Physician Agency, Consumerism, and the Consumption of Lower-Limb MRI Scans[☆]

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Abstract: We study where privately insured individuals received planned MRI scans. Despite significant out-of-pocket costs for this undifferentiated service, privately insured patients often received care in high-priced locations when lower priced options were available. The median patient in our data has 16 MRI providers within a 30-minute drive of her home. On average, patients bypassed 6 lower-priced providers between their homes and their actual treatment locations. Referring physicians heavily influence where patients receive care. The share of the variance in the prices of patients' MRI scans explained by referrer fixed effects (52 percent) is dramatically greater than the share explained by patient cost-sharing (< 1 percent), patient characteristics (< 1 percent), or patients' home HRR fixed effects (2 percent). In order to access lower cost providers, patients must generally diverge from physicians' established referral patterns.

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I. Introduction

Over the last two decades, policy-makers and private firms in the United States (US) have attempted to reduce health care costs by increasing patients' out-of-pocket cost exposure. From 2007 to 2017, out-of-pocket health care spending in the US increased by approximately 60 percent (Rae et al., 2019). At present, 55 percent of workers 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 2017 were $779 (Kaiser Family Foundation, 2019; Rae et al., 2019). However, to date, the simple prediction from price theory - that increased cost sharing together with accessible pricing information would induce patients to change where they consume care - has not been well supported by the empirical evidence on patient behavior. Specifically, there is scant empirical evidence that when they are enrolled in a deductible plan or given access to price transparency tools, patients increasingly attend low cost care locations for health care services that are relatively undifferentiated (Brot-Goldberg et al., 2017; Desai et al., 2017; Mehrotra et al., 2017).

Using data from a large commercial insurer, we study where individuals age 19 to 64 with private health insurance, high out-of-pocket cost exposure, and access to a price transparency tool received planned lower-limb MRI scans. We analyze the frequency that patients bypassed receiving care at lower price MRI locations and, instead, received care at more expensive providers. We focus, in particular, on quantifying the influence of referring physicians on the locations where patients received imaging services.

This paper is, at its core, descriptive. We describe the money (theirs and the payers') that patients left on the table, identify the factors that explain the variation in the price of the care patients received, and then identify the referral patterns of orthopedic surgeons. Finally, we explore whether the referral patterns of vertically-integrated orthopedists differ from the referral patterns of independent orthopedists.

Advanced imaging studies (e.g. MRI and CT scans) constitute approximately 3 percent of health care spending in the US and are a convenient setting to explore the relative influence of physician preferences and pre-established referral patterns on where patients receive care. Previous studies have found that over 40 percent of health care services are potentially shoppable by consumers (White and Eguchi, 2014; Frost and Newman, 2016). To be shoppable, these studies stipulate that patients must be able to have more than one option over where they receive care, have the ability to schedule when they will receive care, and be able to compare price and quality across multiple providers. Among the range of services that scholars and policy-analysts consider shoppable, planned lower-limb MRI scans are among the least differentiated health care services with respect to clinical quality, are unlikely to produce adverse events, are relatively expensive, and can generally be scheduled in advance of care. They should, therefore, be among the health care services most amenable to patient 'shopping'. As a result, we view our results as a likely lower bound on the extent to which physicians' preferences and established referral patterns influence where patients receive care.

Outside of health care, economists generally believe that utility-maximizing consumers are capable of effectively shopping for simple goods and services (Samuelson, 1997). Even for more complex goods, such as automobiles, there is evidence that consumers can capably observe and navigate tradeoffs between complex characteristics, like fuel efficiency, horsepower, and cabin luxury (Berry et al., 1995). As early as Arrow (1963), however, it has been argued that uncertainty and information asymmetry in the health care sector give rise to "the special economic problems of medical care," including those stemming from the agency relationship between physician and patient. It is this agency relationship and, in particular, the influence of referring physicians, that we focus on in this analysis.

Within our sample, the prices of lower-limb MRI providers vary extensively within regions. For example, the MRI provider in the 80th price percentile in the typical hospital referral region (HRR) is 1.74 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 $1,475.41, while non-hospital-based lower-limb MRIs were, on average, priced at $644.52. 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 50,409 MRIs in our data, only 0.004 percent of scans (2 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 emblematic of the patterns we observe in our data. Figure 1 shows the price of MRI providers in a large urban hospital referral region (HRR).[1] Each column is a provider that delivered at least one lower-limb MRI in 2013. The height of the columns (left vertical axis) shows the average price of an MRI. The darker columns are hospitals, while the lighter columns are non-hospital MRI providers. The dots (right vertical axis) show the number of cases treated at each provider. In this particular HRR, the provider in the 80th percentile of prices in the area is 3.1 times more expensive than the provider in the 20th percentile. The most expensive provider is 8 times as expensive as the lowest-cost provider. Moreover, the highest priced provider has the highest volume of MRI scans in this HRR.

Across 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 55.16 percent, insurer contributions would decrease by 61.32 percent ($333.55), and patient out-of-pocket costs would be reduced by 44.24 percent ($135.76). We refer to this counterfactual as the 'maximum potential savings'.

Ultimately, a significant portion of the maximum potential savings available to patients and insurers is accessible without patients having to travel farther for care. For example, total spending on lower-limb MRI scans would be reduced by 35.83 percent if patients accessed the lowest priced provider available within the same drive time as the facility where they received care. This result occurs because patients, on average, bypassed 6 lower-priced providers between their home and the location where they received their scan. In addition, while the average patient in our sample had $307 in out-of-pocket costs, we do not find that individuals exposed to cost-sharing went to lower priced providers.

We then carry out an ANOVA to understand the factors that explain the largest share of the variance in the price of individuals' lower-limb MRI scans. We study the 35,819 lower-limb scans delivered to our sample of patients in 2013 and analyze the relative contribution of patient cost sharing (whether patients were over their deductible or not), patient characteristics (their Charlson comorbidity score, age, sex, and race), HRR fixed effects, and fixed effects for the orthopedic surgeon who ordered their MRI. We find that referring physicians heavily influenced where patients received care. Based on our ANOVA, referrer fixed effects in our analytic sample explain 80 82 percent of the explained variance (52 percent of the overall variance) in the price of

[1] HRRs are market definitions created by the Dartmouth Atlas Project. More information on HRRs can be obtained at https://www.dartmouthatlas.org/faq/.

an MRI scan. Indeed, referrer fixed effects explain a significantly larger share of the variance in the price of MRIs than patient residential ZIP code (ZCTA) fixed effects, HRR fixed effects, patient characteristics, or patient cost sharing. To illustrate the null and show that the share of spending explained by referrers is not a mechanical effect of introducing a large number of fixed effects, we run our ANOVA on each of 1000 draws of our data in which we randomly assign all patients from our analytic sample to referring physicians in their HRRs. Across the 1,000 runs of our ANOVA on randomly assigned data, referrer fixed effects capture, on average, 9.7 percent of the variance in the price of patients' MRI scans.

We offer some of the first analysis of physicians' referral patterns. We find that orthopedic surgeons send their patients to a narrow group of imaging locations: the median referring orthopedic surgeon in our sample sent 80 percent of her referrals to a single imaging provider. Further, the median referring orthopedic surgeon sent 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 significantly lower their out-of-pocket costs and reduce total MRI spending, patients must diverge from the established referral pathways of their referring physicians. This suggests that there is a role for insurers to nudge physicians to refer in a more cost-effective manner and generate greater price elasticity for MRI scans.

Ultimately, 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. For example, in the last decade, there has been a marked increase in the share of physician practices that are owned by hospitals (Baker et al., 2014). Existing evidence suggests that physicians who are vertically-integrated with a hospital are more likely to refer patients to a hospital (Baker et al., 2016). We find patients with a vertically integrated referring physician had scans that were 36.3 percent more expensive and were 27 percent more likely to receive a hospital-based scan. There was no difference in patient characteristics between those who went to referring physicians who typically sent patients to high cost locations and those who sent patients to low cost locations.

Our results have implications for the academic literature and for policy-makers. Existing models of patient choice often use the distance between patients and providers as the primary determinant of where patients receive care (see Gowrisankaran et al., 2015; Capps et al., 2003; Ho, 2006 as examples). While this may be appropriate for emergency care, our results suggest that, particularly for planned care, economists should integrate the effect of physician agency into their choice models. Ultimately, our results suggest that a patient's referring physician is the strongest determinant of the cost of the MRI scan that a patient receives and whether they receive a hospital-based MRI scan.[2]

On the policy front, while consumer theory suggests that greater price transparency and out-of-pocket cost exposure in health care could lead to large efficiency gains, our work shows that these standard incentives do not perform well in real world health care markets. We show that this is, in part, because of the influence of agents. As a result, incentivizing providers to make more efficient referrals or aligning physician and patient incentives are likely more effective approaches to reducing health care costs than exclusively targeting patients with monetary and non-monetary incentives. Finally, our work also suggests that because of the outsize influence referring physicians have on where patients receive care, regulators must consider the implications of vertical transactions between physician groups and hospitals on vertical foreclosure and health spending.

This paper is structured as follows. In Section II, we give background on insurance plan design, describe the use of price transparency tools, and highlight the role of physician agency in health care decision-making. In Section III, we describe our data, how we identify prices, and how we identify where patients could have alternatively received care, and what they would have paid for care at those locations. We present our results in Section IV. We offer a discussion of our results and conclude in Section V.

II. Background on Price Transparency, Health Care Shopping, and Physician Agency

Advanced imaging studies – magnetic resonance imaging (MRI) and computed tomography (CT) scans – account for approximately 3 percent of US health spending (Iglehart, 2009). There has been significant interest in the potential for patients to shop for advanced imaging studies, like lower-priced lower-limb MRI scans, because they are high priced and relatively

[2] Our results should not be misinterpreted as stating that a patient-provider distance does not matter. Distance does matter. We observe patients travelling 26 minutes, on average, for care. They do not, for example, travel an hour. However, our results suggest that inside some reasonable distance bound, physician preferences and their established referral patterns have more influence than patient-provider distance.

undifferentiated. However, most analysis of the impact of health care transparency tools on patient shopping for advanced imaging services have found that they have had a very modest effect, in part, because they are rarely used by patients.

Lieber (2017) and Whaley et al. (2014) estimate that the actual users of price transparency tools save approximately 15 percent on the price of imaging services. However, Brown (2019a) 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) and work by Sinaiko and Rosenthal (2016), which found that less than 2 percent of Aetna customers used the firm's price transparency tool.

