# Essays on the Impact of Financial Incentives

# on Medicaid Service Provision and Patient Outcome


BY

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THESIS

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This thesis is dedicated to my husband, John, and my daughter, Tess, who encouraged me and made me laugh during the toughest times. I also thank my family for the countless hours they spent taking care of Tess and the prayers they said on our behalf so that both John and I can graduate. This truly would not have been possible without their support.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACA | Affordable Care Act |
| ACO | Accountable Care Organization |
| AHA | American Hospital Association |
| APC | Ambulatory Patient Classification |
| CABG | Coronary Artery Bypass Grafting |
| CI | Confidence Interval |
| CPT | Current Procedural Terminology |
| CT | Computed Tomography imaging |
| DO | Doctor of Osteopathic Medicine |
| DSH | Disproportionate Share Hospital |
| E/M | Evaluation and Management services |
| EAP | Enhanced Ambulatory Patient |
| ED | Emergency Department |
| FE | Fixed Effects |
| FFS | Fee-for-Service |
| ICD-9 | International Classification of Diseases, Ninth Revision |
| IDS | Integrated Delivery System |
| IP | Inpatient file |
| IQR | Interquartile Range |
| M&A | Merger and Acquisition |
| MACRA | Medicare Access and Children’s Health Insurance Program Reauthorization Act |
| MAX | Medicaid Analytic eXtract files |
| MAXPC | MAX Provider Characteristics file |
| MD | Doctor of Medicine |
| MRI | Magnetic Resonance Imaging |
| MSA | Metropolitan Statistical Area |
| OBRA | Omnibus Budget Reconciliation Act |
| OPD | Hospital Outpatient Department |
| OT | Other Therapy file |
| PCCM | Primary-case Case-management |
| PS | Personal Summary file |
| SAIPE | Small Area Income and Poverty Estimate |
| SCHIP | State Children’s Health Insurance Program |
| TIN | Tax Identification Number |

# SUMMARY

The first chapter is titled, "The Effect of Physician-Hospital Integration on Medicaid Access to Care and Utilization: Findings from Louisiana's Medicaid Market." The U.S. healthcare market has seen a rapid increase of physician-hospital integration with share of hospital-employed physicians increasing from 26% to 44% during 2012-2018. However, it is largely unknown how this trend affects the Medicaid population. This study intends to bridge that gap by relating county/parish-level measures of physician-hospital integration to patient-level measure of access to care and Medicaid service utilization. It focuses on Louisiana, where the entirety of the Medicaid population is under a Fee-for-service payment scheme during the study period of 2008-2010. Among 64 counties, county-level physician-hospital integration increased from 2008 to 2010 by a mean of 1.5 percentage points, with considerable variation in changes across counties (interquartile range, -4 to 29 percentage points).

I find no statistically significant relationship between greater physician-hospital integration in a county on overall access to physician services for Medicaid beneficiaries. However, I find that where Medicaid patients see physicians changes following greater availability of integrated physicians in an area, namely from office to hospital outpatient department. This suggests that greater physician integration could imply a decrease in quality of care for Medicaid patients in terms of continuity of care and patient satisfaction.

Greater integration also leads to a large increase (140%) in use of imaging procedures among children. On the other hand, I find minimal impacts on use of lab tests. These results on the use of ancillary services suggest that joining providers of complementary services may lead to increase in the use of lucrative procedures. I also estimate a precise zero impact on the use of inpatient services. Lastly, I find that greater physician-hospital integration results in reduced emergency department service usage (-85%) among adults, which may suggest that there may be some efficiency gain following integration. As the trend toward integration intensifies, it will be important for policy makers to consider the consequences of greater integration that may be unique to the Medicaid population.

The second chapter is titled, "How Does Changes in Fee-for-Service Payment Impact the Utilization of Imaging Exams? Evidence from Medicaid." Diagnostic imaging services are expensive, and overutilization of the imaging exams contribute to increasing medical expenditure in the U.S. I test whether the Fee-for-service (FFS) payment scheme drives the utilization of these lucrative services using detailed Medicaid claims data in twelve states over a five-year period (2003-2004 and 2008-2010).

Using a difference-in-differences design, I find that increasing Medicaid-to-Medicare fee ratio from 0.7 to 1 is generally associated with a large and positive effect on utilization of X-ray, diagnostic ultrasound, and CT scans and a negative effect on MRI use. The effect sizes tend to be larger in outpatient hospitals than in office. I also examine whether low-value imaging services, spine imaging among back pain patients and brain imaging among headache patients, are impacted by the fee change. I also find that the fee increase is associated with a positive probability of receiving the low-value imaging services, except for spine and brain MRIs. However, none of the estimates are statistically significant at the 5%-level or precisely measured. While this study does not provide conclusive evidence on the relationship between Medicaid FFS reimbursement rates and utilization response, it offers a perspective on how to think about physician's decision to supply care to patients in terms of income and substitution effects in a unique Medicaid environment.

# 1. The Effect of Physician-Hospital Integration on Medicaid Access to Care and Utilization: Findings from Louisiana's Medicaid Market

## 1.1 Introduction

Medicaid has had difficulty attracting providers, and policy makers have long expressed concerns about access to physician services for Medicaid patients (Baker and Royalty 2000; Zuckerman et al. 2009). Following the Affordable Care Act (ACA) of 2010, more than 16 million enrollees were added to the program and ensuring adequate access for Medicaid beneficiaries has been an ongoing concern. Many existing studies examine various factors impacting physician participation in Medicaid, such as low reimbursement rates, payment delays, administrative burden, and staffing structure (Cunningham and Nichols 2005; Decker 2009; Decker 2015; Fanning and Alteriis 1993; Long 2013; Richards and Polsky 2016; Richards et al. 2016; Shen and Zuckerman 2005). However, little is known about how recent changes in the physician market, namely, movement away from traditional, solo practices to hospital-integrated practices, are impacting Medicaid patient's access to care and utilization of services.

Physician-hospital integration in the U.S. has been growing in recent years. Recent policies such as the ACA of 2010 and the Medicare Access and Children's Health Insurance Program Reauthorization Act (MACRA) of 2015 promote physician-hospital integration (Machta et al. 2019). For example, when doctors and hospitals form an Accountable Care Organization (ACO), they are eligible for cash bonuses under ACA (Baker et al. 2018). As a result, affiliations between provider organizations and hospital systems are replacing independent practices (Burns et al. 2014). Between 2005 and 2014, the share of physician practices owned by hospitals or integrated delivery system (IDS) increased from 31 to 89% (AMGA 2016). A mirrored trend is the decline of solo physician practices. In 2014, 17% of physicians reported that they were in solo practices, in contrast to 25% in 2012 (Kash and Tan 2016).

Some suggest that greater physician-hospital integration could improve access to care among Medicaid patients. Studies argue that hospital-based practice can expand their capacity to accept new Medicaid patients more readily than small practices by equipping practices with more clinical and management tools that help coordinate care (Richards et al. 2016; Sommers et al. 2011). Moreover, large integrated health systems serve every type of patient, whether because of mission, regulatory flat, or concern about public opinion, while independent physicians pick and choose who they serve (Berenson 2017). In fact, majority of Medicaid patient care is given by a small proportion of physicians who tend to practice in hospitals, large groups, and office practices owned by hospitals (Cunningham and May 2006; Sommers et al. 2011). On the other hand, greater physician-hospital integration could have the opposite effect on access to care for Medicaid patients. Studies suggest that hospital's greater market power achieved through physician-hospital integration increases private patient prices, making Medicaid patients financially less attractive to integrated providers (Baker et al. 2014; Capps et al. 2018). Despite the growing interest, little research has been done to link greater physician-hospital integration to changes in access to care and usage of physician services among Medicaid population.

This paper fills the gap in the current literature by examining the association between changes in physician-hospital integration and access to care and utilization of various medical services for Medicaid beneficiaries. Using Fee-for-service (FFS) Medicaid claims data from Louisiana in years 2008-2010, I estimate this relationship by comparing counties with large versus small changes in the share of integrated physicians over time[1]. I also account for time-

[1] In Louisiana, counties are referred to as parishes. I use "county" instead of parish throughout the paper for convenience.

varying patient and county-level characteristics that could be correlated with Medicaid service utilization. Because 100 of Louisiana's Medicaid patients are covered under FFS payment plan during the study period, I capture a comprehensive picture of Medicaid physician market and patient utilization in Louisiana. To measure physician-hospital integration at the county-level, I exploit the billing convention for physician service reimbursements in the Medicaid claim files to identify which physicians are employed by hospitals or IDS. While theory gives ambiguous predictions on the impact of greater physician-hospital integration on access to care and Medicaid service utilization, I empirically assess the relationship using a difference-in-difference framework with detailed, unique Medicaid claim data.

I first study how changes in physician-hospital integration affects access to care, as measured by annual number of evaluation and management (E/M) services that proxy contact with physicians. Next, I investigate whether greater integration of physicians change where the care is given for Medicaid patients. Site of care is important in terms of patient satisfaction and continuity of care. Patients often prefer physician office over other care settings for non-emergency health conditions (Mukamel et al. 2018). While patients tend to see different provider each time they visit hospital-based clinics, they can usually see the same provider in physician office. To examine how patient experience might be, I estimate whether greater integration impacts utilization of E/M services separately by place of service, namely office and hospital outpatient department (OPD). Lastly, I study how use of ancillary services (e.g. imaging and lab tests), inpatient admissions, and emergency department (ED) service use are impacted by greater financial alignment by physicians and hospitals. When primary care physicians, specialists, and hospitals who separately provide complementary services are joined by contract with their financial incentives aligned, patient spending might increase (Berenson 2017; Kocher and Sahni

2011; O'malley et al. 2011). On the other hand, greater integration may improve coordination of care across outpatient and inpatient settings and reduce unnecessary use of costly services, such as inpatient and emergency care (Kocher and Sahni 2011; Wilhoite 2009).

The results indicate that shifting the county's Medicaid physician market from no to full integration is associated with a decrease in overall count of E/M visits per year for children and increase for adults. However, the estimates are not statistically significant and are not sufficiently precise to be conclusive. However, I find significant shifts in where E/M visits occur following increased integration, namely from office to OPD; Greater integration is associated with statistically significant decrease in visits taken place in office for children and statistically significant increase in visits taken place in OPD for children and adults. This shift in site of care could suggest that as more physicians work in hospital outpatient settings following hospital employment, patients simply need to go to hospitals to receive care because less office-based physicians are available in general. Alternatively, the shift might be motivated by payments hospitals receive when they treat more Medicaid patients in hospitals. Physician offices are associated with improved continuity of care and greater patient satisfaction. This finding suggests that greater integration does not necessarily increase access to care as proponents of integration argue but reduce quality of care for Medicaid patients in terms of patient experience and continuity of care.

I find evidence that greater physician-hospital integration leads to greater use of relatively expensive imaging services. Among children, I estimate a statistically significant, precise, and large increase on the annual utilization of imaging services. The estimated coefficient on adults is also positive but smaller and is not estimated with statistical precision. This result is consistent with the supposition that physicians and hospitals who provide complementary services are likely to increase ordering of lucrative imaging services as they financially join to form an integrated entity. However, this result may also be possible simply because it is more convenient for patients to receive imaging tests in same facility as their E/M visit with a physician which increasingly takes place in OPD as integration grows. While the estimated coefficients on lab tests are positive for both age groups, neither are statistically distinguishable from zero and the magnitude of the estimates are small. Given that imaging tests tend to be more expensive than lab tests on average, we would expect to see greater impact of integration on utilization of imaging tests if physicians and hospitals direct ordering of ancillary services to their advantage.

Lastly, I estimate a precise zero effect on use of inpatient services among children and adults. This result is consistent with previous work that observed lack of association between greater integration and utilization of inpatient services among Medicare and privately insured patients (Baker et al. 2014; Capps et al. 2018; Madison 2004; Neprash et al. 2015). In terms of ED-service use, greater integration is associated with a statistically significant and large decrease in utilization among adults and a small and statistically insignificant increase among children. While greater integration was not associated with less inpatient service use, it seems to reduce utilization of costly ED services which may imply that integration could lead to improved efficiency.

The estimates are robust to inclusion or exclusion of county-level covariates that proxy local economic shocks that may impact utilization of Medicaid services. Additionally, the estimates are largely unaffected when I limit the study sample to those who are consecutively enrolled in Louisiana's Medicaid program for the entirety of the study period and may exhibit more consistent utilization patterns.

This study contributes to the existing literature in several ways. It supplements the growing literature on the effect of physician-hospital integration on with a focus on Medicaid patients. Most existing studies examine the effect of greater integration on Medicare or privately insured patient's outcome and prices (Baker et al. 2014; Capps et al. 2018; Ciliberto and Dranove 2005; Cuellar and Gertler 2006; Machta et al. 2019; Madison 2004; Mafi et al. 2017; Neprash et al. 2015). However, few studies look at its effect on Medicaid population and their service utilization, who spends 17% of U.S. health. Although the results on overall access to care is inconclusive, the quality of care might go down for Medicaid beneficiaries as they receive more care in OPD than in office, which is a novel finding. Also, I find evidence for the argument that forming integrated healthcare entity may increase use of lucrative services, such as imaging tests, to the financial advantage of providers. However, I also find evidence in support of integration activities that greater care coordination between outpatient and inpatient setting could reduce utilization of costly ED services. Financial integration between hospitals and physicians is closely scrutinized by antitrust policymakers (Koch et al. 2017). As they assess the pros and cons, it is important to understand that the consequences of integration can vary across patient populations. This study intends to help this understanding.

## 1.2 Background on Physician-Hospital Integration

### 1.2.1 Hospital Perspective

Traditionally, independent physicians were affiliated with the hospitals within the community by serving as the hospital's voluntary medical staff and performing duties, such as on-call coverage, in return for admitting privileges (O'malley et al. 2011). In the 1990s, the move toward managed care and health maintenance organizations pushed hospitals to rapidly purchase physician practices to control referral basis and contain costs. However, integration efforts in the 1990s had largely failed. In purchasing physician practices, hospitals often incurred large losses due to adverse physician selection, insufficient revenue generated by practices, and high acquisition prices. For example, as physicians transitioned from independent practice to hospital employment, hospitals would guarantee physicians close to 100% of their previous year's salary. This arrangement contributed to hospital's losses as hospitals often saw lower productivity levels, higher overhead expenses, and less effective revenue cycle management with their transitioning physicians (Kocher and Sahni 2011). Lack of success in improving physician-hospital collaboration and hospital financial performance led hospitals to downsize their physician networks (Burns and Pauly 2002).

Despite past failure, there has been a steady increase in hospital's practice acquisition and employment of new physicians in recent years. Between 2007 and 2017, primary care physician practices that reported either being part of a health system or owned by a hospital increased by more than two folds (Nikpay et al. 2018). The current wave of physician-hospital integration continues to be motivated by the health care systems' need to maintain a wide network of physicians demanded by patients and health plans (Wilhoite 2009). Moreover, hospitals are motivated to achieve competitive advantage in their service regions as increasing number of physicians aggregate into larger groups that direct referrals and utilization to their own advantage. By employing physicians, they can direct patients to their own hospitals and affiliated specialists to increase admissions, diagnostic testing, and outpatient services (Berenson 2017; Kocher and Sahni 2011; O'malley et al. 2011). A sharp rise in the number of freestanding ambulatory surgery centers and diagnostic imaging sites exacerbates this need for hospitals to integrate with physicians (Burns and Muller 2008).

Lastly, hospitals increasingly employ physicians to prepare for insurer payment reforms, including bundled payments and penalties for preventable hospital readmissions. By employing physicians, hospitals can be flexible when changes in reimbursement methods make providers to bear greater risk of managing patient's health (O'malley et al. 2011).

Although hospitals still incur short-term loss from practice acquisition, they expect positive profit in the long run. Hospitals can lose up to $250,000 annually over the first three years of employing a physician as he establishes himself or transitions his practice (Mertz 2018; Ziskind et al. 2011). The losses decrease by approximately 50% after three years, but even with some persistent loss thereafter, hospitals start generating positive profit on their employed physicians when value of all care, exams, and referrals are taken into account (Kocher and Sahni 2011).

Moreover, hospitals today are using productivity-based compensation, as opposed to guaranteed salaries in the 1990s. Today's employed physician compensation typically incorporates: (1) an element of fixed salary and (2) an incentive component based on production (Wilhoite 2009). This approach attempts to maintain productivity levels and combat the loss of sense of urgency physicians used to have as practice owners. Some hospital systems also provide physicians incentives to use standard medical devices and avoid wasting supplies. Hospitals are also more selective about whom they employ and try to avoid buying practices "for the sake of buying" as they acknowledged doing so in the past. They also lease rather than purchase office space or equipment and increase their administrative management to monitor productivity and quality. (O'malley et al. 2011). Reflecting some success from this recent approach, in a 2015 survey of 23 hospital executives, 22 said that their expectations for practice acquisitions were either fully or partially met (Mertz 2018).

### 1.2.2 Physician Perspective

Physicians inevitably give up some autonomy associated with owning a practice once they become hospital employed. The hiring and firing of staff members and clinical guidelines for caring for the patients are largely dictated by the hospital system (DAS health 2018). Physicians may be able to provide more personalized and patient-focused care in independent setting than as hospital employed physicians (Harris 2019). Hospitals often set policies that are the same across all their practice locations on the assumption that that is the most efficient, even when circumstances call for differing policies. Physicians who want to change a certain policy often must go through multiple levels of management before they can get an answer (Mertz 2018). Even with challenges associated with hospital employment, many physicians are drawn to hospital employment as opposed to running an independent practice.

Under complex changes in delivery system following health care reform, employment provides physicians with financial security and reduces risk of operating own practice. Stagnant reimbursement rates and rising overhead costs pose challenges in managing an independent practice for physicians. Hospitals usually negotiate health plan contracts on behalf of employed physicians, gaining higher rates than independent physicians could negotiate on their own (O'malley et al. 2011). A 2013 survey reported that average first-year salary was higher for physicians working in hospital-owned practices than those working in physician-owned practices. For example, among primary care physicians, those working for hospital-owned practices earned an average first-year salary of $192,554 compared to $185,000 for those working in physician-owned practices (Pallardy 2015).

