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Abstract: We study how individuals with private health insurance choose providers for lower-limb MRI scans. Lower-limb MRI scans are a fairly undifferentiated service and providers' prices routinely vary by a factor of five or more across providers within hospital referral regions. We observe that despite significant out-of-pocket cost exposure, patients often received care in high-priced locations when lower priced options were available. Fewer than 1 percent of individuals used a price transparency tool to search for the price of their services in advance of care. The choice of provider is such that, on average, individuals bypassed 6 lower-priced providers between their home and the location where they received their scan. Referring physicians heavily influence where their patients receive care. The influence of referring physicians is dramatically greater than the effect of patient cost-sharing. As a result, in order to lower out-of-pocket costs and reduce total MRI spending, patients must diverge from the established referral pathways of their referring physicians. We also observe that patients with vertically integrated (i.e. hospital-owned) referring physicians are more likely to have hospital-based (and more costly) MRI scans.

JEL Codes: I1, I11
Keywords: Provider prices, shopping, price transparency, vertical integration, agency

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I. Introduction

The prices received by health care providers vary substantially within small geographic areas, even for fairly undifferentiated services. For example, Cooper et al. (2015) found that the price of hospital-based lower-limb magnetic resonance imaging (MRI) scans varied by a factor of more than 12 across hospitals nationally and by a factor of five or more within hospital referral regions (HRRs).[1] This variation suggests that there is significant potential savings available to patients and insurers if individuals could be treated at low priced locations for services where quality does not vary. Previous studies have found that over 40 percent of health care services are potentially shoppable by consumers (White and Euchi 2014, Frost and Newman 2016). To be shoppable, these studies stipulate that patients must be able to schedule when they will receive care, compare multiple providers, and determine where they will receive services. Nevertheless, despite rapidly rising out-of-pocket costs and the fact that most insurers now offer their beneficiaries access to a price transparency tool, there is scant evidence that patients review provider prices before accessing care or effectively shop for health care services (Desai et al. 2016, Brot-Goldberg et al. 2017).

In this paper, we study how individuals age 19 to 64 with private health insurance consume lower-limb MRI scans. We analyze the frequency that patients forgo receiving care at lower priced locations in lieu of receiving care at more expensive providers. We also study the frictions that appear to prevent patients from accessing lower priced care. Lower-limb MRI scans are among the least differentiated health care services, are relatively expensive, and can generally be scheduled in advance of care. They should, therefore, be one of the most easily shoppable health care services. As a result, we use our evidence on choice of provider of lower-limb MRIs as a window into the extent that health care services more generally are potentially shoppable by consumers.

The data we use in this analysis come from a large private insurer that covers tens of millions of lives per year across all fifty US states. We focus on lower-limb MRI scans that were potentially shoppable – e.g. those that were not delivered in the midst of an ongoing inpatient admission or emergency care.

[1] Hospital referral regions are geographic regions created by researchers at the Dartmouth Institute for Health Care Policy to approximate markets for tertiary medical care in the US. Each HRR generally includes at least one major referral center and the US is divided into 306 HRRs. See www.dartmouthatlas.org/downloads/methods/geogappdx.pdf for more information.

The data we use offers several distinct advantages for this analysis. First, we can observe the prices negotiated between the insurer and providers, as well as patients' out-of-pocket costs. Second, we can infer the networks of patients and construct the potential choice sets that individuals in our data faced when selecting their MRI providers. Third, we can recreate the cost-sharing patients would have faced had they gone to alternate providers. Fourth, we can identify which individuals in our sample used an insurer-provided price transparency tool before getting a scan. Fifth, we have access to prior authorization records which allow us to identify which physicians generally order lower-limb MRI scans (it is orthopedic surgeons). We can then restrict our analysis to lower-limb MRI scans received by patients who saw an orthopedist within three months of the taking of the scan and we can analyze the referring patterns of orthopedic surgeons.

Lower-limb MRI providers' prices vary extensively across providers within regions. According to our data, within the median HRR in the US, the MRI provider in the 80^{th} percentile in an HRR is 1.73 times more expensive than the MRI provider in the 20^{th} 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 was $1,474.35; non-hospital-based lower-limb MRIs were priced at, on average, $642.82.

If MRI scans from a provider needed to be regularly repeated, it could be a sign of substandard quality. However, of the 50,484 MRIs in our analysis, only 0.006 percent of scans (3 scans in total) were repeated within a 90-day window. We take this as evidence that the taking of MRI scans is not differentiated across facilities.

Despite the variation in MRI scan prices across providers, patients often received care in high-priced locations when lower priced options were available. Figure 1 is emblematic of patterns we observe in our data. It shows the price of MRI providers in a large urban HRR. 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 HRR, the provider in the 80^{th} percentile of prices in the area is 2.2 times more expensive than the provider in the 20^{th} percentile and the most expensive provider is 7.5 times as expensive as the lowest-cost provider. Moreover, the highest priced provider has the highest volume of MRI scans in the 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 55.12 percent, with insurer contributions decreasing by 61.22 percent ($333.39), and patient out-of-pocket costs decreasing by 44.23 percent ($135.13).

When we explore the choices consumers make, we do not find that choosing a high cost provider is related to the usual features assumed to drive demand, such as the distance to potential providers. Indeed, a significant portion of the maximum potential savings is available without patients having to travel farther for care. For example, total spending on lower-limb MRI scans would be reduced by 35.81 percent if patients accessed the lowest priced provider available within the same drive time as the practice 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.

