample size by 14,619 to 35,865 MRIs. Lastly, we eliminate all observations that is a singleton in any factor variable category. This reduces the sample size by 13 to 35,852 MRIs. Patient cost sharing fixed effects indicate whether a patient had no cost exposure, had some cost exposure, or bore the full cost of her MRI. We identify a patient's referring orthopedist by analyzing 3-months of claims history for each patient before their MRI occurred. If a patient saw a physician NPI with a specialty of orthopedic surgeon, then we assign this orthopedist's NPI as the patient's "referring orthopedist." Appendix Table A.7 re-runs this ANOVA analysis using patient ZCTA fixed effects in lieu of patient HRR fixed effects.

Table 4: The Association Between Vertical Integration, Scan Price, Referral Locations, and Money Left on the Table

	(1)	(2)	(3)	(4)	(5)
	Total amount paid	Patient contribution	Insurer contribution	Money left on the table	Prob. hospital-based MRI
Vertically integrated referrer	277.19***	89.68***	187.51***	270.20***	0.27***
	(33.68)	(12.20)	(25.54)	(33.93)	(0.04)
Omitted Category: MRIs where the referrer was not vertically-integrated with a hospital					
Mean of Omitted Category	759.53	281.43	478.09	395.01	0.16
Obs.	35,852	35,852	35,852	35,852	35,852
R^2	0.2741	0.0993	0.1685	0.2629	0.2271

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Our standard errors are clustered around referring physicians. An observation is a lower-limb MRI. We limit our analysis to referrals made by orthopedic surgeons who referred more than 5 patients for lower-limb MRIs in 2013 and we do not include singleton patient HRRs (this reduces the sample size from 50,484 to 35,852). The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. We regress several outcome variables on two dummy variables: one denotes if the referring orthopedist is vertically integrated with a hospital and the second denotes if we do not know if the referring orthopedist is vertically integrated with a hospital (i.e. one of the 143 orthopedists whose NPI did not appear in the SK&A data).

Figure 1: Variation in MRI Prices in a Densely Populated Hospital Referral Region



Notes: Each bar is a provider address. Bar height indicates the average price of an MRI at that provider's location (left Y-axis). Grey bars indicate hospitals, while white bars are non-hospitals. The black dots denote the number of lower extremity MRIs in our sample performed at that provider address (right Y-axis). These statistics are derived from the same sample of MRIs described in Table 1.

Appendix – For Online Publication

Appendix A Background on Cost Sharing, MRI Scans, and Agency

Advanced imaging studies – MRIs and computed tomography (CT) scans – account for approximately 3 percent of health spending (Iglehart 2009). In the late 1990s and early 2000s, there was double-digit increase year on year in the rate that advanced imaging studies were being performed, in spite of evidence suggesting that nearly half of studies performed may have been unnecessary (Lee and Levy 2012; Litkowski 2016). In addition to increasing cost sharing and promoting price transparency, insurers have increasingly required that physicians obtain prior approval for advanced imaging studies before the payers will fund them for their beneficiaries. It is estimated that approximately half of insurance plans involve prior authorizations and that between 10 and 20 percent of imaging studies are denied during this process (Lee and Levy 2012; Iglehart 2009). While some research has suggested that prior authorizations have reduced the rates at which advanced imaging studies are performed, there is little evidence that introducing price transparency and encouraging patient shopping has been effective.

Most analysis of the impact of health care transparency tools on patient shopping have found that they have had very little effect, in part, because they are rarely used by patients. Lieber (2017) and Whaley, Schneider Chafen, and Pinkard (2014) estimate that users of price transparency tools save approximately 15 percent on the price of imaging services. However, Brown (2017) found that only 8 percent of consumers having an MRI scan used New Hampshire's transparency website before accessing care. Likewise, Lieber (2017) found that at a large restaurant chain, only 12 percent of the employees searched for price information at least once. Similarly, Desai et al. (2017) found that at a sample of large private firms, fewer than 10 percent of individuals offered the transparency tool used it. These results echo findings from a national survey that suggested only three percent of non-elderly individuals in the U.S. had compared prices across providers before receiving care (Mehrotra et al. 2017). Our data allows us to identify the date that individuals access their price transparency tool and observe what services they searched for.