Also, hospitals often pay malpractice premiums in behalf of employed physicians and provide staffing and management tools to reduce administrative and operating burdens. Employment also significantly reduces physicians' personal level of capital investment to run a private practice yet gives access to cutting edge technology and facilities. For younger, new physicians, some hospitals offer employment-based tuition waiver. Other benefits of hospital employment include leadership roles within the health system and more predictable, shorter hours (Kocher and Sahni 2011; Wilhoite 2009; Ziskind et al. 2011)

### 1.2.3 Patient Perspective

Since many employed physicians remain in the same office as they had previously worked in as an independent physician, a change in a physician's employment status may not seem obvious from the patient's perspective. For Medicaid patients who historically had poor access to independent specialists, a potential benefit of physician-hospital integration may include better access to specialty care (Burns et al. 2014). IDS may improve care for patients with complex medical conditions as it can offer greater coordination among service providers and greater use of clinical data (Kocher and Sahni 2011). Also, greater scope and scale of the services provided by integrated providers has the potential to reduce cost (Wilhoite 2009).

However, the empirical evidence of greater integration is mixed in terms of efficiency, cost, and spending. Trend towards greater physician-hospital integration may affect various patient population differently as physicians face different demand and cost curves associated with each patient base. Especially for Medicaid patients, whose reimbursement rate is lower than that of privately insured or Medicare patients, the implications of greater integration on patients' access to care and utilization are ambiguous. I make theoretical prediction on the effect of greater physician-hospital on Medicaid patients' access and utilization below and empirically assess them using a reduced form framework.

## 1.3 Theory

### 1.3.1 Dual-Market Model of Physician Participation in Medicaid

I consider a "dual-market" model of physician participation in Medicaid to understand what factors influence access to Medicaid services and what role greater physician-hospital integration plays in this framework. A physician sells the same service to patients from two different markets – a high-price and a low-price market. In the high price (private insurance) market, a physician faces a downward sloping demand curve. He is a price-setter, and generally receives reimbursement approaching the fee charged. In the low price (Medicaid) market, the physician is a price-taker. For example, Medicaid physician fees are legislatively established by state Medicaid agencies (Sonchak 2015).

If the intersection point of the physician's marginal cost curve and the marginal revenue curve lies above the Medicaid price, the physician will not serve any Medicaid patients. Physicians participate in Medicaid only when marginal revenue from private patients fall below the Medicaid fee level. Upon Medicaid participation, physicians may accept all patients who contact them or choose to limit their participation in some way (e.g. by accepting only referrals or emergency cases) (Davidsons et al. 1982). When physicians limit their participation, some patients may be forced to rely on emergency room or even to forego health care entirely (Bond et al. 2017; Fossett and Peterson 1989; Perloff et al. 1987; Sloan et al. 1987).

### 1.3.2 Impact of Integration on Access to Care

There are three main mechanisms in which physician-hospital integration impacts Medicaid patient's access to care: (1) changes in relative price of treating Medicaid patients, (2) changes in efficiency, and (3) changes in financial incentives.

First, integrated physicians could bargain for higher commercial prices, reducing the relative price of treating Medicaid patients. This then dampens Medicaid patient's access to care, ceteris paribus. As noted above, reimbursement rates from various insurers shape a physician behavior toward Medicaid patients. When the integrated entity has market power derived from its existing share of the hospital market, it can command higher prices during price negotiations with the private payers[2]. For example, it can threaten to exclude its affiliated hospitals and providers from an insurer's network (Neprash et al. 2015). This leads to higher private market prices and makes Medicaid patients less financially attractive to integrated physicians.[3] Besides negotiating for higher prices, integrated physicians can also receive higher Medicare or commercial payment by exploiting billing rules. Studies have found that post-integration, private and Medicare price increase as providers exploit reimbursement rule that allows hospitals to charge "facility fees" for procedures performed in hospital-owned physician practices (Capps et al. 2018; Neprash et al. 2015). Under the leisure-income model, more generous private reimbursements increase the physician's income, and the opportunity cost of not treating a private patient increase. The income and substitution effects work in the same direction for treating Medicaid patients in response to increase in private pay, and physician's Medicaid participation falls.

Next, if integration lowers costs and increases efficiency, it can increase provider's capacity of provide care across all patient types, including Medicaid patients. Overhead costs

[2] For example, Carilion, the dominant health system in Roanoke Virginia, reportedly charged 4-10 times higher prices for colonoscopy compared to competitors in similar markets (Carreyou 2008).

[3] The opposite occurs if the bargaining power belongs to a commercial insurer with many enrollees in a local market. The insurer negotiates with providers and drives the price down for services. Ceteris paribus, lower private prices means that the pay differential between privately insured and Medicaid patients are reduced. This in turn reduces the physician's preference for privately insured patients. Thus, when insurers have greater bargaining power, Medicaid patients may have better access to care (Bond et al. 2017).

might be lower as a result of integration, for example, when hospitals and practices consolidate record keeping and billing departments. Also, the larger group may be able to bring the price of medical supplies down from price negotiating with vendors (Capps et al. 2018). Efficiency may increase when hospitals and providers coordinate care across inpatient and outpatient settings by using health information technology. Integration can also standardize the choice of cost-effective surgical supplies and evidence-based practices across providers within a health system. Hospitals and providers can also work together to schedule elective procedures in ways that maximize asset utilization (Kocher and Sahni 2011). Greater efficiency and lower costs may encourage physicians to take on more patients across insurance types, thereby increasing access to care for Medicaid patients[4].

Lastly, changes in the way physicians get paid following hospital employment can influence the physician's willingness to serve Medicaid patients. Physicians typically have a different compensation arrangement when they are working in private practices as opposed to being employed by hospitals. In a 2016 survey, 84% of direct hospital employees indicated that more than half or all their compensation came from salary compared to 31% of owners. On the other hand, only 20% of direct hospital employees indicated that more than half or all their compensation came from productivity compared to 42% of owners. (Rama 2018).

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[4] Minimum-efficient scale theory suggests that larger hospital-owned groups can more readily expand their Medicaid patient volume than smaller, independent practices. Fossett and Peterson (1989) argue that minimum-efficient scale, the level of output at which all economies of scale have been realized and long run average costs are at a minimum, for treating private/Medicare and Medicaid patients differs for each firm. Greater costs associated with treating Medicaid patients may make minimum-efficient scale for Medicaid patients larger than for private patients. For example, treating Medicaid patients is often associated with higher administrative burdens (e.g. claim denials, long waits for reimbursement), higher no-show rates, more complex conditions, and low reimbursement rates (Long, 2013). Studies show that integrated practices have greater Medicaid patient base than solo or small private practices. This may be because they have realized all economies of scale through greater number of auxiliary personnel, greater network of physicians, and use of health information technology. Moreover, they can achieve lower average visit costs by spreading the costs over a larger number of Medicaid patients (Sommers et al. 2011). As more physicians join hospital-owned practices, more Medicaid patients may have access to physician services as number (or size) of facilities that have reached minimum-efficient scale grows.

Independent practices generally pay physicians on collection-basis. For collection-based earnings, how quickly payment is received and the relative percentage of private, Medicare, Medicaid, and uninsured patients matter for the physician's earnings. As Medicaid is associated with frequent payment delays and low reimbursement rates, many physicians select against Medicaid patients (Cunningham and O'Malley 2009). While myriad variations exist for employed physician's compensation scheme, many hospital-employed physicians are paid under salary-based model with some productivity element. Being on salary removes the issue of Medicaid's payment delays. Also at least for the salary component, a physician is paid no more for treating a private-pay patient than for treating a Medicaid patient (Mertz 2018). Even with the productivity component, which is usually based on a percentage of billings or collections, transitioning from mostly collection-based to some salary-based compensation scheme lessens the pay discrepancy between commercial and Medicaid patients. Depending on how large the salary share of the physician's total earnings is, physicians may be more likely to treat Medicaid patients after they get paid based on salary. This may still be true even if the relative pay for Medicaid payments decrease due to increase in private pay following greater integration.

In summary, physician-hospital integration can influence Medicaid patient's access to care in several different directions depending on the strength of each mechanism. I empirically assess the consequences of greater integration using detailed Medicaid claims data.

### 1.3.3 Impact of Integration on Utilization of Services

Physician-hospital integration can have mixed implications on utilization of ancillary, inpatient, and ED services. Alignment of financial incentives between providers of complementary services could increase utilization. In a FFS environment, hospitals and their employed physicians have incentives deliver more services as they get reimbursed per-unit. When productivity component of the physician's compensation is large, these incentives may be intensified (Burns et al. 2014). Utilization may increase as hospitals employ physicians to direct inpatient admissions, diagnostic exams, and outpatient services to their own facilities. While there are legal restrictions in place, like the Anti-Stark laws, that prohibit hospitals from directly compensating physicians for referrals, it is extremely difficult to monitor variant of such referrals that effectively pay physicians for referrals (Baker et al. 2014). Greater physician-hospital integration could give physicians incentives to order unnecessary exams or provide avoidable services that benefit partner hospitals (Burns and Muller 2008; Reschovsky and Rich, 2015).

On the other hand, improved coordination across outpatient and inpatient settings may reduce incidences of duplicate tests. Moreover, if patients have greater access to physician services, such as E/M services, they may be able to detect illnesses early on to avoid costly inpatient or emergency room visits. Once again, there is no clear prediction on how greater physician-hospital integration will affect Medicaid service utilization. I empirically assess how patient utilization of various ancillary, inpatient, and ED services change following local market changes in physician-hospital integration. I leverage unique Medicaid claims data and physician characteristics data to empirically explore these possibilities.

### 1.4 Previous Studies on Physician-Hospital Integration

Most studies on the subject focus on the impact of physician-hospital integration on prices and spending, and generally find that greater integration raises prices and has little impact on utilization. In one of the earlier studies on the subject, Cuellar and Gertler (2006) uses panel data of hospitals in Arizona, Florida, and Wisconsin from 1994 to1998 to estimate the impact of physician-hospital integration on hospital performance and prices. The results show that integrated hospitals are no more efficient in terms of cost saving than unintegrated hospitals and have higher prices. The authors suggest public programs, like Medicare and Medicaid, to reconsider their policies that promote hospital-physician integration as hospitals seem to seek integration to gain market power and raise prices. On the other hand, Ciliberto and Dranove (2005) uses a panel of hospital financial data from California for the period of 1994-2001 and find no evidence that integration was associated with significant changes in hospital pricing.

More recently, Baker et al. (2014) examines the consequences of financial integration between physicians and hospitals on hospital prices, spending, and admissions. Using American Hospital Association's hospital survey data, the authors characterize hospital's relationship with physicians depending on how tightly the two entities are financially joined. Then they calculate the share of different organization types by hospitals in each county from 2001 to 2007. Results indicate that an increase in the county-level share of hospital ownership of practices is associated with greater hospital prices and patient spending, but not on hospital volume. Neprash et al. (2015) constructs Metropolitan Statistical Area (MSA)-level measure of physician-hospital integration using Medicare claims. They calculate the measure as the share of physicians in an MSA with billing patterns consistent with employment or practice ownership by a hospital. The paper finds that greater integration is associated with higher prices and spending for outpatient care among privately insured patients in 240 MSAs during 2008-2012. However, they do not find any significant impact of integration on utilization of outpatient services or spending or utilization for inpatient services. Instead of constructing area-level measure of integration, Capps et al. (2018) examines integration activity from the individual physician's perspective. Using a panel data of physicians, the authors examine the acquisition of physician practices by hospitals from 2007 to 2012 and investigate its impact on physician service prices and spending among Medicare enrollees. The results indicate that acquisition led to increase in price for the acquired physicians and increase in spending for enrollees whose primary care physician had integrated.

Other studies show that greater physician-hospital integration has little impact efficiency measured in terms of patient outcomes and cost saving. examine the impact of integration on efficiency of care and they show that utilization is generally not influenced by greater physician-hospital integration. Madison (2004) examines how different degrees of physician-hospital integration impacts the treatment of Medicare patients with acute myocardial infraction diagnosis from 1994 to 1998. She finds that while integrated salary model is associated with higher procedure rates and patient expenditure, there is little evidence that greater integration in aggregate had any measurable impact on patient mortality or readmission rates. Mafi et al. (2017) compares low-value service use after primary care visits at hospital- versus physician-owned practices from 1997 to 2013. Adjusting for patient and provider characteristics, the paper finds no significant differences between visits to hospital-owned versus physician-owned practices in terms of use of low-value antibiotics, CT, MRI, or radiograph procedures. However, a patient visit to hospital-owned practices was associated with a higher likelihood of having more specialty referrals compared to visiting a physician-owned practice. In a systematic review of the literature, Machta et al. (2019) finds that physician-hospital integration was associated with more optimal care for specific conditions but generally showed no impact on mortality and no difference or lower efficiency as measured by utilization, spending, and prices.

To date, only two studies approach this subject from the perspective of Medicaid patients. Richards et al. (2016) examines the implication of physician-hospital integration on practice's acceptance of Medicaid patients. The paper uses data on practice ownership structure across the U.S. from 2009 to 2015 and estimates a model with practice level fixed effects that examined the impact of within-office change in integration status on Medicaid acceptance. The results indicate that integrating with a health system makes a practice more likely to start seeing Medicaid patients. The effect is strongest for smaller primary care practices where integration is associated with a 5% increase in Medicaid participation. No similar change is observed among practices horizontally integrating with a physician group. The paper suggests that policy makers should consider this beneficial side effect – that Medicaid patients have more provider options with greater physician integration – when they weigh the pros and cons of greater integration.

In a cross-sectional analysis, Bond et al. (2017) investigates the effect of greater integration on Medicaid acceptance at the intensive margin or caseload expansion. The paper uses "secret shopper" data that was derived experimentally. The data was used to observe the primary care physician's willingness to accept new Medicaid and privately insured patients in 10 states. While results show that larger physician firms are more willing to take on additional Medicaid appointment, this result is mostly driven by those unaffiliated with integrated health system. Overall, their findings suggest that integrated practices are no more likely to accept Medicaid patients relative to privately insured patients than non-integrated firms.

Most of previous literature on this subject is limited to studying Medicare and commercially insured patients. The results from these studies cannot be readily generalized to

Medicaid patients as Medicaid population experiences unique challenges and has socioeconomic and demographic characteristics generally not shared with the other groups, such as chronic issue with access to care. Financial integration between hospitals and physicians is closely scrutinized by antirust policymakers (Koch et al. 2017). As they assess the pros and cons, it is important to understand that the consequences of integration can vary across patient populations. This study supplements the very small number of studies that focuses on the Medicaid patients' access to care. In addition, it examines how quality of care might be influenced by changes in physician's employment status a previously understudied outcome.

Also, previous studies are limited in that they examine changes in overall utilization, but few investigate how greater integration impact different areas of medical services that may be complementary to each other. Blending of the two providers of complementary medical services – outpatient and inpatient care – under financial arrangements could increase efficiency and/or increase use of lucrative services for the benefit of the providers. To fill this gap, I examine the effect of physician-hospital integration on utilization of various outpatient and inpatient services using previously unused Medicaid claims data.

## 1.5 Empirical Method

To estimate the effect of changes in county-level physician-hospital integration on Medicaid patient's access to care and utilization of Medicaid services, I estimate a two-way fixed effects (FE) model for a patient *i*, at year *t*, residing in county *c*:

$$Q_{ict} = \beta_0 + \beta_1 ShareFI_{ct} + \beta_2 X_{ict} + \beta_3 D_{ct} + \lambda_t + \theta_c + \epsilon_{ict}$$

, where *Q* represents various utilization measures, such as the annual count of E/M services per enrollee. *ShareFI* is the main independent variable of interest and measures the proportion of providers treating patients in county *c* that have billing patterns consistent with being employed by hospitals or IDS (i.e. billing more than 90% of their FFS Medicaid claims to hospitals or IDS). Share of financially integrated physicians can change due to physicians leaving their practice to join hospital-owned practices, hospitals acquiring physician practices, or integrated system entering a market that employ physicians working in the area. *X* is a vector of patient demographic characteristics, such as race, sex, age, and blind and disability status. *D* is county-level factors that may influence the amount of care given to Medicaid patients: unemployment rate, proportion of population in poverty, median household income in each county, and urban/rural status. These factors characterize the size of the Medicaid market determined by the local socioeconomic conditions. The regression will also include county fixed effect and year fixed effect. In this difference-in-differences setting, I compare counties with large versus small changes in physician-integration shares across time in terms of patient utilization outcomes.

The validity of the empirical results relies on the assumption that the changes in the integration measure are exogenous after controlling for fixed county characteristics and local economic conditions that shape demand for Medicaid services. Physician and hospital's integration status is a strategic decision, and it may be likely that unobservable factors affecting the choice to integrate may influence Medicaid patient's service utilization and access to care. For example, physicians who operate more profitable businesses with minimal share of Medicaid patients in their patient panel might be sought out by hospitals for acquisition. This selection of physicians will create a negative bias for the effect of integration on Medicaid access for physician services.

Appendix Figure 1.1 presents a preliminary evidence that this selection may exist. The bar graphs compare the average annual Medicaid caseload (or the number of unique Medicaid beneficiary seen by each servicing ID in a year) by physicians groups depending on their integration status. The “Never” group represents physicians that are never integrated during 2008-2010. The “Always” group indicates physicians that are identified as being integrated during the entire three years. The “Switch” group represents physicians that switched their integration status in 2009. Thus, 2008 represents the pre-integration period and 2009 represents the post period for the switchers. The number in parenthesis next to each group denotes the number of servicing IDs in each group. For switchers, their average annual Medicaid caseload is closer to that of never switchers than those who are always integrated during the pre-period (334 patients for switchers v. 309 for never integrated group v. 442 for always integrated groups). This may imply that physicians who later are employed by hospitals may have lower Medicaid caseload on average pre-employment. However, this comparison does not consider differences between physician groups, such as whether the physician practice is located in an area with larger presence of Medicaid population.