Previous research has posited that greater cost-sharing may be necessary to nudge consumers to shop more effectively for care (Lieber 2017). However, we find little evidence that out-of-pocket costs are strongly predictive of the price of MRIs scans at the locations where patients receive care. Ultimately, a large share of patients in our sample had substantial out-of-pocket exposure for their MRI: 22 percent of patients in our data paid for the entirety of their MRIs out of pocket; 54 percent had non-zero cost-sharing; and 24 percent faced no out-of-pocket costs. On average, the out-of-pocket cost for a scan was $305.53. However, patients' out-of-pocket cost exposure only explains 2.4 percent of variance (4.2 percent of total explained variance) in the price of MRIs that patients across our data received. Consistent with Brot-Goldberg et al. (2017), we further find that patients are not able to effectively differentiate between the spot and shadow prices of MRI providers.

By contrast, we find that referring physicians heavily influence where patients receive care, with referrer fixed effects explaining 51 percent of the variance (92.1 percent of explained variance) in the price of MRI scans that patients receive. Indeed, referrer fixed effects explain a significantly larger share of the variance in the price of MRIs than patient ZIP code (ZCTA) fixed effects.

When we analyze physicians' referral patterns, we find orthopedic surgeons tend to send their patients to a narrow group of imaging locations: each referring orthopedic surgeon in our sample sends, on average, 79 percent of all their referrals to a single imaging provider. Further, the median referring orthopedic surgeon sends zero patients to the lowest cost provider within either 30- or 60-minutes from the patient's home. As a result, in order to lower out-of-pocket costs and reduce total MRI spending, patients must diverge from the established referral pathways of their referring physicians.

Ultimately, the referral decisions of physicians may be suboptimal both because referring physicians lack information on the prices of the facilities where they are sending their patients, and because physicians may be motivated to refer patients to specific providers for reasons other than quality or patient costs. In the last decade, there has been a marked increase in the share of physician practices that are owned by hospitals (Baker, Bundorf, and Kessler 2014). Early 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 having a vertically integrated referring physician raises the total cost of an MRI by 36.5 percent, the amount paid by the patient by 31.9 percent, and the odds a patient receives an MRI at a hospital by 27 percent. However, we do not find that having a vertically integrated referring physician is associated with a lower probability that a scan needs to be repeated.

This paper makes several contributions to the literature. First, we build on prior analysis, such as Cooper et al. (2018), that has found extensive variation in health care providers' prices within areas. This paper highlights how prices for similar services vary across providers and differ as a function of the type of provider offering services. We show that hospital-based lower-limb MRIs are 2.3 times as expensive as scans performed outside the hospital despite that there is no difference in the rate that scans are repeated at these locations. Likewise, we show that patients often leave significant money on the table and attend expensive providers for services where clinical quality does not vary. Indeed, we find that only 14 percent of patients attended the lowest cost provider within a 30-minute drive from their home. Second, we highlight that referring physician is the primary determinant of where patients receive MRI scans. Likewise, because physicians refer their patients to a narrow group of providers, in order for patients and insurers to save money, many patients would need to diverge from their referring physicians' usual referral pathways. Third, we find that referring physicians that are vertically integrated with hospitals are more likely to refer patients to hospitals for lower-limb MRI scans.

These results have implications for the academic literature and for policy-makers. Existing models of patient choice use distance as the primary determinant of where patients receive care (see: Gowrisankaran et al. 2015; Capps et al. 2003; Ho 2006 as examples). Our results suggest that, particularly for planned care, economists should integrate the effect of agency into their choice models. Our results also suggest a mechanism behind observations in the recent literature on deductibles and healthcare spending, such as those made in Brot-Goldberg et al. (2017), which found that introducing deductibles lowered health spending by over 11 percent without inducing individuals to more actively price shop. Our results suggest that once patients touch the health system, where they receive ensuing care is hugely influenced by their referring physician, not out-of-pocket costs or their home address.

On the policy front, our work highlights the limits of demand side cost sharing as a tool to improve patient shopping. Our work also suggests that as regulators consider vertical transactions between physician groups and hospitals, they should consider the potential for those transactions to lead to foreclosure. Likewise, given the reliance patients have on advice from their agents, it is possible that even with significant out-of-pocket cost exposure and the availability of price transparency tools, patients will not be willing to deviate from their referring physicians' recommendations. Going forward, our work suggests that health care funders could more effectively steer patients towards high productivity providers by equipping physicians with information on the prices of potential locations for care and incentivizing them to make more cost-efficient referrals. These results are consistent with Ho and Pakes (2011), which find that insurers with more direct control over physician referrals are able to get lower priced secondary care.

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

From 2000 to 2016, private health insurance premiums for family coverage increased 182 percent in real terms from $6,438 to $18,142 (Kaiser Family Foundation 2017). In an effort to slow premium growth, insurers have steadily increased patient cost sharing and deductible amounts. Deductible size increased 98 percent from 2003 to 2010 (Schoen et al. 2011), and then another 67 percent from 2010 to 2015 (Kaiser Family Foundation 2015). As a result, at present, 46 percent of workers have a deductible of $1,000 or more, with one in four enrolled in a plan with a deductible of at least $3,000 (Kaiser Family Foundation 2017). The belief underlying the growth of these demand side interventions is that increased cost exposure would both reduce moral hazard and encourage patients to become more active consumers of health care services, with more incentive to seek out low-cost, high-quality health care providers.

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

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

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

In the face of lackluster results from increasing deductibles and introducing price transparency tools, some private employers have introduced reference pricing schemes to steer individuals to lower cost providers. These programs involve even greater potential out-of-pocket exposure for patients. 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. A recent analysis found that individuals in a reference pricing program received MRIs that were 12.5 percent lower priced than matched individuals that were not in a reference price program (Robinson, Whaley, and Brown 2016).