Both Lieber (2017) and Brown (2019b) 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 Akin and Platt (2014). Brown (2019b) 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 occurred. 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 and have experimented with paying patients to price shop. 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) 60^{th} percentile of prices in the region where the patient lives. These programs involve even greater potential out-of-pocket exposure for patients.

A recent analysis found that individuals in a reference pricing program received MRIs that were 12.5 percent less expensive than matched individuals that were not in a reference price program (Robinson et al., 2016). Similarly, in a rewards program run by a collection of employers, employees were given $25 to $500 checks if they went to lower priced providers. Among individuals with the opportunity to be rewarded for shopping, 8.2 percent of patients used a price transparency tool, there was a 1.3 percentage-point increase in the probability of receiving care from a lower-priced provider, and average prices of services consumed were reduced by 2.1 percent (Whaley et al., 2019). While the program led to a 4.7 percent reduction in the price of MRI scans and a 3.4 percentage point increase in the use of lower-rice MRI providers, the program did not influence the price of CT scans (Whaley et al., 2019).

One understudied potential explanation for why most consumers do not generally price shop for relatively undifferentiated services 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 treatment (Harris, 2003; Tu and Lauer, 2008). 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 providers motivated by financial gain encourage patients to utilize services those patients do not need (Gruber and Owings, 1996). Physicians may also gain directly or indirectly from the referrals they make. In the 1990s, laws were passed that prohibited physicians from referring patients to facilities where they had an ownership stake (these are often referred to as the Stark laws). However, the law allows physicians who own imaging equipment to benefit directly from referring patients to receive scans within their own practice. Physicians may also gain indirectly from making referrals within the system where they are employed (Baker et al., 2016). Indeed, there is anecdotal evidence of vertically integrated health systems punishing physicians who refer patients outside the system (Kowalczyk, 2018)

If physicians were perfect agents for patients, we would expect 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 that 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 making referrals. Survey evidence suggests that physician referrals are often influenced by physicians' past experiences with providers, physicians' perceptions about access to care, and their personal familiarity with their referral locations (Kinchen et al., 2004; Barnett et al., 2012).

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

IIIa. Primary and Secondary Data

Our primary data set is composed of insurance claims data provided by a large national insurer that covers tens of millions of lives per year and has coverage in all fifty US states. Our main analysis uses data from 2013. We built an analytic sample of claims for the most common MRI scan in our data: lower-limb MRIs performed without contrast.[3] 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 code on a claim.

Our goal is to identify shoppable, homogeneous MRI scans. As a result, we limit our analysis to MRI scans taken during in-network 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 (this accounts for 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 percent of cases).[4] We also restrict our analysis to MRI

[3] 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 and exclude those performed with contrast. MRI scans without contrast make up the vast majority of scans in our data.

[4] 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. We do not include any providers that were out-of-network with any patients. As a result, we are constructing

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.

IIIb. Identifying Patients' Referring Physicians

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 in the three months prior to the taking of an MRI scan.[5] We restrict our analysis to patients who saw an orthopedist in the three months before a scan so that we can assume that the orthopedist a patient saw before a scan is the referring physician. Approximately 60 percent of patients in our sample saw an orthopod within three months of a lower-limb MRI scan. We assume that the orthopedist a patient saw before a scan is the referring physician.[6]

Restricting our analysis to patients who saw an orthopedist three months before a lower-limb MRI scan eliminates 36,909 of 88,292 cases. The remaining 51,383 cases are divided as follows. In 94 percent of these cases, patients only saw a single orthopedic surgeon before a scan took place. In 6 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 971cases (2 percent of 51,383 cases) that cannot be categorized this way.[7] After excluding those observations

a conservative choice set for most patients and may be potentially excluding a modest number of providers who may be in-network.

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

[6] It is possible that we falsely assume that an orthopedist who treated a patient in the three months before a lower-limb MRI scan was the referring physician for the MRI scan. This would generate measurement error in our estimates of the share of the variance in MRI prices explained by referring physicians. In general, this measurement error would lead us to under-estimate the share of the variance in MRI prices explained by referring physicians.

[7] These includes 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.

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 50,409.[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 14,577 patient observations.

To identify whether referring physicians are part of a vertically integrated organization, we merge in data from SK&A. The SK&A physician-level dataset we employ 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.[9] We lose 4.2 percent of referring physicians who fail to match the SK&A data.

IIIc. Measuring Provider Prices

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 contributor has negotiated with facilities and physicians for the taking and reading of MRIs.

We use place of service codes to identify whether an MRI scan was delivered inside or outside of 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. 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.

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[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.

[9] We can link more than 95 percent of the referring physicians in our sample to the SK&A data using the orthopedic surgeon's NPI. 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.

IIId. 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 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 code. 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 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, 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, individuals pay the entirety of the price for care under their deductible and 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 none of the patients in our sample have plans that charge patients a fixed co-payments.

IIIe. Money Left on the Table

[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.

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 and it 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 lower priced location.

IIIf. Patient Cost Sharing

We observe patients' out-of-pocket costs for each MRI they consume. In our analysis of differences in the price of scans as a function of patient cost sharing, we measure whether patients had cost sharing by determining whether or not patients were over their out-of-pocket maximums at the time their scans were taken (and hence had no out-of-pocket exposure). We did not look at the actual price exposure because patients in our sample are enrolled in plans with a combination of deductibles, co-insurance, and out-of-pocket maximums. In the presence of co-insurance and deductibles, out-of-pocket exposure in dollars is mechanically linked to the price of the MRIs individuals consumed. For example, individuals who attended higher priced providers would appear to have higher cost sharing because their scan was expensive.

IIIg. Transparency Tool Use

Our data contributor provides all their beneficiaries (i.e. all individuals in our sample) with free access to an online and app accessible price transparency tool that allows policy-holders to search for providers for given treatments and procedures and sort by distance, the price paid by the insurer, and their out-of-pocket costs. The tool links to claims data, so users can observe their personalized out-of-pocket payments at each location as a function of their plan design and year-to-date spending. The price transparency tool would allow users to identify accurate prices at each potential care location. 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.

IIIh. Provider Quality

In this analysis, we assume that the taking and reading of MRIs is undifferentiated across providers from the patient's perspective. While the actual taking of the MRI scan is largely 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 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 when scans were read by orthopedists versus radiologists. Recall that we limit our sample to patients who see an orthopedist 3 months before 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 taken. For this reason, we assume that the MRI scan service we study is undifferentiated with respect to clinical quality across providers.

IV Results

Iva. Descriptive Statistics

As shown in Table 1, the total price (i.e. sum of allowed amounts on both physician and facilities claims) of the average MRI in our data is $850.85. Twenty-five percent of MRIs in our sample were performed in hospitals. Hospital-based MRIs have an average price of $1,475.41 and cost significantly more than non-hospital-based scans, which have an average price of $644.52.

On average, the patients in our data contribute $306.86 to the cost of MRIs, while the insurer pays $543.99. Twenty-two percent of patients in our data paid for the entirety of their MRI, 54 percent paid some, but not 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 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 2.7 percent of cases, the patient received an MRI on the same day he or she saw an orthopedist.

IVb. Within Region Variation in MRI Prices

There is significant variation in the price of MRI providers within regions, which we define using HRRs. As we illustrate in Table 2, the median HRR has 10 providers in 2013. Across the 302 HRRs in our sample, the median ratio between the 80th and 20th percentile provider prices is 1.74. Likewise, the median coefficient of variation in within HRR MRI provider prices is 0.45. 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. We find qualitatively similar variance when we look at the price dispersion present within hospital service areas (HSAs).

IVc. Maximum Potential Savings

We use our data to 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.'

Table 3 shows that the maximum potential savings for patients and insurers is substantial. 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 $469.31 and a reduction in MRI spending of 55.16 percent. Our data includes over $100 million in total spending on lower-limb MRI scans and approximately one billion dollars in spending on MRI scans of all types, so this reduction is non-trivial. Patient out-of-pocket costs would decrease, on average, by 44.24 percent from $306.86 to $171.10. Likewise, insurers would lower their average spending on each lower-limb MRI by 61.32 percent, from $543.99 to $210.44.

IVd. 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 analyze, in turn, the extent to which each of these factors are associated with the patterns we observe.

The quality dimension manifests itself in the reading of the scan, which is done by the orthopedists in our setting. The remaining measure of clinical quality is only whether the MRI scan is correctly taken or needs to be repeated. However, of the 50,409 MRI scans in our data, only two were repeated within 90 days.

Likewise, we find that patients can access lower-priced providers and obtain significant savings without traveling farther than they already went for care. In Table 4, we test the share of the maximum potential savings that would be available if patients traveled no farther than they already went for care, 15-minutes farther, 30-minutes farther, and 45-minutes farther. As we illustrate, if patients attended the lowest price provider reachable in the time they traveled to reach their original providers, out-of-pocket costs could be reduced by 28 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 Table 3 is available without patients having to travel farther for care. This level of savings is possible because patients had, on average, six providers with lower MRI prices than the location where they actually received care within the same travel-time radius.[12]

When we compare the price of MRI scans delivered to patients with and without cost sharing, we do not find that those exposed to the price of their scan went to lower priced providers. As we illustrate in Appendix Table 1, controlling for patient characteristics and patient HRR fixed effects, patients with price exposure (those below their out-of-pocket maximum at the time their scan was taken) had slightly more expensive MRI scans than patients who had no price exposure. As we illustrate in Appendix Table 2, this result is robust to including referrer fixed effects in our estimation.

One potential explanation for this result could be that 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

[12] This is not to say that distance does not matter. Patients travel, on average, 26 minutes to where they ultimately receive care. If distance did not matter, we would find higher travel distances and that patients bypassed more than six local, lower priced providers.

exceed their out-of-pocket maximum) (Aron-Dine et al., 2015). Past studies have found that when faced with these non-linear contracts (e.g. commercial health insurance plans with high up front cost-sharing and then out-of-pocket maximums or Medicare Part D prescription drug plans with a gap in coverage known as a "donut hole"), individuals respond more sharply to the spot price, not the shadow price (Aron-Dine et al., 2015; Einav et al., 2015; Dalton et al., 2020; Brot-Goldberg et al., 2017).[13]

We do not observe that individuals with high future health spending but non-zero spot prices behave identically to individuals with zero out-of-pock costs. In Appendix Table 3, we subdivide patients with cost exposure into those who have health care costs above and below $5,000 in the three 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. For many individuals, health care costs over $5,000 in the three months after a scan would mean they likely faced a shadow price of zero for their MRI scan. This result is robust when we split those with cost sharing into groups with above and below $5,000 in future health care costs in the six months after their scan (Appendix Table 4), those with cost sharing into groups with above and below $5,000 in future health care costs in the 12 months after their scan (Appendix Table 5), and those with above and below $10,000 in future health care costs in the three, six, and 12 months after their scan (Appendix Tables 6 – 8).