Both Lieber (2017) and Brown (2017) suggest that the use of transparency tools would increase if individuals were more directly exposed to the price of health care services. This proposition is supported by theory modeled by Dionne and Eeckhoudt (1984) and Akın and Platt (2014). Brown (2016) estimates that if individuals had a 50 percent co-insurance rate, this would lead to a 38 percent increase in the number of consumers using price shopping tools. Likewise, Lieber (2017) estimated that individuals who met their deductibles were 1.5 percentage points less likely to search for price information. However, when Brot-Goldberg et al. (2017) examined the impact of switching individuals at a large firm from first dollar coverage to high deductible health plans, they did not observe an increase in price shopping in the year the switch took place or in the second year after the switch. In fact, virtually all the reduction in spending that Brot-Goldberg et al. (2017) observed following the introduction of deductibles came from patients reducing the quantity of health care consumed.

In the face of lackluster results from increasing deductibles and introducing price transparency tools, some private employers have introduced reference pricing schemes to steer individuals to lower cost providers. In a reference pricing program, beneficiaries are enrolled in plans where the payer will only fund care up to the price of the provider in the (for example) 60th percentile of prices in the region where the patient lives. These programs involve even greater potential out-of-pocket exposure for patients, although they can be simpler if there is a list of providers that are below the threshold. A recent analysis found that individuals in a reference pricing program received MRIs that were 12.5 percent lower priced than matched individuals that were not in a reference price program (**robinson2016**).

One understudied potential explanation for why consumers do not price shop is the weight patients place on advice from their referring physicians about where to receive care. Survey data suggests that patients rely heavily on the advice of their physicians when determining where to receive care (Harris 2003) though they may not know the reason why a particular provider is being recommended (e.g. location, friendship tie, etc). Patients can be uncertain about many aspects of their care, including what services are necessary and the quality of providers from whom they could receive treatment. This, as Arrow (1963) noted, gives rise to the need for physicians to serve as agents for their patients.

Decades of literature focusing on health care and other sectors has explored the agency relationship and found that agency is often imperfect (Hubbard 1998; Levitt and Syverson 2008). Within the health care sector, there is a large literature that suggests the presence of supplier induced demand, where patients are encouraged by providers to utilize services they do not need in order to reap financial gain (Gruber and Owings 1996). Physicians may also gain directly or indirectly from the imaging referrals they make. In the 1990s, laws were passed that prohibited physicians from referring patients to facilities where the physicians had an ownership stake (these are often referred to as the Stark laws). However, the law allows physicians to own their own imaging equipment, refer patients to receive scans from inside their owned facilities, and benefit directly. Physicians may also gain indirectly from making referrals within the system where they are employed (Baker, Bundorf, and Kessler 2016).

If physicians were perfect agents for patients, we would expect that aspects of care that are important to the patient (such as out-of-pocket costs) to influence referral choices even if the patient had no direct input into the decision. However, the referrals physicians make may differ from the choices that would be made by a perfectly informed patient, both because the physician may not be fully informed about the patient preferences and patients' out of pocket costs, and because maximizing patient welfare may not be physicians' only objective when they refer patients.

Appendix B Description of Data, Data Cleaning, and Methods

B.1 Identifying Shoppable Lower-Limb MRIs

We build an analytic sample of claims for the most common MRI scan in our data: lower extremity MRIs performed without contrast.[4] We identify lower-limb MRIs in our data as those cases involving either a physician or facility claim with a Current Procedural Terminology (CPT) code of 73721. We identify whether or not a scan was performed in a hospital using the place of service codes on a claim.

Our goal is to identify shoppable, homogenous MRI scans. As a result, we limit our analysis to MRI scans taken during visits where no health care services were provided on the claim other than the "reading" and "taking" of the MRI (this excludes 14 percent of observations). We also exclude MRIs performed during an inpatient stay or as part of an emergency episode, since patients in these cases are unlikely to be able to actively choose where to receive care (less than 1 percent of cases). We limit our analysis to individuals age 19 to 64, exclude cases where there were coordinated benefits (i.e. our insurer co-funded the care with another insurer) (10 percent of cases), exclude cases where the MRI provider was more than a two hour drive from the patient's home ZIP code (3 percent of cases), and exclude cases performed at out-of-network facilities (2

[4]MRI scans can be carried out with or without contrast. MRIs with contrast have higher image clarity and can better show soft tissue, but require the patient to be injected with a contrasting agent called gadolinium. In this analysis, we focus on lower-limb MRI scans performed without contrast. MRI scans without contrast make up the vast majority of scans in our data.

percent of cases).[5] We also restrict our analysis to MRI scans performed on individuals who were continuously enrolled for at least three months in a point of service (POS) insurance product (the modal insurance product offered by our data contributor). We focus on individuals with POS plans because network breadth and the prices insurers have negotiated with providers may differ across the types of insurance products they offer. Applying these restrictions to our data leaves us with an initial sample of 88,292 MRI scans.