Another possible source of bias is patient sorting. Sicker patients may seek care from integrated physicians who have larger specialist network and have access to more updated health technology and facilities. Using private insurance claims, Capps et al. (2018) find that lower-risk enrollees are more likely to sort away from integrated physicians to less expensive physicians. If higher-risk patients are more likely to receive care from integrated physicians and use more services, the effect of sorting will be erroneously attributed to the effect of integration and create a positive bias.

By including county fixed effects, I control for time-invariant county characteristics that is correlated with the selection of physicians that serve patients from that county and the selection of patients, such as the presence of existing hospital systems in an area or county-level average patient health status. A vector of year fixed effects accounts for any statewide effects in the healthcare market, such as the effect of increase in prices of health care that leads to increase in Medicaid prices or changes in Medicaid eligibility in Louisiana over the years. To further account for patient sorting, I only include physicians as part of the integration share measure for a county if he serves a sizeable share of his Medicaid patient from that county. Specifically, if the physician sees patients from a county for only a small number of claims (bottom 10% of claim counts across providers), then I do not include the physician for measuring integrated share for that county. This method of calculating the integration measure precludes the physician being counted towards a county's integration share due to a few patients seeking out integrated physicians in counties where most residents in the county does not receive care in. Appendix A gives more detailed explanation for sample selection method for the physicians that enter into calculation for the county-level integration share.

To check if the estimation results depend on the characteristics of Medicaid patients included in the study sample, I perform similar analyses to a subset of patients who are in the study sample for the entirety of the study period. That is, I limit Medicaid patients to those who are enrolled in Louisiana's Medicaid program for three years from 2008 to 2010. Medicaid beneficiaries often experience disruptions in coverage, often referred to as "churning," where enrollees come in and out of the program due to economic or health shocks. People who experience coverage disruptions are more likely to delay care, receive less preventative care, and increase the number of ED visits. I already limit the main sample to those who are enrolled for at least 11 months during the year to measure utilization at the yearly level. I thereby eliminate the issue with churning within a year. By further limiting the sample to those who are consistently enrolled for the entire 3 years, I can perform the analysis on patients who are more likely to exhibit consistent utilization pattern across the sample period. I note here that the estimates are similar with this alternative study sample.

I first examine the effect of changes in physician-hospital integration in a county on annual utilization of E/M services per beneficiary, which proxy contact with physicians during the year. I also examine where the care is given, namely physician office and OPD. Greater number of physicians working in hospital clinics may improve patient access, not necessarily through changes in physician willingness to see Medicaid patients, but simply by providing care in hospital settings which take on more Medicaid cases at baseline. To examine this possibility, I estimate whether changes in physician-hospital integration impacts utilization of E/M services separately by place of service, namely office and OPD. I then examine the effect of integration on use of ancillary services, such as imaging exams and laboratory tests, that may direct and generate revenue for the hospital system that employ physicians that treat Medicaid patients in a county. I also estimate how inpatient admission and ED use are impacted by greater integrated providers that see patients from a county. Integration may be a strategy employed by hospitals to secure inpatient referral base, and this analysis tests for this hypothesis. On the other hand, if greater access to integrated physicians lead and increase efficiency, use of costly inpatient and/or ED services may be circumvented.

In summary, I perform linear regressions to estimate the associations between changes in county-level physician-hospital integration and patient-level changes in utilization measures. The unit of analysis is enrollee-year. The robust standard errors are clustered at the county level. I fit a model of year indicators to control for statewide trends, county indicators to control for time invariant differences between markets, county-level physician-hospital integration share, and covariates that proxy local economic conditions. The estimated coefficient on *ShareFI* is the mean change in utilization measure associated with a market changing from no integration to full integration. Equivalently, it is an estimate of changes in utilization of an individual patient if the patient's physician joined or were acquired by a hospital.

### 1.6 Data

Data on health care provision to Medicaid beneficiaries and Medicaid physician market in Louisiana comes from Medicaid Analytic eXtract (MAX) files. MAX data is an annual state-specific files that contain person-level enrollment and event-level services data for each Medicaid enrollee. MAX data used in this study includes: The Other Therapy (OT) file, which contains claims for mostly outpatient-based services, the Inpatient (IP) file, which contains claims for inpatient hospital services, and the Personal Summary (PS) file, which contains enrollee's monthly eligibility and demographic data. I use the OT file to construct outpatient-based utilization outcomes, such as annual count of E/M visits, imaging exams, laboratory tests, and days spent using ED-related services. I use the IP file to construct the annual count of inpatient claims per enrollee. Lastly, I use the PS file to obtain beneficiary characteristics, such as age, race, sex, and blind and disability status, and whether he or she had coverage under full benefit, FFS Medicaid payment plan for at least 11 months during the year. To measure county-level physician-hospital integration, I exploit the feature of the OT file that identifies the rendering physician and the billing entity for each service reimbursed on a FFS basis.

The MAX data are merged with county-level economic information. County-level unemployment data is sourced from the Bureau of Labor Statistics – Local Area Unemployment Statistics. Estimates of county-level poverty rate and median household income comes from Small Area Income and Poverty Estimate (SAIPE) program. Lastly, urban/rural indicator for Louisiana's counties come from rural definition based on Office of Management and Budget's metro versus non-metro counties.

### 1.6.1 Measuring County-level Physician-Hospital Integration

The key independent variable in this paper is the degree of physician-hospital integration in each county in Louisiana from 2008 to 2010. An ideal data would allow me to identify which physicians were acquired by hospitals and how patient utilization changes as his physician is integrated. However, this information is not readily available. Instead, I measure share of integrated physicians who treat Medicaid beneficiaries in a county in each year by exploiting how physicians bill for their reimbursements in Medicaid claims.

Each Medicaid claim is associated with a state-assigned servicing provider ID ("servicing ID") that identifies who rendered the Medicaid service to a patient[5]. Each claim is also associated with a state-assigned billing provider ID ("billing ID") that identifies the billing entity being reimbursed for the procedure. When a hospital acquires a physician practice or employs a physician, the hospital's provider numbers replace those of the physicians on the claims for billing (AMA 2018). For example, when an independent physician bills for Medicaid service, the

[5] Non-physician (MD or DO) providers can also render services to Medicaid patients. To avoid counting nurse practitioners and other non-physician providers into the integration measure, I drop if the servicing ID is associated with more than 10% of dental, nurse practitioner, or other practitioner service claims in each year. Appendix A, Appendix Table 1.10, provides detail on the share of servicing IDs that are dropped due to this sample restriction.

claim will have the same servicing ID and billing ID. Once his practice is acquired by a hospital and he is compensated under a contract with a hospital, the claims he submit will have his servicing ID and the hospital's billing ID.

I exploit this billing convention to calculate the share of each servicing ID's claims that gets billed to hospitals or IDS. Thus for each physician $i$, I measure the following:

$$Share\ hospitals/IDS_i = \frac{No.of\ claims\ billed\ to\ hospitals/IDS_i}{Total\ no.of\ claimsi}$$

Billing IDs are linked to publicly available MAX Provider Characteristics (MAXPC) data to identify whether the ID belongs to a hospital or IDS (as opposed to independent practitioners or private groups). Note that a physician's integration status is unique in each year and same across counties. Because Louisiana's entire Medicaid population is billed under FFS payment system, analyzing the FFS claims to derive integration status covers the entirety of Louisiana's Medicaid system across counties. However, this measure of integration is subject to error if the physician only sees a few Medicaid patients and bills them to the contracted hospitals and bills the rest of his patient base to another entity (e.g. himself). To avoid identifying effects off of changes in physician-hospital integration driven by random shifts in billing entity for each servicing ID that treat only a small Medicaid cases, I drop servicing IDs with annual FFS claim count at the bottom 20$^{th}$ percentile (the threshold is about 15-19 claims in each year). This method of measuring integration status for each physician is correct if a physician's Medicaid billing pattern is representative of how he bills for his services across patients with different insurance types. Appendix A and Appendix Table 1.10 details the number of servicing IDs that gets excluded due to this restriction.

Once I have identified integrated physicians in each year, I calculate the proportion of physicians that bill exclusively (90-100%) to hospitals/IDS in each county. The annual measure of physician-hospital integration for physicians who treat patients from county *c* is:

$$Share\ FI_{ct} = \frac{No.of\ Integrated\ Physicians_{ct}}{Total\ no.of\ Physicians_{ct}}$$

I exclude physicians if they see only a small share of their patient base from county *c*. For example, if physician *i* sees 100 Medicaid patients from county A and only 2 patients from county B, I exclude physician *i* from the integration measure for county B. This prevents physicians being counted towards a county's integration share because a few patients seek out care from integrated physicians in counties outside of where most patients from the county seeks care. Since a physician can serve patients from multiple counties, a physician can be counted multiple times towards the integration measures across counties. I also note that since a physician can have multiple servicing IDs associated with him, each servicing ID does not represent a unique physician.

This paper measures physician-hospital integration using Medicaid claims data. Thus the integration measures are limited to physicians participating in Medicaid. While the methods used in this study captures the degree of financial integration between physicians and hospital or IDS who submit at least 15-19 claims per year to Medicaid, the overall physician market change that involves physicians who mostly serve Medicare and privately patients is not be captured. Also, about 1-2% of the claims in each year are associated with billing IDs that I cannot identify as hospital/IDS or non-hospital/IDS. To keep the measure of integration conservative, I assign these small number of claims with unknown billing IDs as non-hospitals/IDS. This will likely underestimate the true integration share in each county but given the small number of claims associated with these unknown billing IDs, the integration measure is largely unaffected. Appendix A provides a more detailed explanation of the sample restrictions for servicing ID and the overall methodology for constructing the county-level physician-integration measure.

Table 1.1 shows the changes in county-level physician-hospital integration share and other covariates from 2008 to 2010. Among 64 counties, the proportion of providers with billing patterns consistent with being employed by hospital was around 15% in 2008 (interquartile range (IQR) 10 to 16%). By 2010, the average share of integrated physicians increase to 17% (IQR 12 to 19%)[6]. The first two panels in Figure 1.1 illustrates the variation in share of integrated providers in each county in 2008 and 2010. While the average change from 2008 to 2010 was about 2 percentage points across counties, this change varied considerably across counties (IQR -4 to 29 percentage points). The last panel in Figure 1.1 illustrates this point. First row of Table 1.2 also shows that changes in physician-hospital integration varied considerably across counties. The mean of change for counties below-median change was -5.8 and the mean change for counties above-median change was 38.4. This implies that during the study period, some counties experienced disintegration to some degree while others experienced a large growth in physician employment by hospitals on average.

The rest of the rows in Table 1.1 shows changes county-level economic conditions. Over the years, counties in Louisiana experienced increase in unemployment, increase in population under poverty, and decrease in the median household income. This likely increased enrollment in Medicaid program and consequently increased overall utilization among enrollees. Year fixed effects account for the overall changes in Medicaid utilization trends within the state that are

[6] At the individual servicing ID level, the share of integrated servicing IDs grows from 12.4% in 2008 to 14% in 2010 as presented in the bottom row of Appendix Table 1.10.

common across counties. Time-varying county differences in utilization trends are accounted by these county-level covariates.

Table 1.2 compares changes in county-level characteristics by above and below-median changes in physician-hospital integration. Counties with above- versus below-median growth in physician-hospital integration exhibited different changes in economic characteristics, as shown by the p-value from performing a test on mean difference between the two groups. Counties with below-median change in physician-hospital integration generally experienced less growth in unemployment and poverty rate than counties with above-median change. Taken together, these statistics suggest that patients in areas with less economic growth were increasingly more likely to be treated by integrated physicians over the years. If hospitals non-randomly acquire physician practices that are more likely to see patients from low-growth counties, the estimate on the effect of physician-hospital integration share will be biased upwards. While my empirical model controls for time-invariant, unobservable county-level differences that may be correlated with physician practice selection, the bias may still remain.

### 1.6.2 Measuring Enrollee-level Utilization of Medicaid Services

I measure access to care by the number of E/M services a patient has received per year. Both primary care and specialty physicians perform E/M services when they meet patients to evaluate their health needs, identify diagnoses, and describe treatment plans (Chen et al. 2018). Thus the annual count of E/M services proxy contact with healthcare providers. I stratify this measure by E/M services received in office and OPD, to examine the shift in site of care for Medicaid patients in response to changes in integration of physician. For each Medicaid enrollee with FFS claims, I count the number of E/M services he has received in each year identified by ten E/M CPT codes (99201-99205 for new patient visits; 99211-99215 for established patient visits). I also count the annual number of imaging services claim (CPT 70000-79999) and laboratory and pathology tests claim (CPT 80047-89398). For inpatient service utilization, I count the annual number of inpatient claims from the MAX IP file. Lastly, I count the number of days an enrollee has used ED related services in a year using the OT file. For each of these outcomes, beneficiaries who are on full benefit program under FFS payment for at least 11 months in a year but did not use the service of interest are assigned zero quantity for that outcome.

The study sample has 1,874,580 children (ages 1-19) and 357,986 adult (ages 20-64) Medicaid beneficiaries living in 64 counties in Louisiana from 2008-2010. They are on full benefit, FFS Medicaid program for at least 11 months of the year[7]. Individuals enrolled in both Medicare and Medicaid are excluded from the analysis since both Medicaid and Medicare are likely responsible for the payment and coverage of services. Since utilization information for those on State Children's Health Insurance Program (SCHIP) are not recorded in full in the OT files, I only include those who are enrolled in Medicaid but are not on either Medicaid expansion for CHIP or a separate title XXI CHIP program. Lastly, those who are deceased during the sample year are dropped.

Table 1.3 presents demographic characteristics of sample Medicaid beneficiaries in Louisiana in 2008. While there are about equal number of male and female beneficiaries among children, about 70% of the adult sample are females. This observation is consistent with the Medicaid eligibility expansion among parents of dependent children, more likely to be women, that occurred during the study period. The racial composition is similar across age groups, with

[7] This sample restriction was placed so that I measure utilization of Medicaid services not limited by benefit scope or how long the beneficiary is eligible for and enrolled during the year.

African American beneficiaries making up close to 60% of the sample, followed by whites (35%), Hispanics (2%) and Asians (1%). As expected, much greater share of adult sample is classified as blind and disabled (60%) than children (6%). Overall, adults are more likely to receive E/M visits, imaging exams, lab tests, inpatient services, and emergency care than children enrollees.

### 1.7 Results

I estimate the impact of the changes in share of integrated physicians treating Medicaid patients in each county on access to care and service utilization among Medicaid beneficiaries in Louisiana. Theory gives ambiguous predictions for each outcome. Greater physician-hospital integration may lower the relative price of Medicaid patients and consequently reduce physician participation in Medicaid. If greater efficiency is achieved through better care coordination between physicians and hospitals through integration, physicians may be able to treat more patients across all insurance types, including Medicaid patients. If salary portion of the physician's compensation is large enough, payment differential across patient types may effectively disappear from the perspective of the physician that he may be more willing to treat Medicaid patients. Depending on the strength of each of these mechanisms, Medicaid patient's access to physician services may increase or decrease. In terms of utilization, if the integrated entity directs ordering of imaging and/or lab tests and inpatient services to their own facilities, utilization of such services may increase. On the other hand, improved efficiency in care may imply that duplicated tests, inpatient admission, and ED services may decrease.

Figure 1.2 presents the estimated coefficients on each outcome by age group. Each point represents the average change in outcomes associated with a change in physician-hospital integration from 0 to 100% experienced by counties in Louisiana from 2008 to 2010. The error bars denote 95% confidence intervals. Estimated coefficients from full regressions are given in Tables 1.4-1.5. Increasing the county's Medicaid physician market from no to full integration is associated with sizeable changes in annual number of E/M visits among children (15% decrease) and adults (27% increase). However, both estimates are not statistically distinguishable from zero, and the relatively large confidence interval suggests that the results are inconclusive. However, I find that greater integration is associated with shifts in where E/M visits occur, namely from office to OPD. Greater availability of integrated physicians that treat Medicaid patients in a county is associated with statistically significant decrease in visits taken place in office for children (40% decrease) and not statistically significant decrease for adults (49% decrease). Increase in integration also more than doubles the OPD-based E/M visits for children and adults. These estimates are statistically significant and precisely estimated.

For imaging services, greater integration is associated with a statistically significant and precisely estimated increase in utilization among children (140% increase). The estimates are smaller, positive for adults (55% increase), but statistically insignificant and imprecise for adults. While estimated coefficients on lab tests are positive for both age groups, the estimates are practically small (22% increase for children and 4% increase for adults), and neither are statistically distinguishable from zero nor precisely estimated. For inpatient services, I estimate a precise zero impact of increase in physician-hospital integration on utilization for children and adults. Lastly, greater integration is associated with statistically insignificant and small changes in ED-related service use by children (8% increase), but statistically significant and sizeable decrease for adults (85% decrease).

I explain the detailed estimates here. Column 1 in Tables 1.4 and 1.5 show the estimated coefficients on annual count of E/M visits (across all places of service). An increase in physician-hospital integration from no to full integration results in a statistically insignificant decrease in E/M visits by 0.49 visits annually for children. Relative to mean E/M visits in 2008 of 3.25, this is equivalent to a 15% decrease. For adults, increase in integration results in 1.12 additional E/M visits per year. This is equivalent to a 27% increase in E/M visits relative to the mean E/M visit counts in 2008 of 4.19. Compared to other studies that examine the effect of various policy changes on number of physician visits, these effect size seem large. For example, Callison and Nguyen (2017) estimate that increasing the Medicaid-to-Medicare fee ratio by 10-percentage point increases the number of office visits by 0.63 visits per year for an adult Medicaid enrollee, an 11% increase compared to the baseline mean number of office visits. In an earlier study, Cohen and Cunningham (1995) shows that a 10-percentage point increase in the Medicaid-to-Medicare ratio raises the number of preventative visits for children by 5%. While the magnitude of the effect of greater integration in E/M visits is sizeable, Figure 1.2 shows that the 95%-confidence interval includes zero-effects with relatively large intervals. This suggests that the result on overall E/M visits among children and adults is inconclusive.