One understudied but potential explanation for why consumers do not price shop is the weight patients place on advice from their referring physicians about where to receive care. There is evidence that physician referral decisions and physician behavior can play a large role in determining the course of and cost of treatment. Survey data suggests that patients rely heavily on the advice of their physicians when determining where to receive care (Harris 2003). 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 inside and outside of the health care space has explored the agency relationship and found that agency is often imperfect (Hubbard 1998, Levitt and Syverson 2008). Within the health care space, there is a large literature that suggests the presence of supplier induced demand, where patients are encouraged by providers to utilize services they do not need in order reap financial gain (Gruber and Owings 1996). Physicians may also gain directly or indirectly from the referrals they make. This is particularly true in the case of advanced imaging. In the 1990s, laws were passed that prohibited physicians from referring patients to facilities where the physicians had an ownership stake (these are often referred to as the Stark laws). However, the law allows physicians to own their own imaging equipment, refer patients to receive scans from inside their facilities, and benefit directly. Likewise, physicians can gain indirectly from making referrals within the system where they are employed (Baker et al. 2015). If physicians were perfect agents for patients, we would expect that aspects of care that are important to the patient (such as out-of-pocket costs) to influence referral choices even if the patient had no direct input into the decision. However, the referrals physicians make may differ from the choices that would be made by a perfectly informed patient, both because the physician may not be fully informed about the patient preferences and patients' out of pocket cost sharing obligations, and because maximizing patient welfare may not be physicians' only objective when they refer patients.

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 primary analysis uses data from 2013. We build an analytic sample of claims for the most common MRI scan in our data: lower extremity MRIs performed without contrast.[2] We identify lower-limb MRIs in our data as those cases involving either a physician or facility claim with a Current Procedural Terminology (CPT) code of 73721. We identify whether or not a scan was performed in a hospital using the place of service codes on a claim.

Our goal was to identify shoppable, homogenous MRI scans. As a result, we limit our analysis to MRI scans taken during visits where no health care services were provided on the claim other than the reading and taking of the MRI (this excludes 14 percent of observations). We also exclude MRIs performed during an inpatient stay or as part of an emergency episode, since patients

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

in these cases are unlikely to be able to actively choose where to receive care (less than 1 percent of cases). We limit our analysis to individuals age 19 to 64, exclude cases where there were coordinated benefits (i.e. our insurer co-funded the care with another insurer) (10 percent of cases), exclude cases where the MRI provider was more than a two hour drive from the patient's home ZIP code (3 percent of cases), and exclude cases performed at out-of-network facilities (2 percent of cases).[3] We also restrict our analysis to MRI scans performed on individuals who were continuously enrolled for at least three months in a point of service (POS) insurance product (the modal insurance product offered by our data contributor). We focus on individuals with POS plans because network breadth and the prices insurers have negotiated with providers may differ across the types of insurance products they offer. Applying these restrictions to our data leaves us with an initial sample of 88,292 episodes.

IIIb. Identifying Patients' Referring Physicians

Nearly all of the beneficiaries in our data needed to have their MRI scan prior authorized by the insurer before the scan would be funded by the insurer. We have data that identifies the physician who requested each patient's prior authorization. In most cases, the physician who ordered the prior authorization for the MRI scan is the patient's referring physician.[4] We can identify the specialties of physicians who ask for prior authorization of lower-limb MRI scans. The prior authorization data from our insurer suggested the majority of physicians who ordered prior authorizations for lower-limb MRI scans were orthopedic surgeons. As a result, in order to identify the referring physicians for each lower-limb MRI scan in our data, we used the claims history of each patient in our sample to find patients who received a lower-limb MRI scan and had at least one office visit with an orthopedic surgeon within three months of the taking of an MRI scan.[5] We restricted our analysis to patients who saw an orthopedist within three months of a scan so that we can assume that the orthopedist a patient saw before a scan was their referring physician.

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[3] 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.

[4] A patient's physician generally requests a prior authorization for an MRI scan. The prior authorization identifies the provider where patients will receive their MRI scan. If the patient chooses to receive care from another location, they will need to obtain a new prior authorization. This can either be generated by their original referring physician or by the medical group that will be delivering the MRI scan. As a result, while prior authorization data is informative about the specialties of physicians who order lower-limb MRIs, it does not provide a definite identification of the physician who ordered a patient's MRI.

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

Restricting our analysis to patients who saw an orthopedist three months before a lower-limb MRI scan eliminates 36,652 of 88,292 cases. The remaining 51,640 cases are divided as follows. In 93 percent of these cases, patients only saw a single orthopedic surgeon before a scan took place. In 7 percent of cases, however, the patient saw two or more different orthopedic surgeons before a scan occurred. For such patients, we identify whether the patient saw an orthopedic surgeon after the scan. We assume that the orthopedic surgeon who saw the patient both before and after the scan was the referring physician. This captures 68 percent of the cases where patients saw two or more orthopedists before a scan. We exclude the remaining 1,153 cases (2 percent of 51,640 cases) that cannot be categorized this way.[6] After excluding those observations, and three observations for which the patient was the only person in their HRR to receive a lower-limb MRI scan, we are left with a final analytic sample size of 50,484.[7] When we transition to analyzing the behavior of referring physicians, we further limit our analysis to referring physicians who ordered at least 5 lower-limb MRIs for patients in our sample population. Doing so excludes 14,619 patient observations.

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, for most physicians in the United States, 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.[8]

IIIc. Transparency Tool Use

The data contributor provides all beneficiaries (i.e. all individuals in our sample) with free access to a tool that allows policy-holders to search for providers and sort by distance and price. The tool

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[6] 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.

[7] 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.

[8] 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.

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

IIId. Identifying 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.