B.2 Identifying Patients' Referring Physicians

Nearly all of the beneficiaries in our data needed to have their MRI scan prior authorized by the insurer before the scan would be funded by the insurer. We have data that identifies the physician who requested each patient's prior authorization. We can identify the specialties of physicians who ask for prior authorization of lower-limb MRI scans. The prior authorization data from our insurer indicates that the majority of physicians who order prior authorizations for lower-limb MRI scans are orthopedic surgeons. As a result, in order to identify the referring physicians for each lower-limb MRI scan in our data, we use the claims history of each patient in our sample to find patients who receive a lower-limb MRI scan and have at least one office visit with an orthopedic surgeon within three months of the taking of an MRI scan.[6] We restrict our analysis to patients who saw an orthopedist within three months of a scan so that we can assume that the orthopedist a patient saw before a scan is the referring physician.

Restricting our analysis to patients who saw an orthopedist three months before a lower-limb MRI scan eliminates 36,652 of 88,292 cases. The remaining 51,640 cases are divided as follows. In 93 percent of these cases, patients only saw a single orthopedic surgeon before a scan took place. In 7 percent of cases, however, the patient saw two or more different orthopedic surgeons before a scan occurred. For such patients, we identify whether the patient saw an orthopedic surgeon after the scan. We assume that the orthopedic surgeon who saw the patient both before and after the scan was the referring physician. This captures 68 percent of the cases where patients saw two or more orthopedists before a scan. We exclude the remaining 1,153 cases (2 percent of 51,640 cases) that cannot be categorized this way.[7] After excluding those observations and three observations for which the patient was the only person in their HRR to receive a lower-limb MRI scan, we are left with a final analytic sample size of 50,484.[8] When we transition to analyzing the behavior of referring physicians, we further limit our analysis to referring physicians who ordered at least 5 lower-limb MRIs for patients in our sample population. Doing so excludes 14,619 patient observations.

B.3 Measuring MRI Providers' Prices

We use place of service codes to identify whether an MRI scan was delivered inside or outside a hospital. For hospital-based MRIs, we observe a physician claim for the "reading" of the MRI scan and a facility claim for the "taking" of the MRI scan (this is identified via the presence of a CPT code of 73721). We calculate the total price of a hospital-based MRI scan as the sum of the service lines on the physician and facility claims with a CPT code of 73721 that occurred on the same date with the same patient identifier.

[5]Our data divides patients into five-year age bands. However, individuals aged 18 years are lumped in with individuals under age 18. Since 18 year-old individuals could not be distinguished from minors, we focused on individuals aged 19 to 64.

[6]We identify an orthopedic surgeon by the physician's National Provider Identifier (NPI) number.

[7]These include cases where 1) the patient saw multiple orthopedists both before and after a scan; 2) the patient visited with multiple orthopedists before the scan but none afterwards; and 3) the patient saw multiple orthopedists before the scan and saw one or more orthopedists after the scan who were not the same orthopedists as the ones they saw before the MRI.

[8]We do this to remain consistent with rules in our data use agreement that preclude us from analyzing HRRs with very small numbers of cases.

For non-hospital-based MRIs, providers typically bill for both the taking and reading of an MRI scan on a physician claim. As a result, we calculate the total price of a non-hospital-based MRI scan as the physician claim with a CPT code of 73721.

B.4 Constructing Patients' Choice Sets and Identifying Counterfactual Payments

For each patient who underwent an MRI in our sample, we construct a choice set of MRI providers within a 60-minute drive of each patient's home. To do so, we begin by identifying every provider that delivered an MRI scan to a patient in our sample. Next, we calculate travel times between each patient's home ZIP code (ZCTA) and the addresses of all providers within 100 miles of the patient's ZIP. This is done using the online routing API (application programming interface) provided by "Here", a commercial mapping company. The "Here" software uses average traffic patterns and user reported data to estimate travel time, by car, between two locations. By using travel time instead of distance, we allow patients in rural areas to travel farther in the same amount of time than patients in densely populated cities.