On the other hand, I find that greater physician-hospital integration is associated with shifts in where E/M visits occur, namely from physician office to OPD. Columns 2-3 in Tables 1.4 and 1.5 present this result. For children, increase in physician-hospital integration is associated with a statistically significant reduction in office-based E/M visits by one visit per year at the 10%-level. This is equivalent to a 40% decrease relative to the mean office-based E/M visit in 2008 of 2.79. The negative effect of integration on office-based E/M visits is similar for adults, except that the estimated coefficient lacks statistical precision. For adults, greater integration is associated with a statistically insignificant estimate of -1.41, which is equivalent to a 49% decrease relative to the mean office-based visit of 2.91. A mirrored result is an increase in E/M visit taken place at OPD. Increase in integration is associated with a statistically significant increase in OPD-based E/M visits by 0.32 for children and 1.21 for adults. Considering that the average annual count of OPD-based E/M visits are 0.14 and 0.45 for each age group, a county going from no to full physician-hospital integration more than doubles the OPD-based E/M visits for Medicaid beneficiaries. While the estimated coefficient on office-based E/M visits lacks statistical precision for adults, the paralleled results between children and adults suggest that there is evidence of shift in site of care for E/M visits among Medicaid beneficiaries following greater integration in Medicaid physician market.

This result could suggest that as more physicians work in hospital outpatient settings, patients may simply need to go to outpatient hospital departments to receive care because less office-based physicians are available in general. Thus the shift in site of care is a mechanical result of physician employment in hospital settings which will increase the *ShareFI* measure. Another possible reason for this shift is hospitals' motivation to receive Disproportionate Share Hospital (DSH) payments for taking on greater Medicaid caseloads. State Medicaid agencies pay DSH payments to hospitals that serve a relatively higher share of low-income patients, including Medicaid beneficiaries and the uninsured. DSH payments are intended to improve the financial stability of safety-net hospitals that are less able to rely on other revenue sources to offset uncompensated or less profitable care (MACPAC 2011). It can be hypothesized that as hospitals increasingly employ physicians at their clinics or acquire private practices, they might direct low-income population to their OPD clinics to receive higher DSH payments.

Access to care in physician office is thought to improve continuity of care and is associated with higher patient satisfaction compared to OPD clinics, where physicians often change each visit (Decker 2007; Starfield et al. 1979). These findings suggest that greater physician-hospital integration does not necessarily improve Medicaid patient's access to physician services but lowers quality of care in terms of patient experience.

Columns 4-5 in Tables 1.4 and 1.5 present results for ancillary services. Greater physician-hospital integration is associated with a statistically significant increase in imaging services among children and positive but relatively small and statistically insignificant effect for adults. Specifically, an increase of physician-hospital integration from 0 to 100% results in 0.77 additional imaging exams among children (140% increase relative to mean imaging count in 2008 of 0.55) and the estimate is statistically significant at the 5%-level. As shown in Figure 1.2, the tight interval around this estimate suggests that this result is estimated with statistical precision. For adults, greater integration is associated with a statistically insignificant increase of 1.22 (55% relative increase to the mean imaging count in 2008 of 2.21). However, the coefficient is not estimated with statistical precision. To put the magnitude of the effects in context, these estimates are equivalent to increasing the rate of imaging exams per 1,000 Medicaid beneficiaries from 550 to 1320 among children and from 221 to 343 among adults. The analysis suggests that greater physician-hospital integration leads young Medicaid beneficiaries to increase utilization of imaging services. This result is consistent with the prediction that providers of complementary services financially joining is likely to increase ordering of relatively expensive imaging tests. An alternative explanation of this result is that as more patients receive E/M visits in OPD where imaging equipment is readily available, ordering and receiving imaging tests is more convenient for physicians and patients.

While estimated coefficients on lab tests are positive for both age groups, neither are statistically distinguishable from zero at the 5-percent level and the magnitude of the estimates is small. Specifically, greater integration is associated with increase in the number of lab tests per year by 0.57 tests for children (22% increase relative to the mean lab test count in 2008 of 2.55). For adults, greater integration results in additional 0.50 tests per year per beneficiary (4% increase relative to the mean lab test count in 2008 of 11.45). Overall, the estimates on the utilization of laboratory and pathology services are not precisely estimated and the magnitude of the estimates are economically small. If the integrated physician-hospital entity is motivated by financial incentives to direct utilization of ancillary services to their advantage, we would expect to observe greater impact for imaging tests as they tend to be more lucrative than lab tests on average.

Inpatient admission is also not impacted as shown in Column 6 in Tables 1.4 and 1.5. I estimate a precise zero impact of greater physician-hospital integration on the inpatient admission for both age groups. The estimated coefficient for the inpatient claim count is 0.02 for children (33% increase relative to mean number of inpatient claims in 2008 of 0.06) and -0.07 for adults (24% decrease relative to mean number of inpatient claims in 2008 of 0.28). Both are not statistically significant at 5-percent level but have tight intervals around zero. Lastly, column 7 in Tables 1.4 and 1.5 presents estimated coefficients for days using ED-related service. greater physician-hospital integration is associated with statistically insignificant and small changes in ED-related service use by children (point estimate of 0.06, equivalent to 8% increase relative to the mean ED-days in 2008 of 0.7). On the other hand, greater integration leads to statistically significant and a sizeable decrease in ED-related service use by adults. Specifically, going from zero to full integration decreases days using ED-related services by -1.7, which is statistically significant at the 5%-level and is equivalent to 85% decrease relative to 2008 average days spent using ED-related services of 2.02. This result speaks to the prediction that better care coordination between outpatient and inpatient setting may decrease use of costly ED services as physicians and hospitals integrate. In fact, it is more profitable for hospitals to have less Medicaid patients visit the ED so that ED resources can be directed to privately insured patients who generate profit. A 2014 study of public and private ED data shows that privately insured patients entirely subsidize all other ED patients and that hospitals only make profit on ED services only if enough privately insured patients use the ED. For example, privately insured ED patients is associated with a 39.6 profit margin while Medicare patients is associated with -15.6 percent. The numbers are even lower for Medicaid and uninsured patients, with -35.9 percent and -54.4 percent operating margin for hospitals, respectively (Nagasako et al. 2014). Lastly, it is understandable that the effect on ED use is only realized for adults given that children are far less likely to use ED-related services than adults at baseline.

Appendix Tables 1.1-1.7 present regression estimates for each outcome across age groups with and without county-level covariates, namely unemployment rate, percent population in poverty, median household income, and urban/rural indicator. Across various outcomes, the estimates are not appreciably affected by the inclusion and exclusion of these county-level characteristics. County covariates that proxy local economic characteristics, unemployment rate, percent poverty, and median household income, have minimal impact on the utilization measures. However, utilization tends to be greater for Medicaid beneficiaries residing in urban counties as opposed to rural counties. For example, residing in an urban county is associated with greater E/M visits overall for both children and adults, and greater E/M visits occurring in physician office. On the other hand, urban county is associated with less E/M visits in OPD. For children, urban county is associated with greater imaging, less lab tests, less inpatient service utilization, and little change in days using ED-related service. For adults, urban county is associated with greater imaging, greater lab tests, no change in inpatient services, and more ED-related service use. This is consistent with the observation that patients in urban areas have greater access to care in general.

To check if the estimates are sensitive to the characteristics of Medicaid patients that go in and out of the data over the years, I perform similar analysis using a fixed set of patient samples. Specifically, I limit the patient sample to those who are present in the data consecutively for the entire study period of 2008-2010. This restricts the sample those who are more likely to exhibit consistent utilization pattern across the sample period. The estimates are presented in Appendix Tables 1.8 and 1.9. While the magnitude of the estimates tend to the smaller than the main estimates, the direction of the estimated coefficients are generally the same and the overall results are similar.

This paper's finding on less office-based physician visit among Medicaid beneficiaries following greater integration may seem in contrast to the previous studies on the topic with a Medicaid focus. To reiterate, Richards et al. (2016) finds a positive relationship between greater integration and office-based physician's Medicaid participation at the extensive margin. Bonds et al. (2017) finds no difference in Medicaid caseload between integrated versus non-integrated physician offices in a cross-sectional comparison. Besides differences in setting, data, and methodology among mentioned studies, this paper does not distinguish the difference in physician's Medicaid acceptance (extensive margin) versus caseload expansion (intensive margin). Thus, even if greater integration leads physician offices to start accepting Medicaid patients, if physician offices on average reduces their Medicaid caseload, greater integration can still result in less office-based physician visits.

No effect on inpatient service utilization is consistent with earlier works that examine the same outcome among Medicare and privately insured patients (Baker et al. 2014; Capps et al. 2018; Neprash et al. 2015). This reinforces the argument that financial integration between physicians and hospitals does not necessarily ensure clinical integration, meaning improved coordination of care between inpatient and outpatient settings that increase efficiency of care. However, this study's novel finding on reduced ED service use among adult Medicaid beneficiaries suggest there may be some gains to efficiency in terms of reductions in costly ED related services.

Another novel finding from this study is the evidence of increase in utilization of imaging services among Medicaid beneficiaries. This result is in contrast to Capps et al. (2018) which finds no evidence of increase in imaging spending among Medicare patients whose primary care physician transitions to hospital employment (however, the authors also find minimal impact on use of lab tests, which is similar to the findings from this study). Mafi et al. (2017) also finds that low-value imaging service use does not differ between patients who visit hospital versus physician-owned practices (their sample includes privately insured, Medicare, and Medicaid patients).

However, as the analysis from this study is limited to Medicaid patients in Louisiana, the results may not be generalizable to different markets with different patient population under various health plan, including Medicaid managed care (Details on the healthcare landscape in Louisiana can be found in Appendix B).

### 1.8 Conclusion

This paper examines the effect of greater physician-hospital integration on Medicaid patient's access to physician services and utilization of various Medicaid services. I use FFS Medicaid claims data for children and adult beneficiaries in Louisiana from 2008 to 2010 to measure county-level share of integrated physicians and to construct utilization measures. Because 100% of Medicaid beneficiaries during the study period are covered under FFS payment plan, I capture a comprehensive picture of Medicaid physician market and patient's utilization in Louisiana using this data. To measure physician-hospital integration at the county-level, I exploit the billing convention for physician service reimbursements in the Medicaid claim files, in which when physicians switch employment, their physician services get billed to the new employer (e.g. hospital). I use this feature to identify which physicians are employed by hospitals or IDS in each year.

Theory gives ambiguous predictions on the impact of greater physician-hospital integration on access to care and patient utilization. Physician employment by hospitals may reduce the relative price of treating Medicaid patients, increase efficiency of care for all types of patients, and change the physician's compensation scheme from largely collection-based to salary-based that effectively reduces the pay different across patient groups. Based on the strength of each of these mechanisms, Medicaid patient's access to care can increase or decrease. Utilization may also increase or decrease depending on the impact of integration on efficiency in care delivery. To empirically assess these relationships, I use a difference-in-differences design that compare counties with large versus small changes in the share of integrated physicians over time, while accounting for time-varying patient and county-level characteristics that could be correlated with utilization of Medicaid services.

I find inconclusive evidence on the effect of greater physician-hospital integration on overall E/M visits per year. However, I find evidence that it is associated with a shift in site of care for E/M services, namely from office to OPD. Specifically, a county going from no to full physician-hospital integration more than doubles OPD-based visits for both children and adult Medicaid beneficiaries. This result is statistically significant and precisely estimated. On the other hand, the mirrored result is decrease in office-based visits for both age groups, although the estimate is only significant at the 10%-level for children. This shift in care site might be motivated by payments hospitals receive when they treat more Medicaid patients in hospital-based clinics. Or this could suggest that as more physicians work in hospital outpatient settings, patients simply need to go to hospitals to receive care because less office-based physicians are available in general. Receiving care in offices is thought to improve continuity of care and is associated with higher patient satisfaction compared to OPD clinics, where physicians frequently change each visit. Thus this finding may imply that greater physician-hospital integration does not necessarily improve Medicaid patient's access to care but lowers quality of care in terms of continuity of care and patient experience.

I find evidence that greater physician-hospital integration leads to greater use of relatively lucrative imaging services. Among children, I estimate a statistically significant, precise, and large effect on the annual utilization of imaging services (140% increase). The estimated coefficient on adults is also positive but smaller (55% increase) and is not estimated with statistical precision. This result is consistent with the supposition that physicians and hospitals who provide complementary services are likely to increase ordering of lucrative imaging services as they financially join to form an integrated entity. However, this result may also be possible simply because it is more convenient for patients to receive imaging tests in same facility as their

E/M visit with a physician which increasingly takes place in OPD as integration grows. While the estimated coefficients on lab tests are positive for both age groups, neither are statistically distinguishable from zero and the magnitude of the estimates are small. Given that imaging tests tend to be more expensive than lab tests on average, we would expect to see greater impact of integration on utilization of imaging tests if physicians and hospitals direct ordering of ancillary services to their advantage.

Lastly, I estimate a precise zero effect on use of inpatient services among children and adults. In terms of ED-service use, greater integration is associated with a statistically significant and large decrease in utilization among adults (85% decrease) and a small and statistically insignificant change among children (8% increase). This may imply that integration improves some aspects of efficiency of care by reducing use of costly ED services. In fact, hospitals have an incentive to reduce ED visits by Medicaid patients, because privately insured patients are a source of profit in ED for hospitals whereas they lose money on each additional Medicaid patient's visit to the ED.

The estimates are not sensitive to inclusion or exclusion of county-level covariates that describe local economic shocks that may impact utilization of Medicaid services. Moreover, the findings are robust to limiting the analysis to a subset of Medicaid patients who are continuously enrolled for the entirety of the study period and who may exhibit more consistent utilization patterns.

Ongoing studies show an emerging trend toward greater physician-hospital integration (Bond et al. 2017; Capps et al. 2018; Scott et al. 2017). Questions about the effect of physician-hospital integration on Medicaid patient access is especially relevant because the ACA creates incentives that are likely to intensify the ties between hospitals and physicians (Baker et al.

2018). Nonetheless, there is limited research on the consequences of physician-hospital integration on Medicaid patients' access to care. This study contributes to the literature by using unique Medicaid data that captures almost the entirety of Louisiana's Medicaid market. It describes different mechanisms that can influence the physician's decision to treat Medicaid patients, and bridges the gap in understanding on how the growing integration trend impacts Medicaid population on various health service utilization.

While proponents of greater physician-hospital integration predict access to care will increase following integration activities, findings from this study suggests that quality of care may suffer, in terms of continuity and patient experience, as site of care shifts from physician office to OPD-based clinics with greater integration (Berenson 2017). I also observe two phenomena that are consistent with behaviors from physicians and hospitals that are motivated by joined financial incentives – increasing use of lucrative imaging services and decreasing use of ED services by Medicaid patients. Alternative explanations of these observations exist, such as convenience factor for imaging tests and increase in efficiency of care. Nonetheless, it is a noteworthy result as it speaks to the negative speculations around physician-hospital integration activity that the united entity will direct patient care to their financial advantage.

With Medicaid enrollment numbers swelling by the millions, how greater physician-hospital integration impacts Medicaid patient's healthcare is an important research question. As trend toward integration intensifies and Medicaid enrollment continues to grow, it will be important for policy makers to consider the consequence of greater integration that may be unique to Medicaid population across various medical service utilization.

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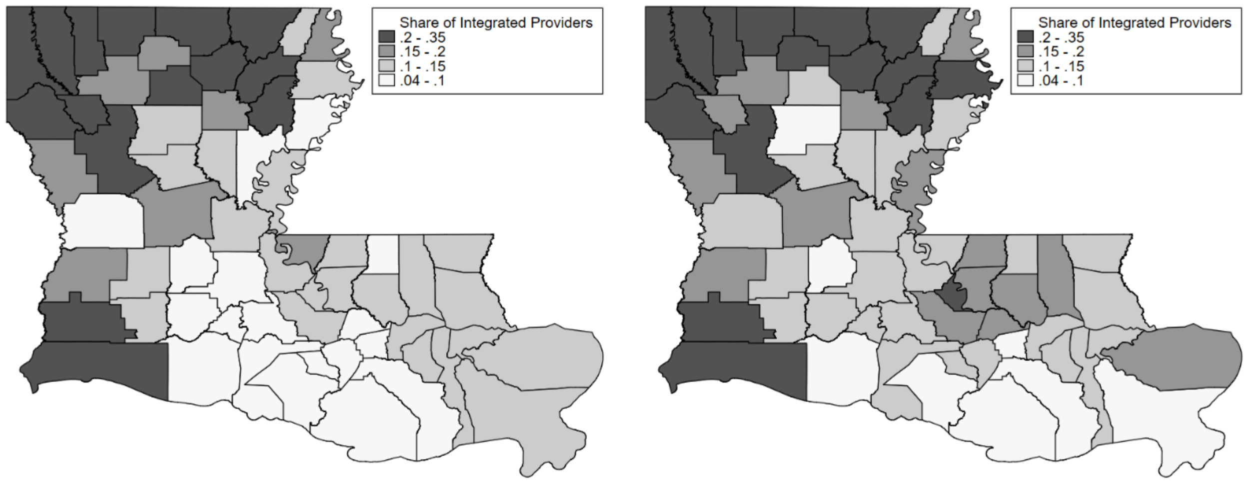
## 1.10 Tables and Figures