For every MRI performed in our analytic sample, we identify a "primary" provider. If a facility claim is present – as is the case for procedures performed in a hospital – the facility is taken as the primary provider. If not – as is typical for procedures occurring at free-standing imaging centers or clinics – the procedure is assigned to the provider on the physician service line with the greatest total payment. Having aside a "primary" provider to each claim, we sum across service-lines to arrive at a combined price per case that includes the taking and reading of the scan.

In this analysis, we implicitly assume that the taking and reading of MRIs is undifferentiated across providers. While the actual taking of the MRI scan is plausibly undifferentiated, there is evidence of differentiation in the reading of MRI scans across radiologists. For example, Briggs et al. (2007) 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. As a result, because orthopedists tend to review the results of scans themselves and perform as well as radiologists in finding injury on lower-limb MRIs, we assume that both the taking and the reading of scans are undifferentiated with respect to clinical quality across providers.

IIIe. Constructing Patient Choice Sets and Estimating Payments at Alternate Providers

For each patient who underwent an MRI in our sample, we construct an alternative choice set of MRI providers within a 60-minute drive of each patient's home. To do so, we begin by identifying every provider that delivered an MRI scan to a patient in our sample. Next, we calculate travel times between each patient's home ZIP code (ZCTA) and the addresses of all providers within 100 miles of the patient's ZIP. This is done using the online routing API (application programming interface) provided by "Here", a commercial mapping company. The "Here" software uses average traffic patterns and user reported data to estimate travel time, by car, between two locations. By using travel time in lieu 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 historical prices of scans at that provider. Our combined price is based on 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. While we do not directly observe beneficiaries' plan characteristics, we can infer plan benefit designs from our data. To infer what patients would have paid at lower-priced locations, we rely on two facts. First, when moved to a lower priced provider, a patient will never pay more towards her deductible than she did on her original episode. Second, coinsurance rates can be inferred for all patients who exceeded their deductible and needed to pay coinsurance.[9] Our task of inferring co-insurance is made easier by the fact that patients in our sample do not pay fixed co-payments.

IIIf. Money Left on the Table

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.

[9] 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.

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.

IV Results

IV.a 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 $850.07. Twenty-five percent of MRIs in our sample were performed in hospitals. Hospital-based MRIs have an average price of $1,474.35 and cost significantly more than non-hospital-based scans, which have an average price of $642.82.

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

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

IV.b Within Market Variation in MRI Prices

There is significant variation in the price of MRI providers within markets, which we define using HRRs. As we illustrate in Table 2, the median HRR has 10 providers who delivered at least one scan to our sample population in 2013. Across the 302 HRRs in our sample, the median ratio between the 80th and 20th percentile provider prices is 1.73. 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.

IV.c 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 in lieu 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 $468.53 and a reduction in MRI spending of 55.12 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 44.23 percent from $305.53 to $170.40. Likewise, insurers would lower their average spending on each lower-limb MRI by 61.22 percent, from $544.54 to $211.15.

IV.d 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 include quality, distance from home, and price. We analyze, in turn, the extent to which each of these factors may be driving the patterns we observe.

While MRI providers may differ on non-clinical aspects of care, we can assess the extent they differ on one key dimension of clinical quality: the rate scans that must be repeated. The presence of a repeated scan might be indicative that the quality of the first scan was sub-par. However, as we illustrate in Table 4, of the 50,484 MRI scans in our data, only three were repeated within 90-days.

We also find that patients can access lower-priced providers and obtain significant savings without travelling farther than they already went for care. In Table 5, we test the share of the maximum potential savings that would be available if patients travelled no farther than they already went for care, 15-minutes minutes farther, 30-minutes farther, and 45-minutes farther. As we illustrate, if patients attended the lowest price provider reachable in the time they traveled to reach their original providers, out-of-pocket costs could be reduced by 27 percent, insurance spending could be reduced by 41 percent, and total spending on lower-limb MRIs could be reduced by 36 percent. As a result, 65 percent of the maximum potential savings outlined in 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.

In Table 6, we do find evidence that, while not causal, is suggestive that individuals with higher out-of-pocket costs receive cheaper lower-limb MRI scans. For example, we observe that relative to individuals who bore the full cost of their scan in out-of-pocket costs, individuals with zero price exposure had MRIs that were $101 more expensive, they left $97 more dollars on the table, and they were three percentage points more likely to receive a hospital-based scan.

However, because of the structure of insurance plans, individuals may have spot prices (i.e. the price they pay when they access care) that differ markedly from their shadow prices (i.e. the expected true price given that some individuals will exceed their out-of-pocket maximum). Previous research has found that when faced with these non-linear contracts (e.g commercial health insurance plans with high up front cost-sharing and then out-of-pocket maximums or Medicare Part D prescription drug plans with a gap in coverage known as a “donut hole”), individuals tend to respond to the spot price, not the shadow price (Einav, Finkelstein, and Schrimpf 2015; Dalton, Gowrisankaran, and Town 2015; Brot-Goldberg et al. 2017).

Consistent with previous findings, individuals in our sample do not appear to effectively differentiate between spot and shadow prices. Unfortunately, our data do not allow us to discern where patients are with regards to spending towards their deductible or out-of-pocket maximum. However, we can observe individuals’ health spending in the three, six, and 12 months after the taking of their MRI scan.