The price of an MRI at each provider is calculated as the average of the inflation-adjusted prices of scans at that provider during our time period. The price we calculate includes the payments for the taking and reading of an MRI scan.[9] Our combined price is the allowed amount, so it includes both the patient and insurer contributions to total payment for a scan. We then estimate what patients and our data contributor would pay for a lower-limb MRI scan at alternate, lower-priced providers.[10] While we do not directly observe beneficiaries' plan characteristics, we can infer plan benefit designs from our data. To infer what patients would have paid at lower-priced locations, we rely on two facts. First, when moved to a lower priced provider, a patient will never pay more towards her deductible than she did on her original episode. Second, coinsurance rates can be inferred for all patients who exceed their deductible and need to pay coinsurance.[11] Our task of inferring co-insurance is made easier by the fact that patients in our sample do not pay fixed co-payments.

[9] Non-hospital-based scans include the reading and taking of an MRI scan on a single physician service line. Hospital-based scans include a physician and a facility claim. Because two different hospital-based MRI cases may involve different radiologists, when we calculate the average combined price of the taking and reading of a scan at a hospital, we also use the average price of the readings of scans at that facility.

[10] We do not need to calculate the level of counterfactual prices at facilities with a higher allowed amount than the chosen facility because these are not used in our counterfactual calculations.

[11] We assume the coinsurance rate c that we observe for patient i who received care at provider j would be the same co-insurance rate that patient i would pay at other locations. This is an assumption that our data contributor has told us applies in virtually every case in the data. The insurer in our data does not have co-payments for MRI scans.

Table A.1: Variation in MRI Prices within HRRs

	Mean	S.D.	Min	P25	Median	P75	Max	N
Number of providers	17	20	1	5	10	21	163	302
Number of hospitals	6	7	0	2	4	8	44	302
Ratio of providers in 80th/20th price distribution	2.05	0.96	1.00	1.34	1.73	2.59	5.97	302
Coef. of variation of price	0.44	0.18	0.00	0.32	0.45	0.55	1.07	301
Share of largest provider	0.39	0.21	0.05	0.23	0.35	0.50	1.00	302
Proportion of HRRs where most expensive provider is a hospital	0.89							302
Proportion of HRRs where largest provider is a hospital	0.25							302

Notes: Each observation is an HRR. These statistics are derived from the same set of MRIs described in Table 1. There are a total of 306 HRRs in the United States. Two provider HRRs are not represented in our sample. Additionally, because we exclude singleton patient HRRs, this reduces the number of provider HRRs in our sample to 302. There is an additional provider HRR where only a single MRI was provided in that HRR to our sample of patients in 2013; this is why we are only able to calculate the coefficient of variation for 301 provider HRRs. The "largest" provider is the location that performs the greatest number of MRIs within an HRR.

Table A.2: 90-Day MRI-Repeat Rate for Hospital-Based and Non-Hospital-Based Providers

	# of Repeated MRIs	Mean	S.D.	N
Hospital-Based	1	0.000079	0.008915	12,583
Non-Hospital-Based	2	0.000053	0.007264	37,901
Difference in Means	0.000027			
Two-sided t-test of difference:	0.7364			

Notes: This table displays the number of patients in our sample who had a lower-extremity MRI repeated within 90-days of their original MRI date. We compare the repeat rate of MRIs for patients who received their original MRI from a hospital and those who received their original MRI from a non-hospital provider (e.g. an imaging center or doctor's office).

Table A.3: Average Payments, Money Left on the Table, and the Probability of a Hospital-Based Scan for Patients with and without Out-of-Pocket Exposure

	(1)	(2)	(3)
	Total amount paid	Money left on the table	Prob. hospital-based MRI
No price exposure	100.68***	97.06***	0.03***
	(8.95)	(8.82)	(0.01)
Some price exposure	239.58***	229.24***	0.17***
	(11.51)	(11.40)	(0.01)
Omitted Category: Patients who bore the full cost of their MRIs			
Obs.	50,484	50,484	50,484
R^2	0.2709	0.2434	0.2094

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions use the sample of MRIs described in Table 1 and are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects.