Of note, as we illustrate in Appendix Table 9, very few individuals searched for the price of an MRI scan before receiving the service. Of the 50,409 lower-limb MRI scans in our sample, patients used the price transparency tool supplied by the insurer prior to receiving care in only 375 cases (0.74 percent). This result is consistent with previous analysis from Desai et al. (2017) that few privately insured individuals use price transparency tools before accessing care.

IVe. Identifying the Factors that Explain the Variation in MRI Prices and Money Left on The Table

In this section, we carry out an analysis of variance (ANOVA) to identify the factors that explain variance in the price of patients' MRI scans and better understand the factors influencing where patients receive care. We identify the share of the variance of lower-limb MRI scan prices, total amount of money left on the table, and whether an MRI scan is performed in a hospital. In our ANOVA, we include controls for patients' out-of-pocket price exposure (a binary indicator of

[13] Aron-Dine et al. (2015) find that individuals do respond to shadow prices.

whether or not patients faced cost-sharing for their scan), patient demographic characteristics (year of birth, Charlson comorbidity score, race, and sex), fixed-effects for patients' home HRR, and fixed-effects for patients' referring physicians.

Our results suggest that referring physicians heavily influence where patients receive care. As we illustrate in Table 5, 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 52.5, 51.5, and 55.1 percent of the variance in each variable, respectively.[14]

One concern might be that the high partial R^2 for referring physicians in our ANOVA is mechanically driven by the large number of referrer physician fixed effects. To address this concern, we run an ANOVA separately on 1,000 draws of our data, where we randomly assign every patient in our sample to referring physicians in the same HRR, maintain the numbers of referrals per physician, and identify the share of the variance explained by referrer fixed effects. Results from this exercise are presented in Figure 2. As it illustrates, the mean share of the variance in the price of patients' lower-limb MRI scan explained by referring physicians when we randomly assign patients to physicians in their HRR is 9.7 percent (the mean share of the variance explained by referrer fixed effects estimated from 1,000 random draws also explains 9.7 percent of the variance in the money left on the table and the probability of a patient receiving an MRI scan at a hospital).[15] The 5th and 95th percentile of the variance in share of patients' MRI scans explained by referrer fixed effects is 9.2 percent and 10.1 percent, respectively. The partial R^2 estimate for referring physician fixed effects that we report in Table 5 – 52.5 percent – is well above the partial R^2 estimated on referrer fixed effects in our randomization exercise, showing that approximately

[14] In Appendix Table 10, we carry out a similar decomposition using an alternative approach, taking MRI price, money left on the table, and an indicator for whether a patient had a hospital-based lower-limb MRI as dependent variables in separate regressions. We then sequentially add in controls for patient characteristics, patient cost sharing fixed effects, patient home HRR fixed effects and referrer fixed effects, and then report the corresponding R^2 for each regression. Using this alternative decomposition strategy, we still find that referring physicians have significant influence over where patients receive care and the amount of money left on the table. As we illustrate in Column (6) of Appendix Table 10, including patient controls, patient cost sharing fixed effects, and fixed effects for patients' home HRR explains 24.4 percent of the price of MRIs, 23.3 percent of money left on the table, and 18.7 percent of whether a patient received a hospital-based MRI. Notably, however, as we illustrate in Column (8), adding referrer fixed effects raises the R-squared in each regression to 0.641, 0.628, and 0.635, respectively. Under this alternative decomposition strategy, this implies that even after controlling for the HRR in which a patient lives, referrer fixed-effects explain an additional 39.7 percent of the variance in the price of MRIs, 39.5 percent of the variance in money left on the table, and 44.8 percent of the variance in whether a patient received a hospital-based MRI scan.

[15] We obtain an R^2 of 9.6, 9.6, and 9.6 percent, respectively, for referrer fixed effects when we run 1,000 draws on data where we randomly assign patients to any referring physician in the US.

42.77 percent (52.47 – 9.7) of the variance captured by referrer fixed effects in our ANOVA cannot be explained by the mechanical effect of including a large number of referrer fixed effects.

As an alternative approach to illustrate that our results are not highly sensitive to the number of referrals per orthopod, we measure the share of the variance explained by referrer fixed effects when we restrict our sample to orthopods that referred 8 or more patients (the median number of referrals), 10 or more (the 62th percentile), 12 or more (the 75th percentile) or 20 or more (the 91th percentile). These results are presented in Appendix Table 11. Across these four specifications, referrer fixed effects explain 49.3, 48.1, 47.7, and 44.0 percent of the variance in MRI prices, respectively.

We also illustrate that this result is robust to a range of alternative specifications. First, as we illustrate in Appendix Table 12, 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. In this specification, the share of the variance explained by referrer fixed effects is 48.9 percent. Second, in Appendix Table 13, we illustrate that these results are robust to measuring patient cost sharing using a continuous measure of patient cost sharing. When measured using a continuous measure of cost sharing, cost sharing explains 5.29 percent of the variance (as opposed to 0.13 in our main specification, where cost sharing is defined using a binary indicator of cost exposure or not) and referrer fixed effects explain 49.93 percent of the variance.

Finally, a portion of our sample is enrolled in an insurance plan that includes prior authorization of MRI scans. However, based on conversations with our data vendor, the prior authorizations were not binding. To that end, we see patients who had a prior authorization denied, but who still received an MRI scan funded by our payer. We employ two strategies to illustrate that the prior authorization process is not driving our results using data from 2014 (the only year we have prior authorization data). At baseline, as we illustrate in Appendix Table 14, we observe that referrer fixed effects explain 51.5 percent of the variance in the price of MRI scans in 2014 (versus 52.5 percent in 2013). In 2014, we observe that 68 percent of patients are enrolled in a plan with prior authorization. In Appendix Table 15, we carry out our main decomposition across the 2014 data, but include an indicator for whether the patient was enrolled in a plan with prior authorization. Being in a prior authorization plan explained less than one percent of the variance in the amount paid for MRI scans and referrer fixed effect explain 51.5 percent of the variance in MRI prices. In Appendix Table 16, we show our main decomposition results for 2014 in Columns

(1) and (2) then include the decomposition results for patients in 2014 enrolled in a plan with prior authorization (Columns (3) and (4)) and without prior authorization (Columns (5) and (6)). The share of the variance in MRI scan prices explained by referrer physician fixed effects does not meaningfully differ for patients enrolled in plans with and without prior authorization.

IV.f Referring Physicians, Prices, and Money Left on the Table

The median referring orthopedic surgeon in our analytic sample made eight referrals for lower-limb MRIs in 2013 (Table 6). The median orthopedic surgeon sent patients to two locations and their modal referral location received 80 percent of the referrals.

As we illustrate in Table 7, in order for patients and insurers to access a large portion of the potential savings, for the most part, patients need to diverge from referring physicians' established referral patterns. For example, if all patients received an MRI from the modal location where orthopedists referred their patients, it would result in only a 10.72 percent reduction in MRI spending and achieve only 19.62 percent of the maximum potential savings.

One potential concern is that patients who require high cost or hospital-based MRIs might endogenously select into orthopedic surgeons with particular referral patterns. That is, referral patterns could reflect patient preferences and characteristics as opposed to reflecting providers' preferences. While we cannot rule this out entirely, to illustrate that this is unlikely to be the case, we identify the characteristics of patients at orthopedists who send no patients for hospital-based scans (Column (1) in Appendix Table 17) (50 percent of referring physicians our sample) and the characteristics of patients at the 25 percent of orthopods who send more than 38 percent of their patients for hospital-based scans (Column (2) in Appendix Table 17). Likewise, we identify the characteristics of patients who received referrals from orthopedists with mean prices in the bottom 25 percent of the distribution (Column (4) in Appendix Table 17) in their HRR and those in the top 25 percent of the distribution (Column (5) in Appendix Table 17) in their HRR. As we illustrate, there are not significant differences in patient characteristics across these groups.

The ownership structure of the practices where referring physicians work also influences where patients receive care. Within our sample, as we describe in Table 6, 14 percent of orthopedic surgeons worked in hospital-owned practices. Figure 3 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. There is significant heterogeneity in this outcome. Vertically integrated physicians are more likely to send patients for hospital-based scans. As we illustrate in Table 6, among non-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.

One argument in favor of vertical integration between physicians and hospitals is that it could increase care coordination (Baicker and Levy, 2013). In our context, for example, orthopedic surgeons in vertically-integrated organizations might have more seamless access to the results of their patients' MRI scans via electronic medical records and their patients might be able to receive a scan without having to seek care at a different location. 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. Paying a higher price for vertical integration solely to get better transfer of the scan is not likely to be warranted considering that it would have a negligible impact on clinical quality of care.

Table 8 presents results from a cross-sectional 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. While these results are not causal, 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 \$276.52 more expensive. This results in an additional \$88.50 in out-of-pocket costs, \$188.02 more spending by insurers, and another \$269.14 left on the table.

V Discussion and Conclusion

We show that despite having access to a price transparency tool and often significant out-of-pocket cost exposure, patients consuming planned lower-limb MRI scans leave significant money on the table when receiving this undifferentiated service. If patients attended the lowest priced provider within the distance they already traveled for care, they could have reduced their out-of-pocket costs by \$84.37 (27.49 percent) and lowered insurer spending by \$220.49 (40.53 percent).

This, in part, reflects that the mean patient in our sample travelled past six lower-priced providers en route to where they ultimately received care.

While consumer theory suggests that greater price transparency in health care could lead to large efficiency gains, realizing those gains is complicated by the centrality of the agency relationship between physicians and their patients. Because of uncertainty over treatment and significant information asymmetries between patient and provider, patients often rely on the medical professionals treating them for advice. Consistent with the emphasis placed on the physician's role as an agent for the patient (e.g. Arrow, 1963), we find that a patient's referring physician is the strongest determinant of the cost of the MRI scan that a patient received, the money they left on the table, and whether or not the patient received a hospital-based MRI scan. In our decomposition, referring physician fixed effects explain 82 percent of the explained variance in price of an MRI a patient received (52 percent of the total variance).