In Appendix Table 1, we further subdivide those patients some cost with some or total cost exposure into those who have health care costs above and below $5,000 in the six months after they received care. A threshold of $5,000 was chosen as most plans from our insurer have out-of-pocket maximums of $5,000. For many individuals, health care costs over $5,000 in the six months after a scan would mean they faced a shadow price of zero for their MRI scan. When we differentiate between individuals who bore the full cost of their MRI with low future spending (e.g. those with a spot price that matches their shadow price) and those who likely bore the full cost of their MRI but had high future spending (e.g. those who had a shadow price that is considerably lower than their spot price), we find that there is no statistically significant difference between the prices of their MRIs. This result is robust when we split those with cost sharing into groups with above and below $5,000 in future health care costs in the three months after their scan (Appendix Table 2), those with above and below $10,000 in future health care costs in the six months after a scan (Appendix Table 3), and those above and below $5,000 and above and below $10,000 in the 12 months after a scan (Appendix Table 4 and 5).

Of note, as we illustrate in Appendix Table 6, very few individuals searched for the price of an MRI scan before receiving the service. Of the 50,484 lower-limb MRI scans in our sample, patients used the price transparency tool supplied by the insurer prior to receiving care in only 374 of 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.

IV.e Drivers of Money Left on The Table

In this section, we carry out an analysis of variance (ANOVA) to identify the factors that explain why money is left on the table and better understand the factors influencing where patients receive care. We identify the drivers 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, 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 7, referrer fixed-effects explain the largest share of the variance in the price of MRIs, money left on the table, and whether or not a patient received a hospital-based MRI scan. Indeed, referrer fixed effects explain 51.47, 50.38, and 54.39 percent of the variance in each variable, respectively. As we illustrate in Appendix Table 7, this result remains robust when we substitute fixed effects for the ZIP code where the patient lives for fixed effects for the HRR where the patient lives. These results are also robust to excluding the 20 percent of MRI cases that were delivered on the same day a patient saw an orthopedic surgeon.

In Appendix Table 8, 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 8, including patient controls, patient cost sharing fixed effects, and fixed effects for patients' home HRR explains 27.4 percent of the price of MRIs, 26.2 percent of money left on the table, and 21.1 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 0.647, 0.634, and 0.640, respectively. This implies that even after controlling for the HRR in which a patient lives, referrer fixed-effects explain an additional 37.3 percent of the variance in the price of MRIs, 37.2 percent of the variance in money left on the table, and 42.9 percent of the variance in whether a patient received a hospital-based MRI scan.

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

The average referring orthopedic surgeon made 10 referrals for lower-limb MRIs in 2013 (Table 8). The median orthopedic surgeon sent patients to 2.5 locations and the median referring physician's modal referral location received 79 percent of the referrals.

As we illustrate in Table 9, in order for patients and insurers to save money, for the most part, patients need to diverge from referring physicians' established referral patterns. Indeed, if all patients received an MRI from the modal location where orthopedists referred their patients, for example, it would result in only a 10.72 percent reduction in MRI spending and achieve only 19.65 percent of the maximum potential savings.

The ownership structure of the practices where referring physicians work also influences where patients receive care. Within our sample, as we describe in Table 8, 14 percent of orthopedic surgeons worked in hospital-owned practices. Figure 2 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 across referring physicians and vertically integrated physicians are more likely to send patients for hospital-based scans. As we illustrate in Table 8, among non-vertically-integrated referring physicians, the mean orthopedic surgeon sent 19 percent of her patients for a hospital-based scan (the median physician sent no patients to hospitals). By contrast, the mean vertically-integrated referring physician sent 52 percent of her patients for a hospital-based MRI (the median physician sent 57 percent to hospitals).

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 an outside location.

Table 10 presents results from a regression in which each observation is an MRI scan and the dependent variable is either the total price of an MRI, the patient contribution, the insurer contribution, the money left on the table, an indicator for whether a patient had a hospital-based scan, or an indicator for whether an MRI scan was repeated. In addition to controlling for patient characteristics and the patient's HRR, we include an indicator for whether a patient's referring physician is part of a hospital-owned practice. We observe that patients with a vertically integrated referring physician were 27 percentage points more likely to receive a hospital-based MRI and had scans that were $277.19 more expensive. This results in an additional $89.68 in out-of-pocket costs, $187.51 more spending by insurers, and another $270.20 left on the table. However, we find that patients with a vertically integrated referring physician have no difference in the rate their scans needed to be repeated relative to patients with a non-vertically integrated referring physician.

V. Conclusions

We explore the extent to which health care is currently shoppable by patients by examining how individuals with private health insurance currently consume pre-planned lower-limb MRI scans. Lower-limb MRI scans are a useful procedure to study for this analysis because they are plausibly homogenous and can be planned in advance by patients. We posit that if patients struggle to effectively choose an imaging provider, they are likely to struggle when they make even more complicated consumption decisions.

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

Ultimately, we find that referring physician is the strongest determinant of the cost of the MRI scans patients receive, the money that is left on the table, and whether or not a patient has a hospital-based MRI scan. In our decomposition, referring physician fixed effects explain 51.47 percent of the variance in price of an MRI a patient received (92.08 percent of the explained variance). Our results speak to the importance of the agency relationship in determining where patients receive care. We observe that the median referring physician (orthopedic surgeons in our sample) refer patients to three MRI providers, while the modal location where they send their patients tend to capture 79 percent of their referrals. As a result, we find that in order to attend a cheaper MRI provider and save money, patients need to be diverted from their physicians' pre-established referral pathways.

Modifying referral patterns is complicated because physicians' referrals are linked to the ownership structure of their medical practices. Patients who were treated by an orthopedic surgeon working in a hospital-owned practice received more expensive MRI scans, left more money on the table, and were 27 percent more likely to receive a hospital-based scan. We find no evidence that having a vertically-integrated referring physician lowers the rate that MRI scans need to be repeated.