Table A.4: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $5,000 in Spending within 6 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
No price exposure	103.12***	98.56***	0.03***
	(9.27)	(9.15)	(0.01)
Some price exposure and high future health care costs	31.57***	25.54***	0.02***
	(7.07)	(6.82)	(0.01)
Some price exposure and low future health care costs	229.57***	220.66***	0.16***
	(11.87)	(11.78)	(0.01)
Bore the full cost of their MRI and high future health care costs	7.07	4.32	−0.00
	(7.02)	(6.88)	(0.01)
Omitted Category: Patients who bore the full cost of their MRIs and had low future health care costs			
Obs.	50,484	50,484	50,484
R^2	0.2713	0.2437	0.2098

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. This table compares the average MRI price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $5,000 in health care costs in the six months following their MRIs. Of the 50,484 MRIs in our sample, 19,483 patients (38.6%) were "high" future health care cost patients.

Table A.5: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $5,000 in Spending within 3 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
No price exposure	100.73***	97.07***	0.03***
	(9.18)	(9.06)	(0.01)
Some price exposure and high future health care costs	39.17***	32.55***	0.03***
	(7.53)	(7.29)	(0.01)
Some price exposure and low future health care costs	227.15***	218.87***	0.16***
	(11.75)	(11.65)	(0.01)
Bore the full cost of their MRI and high future health care costs	0.45	0.26	−0.00
	(7.45)	(7.33)	(0.01)
Omitted Category: Patients who bore the full cost of their MRIs and had low future health care costs			
Obs.	50,484	50,484	50,484
R^2	0.2715	0.2438	0.2099

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. This table compares the average MRI price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $5,000 in health care costs in the three months following their MRIs. Of the 50,484 MRIs in our sample, 19,483 patients (38.6%) were "high" future health care cost patients.

Table A.6: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $10,000 in Spending within 6 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
No price exposure	101.75***	97.55***	0.03***
	(9.08)	(8.95)	(0.01)
Some price exposure and high future health care costs	68.86***	58.69***	0.05***
	(10.01)	(9.73)	(0.01)
Some price exposure and low future health care costs	226.76***	217.87***	0.16***
	(11.31)	(11.20)	(0.01)
Bore the full cost of their MRI and high future health care costs	4.69	1.25	0.00
	(9.56)	(9.50)	(0.01)
Omitted Category: Patients who bore the full cost of their MRIs and had low future health care costs			
Obs.	50,484	50,484	50,484
R2	0.2723	0.2445	0.2107

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. This table compares the average MRI price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $10,000 in health care costs in the six months following their MRIs. Of the 50,484 MRIs in our sample, 9,861 patients (19.5%) were "high" future health care cost patients.

Table A.7: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $5,000 in Spending within 12 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
No price exposure	105.41***	100.97***	0.03***
	(9.51)	(9.40)	(0.01)
Some price exposure and high future health care costs	30.44***	25.07***	0.02***
	(6.65)	(6.42)	(0.01)
Some price exposure and low future health care costs	229.50***	220.95***	0.16***
	(12.10)	(12.00)	(0.01)
Bore the full cost of their MRI and high future health care costs	11.02*	9.11	0.00
	(6.57)	(6.47)	(0.01)
Omitted Category: Patients who bore the full cost of their MRIs and had low future health care costs			
Obs.	50,484	50,484	50,484
R^2	0.2713	0.2437	0.2097

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. This table compares the average MRI price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $5,000 in health care costs in the twelve months following their MRIs. Of the 50,484 MRIs in our sample, 23,963 patients (47.5%) were "high" future health care cost patients.

Table A.8: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $10,000 in Spending within 12 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
No price exposure	100.99***	96.74***	0.03***
	(9.10)	(8.97)	(0.01)
Some price exposure and high future health care costs	57.84***	52.20***	0.04***
	(8.22)	(8.02)	(0.01)
Some price exposure and low future health care costs	223.97***	214.54***	0.16***
	(11.30)	(11.19)	(0.01)
Bore the full cost of their MRI and high future health care costs	−1.17	−3.91	−0.00
	(8.47)	(8.40)	(0.01)
Omitted Category: Patients who bore the full cost of their MRIs and had low future health care costs			
Obs.	50,484	50,484	50,484
R2	0.2721	0.2444	0.2103

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. This table compares the average MRI price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $10,000 in health care costs in the twelve months following their MRIs. Of the 50,484 MRIs in our sample, 13,445 patients (26.6%) were "high" future health care cost patients.