(a) 2008 (b) 2010

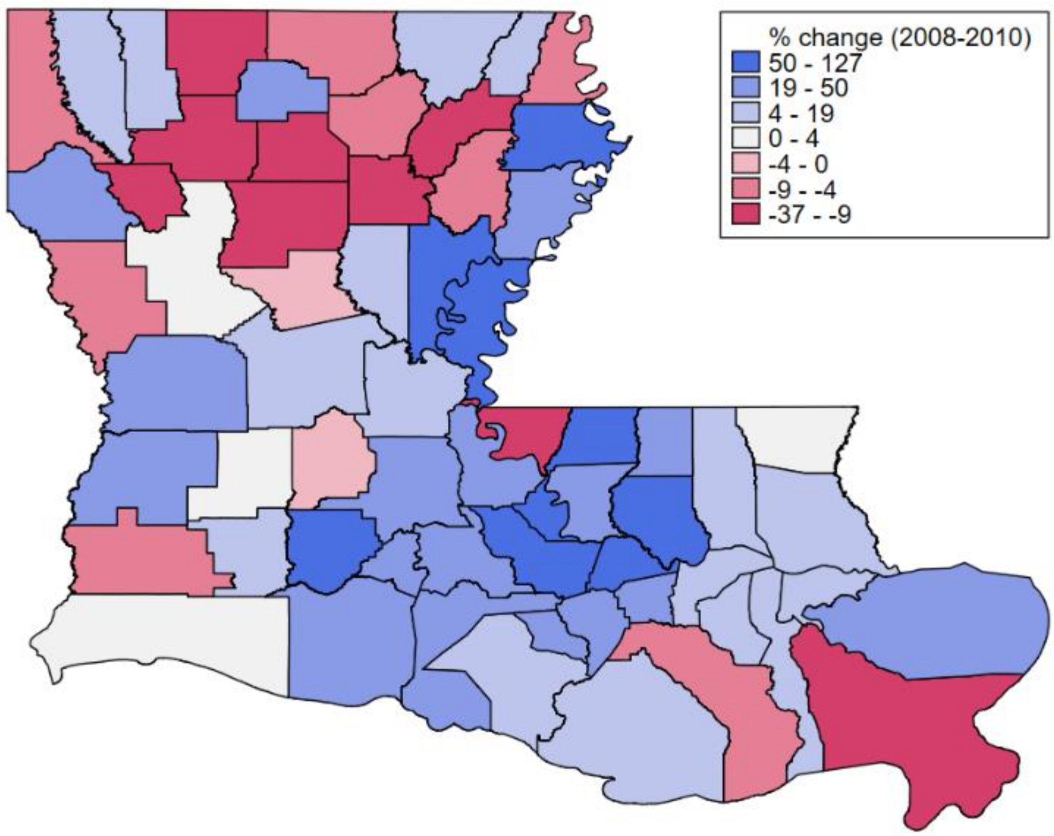
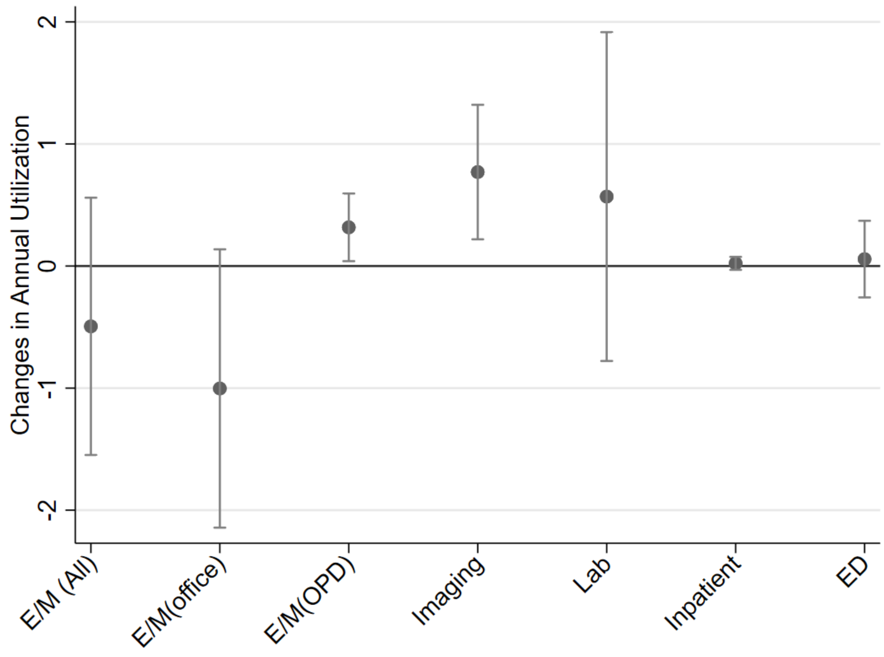


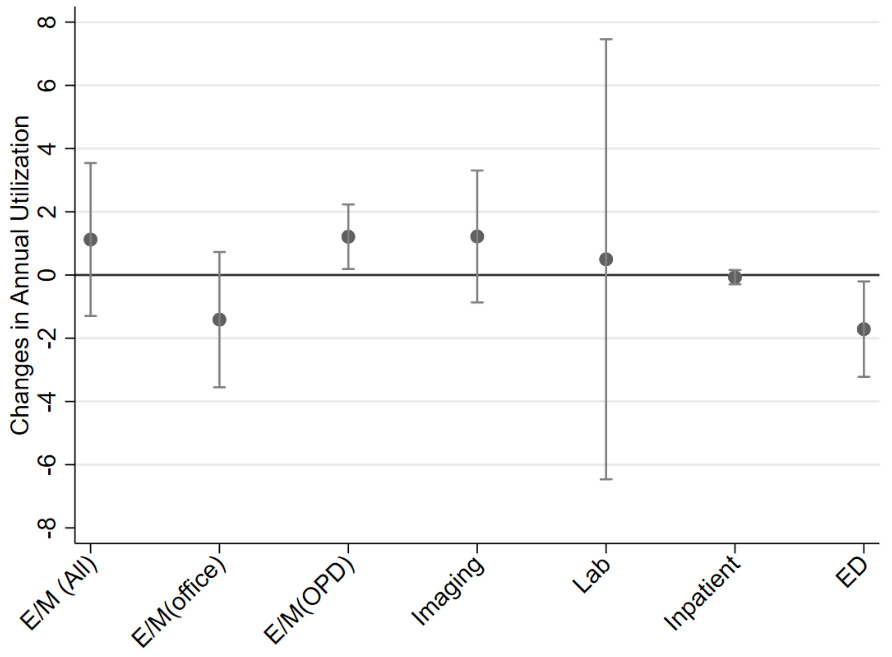

***Figure 1.1***

*Changes in County-level Share of Integrated Physicians 2008-2010*

*Notes:* The first left panel shows the share of integrated physicians in Louisiana's 64 counties as of 2008, and the right panel shows the same areas in 2010. The bottom panel shows the percent changes in integrated provider share from 2008 to 2010, with darker blue colors indicating increase in physician-hospital integration and darker red color indicating decrease in integration.




(a) Children (Ages 1-19)




(b) Adults (Ages 20-64)

***Figure 1.2***

*Estimates of Change in Annual Utilization per Enrollee*

*Notes:* Estimates of change are associated with increase in physician-hospital integration from 2008 to 2010. Each point represents the average change in utilization measures associated with a change in physician-hospital integration from 0 to 100 percent experienced by counties in Louisiana from 2008 to 2010. Error bars denote 95% CIs. Estimated coefficients from full regression results are given in Tables 1.4-1.5.

***Table 1.1***

*Changes in County-level Characteristics from 2008 to 2010*

| | (1) 2008 | | (2) 2010 | |
|---|---|---|---|---|
| County-level Characteristics | Mean | IQR | Mean | IQR |
| Physician-Hospital Integration, % | 15.1 | (10.3 to16.2) | 16.6 | (11.8 to 18.9) |
| Population Unemployed, % | 5.1 | (4.5 to 5.7) | 8.2 | (7.4 to 8.7) |
| Population in Poverty, % | 18.5 | (15 to 22) | 19.7 | (17 to 22) |
| Median Household Income, $ | 42,105 | (37,047 to 47,065) | 41,799 | (36,814 to 46,500) |
| No. of counties | 64 | | 64 | |

*Notes:* Physician-hospital integration measure is calculated from MAX OT files 2008-2010. IQR is the interquartile values of each county-level characteristics. County-level unemployment rate data comes from the Bureau of Labor Statistics – Local Area Unemployment Statistics. Estimates of county-level poverty rate and income comes from Small Area Income and Poverty Estimate (SAIPE) program.

***Table 1.2***

*Comparison of Percent Changes in County-level Characteristics*
*by Above- vs. Below-Median Changes (2008-2010) in Physician-Hospital Integration*

| | (1) Below Median | | (2) Above Median | | |
|---|---|---|---|---|---|
| County-level Characteristics | Mean | IQR | Mean | IQR | p-value |
| Physician-Hospital Integration, % | -5.8 | (-9.5 to 4.3) | 38.4 | (19.6 to 53.8) | <0.001 |
| Population Unemployed, % | 55.7 | (44.6 to 67.6) | 65.4 | (52.8 to 78.3) | 0.05 |
| Population in Poverty, % | 2.0 | (-4.4 to 7.4) | 8.6 | (0 to 18.2) | 0.02 |
| Median Household Income, $ | 0.3 | (-2.9 to 3.9) | 0.9 | (-1.0 to 3.5) | 0.62 |
| No. of Counties | 32 | | 32 | | |

*Notes:* Physician-hospital integration measure is calculated from MAX OT files 2008-2010. IQR is the interquartile values of each county-level characteristics. County-level unemployment rate data comes from the Bureau of Labor Statistics – Local Area Unemployment Statistics. Estimates of county-level poverty rate and income comes from Small Area Income and Poverty Estimate (SAIPE) program.

***Table 1.3***

*Demographic Characteristics of Medicaid Beneficiaries in 2008*

| | Children | | Adults | |
|---|---|---|---|---|
| | Mean | sd | Mean | sd |
| Female | 0.49 | (0.50) | 0.73 | (0.44) |
| Age | 8.92 | (5.35) | 38.66 | (13.14) |
| White | 0.35 | (0.48) | 0.35 | (0.48) |
| Black or African American | 0.57 | (0.49) | 0.59 | (0.49) |
| Hispanic or Latino | 0.02 | (0.13) | 0.01 | (0.08) |
| Asian | 0.01 | (0.08) | 0.01 | (0.07) |
| Blind and disabled | 0.06 | (0.24) | 0.59 | (0.49) |
| No. of E/M visits | 3.25 | (4.18) | 4.19 | (5.20) |
| No. of E/M visits in Office | 2.79 | (3.69) | 2.91 | (3.73) |
| No. of E/M visits in OPD | 0.14 | (0.85) | 0.45 | (1.51) |
| No. of imaging exams | 0.55 | (1.71) | 2.21 | (4.83) |
| No. of lab tests | 2.55 | (6.26) | 11.45 | (17.27) |
| No. of IP claims | 0.06 | (0.31) | 0.28 | (0.89) |
| No. of ED days | 0.69 | (2.15) | 2.02 | (5.01) |
| Observations | 587,325 | | 111,332 | |

*Notes:* Data are from MAX OT files 2008-2010. Outcome variables include the beneficiary-level annual number of evaluation and management (E/M) visits (CPT 99201-99205, 99211-99215) across any places of service, in office, and in OPD (hospital outpatient department), imaging procedure (CPT 70000-79999), laboratory test procedure (CPT 80047-89398), inpatient services received, and the number of days using emergency department (ED).

***Table 1.4***

*OLS Estimates of the Effect of Integrated Physician Share on Utilization of Medicaid Services Among Children (Ages 1-19)*

| | Children | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) E/M visit | (2) E/M visit (Office) | (3) E/M visit (OPD) | (4) Imaging | (5) Lab tests | (6) IP services | (7) ED days |
| Share of Integrated Providers | -0.494 | -1.003* | 0.317** | 0.770*** | 0.569 | 0.022 | 0.057 |
| | (0.527) | (0.570) | (0.139) | (0.276) | (0.674) | (0.027) | (0.157) |
| Unemployment Rate | 0.012 | 0.018 | 0.001 | 0.009 | 0.050** | -0.001 | -0.012*** |
| | (0.028) | (0.027) | (0.004) | (0.006) | (0.019) | (0.001) | (0.004) |
| Percent Poverty | 0.025** | 0.013 | 0.003 | -0.009*** | 0.004 | -0.0001 | 0.001 |
| | (0.010) | (0.008) | (0.002) | (0.004) | (0.009) | (0.0003) | (0.002) |
| Median HH Income | -0.000001 | -0.000004 | 0.000002 | -0.000001 | 0.00001 | -0.0000001 | -0.000002 |
| | (0.000014) | (0.000014) | (0.000002) | (0.000004) | (0.00001) | (0.0000001) | (0.000003) |
| Urban Indicator | 0.800*** | 0.875*** | -0.077*** | 0.155*** | -0.615*** | -0.049*** | 0.052 |
| | (0.192) | (0.196) | (0.026) | (0.055) | (0.126) | (0.004) | (0.048) |
| County-level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean of D.V. in 2008 (sd) | 3.25 (4.18) | 2.79 (3.69) | 0.14 (0.85) | 0.55 (1.71) | 2.55 (6.26) | 0.06 (0.31) | 0.69 (2.15) |
| No. of Counties | 64 | 64 | 64 | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 1,874,580 | 1,874,580 | 1,874,580 | 1,874,580 | 1,874,580 |

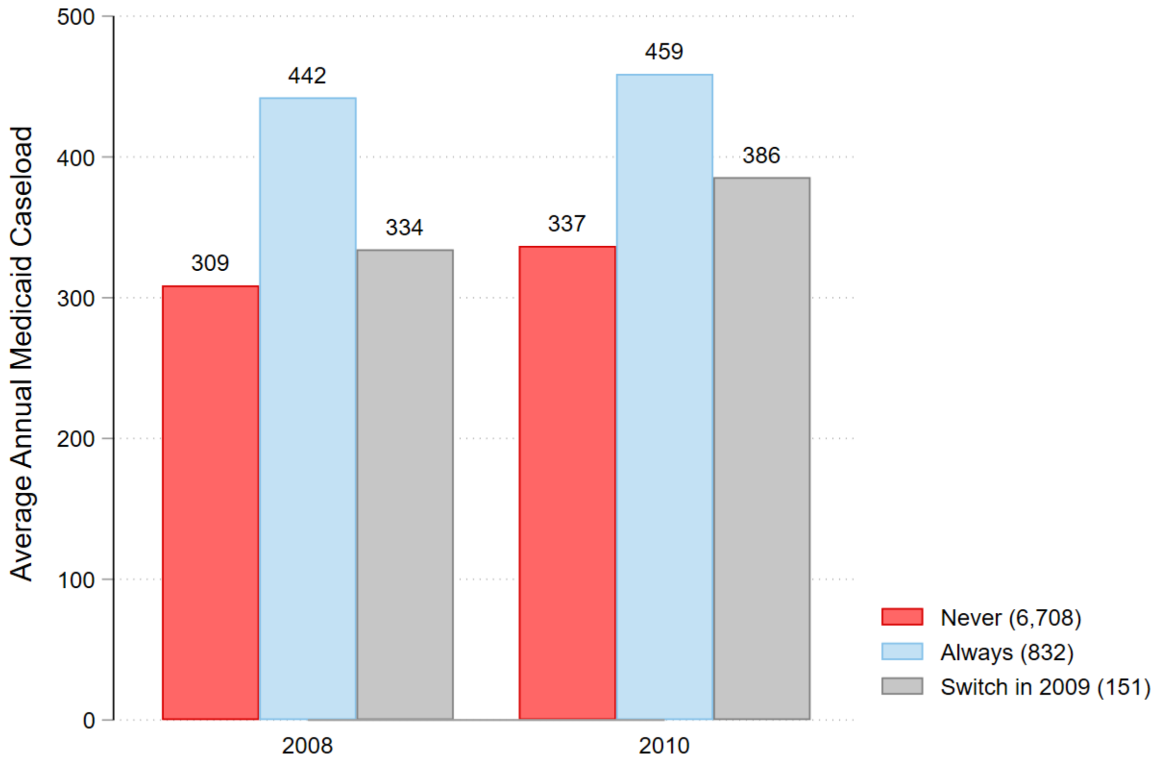
*Notes:* Data are from MAX OT files 2008-2010. In each column, the dependent variable is the number of evaluation and management (E/M) visits (CPT 99201-99205, 99211-99215) across all places of service, E/M visits in office, E/M visits in OPD (hospital outpatient department), imaging procedure (CPT 70000-79999), laboratory and pathology test procedure (CPT 80047-89398), inpatient services received, and the number of days using emergency department (ED) related services that a Medicaid beneficiary has received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Table 1.5***

*OLS Estimates of the Effect of Integrated Physician Share on Utilization of Medicaid Services Among Adults (Ages 20-64)*

| | Adults | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1)<br>E/M visit | (2)<br>E/M visit<br>(Office) | (3)<br>E/M visit<br>(OPD) | (4)<br>Imaging | (5)<br>Lab tests | (6)<br>IP services | (7)<br>ED days |
| Share of Integrated Providers | 1.124 | -1.412 | 1.211** | 1.220 | 0.499 | -0.068 | -1.712** |
| | (1.211) | (1.071) | (0.511) | (1.044) | (3.483) | (0.112) | (0.755) |
| Unemployment Rate | -0.027 | 0.013 | -0.023 | -0.023 | 0.195** | -0.001 | -0.001 |
| | (0.042) | (0.039) | (0.013) | (0.020) | (0.093) | (0.003) | (0.024) |
| Percent Poverty | 0.035* | 0.005 | 0.012 | 0.006 | -0.020 | 0.002 | 0.012 |
| | (0.020) | (0.009) | (0.012) | (0.014) | (0.043) | (0.001) | (0.012) |
| Median HH Income | -0.00003 | -0.000043 | 0.000008 | -0.00003 | -0.0001 | -0.000001 | -0.00001 |
| | (0.00002) | (0.000022) | (0.000009) | (0.00002) | (0.0001) | (0.000002) | (0.00002) |
| Urban Indicator | 0.958*** | 1.151*** | -0.200 | 1.304*** | 3.880*** | 0.014 | 0.609*** |
| | (0.280) | (0.266) | (0.140) | (0.213) | (0.888) | (0.029) | (0.215) |
| County-level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean of D.V. in 2008 (sd) | 4.19 (5.20) | 2.91 (3.73) | 0.45 (1.51) | 2.21 (4.83) | 11.45 (17.3) | 0.28 (0.89) | 2.02 (5.01) |
| No. of Counties | 64 | 64 | 64 | 64 | 64 | 64 | 64 |
| No. of Obs. | 357,986 | 357,986 | 357,986 | 357,986 | 357,986 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. In each column, the dependent variable is the number of evaluation and management (E/M) visits (CPT 99201-99205, 99211-99215) across all places of service, E/M visits in office, E/M visits in OPD (hospital outpatient department), imaging procedure (CPT 70000-79999), laboratory and pathology test procedure (CPT 80047-89398), inpatient services received, and the number of days using emergency department (ED) related services that a Medicaid beneficiary has received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$




***Appendix Figure 1.1***

*Comparison of Average Annual Medicaid Caseload by Physician's Integration Status*

*Notes:* The height of the bars denote the average annual Medicaid caseload (or the number of unique Medicaid patients seen by each servicing ID in a year). The "Never" group indicates servicing IDs that are never integrated during 2008-2010. The "Always" group indicates servicing IDs that are identified as being integrated during 2008-2010. The "Switch" group represents servicing IDs that switched their integration status in 2009. Thus 2008 represents pre-integration period and 2009 represents the post period for the switchers. The number in parenthesis next to each group denotes the number of servicing IDs in each group.