The title of our paper poses a question: Is health care shoppable? Our evidence suggests that, at present, the answer is "no". While this does not mean patients will be forever unable to price shop, it is striking that even in the face of very large deductibles, fewer than 1 percent of patients in our sample searched for the price of MRI scans on the freely available price transparency tool they were provided with before accessing care. Going forward, our findings suggest that because of the weight patients appear to place on the advice of their referring physicians, it is unlikely that a significant number of patients will use information from an app or from a pricing webpage, or to diverge from where their physicians typically send patients for imaging studies. Given that we observe these results for patients consuming lower-limb MRI scans, it is even less likely that patients will actively price shop for more complex and differentiated services.

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

On the policy front, much of the focus for insurers has been on benefits design and on determining how to use 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. Our results highlight a potential explanation for Brot-Goldberg et al's (2017) results. While 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. While more targeted cost sharing (e.g. reference pricing) may be more impactful than current benefit design, our findings highlight the need for policy-makers to incentivize referring physicians to make more efficient referrals or for firms to steer patients towards orthopedists 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 2016).

Our work also has implications for antitrust enforcement. Over the last two decades, there has been a marked increase in the vertical integration of hospitals and physicians (Kocher and Sahni 2011). Our work suggests that when physician practices are owned by hospitals, it can influence physicians' referral patterns and expose patients to higher out-of-pocket costs. While our work is not causal, it highlights the need to rigorously study the effect of vertical integration on health care costs, treatment decisions, and referral pathways.

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Table 1: Descriptive Statistics

	Mean	S.D.	P25	Median	P75	N
Total amount paid (all MRIs)	850.07	535.48	474.88	647.82	1,049.75	50,484
Total amount paid (hospital-based MRIs)	1,474.35	559.82	1,049.59	1,427.50	1,839.97	12,583
Total amount paid (non-hospital-based MRIs)	642.82	324.89	451.05	546.65	746.53	37,901
Amount paid by patient	305.53	365.20	20.32	178.35	471.96	50,484
Amount paid by insurer	544.54	523.07	105.57	439.36	756.41	50,484
Proportion of MRIs performed in hospitals	0.25					50,484
Travel time to provider (min.)	26	18	14	22	33	50,484
No. of providers within 30-minutes	21	21	6	16	30	50,484
No. of providers within 60-minutes	69	59	28	52	85	50,484
No. of providers closer to patient than one attended	13	23	1	5	15	50,484
Share of patients with zero cost-sharing	0.24					50,484
Share of patients who bore some (but not all) of the cost of their MRIs	0.54					50,484
Share of patients who bore the full cost of their MRIs	0.22					50,484
Future health care spending within 3-months after MRI	4,996.80	9,279.13	301.19	1,395.33	6,429.80	50,484
Future health care spending within 6-months after MRI	6,686.95	12,462.61	560.67	2,735.72	8,204.88	50,484
Future health care spending within 12-months after MRI	9,093.23	17,333.17	1,080.95	4,501.89	10,563.29	50,484

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 MRI. 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	163	302
Number of hospitals	6	7	0	2	4	8	44	302
Ratio of providers in 80th/20th price distribution	2.05	0.96	1.00	1.34	1.73	2.59	5.97	302
Coef. of variation of price	0.44	0.18	0.00	0.32	0.45	0.55	1.07	301
Share of largest provider	0.39	0.21	0.05	0.23	0.35	0.50	1.00	302
Proportion of HRRs where most expensive provider is a hospital	0.89							302
Proportion of HRRs where largest provider is a hospital	0.25							302

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

Table 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	% Reduction in Spending	Mean Payment	Mean Savings	% Reduction in Spending	Mean Payment	Mean Savings	% Reduction in Spending
$850.07	$468.53	55.12%	$305.53	$135.13	44.23%	$544.54	$333.39	61.22%

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 the counterfactual price the patient could have received had she gone to that provider.

Table 4: 90-Day MRI-Repeat Rate for Hospital-Based and Non-Hospital-Based Providers

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

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

Table 5: 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		
	% max savings	% reduction of total spend	Savings per case ($)	% max savings	% reduction of total spend	Savings per case ($)	% max savings	% reduction of total spend	Savings per case ($)
No farther	64.98%	35.81%	304.45	62.11%	27.47%	83.93	66.14%	40.50%	220.52
+ 15 Minutes	88.44%	48.74%	414.36	86.75%	38.37%	117.23	89.12%	54.57%	297.13
+ 30 Minutes	96.28%	53.07%	451.11	95.49%	42.23%	129.04	96.61%	59.15%	322.07
+ 45 Minutes	99.48%	54.83%	466.07	99.37%	43.95%	134.28	99.52%	60.93%	331.79

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 realized had they gone to the cheapest provider within 60-minute drives of their homes (i.e. what we call the “maximum potential savings”).

Table 6: Average Payments, Money Left on the Table, and the Probability of a Hospital-Based Scan for Patients with and without Out-of-Pocket Exposure

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

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

Table 7: ANOVA of MRI Price, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan

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

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

Table 8: 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	3,442
Proportion of hospital-owned orthopedists[1]	0.14							3,299
No. locations where patients received MRIs	2.8	1.7	1.0	2.0	2.5	4.0	13.0	3,442
HHI of referrals	6,358	2,616	1,093	4,118	6,543	8,673	10,000	3,442
Proportion of cases sent to modal MRI location	0.73	0.23	0.13	0.56	0.79	0.93	1.00	3,442
Share of patients sent to a hospital	0.24	0.34	0.00	0.00	0.04	0.40	1.00	3,442
Share of patients sent to a hospital for vertically-integrated referrers	0.52	0.40	0.00	0.06	0.57	0.94	1.00	467
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	2,832
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	3,442
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	3,442

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 7, including the singleton observations. [1]Of the 3,442 referring orthopedist NPIs in our sample, 143 did not appear in the SK&A data; this is why we are only able to calculate the proportion of hospital-owned referrers across 3,299 orthopedists in our sample.