We observe that the median referring physician (orthopedic surgeons in our sample) refers patients to two MRI providers, while the modal location where they send their patients capture 80 percent of their referrals. The implication of this finding is that many patients will need to be diverted from the pre-established referral pathways of their physicians in order to obtain cheaper MRIs. These results indicate the need for insurers to work with physicians themselves, rather than exclusively loading incentives on patients, in order to reduce spending.

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. Changing the referral patterns of physicians will be challenging when the physicians work for hospitals that offer expensive MRIs and the physicians are rewarded for keeping referrals within the system where they work.

Relative to other health care services, lower-limb MRI scans are relatively undifferentiated with respect to quality. Likewise, because we focused on planned (non-emergent) procedures among a population with easy access to a price transparency tool, patients had ample opportunity to compare providers' prices and determine where to receive care. As a result, we view this analysis as providing a lower bound on the extent to which physician preferences and their established referral patterns influence where patients receive care. While it is possible that patients become more attentive to where they receive care as the risks associated with their care increase, we think it is unlikely that, even in those circumstances, physician advice would carry less weight vis-à-vis referral locations than it carries relative to the setting we are examining in this study.

Our work has direct implications for the study of health care markets. Most models of how patients choose where to receive care do not explicitly model the role of referring physicians and often assume that the distance between patients and providers is the primary determinant of where patients receive care. While a patient's distance to their provider does influence where a patient receives care, for care where individuals rely on the advice of their referring physicians, referring physicians' preferences may outweigh the effects of cost-sharing and differences in travel time (particularly relatively short differences in distance across providers) in determining treatment locations. Our work suggests that economists should integrate the impact of agency into models of patient choice, particularly in non-emergent settings.

On the policy front, has implications for antitrust enforcement. Over the last two decades, there has been a marked increase in the vertical integration of hospitals and physicians (Scott et al., 2017). Our work is consistent with the literature that demonstrates that when physician practices are owned by hospitals, it can influence physicians' referral patterns and expose patients to higher out-of-pocket costs. We quantify the fiscal impact of that integration, and more broadly the consequences of decisions to bypass less expensive providers, in a reasonably homogeneous clinical area.

Our work also informative about for the role of demand side cost sharing and the need for incentives for physicians. Over the last 20 years, much of the focus for insurers has been on shifting benefits design and relying on demand side cost sharing to drive patients to consume health care more efficiently. However, Brot-Goldberg et al. (2017) found that deductibles are a blunt tool that reduce health care spending, but do not induce individuals to price shop. We highlight a potential explanation for Brot-Goldberg et al.'s (2017) results. Their results suggest that demand side cost sharing may reduce the rates that individuals access care (with uncertain impacts on welfare); our results suggest that once individuals meet with their physician, in the case of lower-limb MRIs, they rely heavily on their physician's advice about where to receive subsequent care. Because patients appear to struggle to identify the prices of scans at potential MRI providers and put a high weight on the advice of their physician, the share of the variance in MRI prices explained by patient cost sharing is low.

Though targeted programs and benefit designs, such as reference pricing or rewards programs, may alter treatment locations, our results suggest the need for policy-makers and, in particular, insurers to incentivize *physicians* to make more efficient referrals, and for firms to steer patients towards physicians who make efficient referrals. Previous work has found that when physicians are incentivized to be mindful of the costs of their referrals, this can lead to significant savings (Ho and Pakes, 2014). Likewise, evaluations of public and commercial alternative payment models that incentivize physicians to shop find that redirecting changing physician incentives can generate significant savings (Carroll et al., 2018, Song et al., 2019). In short, price conscious referring physicians are likely to be crucial for raising the price elasticity of MRI scans and many other health care services.

References

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

Aron-Dine, Aviva, Liran Einav, Amy Finkelstein, and Mark Cullen. 2015. "Moral Hazard in Health Insurance: Do Dynamic Incentives Matter?" *Review of Economics and Statistics* 97 (4): 725–741. https://doi.org/10.1162/REST_a_00518.

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

Baicker, Katherine, and Helen Levy. 2013. "Coordination versus Competition in Health Care Reform." *New England Journal of Medicine* 369 (9): 789–791. 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." *Health Affairs* 33 (5): 756–763. https://doi.org/10.1377/hlthaff.2013.1279.

Baker, Laurence C., M. Kate Bundorf, and Daniel P. Kessler. 2016. "The Effect of Hospital/Physician Integration on Hospital Choice." *Journal of Health Economics* 50: 1–8. https://doi.org/10.1016/j.jhealeco.2016.08.006.

Barnett, Michael L., Nancy L. Keating, Nicholas A. Christakis, A. James O'Malley, and Bruce E. Landon. 2012. "Reasons for Choice of Referral Physician among Primary Care and Specialist Physicians." *Journal of General Internal Medicine* 27 (5): 506–512. https://doi.org/10.1007/s11606-011-1861-z.

Berry, Steven, James Levinsohn, and Ariel Pakes. 1995. "Automobile Prices in Market Equilibrium." *Econometrica* 63 (4): 841–890. https://doi.org/10.2307/2171802.

Brady, Adrian P. 2017. "Error and Discrepancy in Radiology: Inevitable or Avoidable?" *Insights into Imaging* 8: 171–182. https://doi.org/10.1007/s13244-016-0534-1.

Briggs, G. M., P. A. Flynn, M. Worthington, I. Rennie, and C. S. McKinstry. 2008. "The Role of Specialist Neuroradiology Second Opinion Reporting: Is There Added Value?" *Clinical Radiology* 63 (7): 791–795. https://doi.org/10.1016/j.crad.2007.12.002.

Brot-Goldberg, Zarek C., Amitabh Chandra, Benjamin R. Handel, and Jonathan T. Kolstad. 2017. "What Does a Deductible Do? The Impact of Cost-Sharing on Health Care Prices, Quantities, and Spending Dynamics." *Quarterly Journal of Economics* 132 (3): 1261–1318. https://doi.org/10.1093/qje/qjx013.

Brown, Zach Y. 2019a. "Equilibrium Effects of Health Care Price Information." *The Review of Economics and Statistics* 101 (4): 699–712. https://doi.org/10.1162/rest_a_00765.

Brown, Zach Y. 2019b. "An Empirical Model of Price Transparency and Markups in Health Care." Working Paper. http://www-personal.umich.edu/~zachb/zbrown_empirical_model_price_transparency.pdf.

Carrol, Caitlin, Chernew, Michael, Fendrick, A. Mark, Thompson, Joe, Rose, Sherri. 2018. "Effects of Episode-Based Payment on Health Care Spending and Utilization: Evidence from Perinatal Care in Arkansas." *Journal of Health Economics* 61: 47-62.

Capps, Cory, David Dranove, and Mark Satterthwaite. 2003. "Competition and Market Power in Option Demand Markets." *The RAND Journal of Economics* 34 (4): 737–763. https://doi.org/10.2307/1593786.

Dalton, Christina M., Gautam Gowrisankaran, and Robert J. Town. 2020. "Salience, Myopia, and Complex Dynamic Incentives: Evidence from Medicare Part D." *Review of Economic Studies* 87 (2): 822–869. https://doi.org/10.1093/restud/rdz023.

Dartmouth Atlas Project. n.d. "FAQ." Accessed June 12, 2020. https://www.dartmouthatlas.org/faq/.

Desai, Sunita, Laura A. Hatfield, Andrew L. Hicks, Anna D. Sinaiko, Michael E. Chernew, David Cowling, Santosh Gautam, Sze Jung Wu, and Ateev Mehrotra. 2017. "Offering a Price Transparency Tool Did Not Reduce Overall Spending among California Public Employees and Retirees." *Health Affairs* 36 (8): 1401–1407. https://doi.org/10.1377/hlthaff.2016.1636.

Dionne, Georges, and Louis Eeckhoudt. 1984. "Insurance and Saving: Some Further Results." *Insurance Mathematics and Economics* 3 (2): 101–110. 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." *Quarterly Journal of Economics* 130 (2): 814–899. https://doi.org/10.1093/qje/qjv005.

Figueiredo, Sergio, Luis Sa Castelo, Ana Daniela Pereira, Luis Machado, Joao Andre Silva, and Antonio Sa. 2018. "Use of MRI by Radiologists and Orthopaedic Surgeons to Detect Intra-Articular Injuries of the Knee." *Revista Brasileira de Ortopedia (English Edition)* 53 (1): 28–32. https://doi.org/10.1016/j.rboe.2016.12.013.

Frost, Amanda, and David Newman. 2016. "Spending on Shoppable Services in Health Care." *Health Care Cost Institute, Issue Brief No. 11*. https://www.healthcostinstitute.org/images/easyblog_articles/110/Shoppable-Services-IB-3.2.16_0.pdf.

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

Gruber, Jonathan, and Maria Owings. 1996. "Physician Financial Incentives and Cesarean Section Delivery." *The RAND Journal of Economics* 27 (1): 99–123. https://doi.org/10.2307/2555794.

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

Ho, Kate, and Ariel Pakes. 2014. "Hospital Choices, Hospital Prices, and Financial Incentives to Physicians?" *American Economic Review* 104 (12): 3841–3884. https://doi.org/10.1257/aer.104.12.3841.

Ho, Katherine. 2006. "The Welfare Effects of Restricted Hospital Choice in the US Medical Care Market." *Journal of Applied Econometrics* 21 (7): 1039–1079. https://doi.org/10.1002/jae.896.

Hubbard, Thomas N. 1998. "An Empirical Examination of Moral Hazard in the Vehicle Inspection Market." *The RAND Journal of Economics* 29 (2): 406–426. https://doi.org/10.2307/2555895.

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

Kaiser Family Foundation. 2019. "Employer Health Benefits Annual Survey: 2019." *The Henry J. Kaiser Family Foundation and Health Research & Education Trust*. http://files.kff.org/attachment/Report-Employer-Health-Benefits-Annual-Survey-2019.