***Appendix Table 1.1***

*OLS Estimates of the Effect of Integrated Physician Share on Access to Care*
*Dependent Variable: Annual Number of Evaluation and Management Visits per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | No. of E/M Visits | No. of E/M Visits | No. of E/M Visits | No. of E/M Visits |
| Share of Integrated Providers | -0.251 | -0.494 | 1.237 | 1.124 |
| | (0.556) | (0.527) | (1.261) | (1.211) |
| Unemployment Rate | | 0.012 | | -0.027 |
| | | (0.028) | | (0.042) |
| Percent Poverty | | 0.025** | | 0.035 |
| | | (0.010) | | (0.020) |
| Median Household Income | | -0.000001 | | -0.00003 |
| | | (0.000014) | | (0.00002) |
| Urban Indicator | | 0.800** | | 0.958** |
| | | (0.192) | | (0.280) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 3.25 (4.18) | 3.25 (4.18) | 4.19 (5.20) | 4.19 (5.20) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of evaluation and management (E/M) services (CPT 99201-99205, 99211-99215) a Medicaid beneficiary received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Appendix Table 1.2***

*OLS Estimates of the Effect of Integrated Physician Share on Access to Care*
*Dependent Variable: Annual Number of Office-based Evaluation and Management Visits per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Office-based visits | No. of E/M Visits | No. of E/M Visits | No. of E/M Visits | No. of E/M Visits |
| Share of Integrated Providers | -0.863 | -1.003* | -1.515 | -1.412 |
| | (0.570) | (0.570) | (1.151) | (1.071) |
| Unemployment Rate | | 0.018 | | 0.013 |
| | | (0.027) | | (0.039) |
| Percent Poverty | | 0.013* | | 0.005 |
| | | (0.008) | | (0.009) |
| Median Household Income | | -0.000004 | | -0.000043* |
| | | (0.000014) | | (0.000022) |
| Urban Indicator | | 0.875*** | | 1.151*** |
| | | (0.196) | | (0.266) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 2.79 (3.69) | 2.79 (3.69) | 2.91 (3.73) | 2.91 (3.73) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of evaluation and management (E/M) services (CPT 99201-99205, 99211-99215) delivered in office, a Medicaid beneficiary received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Appendix Table 1.3***

*OLS Estimates of the Effect of Integrated Physician Share on Access to Care*
*Dependent Variable: Annual Number of OPD-based Evaluation and Management Visits per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPD-based visits | No. of E/M Visits | No. of E/M Visits | No. of E/M Visits | No. of E/M Visits |
| Share of Integrated Providers | 0.359** | 0.317** | 1.297** | 1.211** |
| | (0.148) | (0.139) | (0.549) | (0.511) |
| Unemployment Rate | | 0.001 | | -0.023 |
| | | (0.004) | | (0.013) |
| Percent Poverty | | 0.003 | | 0.012 |
| | | (0.002) | | (0.012) |
| Median Household Income | | 0.000002 | | 0.000008 |
| | | (0.000002) | | (0.000009) |
| Urban Indicator | | -0.077*** | | -0.200 |
| | | (0.026) | | (0.140) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 0.14 (0.85) | 0.14 (0.85) | 0.45 (1.51) | 0.45 (1.51) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of evaluation and management (E/M) services (CPT 99201-99205, 99211-99215) delivered in OPD (hospital outpatient department) setting a Medicaid beneficiary received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## *Appendix Table 1.4*

*OLS Estimates of the Effect of Integrated Physician Share on Utilization of Imaging Procedures*
*Dependent Variable: Annual Number of Imaging Procedures per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (4) | (5) |
| | No. of Imaging | No. of Imaging | No. of Imaging | No. of Imaging |
| Share of Integrated Providers | 0.711*** | 0.770*** | 1.093 | 1.220 |
| | (0.256) | (0.276) | (1.034) | (1.044) |
| Unemployment Rate | | 0.009 | | -0.023 |
| | | (0.006) | | (0.020) |
| Percent Poverty | | -0.009** | | 0.006 |
| | | (0.004) | | (0.014) |
| Median Household Income | | -0.000001 | | -0.00003* |
| | | (0.000004) | | (0.00002) |
| Urban Indicator | | 0.155*** | | 1.304*** |
| | | (0.055) | | (0.213) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 0.55 (1.71) | 0.55 (1.71) | 2.21 (4.83) | 2.21 (4.83) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of imaging procedure (CPT 70000-79999) a Medicaid beneficiary received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Appendix Table 1.5***

*OLS Estimates of the Effect of Integrated Physician Share on Utilization of Laboratory Tests*
*Dependent Variable: Annual Number of Laboratory and Pathology Tests per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | No. of lab tests | No. of lab tests | No. of lab tests | No. of lab tests |
| Share of Integrated Providers | 0.754 | 0.569 | 0.594 | 0.499 |
| | (0.669) | (0.674) | (3.559) | (3.483) |
| Unemployment Rate | | 0.050** | | 0.195** |
| | | (0.019) | | (0.093) |
| Percent Poverty | | 0.004 | | -0.020 |
| | | (0.009) | | (0.043) |
| Median Household Income | | 0.00001 | | -0.0001 |
| | | (0.00001) | | (0.0001) |
| Urban Indicator | | -0.615*** | | 3.880*** |
| | | (0.126) | | (0.888) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 2.55 (6.26) | 2.55 (6.26) | 11.45 (17.27) | 11.45 (17.27) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of laboratory and pathology test procedure (CPT 80047-89398) a Medicaid beneficiary received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## *Appendix Table 1.6*

*OLS Estimates of the Effect of Integrated Physician Share on Inpatient Service Utilization*
*Dependent Variable: Annual Number of Inpatient Claims per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (4) | (5) |
| | No. of IP Services | No. of IP Services | No. of IP Services | No. of IP Services |
| Share of Integrated Providers | 0.019 | 0.022 | -0.058 | -0.068 |
| | (0.026) | (0.027) | (0.107) | (0.112) |
| Unemployment Rate | | -0.001 | | -0.001 |
| | | (0.001) | | (0.003) |
| Percent Poverty | | -0.0001 | | 0.002 |
| | | (0.0003) | | (0.001) |
| Median Household Income | | -0.0000001 | | -0.000001 |
| | | (0.0000001) | | (0.000002) |
| Urban Indicator | | -0.049*** | | 0.014 |
| | | (0.004) | | (0.029) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 0.06 (0.31) | 0.06 (0.31) | 0.28 (0.89) | 0.28 (0.89) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of inpatient services claims a Medicaid beneficiary has had in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### *Appendix Table 1.7*

*OLS Estimates of the Effect of Integrated Physician Share on Emergency Department Service*
*Dependent Variable: Annual Number of Days using Emergency Department (ED) Related Services per Beneficiary*

| | Children | | Adults | |
|---|---|---|---|---|
| | (1) | (2) | (4) | (5) |
| | ED days | ED days | ED days | ED days |
| Share of Integrated Providers | 0.027 | 0.057 | -1.629** | -1.712** |
| | (0.158) | (0.157) | (0.776) | (0.755) |
| Unemployment Rate | | -0.012*** | | -0.001 |
| | | (0.004) | | (0.024) |
| Percent Poverty | | 0.001 | | 0.012 |
| | | (0.002) | | (0.012) |
| Median Household Income | | -0.000002 | | -0.00001 |
| | | (0.000003) | | (0.00002) |
| Urban Indicator | | 0.052 | | 0.609*** |
| | | (0.048) | | (0.215) |
| County-level controls | | Yes | | Yes |
| Mean of D.V. in 2008 (sd) | 0.69 (2.15) | 0.69 (2.15) | 2.02 (5.01) | 2.02 (5.01) |
| No. of Counties | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,874,580 | 1,874,580 | 357,986 | 357,986 |

*Notes:* Data are from MAX OT files 2008-2010. The dependent variable is the number of days a Medicaid enrollee has used emergency department (ED) related services. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses.
** p < 0.10, ** p < 0.05, *** p < 0.01*

## *Appendix Table 1.8*

*Alternative Estimates of the Effect of Integrated Physician Share on Utilization of Medicaid Services Among Children (Ages 1-19)*

| | Children | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) E/M visit | (2) E/M visit (Office) | (3) E/M visit (OPD) | (4) Imaging | (5) Lab tests | (6) IP services | (7) ED days |
| Share of Integrated Providers | -0.248 | -0.826 | 0.334 | 0.811* | 0.494 | -0.021 | 0.047 |
| | (0.661) | (0.696) | (0.143)* | (0.285) | (0.764) | (0.034) | (0.148) |
| Unemployment Rate | 0.028 | 0.024 | 0.005 | 0.007 | 0.030 | -0.001 | -0.007 |
| | (0.025) | (0.025) | (0.004) | (0.006) | (0.021) | (0.001) | (0.006) |
| Percent Poverty | 0.023* | 0.014 | 0.004 | -0.009* | 0.005 | 0.001 | 0.002 |
| | (0.010) | (0.008) | (0.002)* | (0.004) | (0.010) | (0.000) | (0.003) |
| Median HH Income | 0.000003 | 0.000003 | 0.000001 | -0.0000001 | -0.000001 | -0.000001 | -0.00001 |
| | (0.00002) | (0.00002) | (0.000002) | (0.000004) | (0.00001) | (0.000001) | (0.000003) |
| Urban Indicator | 0.678* | 0.719 | -0.064 | 0.154* | -0.367 | -0.030 | 0.117 |
| | (0.217) | (0.201)* | (0.025)* | (0.056) | (0.143)* | (0.007)* | (0.044)* |
| County-level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean of D.V. in 2008 (sd) | 3.27 (4.15) | 2.81 (3.66) | 0.15 (0.85) | 0.53 (1.66) | 2.33 (5.89) | 0.05 (0.30) | 0.67 (2.09) |
| No. of Counties | 64 | 64 | 64 | 64 | 64 | 64 | 64 |
| No. of Obs. | 1,402,230 | 1,402,230 | 1,402,230 | 1,402,230 | 1,402,230 | 1,402,230 | 1,402,230 |

*Notes:* Data are from MAX OT files 2008-2010. Sample is restricted to children (ages 1-19) who are continuously enrolled in Medicaid from 2008 to 2010. In each column, the dependent variable is the number of evaluation and management (E/M) visits (CPT 99201-99205, 99211-99215) across all places of service, E/M visits in office, E/M visits in OPD (hospital outpatient department), imaging procedure (CPT 70000-79999), laboratory and pathology test procedure (CPT 80047-89398), inpatient services received, and the number of days using emergency department (ED) related services that a Medicaid beneficiary has received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Appendix Table 1.9***

*Alternative Estimates of the Effect of Integrated Physician Share on Utilization of Medicaid Services Among Adults (Ages 20-64)*

| | Adults | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) E/M visit | (2) E/M visit (Office) | (3) E/M visit (OPD) | (4) Imaging | (5) Lab tests | (6) IP services | (7) ED days |
| Share of Integrated Providers | 0.821 | -1.623 | 0.984 | 0.271 | 0.054 | -0.058 | -1.835 |
| | (1.243) | (1.074) | (0.458)* | (1.031) | (4.055) | (0.115) | (0.857)* |
| Unemployment Rate | -0.019 | 0.026 | -0.024 | -0.043 | 0.162 | -0.005 | -0.029 |
| | (0.045) | (0.040) | (0.012) | (0.021)* | (0.102) | (0.004) | (0.022) |
| Percent Poverty | 0.037 | 0.011 | 0.009 | 0.007 | -0.035 | -0.000 | 0.008 |
| | (0.020) | (0.008) | (0.011) | (0.014) | (0.047) | (0.001) | (0.012) |
| Median HH Income | -0.00001 | -0.00003 | 0.00001 | -0.00001 | -0.00003 | 0.000001 | -0.000003 |
| | (0.00002) | (0.00002) | (0.00001) | (0.00002) | (0.0001) | (0.000003) | (0.00002) |
| Urban Indicator | 0.628* | 1.085 | -0.298 | 0.729 | 2.740 | -0.043 | 0.196 |
| | (0.278) | (0.246)* | (0.138)* | (0.218)* | (0.881)* | (0.032) | (0.233) |
| County-level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean of D.V. in 2008 (sd) | 4.16 (5.07) | 2.91 (3.71) | 0.44 (1.48) | 2.13 (4.32) | 11.29 (17.0) | 0.25 (0.80) | 1.93 (4.69) |
| No. of Counties | 64 | 64 | 64 | 64 | 64 | 64 | 64 |
| No. of Obs. | 219,066 | 219,066 | 219,066 | 219,066 | 219,066 | 219,066 | 219,066 |

*Notes:* Data are from MAX OT files 2008-2010. Sample is restricted to adults (ages 20-64) who are continuously enrolled in Medicaid from 2008 to 2010. In each column, the dependent variable is the number of evaluation and management (E/M) visits (CPT 99201-99205, 99211-99215) across all places of service, E/M visits in office, E/M visits in OPD (hospital outpatient department), imaging procedure (CPT 70000-79999), laboratory and pathology test procedure (CPT 80047-89398), inpatient services received, and the number of days using emergency department (ED) related services that a Medicaid beneficiary has received in a year. All regressions control for age, race, sex, and blind and disability status indicator, county FE and year FE. County-level controls include unemployment rate, poverty rate, median household income, and indicator for urban/rural status. Robust standard errors clustered at the county level are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## 1.11 Appendices

### 1.11.1. Appendix A. Measuring County-level Physician-Hospital Integration

To measure physician-hospital integration, previous work has used American Hospital Association (AHA) annual survey of hospitals (Baker et al. 2014; Ciliberto and Dranove 2005; Cuellar and Gertler 2006; Madison 2004; Scott et al. 2017), SK&A database of physicians (Bond et al. 2017; Richards et al. 2016), consulting firm's merger and acquisition (M&A) reports (Koch et al. 2017). AHA survey polls hospitals and report hospital's relationships with physicians with differing degrees of integration such as Independent Physician Associations, Open/Closed Physician-Hospital Organization, and Fully Integrated Organizations. SK&A polls U.S. office-based physicians and report their practice ownership and organization structure, such as the office's affiliation with a larger physician group or an integrated health system. Finally, M&A reports are used to identify list of physician practices acquired by a health system providing information like target and acquiring firms, transaction date, and number of physicians affected.

Each of this database for identifying physician-hospital affiliation is appropriate depending on the research question and has advantages and disadvantages: The AHA survey is appropriate for the purpose of analyzing ownership of physician practices from hospitals' perspective as it doesn't identify which specific physicians are integrated. SK&A is used to identify integration at the practice level but is limited to a sample of office-based physician practices that may not be representative of the physician market (Baker et al. 2018). Lastly, M&A report is short of capturing all incidents of vertical integration because many mergers are too small to be detected by the report's screens. The transactions in this dataset tend to involve either large health systems or large physician groups (Koch et al. 2017).

Alternatively, other studies construct measure of integration using administrative claim files. My approach is similar to that of Neprash et al. (2015) and Capps et al. (2018), where the authors use the physician's billing patterns to identify whether he has integrated with a hospital. Capps et al. (2018) use the Tax Identification Number (TIN) in the commercial claims data to identify co-ownership and vertical integration. Neprash et al. (2015) assessed physician-hospital integration at the MSA-level by first calculating the share of claims for Medicare outpatient care that was billing with an OPD setting code at the physician-level. Then, they calculated the proportion of physicians billing exclusively with an OPD code in each MSA. Their method is specific to Medicare setting as the changing the billing of claims with place of service code from office to OPD is motivated by financial incentives for integrated physicians to be reimbursed at a higher rate using OPD code as dictated by Medicare payment rules. Medicaid has no similar payment rules to incentivize physicians to bill claims rendered in office as OPD claims.

Medicaid claims data's analogous of TIN's is the state-assigned billing provider ID ("billing ID") that identifies the billing entity being reimbursed for the procedure. Each claim is also associated with a state-assigned servicing provider ID ("servicing ID") that identifies who rendered the Medicaid service to a patient. When a hospital acquires a physician practice or employs a physician, the hospital's provider numbers replace those of the physicians on the claims for billing (AMA 2018). For example, when an independent physician bills for Medicaid service, the claim will have the same servicing ID and billing ID. Once his practice is acquired by a hospital and he is compensated under a contract with a hospital, the claims he submits for his services will have his servicing ID and the hospital's billing ID. I exploit this billing convention to calculate the share of claims for physician services that was billed to hospital or IDS at the physician-level then calculate the proportion of physicians billing exclusively (≥90%)

to hospitals[8]. The average share of physician claims billed to hospitals among integrated physicians is 99%. To avoid identifying effects off of changes in physician-hospital integration driven by random shifts in billing entity for each servicing ID that treat only a small Medicaid cases, I drop servicing IDs with annual FFS claim count at the bottom 20th percentile (the threshold is about 15-19 claims in each year).

Billing IDs are linked to publicly available MAX Provider Characteristics (MAXPC) data to identify whether the ID belongs to a hospital or IDS (as opposed to independent practitioners or private groups). Historically, it has not been possible to conduct provider-based research using MAX claim files because the provider IDs (e.g. servicing/billing IDs) were largely unedited, undocumented, and state-specific. Beginning in February 2009, CMS required states to include NPIs on their service records. MAXPC files link state-assigned provider IDs to NPIs and provide provider characteristics (Bencio et al. 2010; Bencio and Sykes 2012), such as provider name, business name, primary taxonomy (e.g. internal medicine), and entity type (individual versus organization).