Table 9: Savings Available Within Referring Physicians' Established Referral Networks

Savings available if patients attended…

	Total Savings			**Patient Savings**			**Insurer Savings**		
	% max savings	% reduction of total spend	Savings per case ($)	% max savings	% reduction of total spend	Savings per case ($)	% max savings	% reduction of total spend	Savings per case ($)
The modal location where referring physician sends patients	19.65%	10.72%	85.90	16.61%	7.30%	21.49	20.93%	12.71%	64.42

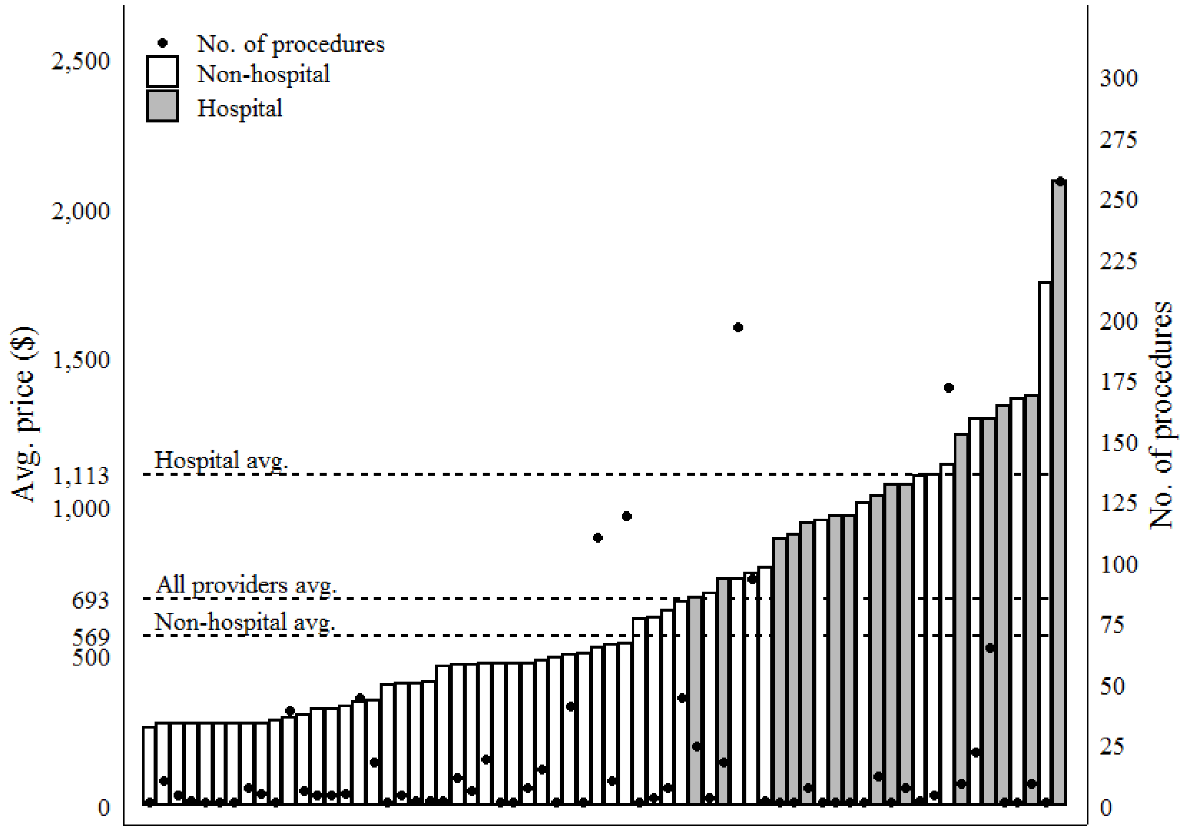
Notes: All calculations in this table are based on the same sample as the one described in Table 7. Like Table 5, this table compares other counterfactuals to the maximum potential savings patients could have experienced had they gone to the lowest cost provider within 60-minute drives of their homes (i.e. the "maximum potential savings" for a patient).

Table 10: 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	277.19***	89.68***	187.51***	270.20***	0.27***	0.00
	(33.68)	(12.20)	(25.54)	(33.93)	(0.04)	(0.00)
Omitted Category: MRIs where the referrer was not vertically-integrated with a hospital						
Mean of Omitted Category	759.53	281.43	478.09	395.01	0.16	0.00
Obs.	35,852	35,852	35,852	35,852	35,852	35,852
R^2	0.2741	0.0993	0.1685	0.2629	0.2271	0.0073