Kim, Allis, Lisa Khoury, Mark Schweitzer, Laith Jazrawi, Charbel Ishak, Robert Meislin, Fred Kummer, and Orrin H. Sherman. 2008. "Effect of Specialty and Experience on the Interpretation of Knee MRI Scans." *Bulletin of the NYU Hospital for Joint Diseases* 66 (4): 272–275. https://pdfs.semanticscholar.org/fa42/f3b9fde191aaf4191d73ceb0d3f9fb0af9b0.pdf.

Kinchen, Kraig S., Lisa A. Cooper, David Levine, Mae Yub Wang, and Neil R. Powe. 2004. "Referral of Patients to Specialists: Factors Affecting Choice of Specialist by Primary Care Physicians." *Annals of Family Medicine* 2 (3): 245–252. https://doi.org/10.1370/afm.68.

Kowalczyk, Liz. 2018. "Steward Health Care Pressured Doctors to Restrict Referrals Outside Chain, Suit Says." *The Boston Globe,* May 24, 2018.

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

Lieber, Ethan M.J. 2017. “Does It Pay to Know Prices in Health Care?” *American Economic Journal: Economic Policy* 9 (1): 154–179. https://doi.org/10.1257/pol.20150124.

Mehrotra, Ateev, Katie M. Dean, Anna D. Sinaiko, and Neeraj Sood. 2017. “Americans Support Price Shopping for Health Care, but Few Actually Seek out Price Information.” *Health Affairs* 36 (8): 1392–1400. https://doi.org/10.1377/hlthaff.2016.1471.

Rae, Matthew, Rebecca Copeland, and Cynthia Cox. 2019. “Tracking the Rise in Premium Contributions and Cost-Sharing for Families with Large Employer Coverage.” Peterson Kaiser Family Foundation Health System Tracker. https://www.healthsystemtracker.org/brief/tracking-the-rise-in-premium-contributions-and-cost-sharing-for-families-with-large-employer-coverage/.

Robinson, James C., Christopher Whaley, and Timothy T. Brown. 2016. “Association of Reference Pricing for Diagnostic Laboratory Testing with Changes in Patient Choices, Prices, and Total Spending for Diagnostic Tests.” *JAMA Internal Medicine* 176 (9): 1353–1359. https://doi.org/10.1001/jamainternmed.2016.2492.

Samuelson, Paul Anthony. 1997. *Economics: The Original 1948 Edition*. McGraw-Hill Education.

Scott, Kirstin W., E. John Orav, David M. Cutler, and Ashish K. Jha. 2017. “Changes in Hospital-Physician Affiliations in U.S. Hospitals and Their Effect on Quality of Care.” *Annals of Internal Medicine* 166 (1): 1–8. https://doi.org/10.7326/M16-0125.

Sinaiko, Anna D., and Meredith B. Rosenthal. 2016. “Examining a Health Care Price Transparency Tool: Who Uses It, and How They Shop for Care.” *Health Affairs* 35 (4): 662–670. https://doi.org/10.1377/hlthaff.2015.0746

Song, Zirui, Yunan Ji, Dana G. Safran, and Michael E. Chernew. 2019. “Health Care Spending, Utilization, and Quality 8 Years into Global Payment.” *New England Journal of Medicine* 381 (3): 252–263. https://doi.org/10.1056/NEJMsa1813621.

Tu, H. T., and Johanna R. Lauer. 2008. “Word of Mouth and Physician Referrals Still Drive Health Care Provider Choice.” *Center for Studying Health System Change*, no. 9. https://www.issuelab.org/resources/11695/11695.pdf.

Whaley, Christopher, Jennifer Schneider Chafen, Sophie Pinkard, Gabriella Kellerman, Dena Bravata, Robert Kocher, and Neeraj Sood. 2014. “Association between Availability of Health Service Prices and Payments for These Services.” *JAMA* 312 (16): 1670–1676. https://doi.org/10.1001/jama.2014.13373.

Whaley, Christopher M., Lan Vu, Neeraj Sood, Michael E. Chernew, Leanne Metcalfe, and Ateev

Mehrotra. 2019. “Paying Patients to Switch: Impact of a Rewards Program on Choice of Providers, Prices, and Utilization.” *Health Affairs* 38 (3): 440–447. https://doi.org/10.1377/hlthaff.2018.05068.

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*, no. 18. http://nihcr.org/wp-content/uploads/2016/07/Research_Brief_No._18.pdf.

Table 1: Descriptive Statistics

	Mean	S.D.	P25	Median	P75	N
Total amount paid (all MRIs)	850.85	535.18	474.88	649.24	1,052.29	50,409
Total amount paid (hospital-based MRIs)	1,475.41	558.96	1,049.59	1,429.51	1,840.12	12,518
Total amount paid (non-hospital-based MRIs)	644.52	326.17	451.05	551.03	748.65	37,891
Amount paid by patient	306.86	365.96	25.41	179.04	474.71	50,409
Amount paid by insurer	543.99	522.65	104.04	438.82	756.41	50,409
Proportion of MRIs performed in hospitals	0.25					50,409
Travel time to provider (min.)	26	18	14	22	33	50,409
No. of providers within 30-minutes	21	21	6	16	30	50,409
No. of providers within 60-minutes	69	59	28	52	85	50,409
No. of providers closer to patient than one attended	13	23	1	5	15	50,409
Share of patients with zero cost-sharing	0.24					50,409
Share of patients who bore some (but not all) of the cost of their MRIs	0.54					50,409
Share of patients who bore the full cost of their MRIs	0.22					50,409
Future health care spending within 6-months after MRI	6,680.55	12,432.15	560.26	2,739.74	8,225.09	50,409
Future health care spending within 12-months after MRI	9,083.29	17,293.12	1,080.36	4,522.09	10,577.21	50,409

Notes: Each observation is a single lower-extremity MRI that occurred in 2013. The sample is limited to patients aged 19-64 who were continuously enrolled in a point of service (POS) insurance product for at least 3 months before their MRIs. We also limit the sample to patients who saw an orthopedist in the 3 months before their MRIs. We exclude patients who received an MRI during an inpatient or emergency room stay. We also exclude patients who traveled more than 2 hours to receive their MRI, and patients who were the only patient in their HRR to receive a lower-limb MRI. Prices and spending are adjusted to 2014 dollars using the CPI.

Table 2: Variation in MRI Prices within HRRs

	Mean	S.D.	Min	P25	Median	P75	Max	N
Number of providers	17	20	1	5	10	21	162	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	1.33	1.74	2.59	5.64	302
Coef. of variation of price	0.44	0.18	0.00	0.33	0.45	0.56	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 amount of MRIs within an HRR.

Table 3: Maximum Potential Savings If Patients Went to Cheapest Provider Within a 60-Minute Drive from Their Home

Total Savings			Patient Savings			Insurer Savings		
Mean Payment ($)	Mean Savings ($)	Perc. Reduction in Spending (%)	Mean Payment ($)	Mean Savings ($)	Perc. Reduction in Spending (%)	Mean Payment ($)	Mean Savings ($)	Perc. Reduction in Spending (%)
850.85	469.31	55.16	306.86	135.76	44.24	543.99	333.55	61.32

Notes: All calculations in this table are based on the sample of patients described in Table 1. 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 the lowest cost MRI provider within a 60-minute drive of her home. We calculated driving times between a patient's home ZIP code (ZCTA) and the MRI provider's address using an API provided by HERE maps, a subscription-based tool capable of calculating precise driving times between ZIP codes and addresses. We used the average price of an MRI at a provider's location to compute a counterfactual price the patient could have received had she gone to that provider.

Table 4: Share of Maximum Potential Savings that is Achievable By Driving Distance

Potential savings if patients travel 'X' minutes farther than where they went for their MRI

	Total Savings			Patient Savings			Insurer Savings		
	Perc. max savings (%)	Perc. reduction of total spend (%)	Savings per case ($)	Perc. max savings (%)	Perc. reduction of total spend (%)	Savings per case ($)	Perc. max savings (%)	Perc. reduction of total spend (%)	Savings per case ($)
No farther	64.96	35.83	304.86	62.15	27.49	84.37	66.10	40.53	220.49
+ 15 Minutes	88.45	48.79	415.13	86.76	38.38	117.79	89.14	54.66	297.34
+ 30 Minutes	96.28	53.11	451.87	95.51	42.26	129.67	96.60	59.23	322.20
+ 45 Minutes	99.47	54.87	466.85	99.37	43.96	134.90	99.52	61.02	331.94

Notes: All calculations in this table are based on the sample of patients described in Table 1. This table compares other counterfactuals to the savings patients could have experienced had they gone to the cheapest provider within 60-minute drives of their homes (i.e. what we call the "maximum potential savings").

Table 5: ANOVA of MRI Prices, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan

	Total amount paid		Money left on the table		Prob. hospital-based MRI	
	(1) Partial R^2	(2) P-Value	(3) Partial R^2	(4) P-Value	(5) Partial R^2	(6) P-Value
Patient cost sharing	0.0013	0.0000	0.0012	0.0000	0.0029	0.0000
Patient Charlson score	0.0005	0.0123	0.0005	0.0192	0.0003	0.1683
Patient sex	0.0000	0.9920	0.0000	0.8217	0.0000	0.8224
Patient year of birth	0.0004	0.1307	0.0003	0.3599	0.0006	0.0160
Patient race	0.0002	0.1742	0.0002	0.1702	0.0001	0.3024
Patient HRR F.E.	0.0187	0.0000	0.0180	0.0000	0.0175	0.0000
Referring orthopedist F.E.	0.5247	0.0000	0.5146	0.0000	0.5505	0.0000
Obs.	35,819		35,819		35,819	

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 10,839 to 3,427 and reduces the sample size by 14,577 to 35,832 MRIs. Lastly, we eliminate all observations that is a singleton in any factor variable category. This reduces the sample size by 13 to 35,819 MRIs. Patient cost sharing is a binary variable which indicates whether a patient had any cost exposure. 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 12 re-runs this ANOVA analysis using patient ZCTA fixed effects in lieu of patient HRR fixed effects.