To identify whether a billing ID is associated with a hospital or hospital systems, I use billing IDs from the OT file to link to MAXPC file and obtain the billing entity's taxonomy code (which identifies whether the billing ID belongs to a hospital or hospital units), business name, entity type (individual versus organization). Because not all hospitals or hospital systems use hospital or hospital units as their primary taxonomy code, I also use their business names to identify whether a billing ID belongs to a hospital. Besides general matching of string variables

[8] Non-physician (MD or DO) providers can also render services to Medicaid patients. To avoid counting nurse practitioners and other non-physician providers into the integration measure, I drop if the servicing ID is associated with more than 10% of dental, nurse practitioner, or other practitioner service claims in each year.

that indicate hospital names (e.g. “hospital”, “university”), I use a list of hospital and health system names from 2016 Compendium of U.S. Health Systems.

The annual measure of physician-hospital integration for physicians who treat patients from county $c$ is:

$$Share\ FI_{ct} = \frac{No.of\ Integrated\ Physicians\ who\ treat\ patients\ residing\ in\ county\ c\ in\ year\ t}{No.of\ Physicians\ who\ treat\ patients\ residing\ in\ county\ c\ in\ year\ t}$$

For the denominator, I also exclude physicians if they see only a small share of their patient base from county *c*. For example, if physician *i* sees 100 Medicaid patients from county A and only 2 patients from county B, I exclude physician *i* from the integration measure for county B. This prevents physicians being counted towards a county’s integration share because a few patients seek out care from integrated physicians in counties outside of where most patients from the county seeks care. Since a physician can serve patients from multiple counties, a physician can be counted multiple times towards the integration measures across counties. I also note that since a physician can have multiple servicing IDs associated with him, each servicing ID does not represent a unique physician.

To identify integrated physicians (for the numerator), I measure the share of each servicing ID’s claims that gets billed to hospitals or IDS. Thus for each physician *i*, I measure the following:

$$Share\ of\ claims\ billed\ to\ hospitals_i = \frac{No.of\ FFS\ claims\ billed\ to\ hospitals}{Total\ no.of\ claims\ billed\ to\ any\ entity}$$

Note that a physician's integration status is unique in each year and same across counties. Because Louisiana's entire Medicaid population is billed under FFS payment system, analyzing the FFS claims to derive integration status covers the entirety of Louisiana's Medicaid system across counties (Details on the healthcare landscape in Louisiana can be found in Appendix B). However, this measure of integration is subject to error if the physician only sees a few Medicaid patients and bills them to the contracted hospitals and bills the rest of his patient base to another entity (e.g. himself). Thus, I exclude servicing IDs with small number of annual claim counts (bottom 10$^{th}$ percentile). In general, the integration measure is assumed to be correct if the physician bills for his patients uniformly across different patient insurance types.

This paper measures physician-hospital integration using Medicaid claims data. Thus the integration measures are limited to physicians participating in Medicaid. While the methods used in this study captures the degree of financial integration between physicians and hospital or IDS who submit at least 15-19 claims per year to Medicaid, the overall physician market change that involves physicians who mostly serve Medicare and privately patients may not be captured. Below, Appendix Table 1.10, shows the sample restrictions placed to exclude servicing IDs that have too few annual number of claims and who appear to be non-physicians (i.e. dentists, nurse practitioners, and other practitioners and those with small number of type of service equal to physician services). The remaining servicing IDs after the sample restrictions are included in the measurement of physician-hospital integration in each county. The bottom row of the table shows that the share of integrated servicing IDs grows from 12.4% in 2008 to 14% in 2010.

***Appendix Table 1.10***

*Sample Restrictions for Servicing IDs*

| | 2008 | 2009 | 2010 |
|---|---|---|---|
| Total no. of servicing IDs without sample restriction | 18,439 | 19,208 | 20,160 |
| (1) No. of servicing excluded due to having bottom 20th percentile of FFS claims | 3,688 | 3,889 | 4,122 |
| - Bottom 20th no. of claims | 15 | 19 | 17 |
| - Average no. of claims among those who are excluded | 9 | 7 | 6 |
| (2) No. of servicing IDs excluded because servicing ID administered dental, nurse practitioner, or other practitioner services | 2,296 | 2,525 | 2,752 |
| (3) No. of servicing IDs excluded because less than 10% of claims are physician services | 2,807 | 2,943 | 3,132 |
| Total no. of servicing IDs included in the study sample | 9,647 | 9,851 | 10,154 |
| - No. of integrated servicing IDs (%) | 1,199 (12.4%) | 1,334 (13.5%) | 1,436 (14%) |

*Notes:* Data on servicing IDs come from MAX OT 2008-2010. Bottom 20th no. of claims indicates the threshold number of annual claims for excluding physicians who have too few claims to identify the integration status.

One limitation of MAXPC data files is that they do not identify all providers in the MAX files and only have data available for 2009 and 2010 (because variable NPI that allows to link state-assigned provider IDs with physician characteristics are only begun to be used in 2009 and forward). This limits the ability to capture all physician-integration relationships within a geographic region during the study period. As far as I am aware, there is no other data that will allow me to identify more physicians than the ones I can identify using MAXPC files. Appendix Table 1.11 shows the number of billing IDs associated with the sample of servicing IDs included in the study. In each year, about 2-4% of billing IDs cannot be identified as either hospital/IDS or non-hospital/IDS (e.g. individual physician practices, group practice, etc.). Appendix Table

1.12 shows the number of unidentified claims. In each year about 1-2% of claims are associated with unidentified billing IDs. To make a conservative choice on the measurement of physician-hospital integration, I assume that non-identified billing IDs are not hospital/IDS. However, the claims associated with the unidentified billing IDs make up only 1-2 % of total claims associated with the servicing IDs included in the sample to calculate the integration measure. Thus, while the share of integrated physicians in an area will tend to be underestimated, the error is likely to be small.

***Appendix Table 1.11***

*Billing ID Identification Rate*

| | 2008 | 2009 | 2010 |
|---|---|---|---|
| Total no. of billing IDs associated with sample servicing ID | 4,877 | 4,846 | 4,868 |
| - No. of billing IDs identified as hospital or IDS | 199 | 201 | 208 |
| - No. of billing IDs identified as non-hospital/IDS entity | 4,552 | 4,527 | 4,477 |
| - No. of billing IDs that cannot be identified | 126 | 118 | 183 |

*Notes:* Data on billing IDs come from MAX OT 2008-2010. I identify billing IDs as hospital/IDS by linking billing ID from the OT file to the provider ID from the MAXPC files 2009-2010. Business name, organization type, and taxonomy classification are used from the MAXPC to make the identification supplemented by hospital and IDS names from 2016 Compendium of U.S. Health Systems

***Appendix Table 1.12***

*Billing ID Identification Rate Weighted by Claim Counts*

| | 2008 | 2009 | 2010 |
|---|---|---|---|
| Total no. of claims associated with the sample servicing IDs | 10,201,754 | 11,546,202 | 11,947,917 |
| - No. of claims with hospital or IDS billing IDs | 1,232,864 | 1,328,111 | 1,325,471 |
| - No. of claims with non-hospital/IDS billing IDs | 8,864,611 | 10,083,471 | 10,332,664 |
| - No. of claims with billing IDs that cannot be identified | 104,279 | 134,620 | 289,782 |

*Notes:* Identification of billing IDs are made by linking the provider IDs from MAXPC 2009-2010 and billing IDs from MAX OT 2008-2010.

### 1.11.2 Appendix B. Louisiana's Healthcare Landscape and Medicaid Program

Louisiana is the 25th most populous state in the U.S. in 2016 with 4.5 million people. Most of Louisiana is rural, but the population is concentrated in handful of counties. Close to 60% of Louisiana's population is non-Hispanic White. Relative to the U.S. overall, Louisiana has much larger share of African Americans (31% vs. 12% nationally) and smaller share of Hispanics (6% versus. 18% nationally). Higher overall share of Louisianans live in poverty compared to the national average (23% vs. 15%). Louisiana ranked 50th overall among the 50 states in terms of population health based on America's Health Ranking 2015. It has higher rates of heart diseases, HIV, drug-related mortality, high teen pregnancy rate, and high cancer incidence rate.

Louisiana Medicaid program is the second largest category of state program behind elementary and secondary education. Its total expenditure is about $6.4 billion during fiscal year 2008/2009. In the same year, 1.2 million Louisianans, about 28% of the state population were enrolled in the program. Children, non-elderly adults, elderly, and the disabled make up most of Louisiana's Medicaid enrollees.

State's safety net hospitals provide free medical care to state residents with incomes at or below 200% of Federal Poverty Line. Since these hospitals mostly provide acute care, there may be fewer options for primary care among low-income population in the state. As of 2014, Louisiana had 118 primary care health professional shortage areas. Those on Medicare and Medicaid have access to community hospitals and physician practices while the uninsured mostly obtain care from the Louisiana State University system's inpatient hospitals and a network of clinics. Louisiana is a major user of Medicaid Disproportionate Share Hospital (DSH) funding. State Medicaid program gives DSH payments to hospitals that serve a high share of low-income or uninsured patients (KFF 2016; MACPAC 2011).

## 2. How Do Changes in Fee-for-Service Payment Impact the Utilization of Imaging Exams? Evidence from Medicaid

### 2.1 Introduction

The volume and cost of diagnostic imaging procedures have grown about twice the rate of other technologies in healthcare during the past ten years (Manohar et al. 2020). It is estimated that diagnostic imaging accounts for 10% ($100 billion) of total annual healthcare costs in the U.S (Jackson 2014). However, many believe that imaging is overutilized in the U.S with some studies suggesting that as much as 20% of advanced imaging fails to provide information that improves patient welfare (Hendee et al. 2010; Lehnert and Bree 2010). While imaging technologies inarguably help improve the physician's ability to detect, diagnose, and treat diseases, unnecessary imaging could have negative financial and health consequences. In 2014, Medicare spent close to $1.5 billion on imaging tests that have little or no clinical benefit (MEDPAC 2012). Moreover, overutilization of medical imaging exposes patients to unnecessary radiation doses that increase the risk of developing cancer (Brenner and Hall 2007). It could also increase incidences of false positive finding that result in unneeded treatments and greater downstream costs[9].

While existing studies document geographic variation in utilization of diagnostic radiology services (Goodman et al. 2013; Venkatesh et al. 2018), limited number of studies examine the causal link between potential driving factors and utilization. One of the most cited key factors influencing overutilization of medical imaging is fee-for-service (FFS) payment scheme, where providers are reimbursed for each imaging procedure administered. Because

[9] For example, an imaging exam may show an abnormality in a patient that doesn't require a treatment, but a physician may still order additional imaging tests to monitor the abnormality or even attempt to treat it that wasn't destined to cause problems (Federico 2014)

more procedures yield more revenue, providers may be incentivized to order additional imaging services beyond medical necessity. In this study, I examine the impact of changes in FFS reimbursements on utilization of imaging procedures using Medicaid claims data. A detailed Medicaid claims data allows for calculating per-service reimbursement rates for a variety of imaging services not available otherwise. The claims data also provides a comprehensive utilization pattern at the enrollee level along with demographic and clinical information. Leveraging this unique data, I assess the impact of changes in Medicaid payment generosity on utilization of some of the most used diagnostic radiology services – X-ray, diagnostic ultrasound, computed tomography (CT) scans, and magnetic resonance imaging (MRI) scans.

Using a difference-in-differences design, this paper tests whether a state's level of Medicaid payments for imaging services, relative to Medicare payment, affects imaging service utilization for Medicaid patients in office and in hospital outpatient department (OPD). I compare patient-level utilization of imaging services in states with relatively large fee versus small fee changes among adult Medicaid beneficiaries. I provide evidence that changes in state-set Medicaid reimbursement rates across years are plausibly exogenous to factors impacting imaging prices and volume. Since the main analysis includes both appropriate and inappropriate imaging utilization, I extend the analysis to focus on a few low-value imaging services, namely back imaging for low-back pain and brain imaging for uncomplicated headache. This analyzes how per-unit reimbursement scheme is contributing to overutilization of imaging services among Medicaid population.

The results indicate that increasing the Medicaid-to-Medicare fee ratio by 0.30 (for example, increasing from the mean ratio of 0.7 to 1) is associated with a positive and large effect on imaging utilization of X-ray, diagnostic ultrasound, and CT scans, and a negative effect for

MRIs. The estimated effect is generally larger for exams taken place in OPD compared to office. Among low-value services, fee ratio increase is associated with an increase in the use of spine X-ray and CT scans and decrease in use of spine MRIs in both office and OPD among back pain patients. For headache patients, fee ratio increase results in greater probability of receiving brain CT in office and OPD and decrease in probability of receiving brain MRI in. While the estimates are robust to controlling for state-level covariates, none of the estimates discussed above are not statistically significantly or precisely estimated. Thus the study does not provide a conclusive result on the relationship between Medicaid reimbursement rates and utilization of imaging services.

In this paper, I present a simple theoretical model to predict physician's treatment decision under Medicaid setting. Providers may respond to changes in reimbursement rates differently for Medicaid patients than for Medicare or privately insured patients. Medicaid patients generally make up a smaller share of a physician's patient mix due to low payment rates, and this has unique implications for the income and substitution effects. I leverage a unique, comprehensive Medicaid claims data to test such implications. The detailed Medicaid claims data allows me to calculate Medicaid prices of various imaging services and examine detailed enrollee-level utilization, which are not available otherwise. Moreover, this paper explores how supply response differs by two major outpatient settings for imaging provision, physician office and OPD. Provider incentives may differ in office and outpatient hospital, and this study is one of the first two explore such differences. About a quarter of 68 million Medicaid beneficiaries are under the FFS system and FFS payments to providers make up more than 50% of Medicaid spending (MACStats 2015). Thus, it is important to understand the consequences of payment system that rewards providers for volume as it impacts medical expenditure and health of a large population. In addition, reducing overutilization of medical imaging is an important policy question that can help reduce healthcare costs without compromising quality of care. Investigating how financial incentives shape imaging utilization is important in making informative policy recommendations.

## 2.2 Background on the Use of Diagnostic Radiology Procedures

Diagnostic radiology is used to diagnose cause of symptoms, screen for different illnesses, guide therapeutic procedures, and monitor disease treatment. For example, when a patient complains about back pain, a physician takes a detailed patient history and may schedule the patient for an MRI appointment to pinpoint the source of pain on top of prescribing pain killers. When a physician places an order for MRI, MRI is scheduled at an imaging facility (e.g. outpatient radiology department) or at the physician's office. MRI is then performed by a technician or radiologist, and the radiologist interprets the image. Finally, the physician (and the patient) receives a report (Kennedy 2009).

Many studies document that a sizable proportion of imaging studies are inappropriate. Even though many clinical studies recommend against imaging for patients with uncomplicated low back pain at least in the initial stage, many physicians order lumbar imaging. A study of Medicaid patients in Washington showed that among low back patients, 14% received an X-ray, CT, or MRI scan within 4 weeks of primary diagnosis (Washington Health Alliance 2014; Reed and Pearson 2016). Rates of inappropriate use of coronary CT angiography was reported to be about 17% (Miller et al. 2010). Lehnert and Bree (2010) reviewed medical records from elective outpatient CT and MRI examinations and found that 26% of them were not considered appropriate. These inappropriate use of imaging increases costs but also poses risk to patients' health. Cumulative exposure to high levels of ionizing radiation from some imaging procedures can increase the likelihood of developing cancer over a patient's lifetime (Brenner and Hall 2007). Some patients may experience serious side effects from contrast media, such as kidney failure (Maddox 2002).

What drives imaging overuse? Hendee et al. (2010) identifies key forces influencing overutilization of medical imaging procedures. First, FFS payment process, where individual imaging costs are reimbursed on a per-procedure basis, is the most often cited reason that contribute to overutilization. Because reimbursement for imaging procedures is high relative to other healthcare services, non-radiologists may add imaging to the services they provide to patients for financial benefit. Levin and Rao (2004) estimated that unnecessary imaging from self-referral costs $16 billion a year in the U.S. In some cases, radiologists may also recommend for additional procedures when he is paid based on the number of procedures he conducts. In a recent survey, 70% of physicians believed that profitability likely leads physicians to order unnecessary procedures (Lyu et al. 2017).

A few other factors could also contribute to overutilization. Diagnostic tests may be part of defensive medicine, where tests are performed to safeguard against possible accusations of malpractice rather than to the benefit of the patient. Alternatively, referring physicians and radiologists may not be familiar with cost-saving alternative procedures[10]. In addition, since most patients incur little financial liability for imaging services, they may demand procedures without understanding the actual benefits or risks. Sometimes costly imaging services that provide

[10] For example, studies report that in cancer care, providers order imaging tests more frequently than recommended due to lack of knowledge on imaging protocols. They inappropriately order advanced imaging for average-risk patients when guidelines specify to use advanced imaging (i.e. MRI) only for patients with high recurrence risk (Manohar et al. 2020).

questionable benefits (e.g. whole-body CT that are advertised as a way to detect early signs of cancer and heart disease) are marketed directly to the patients and encourages them to “self-present” to imaging facilities for specific studies (Manohar et al. 2020). Lastly, imaging studies are often duplicated when previous exams are inadequate or due to difficulty accessing medical records (Lyu et al. 2017).

In this study, I focus on examining the impact of FFS payment incentives on utilization of imaging procedures. While many factors together can contribute to overutilization, payment structure for imaging procedures is a policy target that can be modified along with physician and patient education efforts to reduce overutilization. Specifically, I use the variation in Medicaid payments generated by differences in per-unit service prices across states and years as the treatment variable to estimate the impact of financial incentive changes on the utilization of imaging procedures among Medicaid beneficiaries.