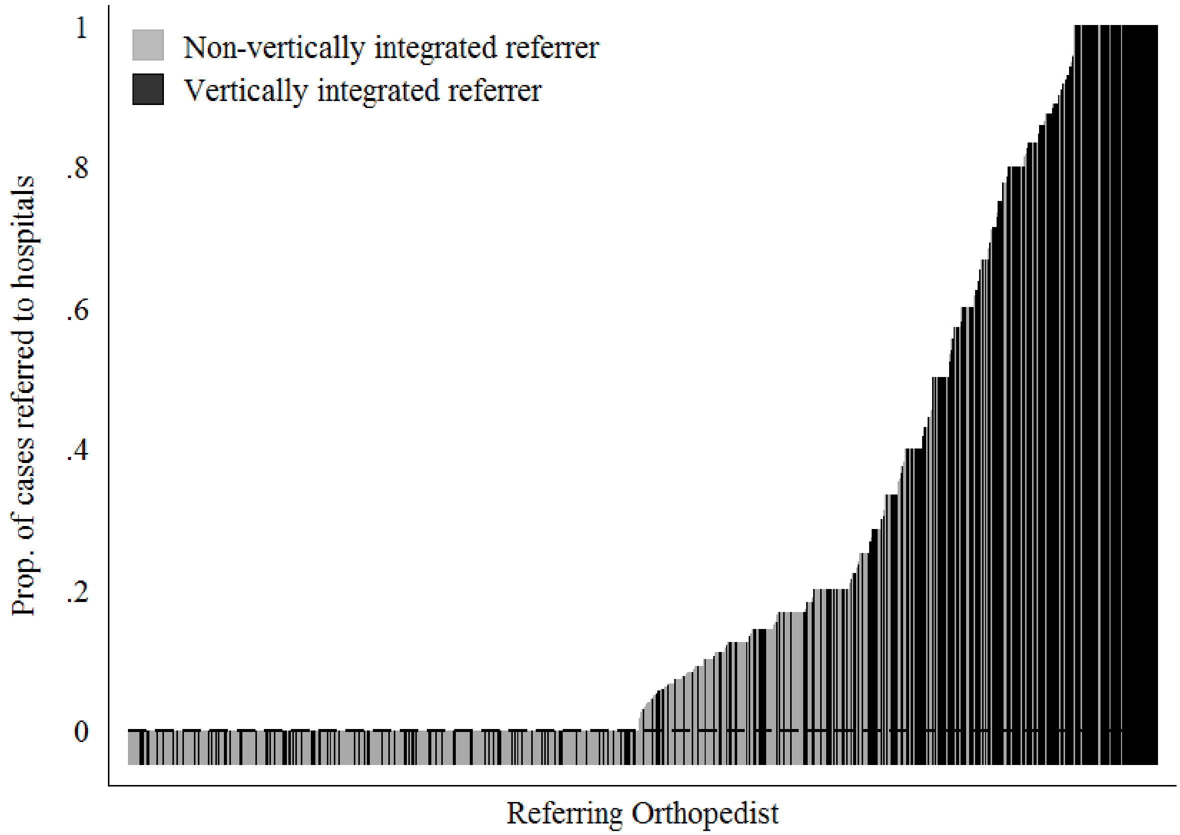
Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions use the sample of MRIs described in Table 7 (i.e. we limit the sample of MRIs to ones where the referring orthopedist made at least 5 referrals and we do not include singleton patient HRRs – this reduces the sample size from 50,484 to 35,852). 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: 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 10 (i.e. orthopedists who made at least five referrals in 2013, excluding singleton patient HRRs). The bar height indicates the proportion of cases an individual orthopedist refers her patients to a hospital. Black bars indicate referrers who are vertically-integrated with a hospital. Grey bars indicate referrers who are not vertically-integrated.

ONLINE APPENDIX

Appendix Table 1: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $5,000 in Spending within 6 Months After the Taking of an MRI.

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

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions 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 price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $5,000 in health care costs in the six months following their MRIs. Of the 50,484 MRIs in our sample, 19,483 patients (38.6%) were "high" future health care cost patients.

Appendix Table 2: Payments and Money Left on the Table for Patients with and without Out-of-Pocket Exposure, Broken Down by Individuals with Over and Under $5,000 in Spending within 3 Months After the Taking of an MRI.

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

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions 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 price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much “money [they] left on the table”) between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but “high” future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and “low” future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define “high” future health care cost patients as those who generated at least $5,000 in health care costs in the three months following their MRIs. Of the 50,484 MRIs in our sample, 19,483 patients (38.6%) were “high” future health care cost patients.

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 $10,000 in Spending within 6 Months After the Taking of an MRI.

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

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 price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $10,000 in health care costs in the six months following their MRIs. Of the 50,484 MRIs in our sample, 9,861 patients (19.5%) were "high" future health care cost patients.

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 12 Months After the Taking of an MRI.

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

Notes: * p<0.10, ** p<0.05, *** p<0.01. These regressions 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 price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $5,000 in health care costs in the twelve months following their MRIs. Of the 50,484 MRIs in our sample, 23,963 patients (47.5%) were "high" future health care cost patients.

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 $10,000 in Spending within 12 Months After the Taking of an MRI.

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

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 price, the probability a patient received a hospital-based MRI, and the average amount of combined patient and insurer savings that could be achieved if patients had gone to the cheapest provider within a 60-minute drive of their home (i.e. how much "money [they] left on the table") between patients who bore the full cost of their MRIs and had "low" future health care costs with four other groups of patients: 1) those who had no price exposure for their MRI (i.e. paid nothing) 2) those who had some price exposure, but "high" future health care costs (i.e. those whose shadow price was zero), 3) those who had some price exposure and "low" future health care costs and 4) those who bore the full cost of their MRI and had "high" future health care costs. We define "high" future health care cost patients as those who generated at least $10,000 in health care costs in the twelve months following their MRIs. Of the 50,484 MRIs in our sample, 13,445 patients (26.6%) were "high" future health care cost patients.

Appendix Table 6: Average Payments and Money Left on the Table for Patients Using the Price Transparency Tool

	(1) Total amount paid	(2) Money left on the table	(3) Prob. hospital-based MRI
Use of Price Transparency Tool	-88.87***	-84.11***	-0.05**
	(22.77)	(22.43)	(0.02)
Obs.	50,484	50,484	50,484
R^2	0.2711	0.2436	0.2094
Transparency Tool Use Rate:	374 of 50,484 cases (0.74%)		

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

Appendix Table 7: ANOVA of MRI Price, Money Left on the Table, and Whether a Patient Received a Hospital-Based Scan-Patient ZCTA Fixed Effects

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

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

Appendix Table 8: Decomposing the Drivers of Patient's MRI Prices and Money Left on the Table

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

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