Table A.9: Average Payments and Money Left on the Table for Patients Using the Price Transparency Tool

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
Use of Price Transparency Tool	-88.87^{***}	-84.11^{***}	-0.05^{**}
	(22.77)	(22.43)	(0.02)
Obs.	50,484	50,484	50,484
R2	0.2711	0.2436	0.2094

Transparency Tool Use Rate: 374 of 50,484 cases (0.74%)

Notes: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. These regressions use the sample of MRIs described in Table 1. The regressions are run at the patient-level with standard errors clustered around providers. The regressions include controls for patient characteristics, including sex, race, year of birth, and 6-month Charlson comorbidity score. We also include patient HRR fixed effects. Use of Price Transparency Tool is an indicator variable equal to 1 if the patient utilized a price lookup tool for an MRI on or before the date of her MRI.

Table A.10: ANOVA of MRI Price, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan – Patient ZCTA Fixed Effects

	Total amount paid		**Money left on the table**		**Prob. hospital-based MRI**	
	(1)	(2)	(3)	(4)	(3)	(4)
	Partial R^2	P-Value	Partial R^2	P-Value	Partial R^2	P-Value
Patient cost sharing F.E.	0.0212	0.0000	0.0212	0.0000	0.0177	0.0000
Patient Charlson score	0.0006	0.0208	0.0006	0.0211	0.0002	0.6943
Patient sex	0.0000	0.9824	0.0000	0.9629	0.0000	0.7589
Patient year of birth	0.0003	0.6310	0.0003	0.6163	0.0005	0.1295
Patient race	0.0002	0.1410	0.0002	0.1452	0.0002	0.1803
Patient ZCTA F.E.	0.1999	0.0000	0.2059	0.0000	0.2094	0.0000
Referring Orthopedist F.E.	0.4835	0.0000	0.4837	0.0000	0.5239	0.0000
Obs.	33,053		33,053		33,053	