Table 6: Description of Orthopedic Surgeons' MRI Scan Referral Patterns

	Mean	S.D.	Min	P25	Median	P75	Max	N
No. of referrals by orthopedists	10	7	5	6	8	12	77	3,427
Proportion of hospital-owned orthopedists[1]	0.14							3,284
No. locations where patients received MRIs	2.8	1.7	1.0	2.0	2.0	4.0	14.0	3,427
HHI of referrals	6,398	2,621	1,056	4,200	6,600	8,756	10,000	3,427
Proportion of cases sent to modal MRI location	0.73	0.23	0.13	0.56	0.80	0.93	1.00	3,427
Share of patients sent to a hospital	0.24	0.34	0.00	0.00	0.03	0.38	1.00	3,427
Share of patients sent to a hospital for vertically-integrated referrers	0.52	0.40	0.00	0.08	0.57	0.93	1.00	458
Share of patients sent to a hospital for non-vertically-integrated referrers	0.19	0.30	0.00	0.00	0.00	0.20	1.00	2,826
Share of patients sent to cost-minimizing location within 30-min drive	0.13	0.23	0.00	0.00	0.00	0.18	1.00	3,427
Share of patients sent to cost-minimizing location within 60-min drive	0.06	0.18	0.00	0.00	0.00	0.00	1.00	3,427

Notes: This table presents summary statistics for the referring orthopedists in our sample. These statistics are derived from the same sample as the one described in Table 5, including the singleton observations. [1]Of the 3,427 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 3,284 orthopedists in our sample.

Table 7: Savings Available Within Referring Physicians' Established Referral Networks

Total Savings			**Patient Savings**			**Insurer Savings**		
Perc. max savings (%)	Perc. reduction of total spend (%)	Savings per case ($)	Perc. max savings (%)	Perc. reduction of total spend (%)	Savings per case ($)	Perc. max savings (%)	Perc. reduction of total spend (%)	Savings per case ($)
19.62	10.72	86.01	16.62	7.30	21.52	20.88	12.71	64.48

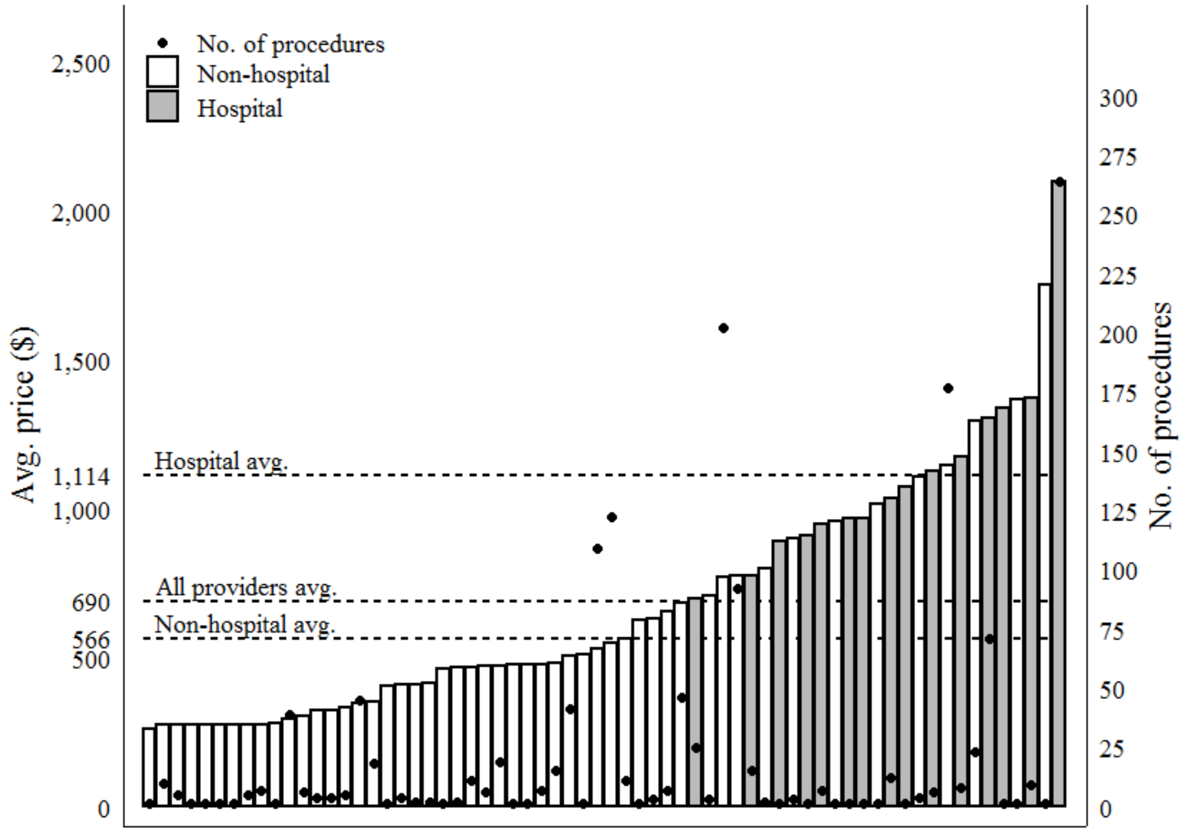
Notes: All calculations in this table are based on the same sample as the one described in Table 5. Like Table 4, this table compares other counterfactuals to the maximum potential savings patients could have experienced had they gone to the lowest cost provider within 60-minute drives of their homes (i.e. the "maximum potential savings" for a patient).

Table 8: The Association Between Vertical Integration, Scan Price, Referral Locations, and Money Left on the Table

	(1) Total amount paid ($)	(2) Patient contribution ($)	(3) Insurer contribution ($)	(4) Money left on the table ($)	(5) Prob. hospital-based MRI	(6) Prob. MRI was repeated
Vertically integrated referrer	276.52***	88.50***	188.02***	269.14***	0.27***	0.00
	(33.50)	(12.39)	(25.80)	(33.83)	(0.04)	(0.00)
Omitted Category: MRIs where the referrer was not vertically-integrated with a hospital						
Mean of Omitted Category	760.74	282.09	478.65	396.42	0.16	0.00
Obs.	35,819	35,819	35,819	35,819	35,819	35,819
R^2	0.2708	0.0993	0.1674	0.2601	0.2231	0.0021

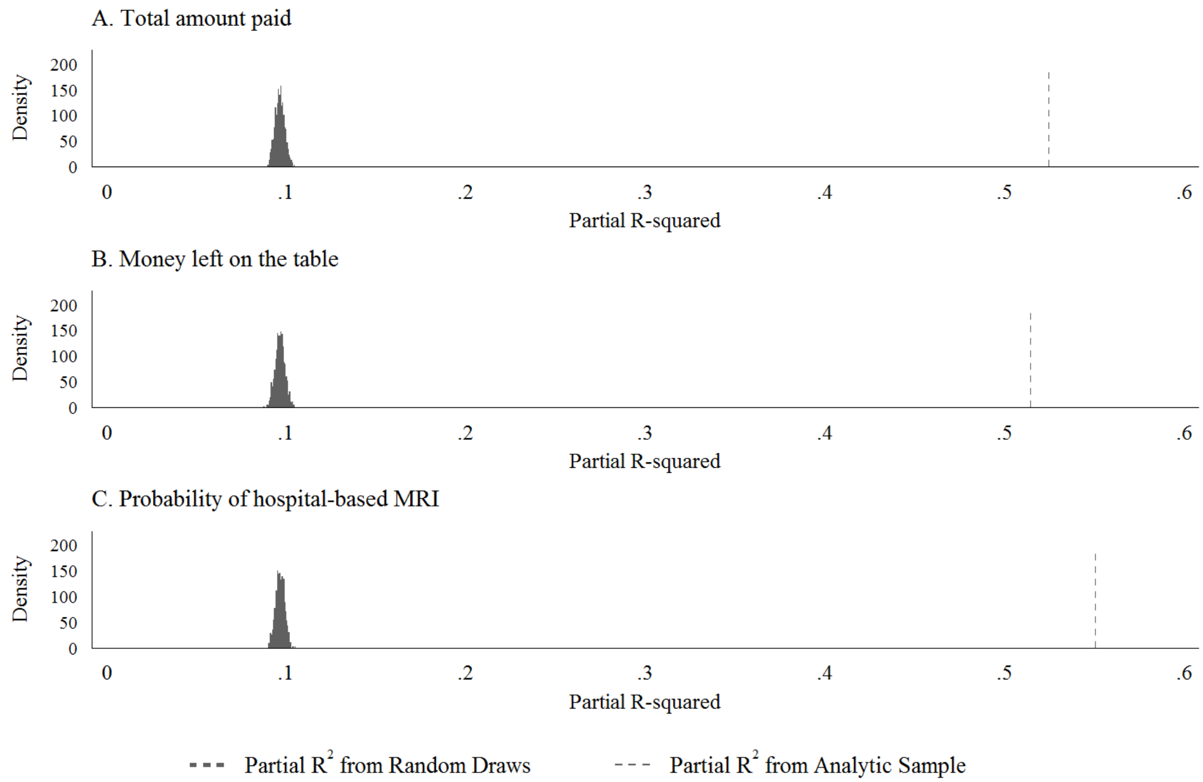
Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 5 (i.e. we limit the sample of MRIs to ones where the referring orthopedist made at least 5 referrals and we do not include singleton patient HRRs - this reduces the sample size from 50,409 to 35,819). 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. 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



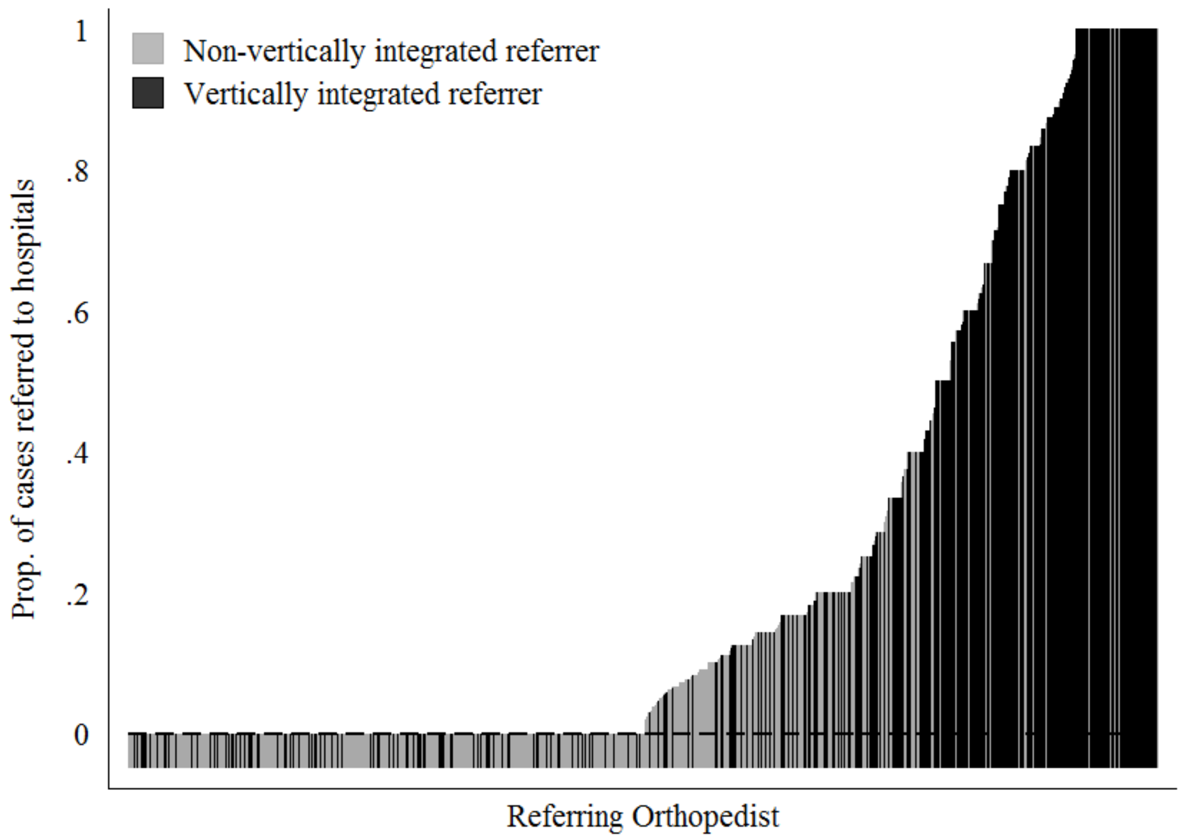
Notes: Each bar is a provider address. Bar height indicates the average price of an MRI at that provider's location (left Y-axis). Grey bars indicate hospitals, while white bars are non-hospitals. The black dots denote the number of lower extremity MRIs in our sample performed at that provider address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

Figure 2: Distribution of Partial R^2s of Referrer Fixed Effects from 1000 Draws Where Patients Are Randomly Distributed Across Referring Physicians in their HRR



Notes: We re-estimate an ANOVA of the total amount paid (Panel A), money left on the table (Panel B), and the probability of a patient receiving a hospital-based MRI scan (Panel C) 1000 times on draws where we randomly distribute all observations from analytic sample to referring physicians in their HRR. We maintain the original numbers of referrals per physician.

Figure 3: 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 5 (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.

ONLINE APPENDIX

Appendix Table 1: Average Payments, Money Left on the Table, and the Probability of a Hospital-Based Scan for Patients with and without Out-of-Pocket Exposure (without Referrer Fixed Effects)

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
Any price exposure	72.05***	67.64***	0.09***
	(6.60)	(6.49)	(0.01)
Omitted Category: Patients who had no price exposure			
Obs.	50,409	50,409	50,409
R^2	0.2407	0.2140	0.1858

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.

Appendix Table 2: Average Payments, Money Left on the Table, and the Probability of a Hospital-Based Scan for Patients with and without Out-of-Pocket Exposure (with Referrer Fixed Effects)

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
Any price exposure	27.43***	26.53***	0.03***
	(4.57)	(4.52)	(0.00)
Omitted Category: Patients who had no price exposure			
Obs.	35,819	35,819	35,819
R^2	0.6405	0.6279	0.6347

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 5 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 and referrer fixed effects.

Appendix Table 3: 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
Any price exposure and high future health care costs	99.40***	91.46***	0.11***
	(8.48)	(8.28)	(0.01)
Any price exposure and low future health care costs	60.03***	57.17***	0.08***
	(6.57)	(6.46)	(0.01)
Omitted Category: Patients who had no price exposure for their MRI			
Obs.	0.2416	0.2147	0.1864
R^2	50,409	50,409	50,409

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 1. 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 prices, 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 had no price exposure for their MRI (i.e. paid nothing) with two other groups of patients: 1) those who had any price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 2) those who had any price exposure and "low" 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 50,409 MRIs in our sample, 15,724 patients (31.2%) were "high" future health care cost patients.

Appendix Table 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
Any price exposure and high future health care costs	94.17***	86.37***	0.11***
	(7.91)	(7.71)	(0.01)
Any price exposure and low future health care costs	58.62***	56.26***	0.08***
	(6.71)	(6.61)	(0.01)
Omitted Category: Patients who had no price exposure for their MRI			
Obs.	0.2415	0.2146	0.1864
R^2	50,409	50,409	50,409

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 1. 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 prices, 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 had no price exposure for their MRI (i.e. paid nothing) with two other groups of patients: 1) those who had any price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 2) those who had any price exposure and "low" 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 50,409 MRIs in our sample, 19,489 patients (38.7%) were "high" future health care cost patients.

Appendix Table 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 12 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
Any price exposure and high future health care costs	92.55***	85.54***	0.11***
	(7.55)	(7.38)	(0.01)
Any price exposure and low future health care costs	54.10***	51.96***	0.08***
	(6.73)	(6.63)	(0.01)
Omitted Category: Patients who had no price exposure for their MRI			
Obs.	0.2417	0.2148	0.1865
R^2	50,409	50,409	50,409

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 1. 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 prices, 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 had no price exposure for their MRI (i.e. paid nothing) with two other groups of patients: 1) those who had any price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 2) those who had any price exposure and "low" 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 50,409 MRIs in our sample, 23,970 patients (47.6%) were "high" future health care cost patients.

Appendix Table 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 3 Months After the Taking of an MRI

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
Any price exposure and high future health care costs	135.01***	121.03***	0.14***
	(11.47)	(11.20)	(0.01)
Any price exposure and low future health care costs	61.82***	58.96***	0.09***
	(6.61)	(6.51)	(0.01)
Omitted Category: Patients who had no price exposure for their MRI			
Obs.	0.2424	0.2153	0.1871
R^2	50,409	50,409	50,409

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 1. 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 prices, 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 had no price exposure for their MRI (i.e. paid nothing) with two other groups of patients: 1) those who had any price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 2) those who had any price exposure and "low" 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 three months following their MRIs. Of the 50,409 MRIs in our sample, 7,255 patients (14.4%) were "high" future health care cost patients.

Appendix Table 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 $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
Any price exposure and high future health care costs	125.07***	113.34***	0.13***
	(9.97)	(9.69)	(0.01)
Any price exposure and low future health care costs	59.55***	56.86***	0.08***
	(6.66)	(6.57)	(0.01)
Omitted Category: Patients who had no price exposure for their MRI			
Obs.	0.2424	0.2153	0.1874
R^2	50,409	50,409	50,409

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 1. 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 prices, 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 had no price exposure for their MRI (i.e. paid nothing) with two other groups of patients: 1) those who had any price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 2) those who had any price exposure and "low" 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 50,409 MRIs in our sample, 9,868 patients (19.6%) were "high" future health care cost patients.

Appendix Table 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
Any price exposure and high future health care costs	114.75***	106.25***	0.12***
	(8.90)	(8.68)	(0.01)
Any price exposure and low future health care costs	57.09***	54.11***	0.08***
	(6.60)	(6.50)	(0.01)
Omitted Category: Patients who had no price exposure for their MRI			
Obs.	0.2423	0.2154	0.1871
R^2	50,409	50,409	50,409

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 1. 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 prices, 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 had no price exposure for their MRI (i.e. paid nothing) with two other groups of patients: 1) those who had any price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 2) those who had any price exposure and "low" 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 50,409 MRIs in our sample 13,452 patients (26.7%) were "high" future health care cost patients.

Appendix Table 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	-93.24***	-88.27***	-0.05**
	(23.37)	(22.92)	(0.02)
Obs.	50,409	50,409	50,409
R^2	0.2708	0.2434	0.2081
Transparency Tool Use Rate:	375 of 50,409 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.

Appendix Table 10: Decomposing the Drivers of Patient's MRI Prices, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total amount paid	0.002	0.005	0.240	0.633	0.007	0.244	0.634	0.641
Money left on the table	0.002	0.003	0.230	0.620	0.005	0.233	0.621	0.628
Prob. hospital-based MRI	0.002	0.010	0.180	0.627	0.012	0.187	0.628	0.635
Obs.	35,819	35,819	35,819	35,819	35,819	35,819	35,819	35,819
Patient controls	Yes	No	No	No	Yes	Yes	Yes	Yes
Patient cost-sharing	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 the total price of an MRI, the amount of money left on the table, or the probability that a patient received a hospital-based MRI. Each observation is an MRI. This analysis uses the same sample of MRIs described in Table 5. The money left on the table is the amount patients could have saved themselves and their insurer if they had gone 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 is a binary variable which indicates whether a patient had any cost exposure. Each column includes a different combination of controls.