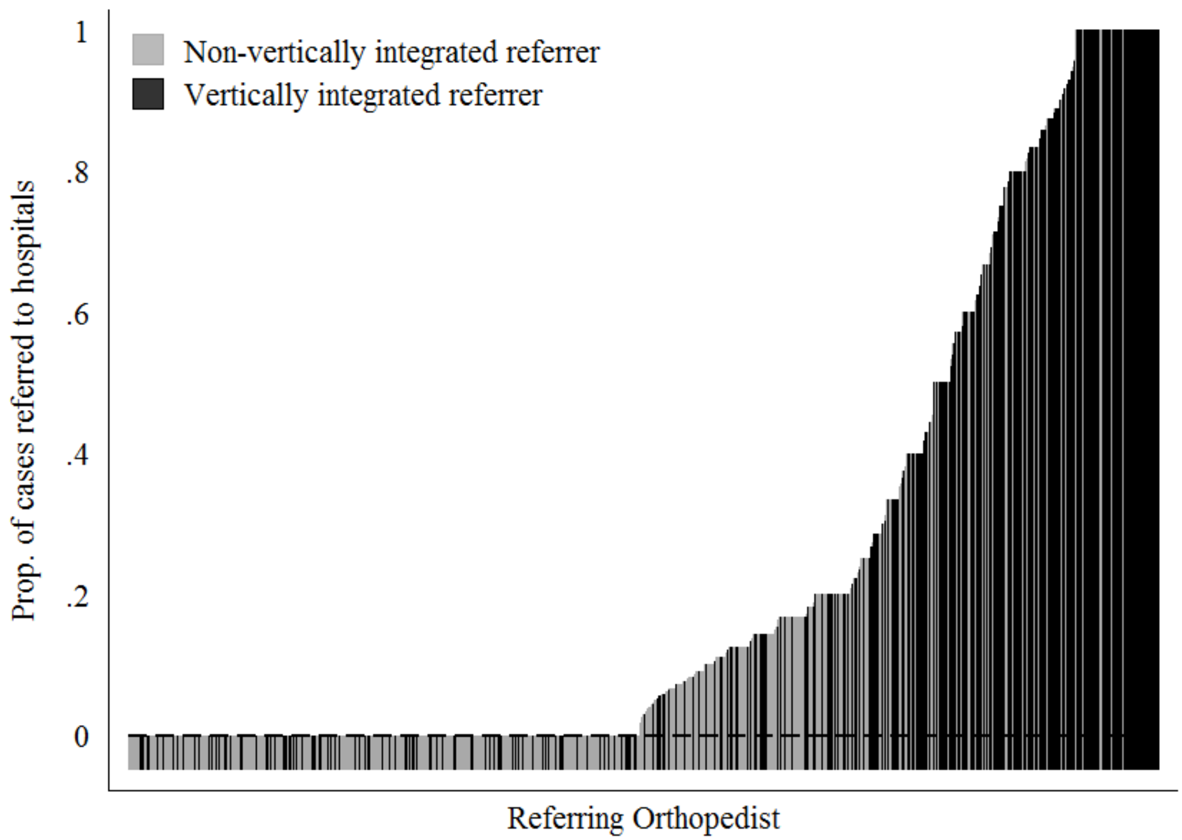
Notes: This table presents the partial R^2s from an analysis of variance (ANOVA) of factors in explaining MRI prices and the amount of money patients could save themselves and their insurer had the patient gone to the minimum cost provider within 60-minute drives of their homes. For example, the entry in the first column and last row of the table indicates that 47.58% of the variation in MRI prices cannot be explained if you exclude referring orthopedist fixed effects from the model. This sample is limited to the same sample of patients described in Table 1. However, instead of removing patients in singleton HRRs, we remove patients in singleton ZCTAs; this changes the sample size from 50,484 to 46,652. In addition, we limit the analysis to patients whose referring orthopedists provided at least 5 referrals in 2013. This reduces the number of referring orthopedists in the sample from 10,039 to 3,441 and reduces the sample size by 12,358 to 34,294 MRIs. Lastly, we eliminate all observations with singleton values within each factor variable. This reduces the sample size by 1,241 to 33,053 MRIs. Patient cost sharing fixed effects indicate whether a patient had no cost exposure, had some cost exposure, or bore the full cost of her MRI. We identify a patient's referring orthopedist by analyzing 3-months of claims history for each patient before their MRI occurred. If a patient saw a physician NPI with a specialty of orthopedic surgeon, then we assign this orthopedist's NPI as the patient's "referring orthopedist."

Table A.11: Decomposing the Drivers of Patients' MRI Prices and Money Left on the Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total amount paid	0.002	0.047	0.243	0.631	0.049	0.274	0.640	0.647
Money left on the table	0.002	0.046	0.232	0.618	0.047	0.262	0.627	0.634
Prob. hospital-based MRI	0.002	0.038	0.184	0.626	0.039	0.211	0.633	0.640
Obs.	35,852	35,852	35,852	35,852	35,852	35,852	35,852	35,852
Patient Controls	Yes	No	No	No	Yes	Yes	Yes	Yes
Patient cost-sharing F.E.	No	Yes	No	No	Yes	Yes	Yes	Yes
Patient HRR F.E.	No	No	Yes	No	No	Yes	No	Yes
Referring Orthopedist F.E.	No	No	No	Yes	No	No	Yes	Yes

Notes: The numbers reported in this table are R^2 values where the dependent variable is either the total price of an MRI or the amount of money left on the table. Each observation is an MRI. This analysis uses the same sample of MRIs described in Table A.7. The money left on the table is the amount patients could have saved themselves and their insurer if they went to the lowest cost provider within a 60-minute drive from their home. Patient controls include sex, race, year of birth, and 6-month Charlson comorbidity score. Patient cost sharing fixed effects indicate whether a patient had no cost exposure, had some cost exposure, or bore the full cost of her MRI. Each column includes a different combination of controls.

Figure A.1: Rate at Which Referring Physicians Send Patients for Hospital-Based MRIs



Notes: Each bar is an orthopedic surgeon. The sample of referrers is limited to the same set used for the analysis in Table A.10 (i.e. orthopedists who made at least five referrals in 2013, excluding singleton patient HRRs). The bar height indicates the proportion of cases an individual orthopedist refers her patients to a hospital. Black bars indicate referrers who are vertically-integrated with a hospital. Grey bars indicate referrers who are not vertically-integrated.