Appendix Table 11: ANOVA of MRI Prices by the Number of Referrals Per Referring Orthopedist

	Patients whose referring orthopedists made 8 or more referrals		Patients whose referring orthopedists made 10 or more referrals		Patients whose referring orthopedists made 12 or more referrals		Patients whose referring orthopedists made 20 or more referrals	
	(1) Partial R^2	(2) P-Value	(3) Partial R^2	(4) P-Value	(5) Partial R^2	(6) P-Value	(7) Partial R^2	(8) P-Value
Patient cost sharing	0.0011	0.0000	0.0009	0.0000	0.0010	0.0000	0.0004	0.0781
Patient Charlson score	0.0006	0.0322	0.0007	0.0222	0.0014	0.0006	0.0010	0.2121
Patient sex	0.0000	0.7428	0.0000	0.7147	0.0000	0.7329	0.0000	0.6566
Patient year of birth	0.0004	0.2959	0.0005	0.2016	0.0008	0.1142	0.0010	0.3556
Patient race	0.0001	0.4272	0.0002	0.2755	0.0002	0.4118	0.0007	0.0926
Patient HRR F.E.	0.0161	0.0000	0.0139	0.0000	0.0142	0.0000	0.0121	0.0010
Referring orthopedist F.E.	0.4933	0.0000	0.4810	0.0000	0.4773	0.0000	0.4399	0.0000
Obs.	26,926		21,999		18,144		8,999	

Notes: This table presents the partial R^2s from an analysis of variance (ANOVA) of factors in explaining MRI prices. This table relies on the same sample of patients described in Table 1. In addition, we limit the analysis to patients whose referring orthopedists made at least 8, 10, 12, or 20 referrals in 2013. This reduces the number of referring orthopedists in the sample from 10,839 to 1,898, 1,314, 945, and 319 and reduces the sample size to 26,943, 22,019, 18,162, and 9,029 MRIs, respectively. Lastly, we eliminate all observations with singleton values within each factor variable. This reduces the sample size by 17, 20, 18, 30 to 26,926, 21,999, 18,144, and 8,999 MRIs, respectively. Patient cost sharing is a binary variable which indicates whether a patient had any cost exposure. 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 12: ANOVA of MRI Prices, 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) Partial R^2	(2) P-Value	(3) Partial R^2	(4) P-Value	(5) Partial R^2	(6) P-Value
Patient cost sharing	0.0010	0.0000	0.0010	0.0000	0.0024	0.0000
Patient Charlson score	0.0005	0.0729	0.0005	0.0736	0.0001	0.7703
Patient sex	0.0000	0.4946	0.0000	0.4256	0.0000	0.7554
Patient year of birth	0.0002	0.7164	0.0002	0.7117	0.0007	0.0383
Patient race	0.0006	0.0034	0.0006	0.0038	0.0003	0.1073
Patient ZCTA F.E.	0.1985	0.0000	0.2035	0.0000	0.2061	0.0000
Referring orthopedist F.E.	0.4888	0.0000	0.4895	0.0000	0.5290	0.0000
Obs.	32,021		32,021		32,021	

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. For example, the entry in the first column and last row of the table indicates that 48.88% of the variation in MRI prices cannot be explained if you exclude referring orthopedist fixed effects from the model. This table relies on 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 50,409 to 46,567. 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 9,960 to 3,146 and reduces the sample size by 13,330 to 33,237 MRIs. Lastly, we eliminate all observations that is a singleton in any factor variable category. This reduces the sample size by 1,216 to 32,021 MRIs. Patient cost sharing is a binary variable which indicates whether a patient had any cost exposure. 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 13: ANOVA of MRI Price, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan (with Patient Cost Sharing as a Continuous Variable)

	Total amount paid		Money left on the table		Prob. hospital-based MRI	
	(1) Partial R^2	(2) P-Value	(3) Partial R^2	(4) P-Value	(5) Partial R^2	(6) P-Value
Patient cost sharing	0.0529	0.0000	0.0510	0.0000	0.0267	0.0000
Patient Charlson score	0.0009	0.0001	0.0008	0.0003	0.0006	0.0019
Patient sex	0.0001	0.1977	0.0001	0.1322	0.0000	0.2885
Patient year of birth	0.0006	0.0075	0.0005	0.0645	0.0008	0.0018
Patient race	0.0011	0.0000	0.0010	0.0000	0.0005	0.0008
Patient HRR F.E.	0.0180	0.0000	0.0177	0.0000	0.0167	0.0000
Referring orthopedist F.E.	0.4993	0.0000	0.4895	0.0000	0.5353	0.0000
Obs.	35,819		35,819		35,819	

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 10,839 to 3,427 and reduces the sample size by 14,577 to 35,832 MRIs. Lastly, we eliminate all observations that is a singleton in any factor variable category. This reduces the sample size by 13 to 35,819 MRIs. Patient cost sharing is a continuous variable. 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 14: ANOVA of MRI Price, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan in 2014

	Total amount paid		**Money left on the table**		**Prob. hospital-based MRI**	
	(1)	(2)	(3)	(4)	(5)	(6)
	Partial R^2	P-Value	Partial R^2	P-Value	Partial R^2	P-Value
Patient cost sharing	0.0013	0.0000	0.0012	0.0000	0.0031	0.0000
Patient Charlson score	0.0005	0.0053	0.0006	0.0037	0.0004	0.0413
Patient sex	0.0003	0.0016	0.0002	0.0044	0.0003	0.0008
Patient year of birth	0.0004	0.1047	0.0004	0.1266	0.0007	0.0036
Patient race	0.0001	0.2860	0.0001	0.2183	0.0000	0.6566
Patient HRR F.E.	0.0160	0.0000	0.0184	0.0000	0.0170	0.0000
Referring orthopedist F.E.	0.5152	0.0000	0.5013	0.0000	0.5283	0.0000
Obs.	37,366		37,366		37,366	

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-minute drives of their homes, and the probability that a patient received a hospital-based MRI. There are 51,949 MRI scans in our analytic sample for 2014. In addition, we limit the analysis to patients whose referring orthopedists made at least 5 referrals in 2014. This reduces the number of referring orthopedists in the sample from 10,918 to 3,485 and reduces the sample size to 37,383 MRIs. Lastly, we eliminate all observations with singleton values within each factor variable. This reduces the sample size by 17 to 37,366 MRIs. Patient cost sharing is a binary variable which indicates whether a patient had any cost exposure. 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 15: ANOVA of MRI Prices, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan in 2014 (Including Prior Authorization Indicator)

	Total amount paid		Money left on the table		Prob. hospital-based MRI	
	(1)	(2)	(3)	(4)	(5)	(6)
	Partial R^2	P-Value	Partial R^2	P-Value	Partial R^2	P-Value
Patient cost sharing	0.0015	0.0000	0.0014	0.0000	0.0033	0.0000
Patient Charlson score	0.0005	0.0052	0.0006	0.0037	0.0004	0.0394
Patient sex	0.0003	0.0018	0.0002	0.0048	0.0003	0.0009
Patient year of birth	0.0004	0.1179	0.0004	0.1438	0.0007	0.0041
Patient race	0.0000	0.7310	0.0000	0.6533	0.0000	0.9091
Patient HRR F.E.	0.0160	0.0000	0.0184	0.0000	0.0170	0.0000
Prior authorization	0.0012	0.0000	0.0013	0.0000	0.0006	0.0000
Referring orthopedist F.E.	0.5153	0.0000	0.5012	0.0000	0.5284	0.0000
Obs.	37,366		37,366		37,366	

N**otes:** 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-minute drives 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 Appendix Table 14. Patient cost sharing is a binary variable which indicates whether a patient had any cost exposure. Prior authorization is an indicator of whether patients were enrolled in plans with prior authorization. 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 16: ANOVA of MRI Prices Using 2014 Analytic Sample and 2014 Patients Enrolled in Plans with and without Prior Authorization

	Results from 2014 Main Analysis		2014 Sample - Patients with Prior Authorization		2014 Sample - Patients without Prior Authorization	
	(1) Partial R^2	(2) P-Value	(3) Partial R^2	(4) P-Value	(5) Partial R^2	(6) P-Value
Patient cost sharing	0.0013	0.0000	0.0007	0.0002	0.0013	0.0050
Patient Charlson score	0.0005	0.0053	0.0003	0.4179	0.0011	0.3645
Patient sex	0.0003	0.0016	0.0003	0.0183	0.0004	0.1094
Patient year of birth	0.0004	0.1047	0.0006	0.2195	0.0013	0.4350
Patient race	0.0001	0.2860	0.0002	0.3778	0.0003	0.5599
Patient HRR F.E.	0.0160	0.0000	0.0225	0.0000	0.0271	0.0000
Referring orthopedist F.E.	0.5152	0.0000	0.5420	0.0000	0.5386	0.0000
Obs.	37,366		21,851		6,900	

Notes: This table presents the partial R^2s from an analysis of variance (ANOVA) of factors in explaining MRI prices. Columns (1) and (2) rely on the same sample of patients described in Appendix Table 14. These columns show the main decomposition results for 2014. Columns (3) and (4) rely on the analytic sample of patients who enrolled in a plan with prior authorization in 2014. Columns (5) and (6) rely on the analytic sample of patients who did not enroll in a plan with prior authorization in 2014. Out of 51,949 patients who received lower-limb MRI scan in 2014, 35,118 patients enrolled in a plan with prior authorization and 16,831 patients did not. Out of 10,918 referring orthopedists, 9,332 orthopedists referred patients enrolled in a plan with prior authorization and 6,723 did not. In each respective sample (patients with and without prior authorization), we then further limit the analysis to patients whose referring orthopedists made at least 5 referrals in 2014 and we also eliminate all observations with singleton values within each factor variable. This reduces the analytic sample of patients who had prior authorization (columns (3) and (4)) to 21,851 MRIs and 2,301 referring orthopedists and reduces the analytic sample of patients who did not have prior authorization (columns (5) and (6)) to 6,900 MRIs and 880 referring orthopedists. Patient cost sharing is a binary variable which indicates whether a patient had any cost exposure. 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 17: Comparison of Patient Characteristics Between Different Groups of Patients

	(1)	(2)	(3)	(4)	(5)	(6)
	Patients whose referring orthopedists sent no patients for hospital-based scans (17,137)	**Patients whose referring orthopedists sent more than 38 percent of their patients for hospital-based scans (7,690)**	**P-value from two-sided t-test**	**Patients who received referrals from orthopedists with mean prices in the bottom 25% of the distribution in their HRR (3,610)**	**Patients who received referrals from orthopedists with mean prices in the top 25% of the distribution in their HRR (7,689)**	**P-value from two-sided t-test**
Patient Charlson score	0.18	0.17	0.75	0.18	0.18	0.56
Share of female patients	0.51	0.51	0.99	0.49	0.50	0.35

Notes: Columns (1), (2), and (3) compare the characteristics of patients whose referring orthopedists sent no patients for hospital-based scans to the characteristics of patients whose referring orthopedists sent more than 38 percent of their patients for hospital-based scans. Columns (1), (2) and (3) rely on the same sample of patients described in Table 5, including the singleton observations. Columns (4), (5), and (6) compare the characteristics of patients who received referrals from orthopedists with mean prices in the bottom 25% of the distribution in their HRR to the characteristics of patients who received referrals from orthopedists with mean prices in the top 25% of the distribution in their HRR. Columns (4), (5), and (6) rely on the same sample described in Table 1. We additionally limit the analysis to HRRs that have at least 100 patients. This reduces the number of patients from 50,409 to 43,437, the number of referring orthopedists from 10,839 to 8,552 and the number of HRRs from 302 to 110. We eliminate patients whose referring orthopedists made less than 5 referrals in 2013. This reduces the number of patients to 32,409 and the number of referring orthopedists to 3,006. The number of HRRs remains the same. The number of patients in each group is in parentheses.