## 2.3 Literature Review

### 2.3.1 Changes in Regulated fees and Utilization Response

Many existing studies use Medicare data to examine the effect of regulated fee changes on treatment decisions. They generally find that physicians respond to fee reduction by increasing volume. Rice (1983) studies a large Medicare fee change in Colorado in 1976 that increased fees for rural physicians and lowered (in relative terms) for urban physicians. He finds that a 10% reduction in payments leads to a 6% growth in medical services and a 3% growth in surgical services. Nguyen and Derrick (1997) also study changes in Medicare prices following the Omnibus Budget Reconciliation Act (OBRA) of 1989, which decreased reimbursement for procedures that were deemed too costly. The authors find that physicians experiencing fee reductions increase Medicare volumes, but the result is significant only for the 20% of physicians who experienced the largest price reductions. Yip (1998) similarly studies the OBRA of 1987 and additionally considers the effect of Medicare fee changes on non-Medicare volumes. She finds that among thoracic surgeons, whose reimbursement rates were significantly reduced by the reform, the volume of coronary artery bypass grafting (CABG) increased among Medicare population. She also finds higher CABG rate among privately insured patients following Medicare fee decrease. More recently, Jacobson et al. (2010) finds that reduction in Medicare fee for chemotherapy drugs led to increase in administration of chemotherapy. The study also reports that providers substituted towards drugs that were relatively less affected by the fee decrease. On the other hand, Clemens and Gottlieb (2014) use Medicare's 1997 price consolidation as the policy variable that generated area-specific price shocks that adjusted physician payments. The study finds that that areas with higher payment increases experience significant increase in health care supply, with elective procedures (e.g. cataract removal) responding much more strongly than less discretionary services (e.g. hip fracture repair).

In the context of Medicaid, most previous work has focused on the effect of fee changes on the delivery of primary care and provide mixed results. Some studies find that more generous Medicaid physicians fees lead to increase in the number of Medicaid patients seen by physicians (Baker and Royalty 2000; Cohen and Cunningham 1995; Decker 2009; Sonchak 2015; White 2012). Other studies show little to no relationship (Atherly and Mortensen 2014; Shen and Zuckerman 2005). Decker (2007) finds that Medicaid fee increase leads to physicians spending more time with their Medicaid patients. Gruber et. al (1999) finds that cesarean deliveries are performed more often when their Medicaid reimbursement rates are higher compared to vaginal deliveries[11].

### 2.3.2 Financial Incentives and Provision of Diagnostic Radiology Procedures

There is a separate, and sizeable literature that focuses specifically on the relationship between physician's financial incentives and ordering of imaging tests. Using private insurance data, Hillman et al. (1990) compares the frequency and costs of imaging exams ordered by physicians who owned imaging equipment in their offices versus those who always referred patients to radiologists. He finds that self-referring physicians, who receives direct payment for the imaging services they order, obtained imaging exams 4 to 4.5 times more than the radiologist-referring physicians. However, earlier studies like this does little to address unobservable differences between the two comparison groups. For example, self-referring physicians may perform more imaging since imaging is simply more convenient when performed in a physician's office. On the other hand, it could be because physicians who are more likely to order more images are also more likely to own the imaging equipment. Based on this analysis alone, it is not possible to tell which group's imaging practice represent more appropriate care or the extent to which financial incentives are contributing to higher use among self-referring physicians.

To identify the use of appropriate care and to assess the extent which financial incentives are responsible for higher levels of use, more recent studies focus on low-value services and use research designs to control for confounding factors. Clemens and Gottlieb (2014), which uses

[11] Johnson and Rehavi (2016) merges California Vital Statistics data with physician licensure data to compare the probability of receiving C-section if the patient is a physician versus a non-physician. They find evidence consistent with physician-induced demand, that financial incentives have a large effect on C-section probability of patients who are non-physicians but have minimal impact on patients who are physicians.

area-specific price shocks following Medicare’s 1997 price consolidation, identifies low back MRI as one of the elective procedures that has large profit margins. The results show that while increase in Medicare reimbursement rate has little effect on the provision of MRIs among back pain patients, it leads to increase in provision of MRIs among non-radiologists. This suggests that physicians adopt imaging technologies when it becomes more lucrative to perform the exams.

Also using FFS Medicare claims data, Baker (2010) makes before-and-after comparisons of MRI usage by providers who started billing for MRI compared to changes in the same time period (1999-2005) for those who were never observed to self-refer an MRI procedure. The analysis adjusts for various confounding factors, such as patient characteristics (e.g. prior year health care spending, presence of comorbidities), includes physician fixed effects to capture time-invariant physician characteristics (e.g. demographic characteristics, underlying preferences about care, and attributes of their geographic area), and year and month fixed effects to account for overall time trends in MRI use. Results show that physicians ordered substantially more scans once they began directly billing for MRIs instead of referring their tests to outside facilities. Extending this study, Shreibati and Baker (2011) studies the downstream service utilization following low back MRI procedure. First, physician’s acquisition of MRI equipment is strongly correlated with the ordering of MRI scans among low back pain patients. They then find that increased MRI use leads to more frequent low back surgeries and increased healthcare spending among patients of orthopedic surgeons.

Results from these studies suggest that financial incentive is an important determinant of healthcare costs and the distribution of health resources in the U.S. However, most of the existing literature on imaging use uses private insurance or Medicare data and focus on a few imaging procedures (most often discussed being low back MRI). The effect of physician's financial incentives on utilization may depend on the patient's demographics or different type of insurance plans. Results from commercial insurance or Medicare program may not be applicable to the case of Medicaid because physicians are much less specialized in Medicaid than they are in Medicare or private insurance. In response to regulated fee changes, income effects dominate in the case of Medicare because physicians who perform Medicare procedures often work primarily in the Medicare sector. On the other hand, substitution effects may dominate in the case of Medicaid because income effects are small on average for physicians seeing Medicaid patients[12]. As a result, although decrease in Medicare fee is associated with increased volume or intensity of treatment, Medicaid fee reduction may produce opposite results.

This study extends the literature in several ways. It adds to a body of previous work that has examined the relationship between financial incentive and use of diagnostic radiology procedures, often using older Medicare or private data. Using detailed Medicaid data from more recent period (2003-2004 and 2008-2010), this study investigates one of the main suspected drivers of overutilization in imaging, FFS payment scheme. Moreover, information on changes in fees and use of care derived from Medicaid claims data are high-quality. Next, I examine the effect of changes in Medicaid fees on a broad range of imaging services, including most used imaging exams (X-ray, diagnostic ultrasound, CT, and MRI) and in specific cases for low-value imaging. Lastly, I examine how changes in FFS Medicaid reimbursement rates impact utilization of imaging services in two separate outpatient settings, physician office and OPD, and study how fee responses differ by place of service.

[12] For example, Gruber et al. (1999) shows that more than 60% of the caseload of the median physician performing a surgery on Medicare beneficiaries comes from Medicare program. However, the median physician delivering Medicaid babies derives only 32% of his caseload from Medicaid.

### 2.4 Conceptual Model

In this section, I present a theoretical model of the physician's treatment decision that involves inducement. The goal is to describe the ambiguous prediction for the effect of Medicaid FFS fee changes on the physician's decision to provide diagnostic radiology services, and to focus on the relative role of income and substitution effects. Demand for care is likely high among Medicaid patients because they only pay nominal copayments for using Medicaid services. Other than time costs for Medicaid patients, the amount of care received by Medicaid patients is therefore determined by the physician's decision to supply the care to them (Decker 2007).

Following McGuire (2000)'s model of physician treatment decision, a physician's utility maximization problem can be written as follows:

$$\text{Max } U = U(Y, I)$$

$$\text{,where } Y = N\big(m_1 x_1(i_1) + m_2 x_2(i_2)\big) \text{ and } I = N(i_1 + i_2)$$

The physician obtains utility *U* from net income *Y*, but disutility from total inducement *I* she conducts. Standard assumptions on the physician's utility function are made: $U_Y > 0;\ U_{YY} < 0;$ $U_I < 0; U_{II} < 0.$ She sees *N* patients who use service 1, for example, diagnostic radiology procedure, and service 2, other services. Quantity of each service is represented by *x* and is determined by the level of inducement *i* with $x' > 0, x'' < 0$. Margin of each service, *m*, is equal to the difference between the physician fee and the cost of service. Other demand factors, such as the patient's out-of-pocket costs, are suppressed since they are invariant.

The physician chooses inducement levels, $i_1$ and $i_2$, to maximize utility. From the first order conditions with respect to $i_1$ and $i_2$, utility maximization can be described as follows:

$$m_1 x_1' = m_2 x_2' = -U_I/U_Y$$

In the equilibrium, quantity is determined by the physician equating the marginal cost (in dollar terms) of induction with the marginal (dollar) return to inducement.

Changes in fees affect physician's decision to induce and affect quantities through both income and substitution effects. Suppose that Medicaid increases the fee for an imaging procedure (service 1), $m_1$, while fees for other services (service 2) do not change. Decrease in $U_Y$ causes $-U_I/U_Y$ to increase, and inducement decreases for both services 1 and 2 to balance out the equation. In other words, a Medicaid fee increase reduces quantities for both services through the income effect. There is also a substitution effect because greater $m_1$ increases the relative return to inducement for service 1; the substitution effect increases inducement for service 1 and decreases inducement for service 2. In summary, income and substitution effects of an own fee increase work in opposite directions and depending on the relative strength of the income and substitution effects, quantity can either increase or decrease in response to own fee increases[13].

In the Medicaid environment, substitution effects may dominate the income effect. The strength of income effect from a sector is proportional to the share of total income coming from that sector. Thus, the smaller the share of total income coming from Medicaid, the likelihood of physicians responding to Medicaid fee increase with increased quantity for the affected Medicaid

[13] On the other hand, income and substitution effects work in the same direction for cross-fee effects and produce unambiguous predictions for service 2. Quantity for service 2 should decrease because fee increase reduces inducement for all services (income effect) and relative returns to inducing for service 2 decrease, thus reducing inducement for service 2 (substitution effect).

service is greater. Physicians in general receive a relatively small portion of their income from Medicaid services. This means that increase in Medicaid fees may lead to higher treatment intensity/volume since substitution effects can be expected to dominate the income effect (Gruber et al. 1999). Nevertheless, the direction of the supply response to a Medicaid fee increase is ambiguous as the relative strength of income and substitution effects ultimately depends on the context of the study and the sample of physicians being studied.

There are reasons to believe that physician inducement may play a role in treatment decision for diagnostic radiology services. First, diagnostic radiology services are lucrative relative to other physician services, and FFS payment system rewards physicians for performing additional tests. In 2003, each 15-minute established Medicaid patient visit was reimbursed at an average of $30 in Texas. On the other hand, Medicaid reimbursed lumbar spine MRI at an average of $961 per scan. Rich et al. (2012) suggests that if the financial reward for using imaging to diagnose the symptoms greatly exceeds the cost, the physician is likely to make himself readily be accessible to patients with such symptoms (or might even invest in marketing the high-margin services to the patient). Next, many diagnostic radiology tests are elective procedures, meaning that physicians have considerable amount of discretion in performing the procedure. While guidelines, such as the American College of Radiology's Appropriateness Criteria, assist providers in making appropriate imaging decisions, physicians report that the guides often do not account for all clinical aspects of the patient. The guidelines may even conflict with the local standard of care (Timbie et al. 2015). In uncertain scenarios without definitive rules, financial incentives might drive the physician's decision for treatment choices for more elective procedures compared to less elective procedure, such as emergency surgery.

I investigate the implication of the model that physician's treatment decision depends on the marginal benefit of care by estimating the effect of changes in Medicaid reimbursement rate on utilization of radiology services in outpatient settings. The two main outpatient settings are physician's private office and OPD. Table 2.1 shows where each imaging modality is performed on FFS basis among adult Medicaid beneficiaries in 2003. 45% of X-rays are performed in OPD and 24% are performed in office. For diagnostic ultrasound, 38% are performed in OPD and 48% in office. For CT, 52% are performed in OPD and 15% are performed in office. Lastly for MRI, 47% are performed in OPD and 40% are performed in offices.

In physician office, imaging exams are performed by physicians who own or lease the equipment in their office and receive direct payments for each exam they administer. Traditionally, non-radiologists refer patients needing an imaging exam to facilities with imaging equipment, and interpretation is done by radiologists. Then the facility and the radiologist bill for the services while the referring physician does not receive any reimbursement for the imaging exam. On the other hand, a physician can bill payers directly if she owns imaging equipment in her office or enter into leasing agreements with independent diagnostic facilities. In this arrangement, the physician can refer patients to the facility and bill insurance companies as if he were using his own equipment (Baker 2010). Inducement is likely to take place when "self-referral" is possible for the physician.

I also examine the relationship between Medicaid fee and imaging tests utilization in OPDs. Imaging is one of the largest sources of outpatient profit for many hospitals, contributing as much as 37% to the bottom line (MedQuest 2018). Unlike inpatient exams, where more volume leads to more costs and no additional revenue, increasing imaging exams in outpatient setting increases revenue. Many physicians are employed or contractually affiliated with hospitals. Hospitals, that receive payments for the services provided by physicians, can incorporate financial incentives into the compensation of physician employees or build into subcontracts with affiliated physicians not directly employed (Kralewski et al. 2000; Rich et al. 2012). Organizations that employ physicians can also manipulate the work environment that reward certain clinical decisions, such as allocating (or withdrawing) support staff and making it easy or difficult to order tests. Some physicians report being pressured to perform lucrative ancillary services (Baker et al. 2014). On the other hand, there is a strong ethical presumption that doctors be left alone to do whatever necessary for the patient's well-being, independent of objectives of hospital administrators who oversee resource allocation and financial decisions. Thus, it is ambiguous whether changes in Medicaid fees will produce a different supply response in hospital outpatient setting than in offices.

**2.5 Empirical Approach**

To examine the effect of Medicaid reimbursement generosity on utilization of diagnostic imaging procedures, I use a difference-in-differences research design. I compare patient-level utilization of imaging procedures in states with relatively large fee changes versus states with relatively small fee changes. I estimate the following equation for a patient *i* in year *t* residing in state *s* for imaging modality *j* administered in place of service *l* (office or OPD):

$$Q_{ijlst} = \beta_0 + \beta_1 (Fee\ Ratio)_{jst} + \beta_2 X_{ist} + \beta_3 D_{st} + state_s + Year_t + \epsilon_{ijlst},$$

where *Q* stands for the number of imaging modality *j* a Medicaid patient *i* has received in a year in a site of service *l*. *Fee Ratio*, the treatment variable of interest, is the Medicaid-to-Medicare fee ratio; I first construct Medicaid and Medicare fee index, which are the weighted average of mean reimbursement fees for various imaging procedures within each modality. Then I divide the Medicaid fee index by a proxy for fee index that a physician could receive from treating non-Medicaid patients. Medicare FFS payment schedule is readily available and provides a good comparison to private fee. The resulting fee ratio compares Medicaid fees for various imaging procedures to the Medicare fee for the same set of services within that state. Standard errors are clustered by state. Because I have relatively few states (twelve), I also report 95% confidence interval obtained using the wild-cluster bootstrap procedure of Cameron and Miller (2015)[14].

Vector *X* includes patient attributes, including age dummies, sex, race, and blind and disability status that may be correlated with utilization of imaging services. Vector *D* includes yearly state-level covariates to control for possible correlation between Medicaid payment generosity and other state-level attributes that affect use of Medicaid services: unemployment rate, Medicaid eligibility thresholds for pregnant women, and the share state revenue from the federal government. I also control for the share of Medicaid beneficiaries on full-benefit, FFS program in a state-year to account for the changes in the composition of beneficiaries in FFS plan that may impact Medicaid fees and the use of diagnostic radiology services[15]. *State* is a vector of state fixed effects accounting for unobserved state-level effects a physician that may be correlated with the legislated Medicaid reimbursements. *Year* is a vector of year fixed effects accounting for any nationwide effects in the health care market, such as the effect of nationwide increase in price of health care that leads to increase in Medicaid prices.

[14] The analysis includes 12 states. I use a 6-point bootstrap weighted distribution to prevent discreteness of p-values with small number of clusters (Webb 2013). The computation is facilitated by the *boottest* command (Roodman, 2019)

[15] During 2003-2010, growth of managed care shifted proportion of Medicaid recipients from FFS to managed care.

A cross-sectional comparison of utilization of imaging services for patients in states with reimbursement rate versus low reimbursement rates has the potential to confound the effect of fees on utilization. For example, patients with greater need for medical care (e.g. elderly population[16]) may sort into in states that set higher reimbursements for Medicaid services in general, including diagnostic imaging services because of greater access for services. Thus, naively comparing patients living in high versus low reimbursement states will yield biased estimates of the effect of Medicaid fee levels on utilization because unobserved patient characteristics associated with state fee levels and utilization will be attributed to the estimated effect of fees. Instead, this study makes longitudinal comparison of states over time by using state FE and year FE. That is, I make within-state comparisons over time while controlling for year effects that are common across states. This study design accounts for time-invariant fixed characteristics of the Medicaid population in the state. To control for time-varying factors that could impact demand for diagnostic radiology services among Medicaid enrollees, I also include yearly patient-level and state-level controls which I explain below.

The identification assumption for the difference-in-differences design is that Medicaid payments are exogenous to factors that influence treatment choice of imaging procedures. State Medicaid agencies set their own reimbursement rates and increase or decrease payment rates. It is likely that changes in Medicaid payments are a response to idiosyncratic state budgetary and political pressures (Chen et al. 2019; Gruber et al. 1999; Sonchak 2015). Estimates may be biased, however, if Medicaid fees respond to changes in macroeconomic conditions in a state. For example, during economic downturn, states may cut or freeze provider rates to control Medicaid spending growth (Smith et al. 2004; Zuckerman et al. 2009). Recessions also may

[16] Smith-Bindman et al. (2008) show that number of imaging tests increased with age across several radiology services, such as X-ray, mammography, ultrasound, MRI, and CT.

impact family income and health as people lose insurance and become eligible for Medicaid following unemployment (Holahan and Garrett 2009).

Similarly, policy changes simultaneous with Medicaid fee changes may bias the estimates. States that increase Medicaid fees may enact concurrent policies, such as Medicaid eligibility expansions that encourage Medicaid take-up and medical service utilization. For example, when unemployment rate rises, state Medicaid agencies may expand Medicaid eligibility in conjunction with increasing Medicaid reimbursement rates to increase access to health care. If expansion of eligibility influences use of Medicaid services, then omitting the Medicaid eligibility criteria will overestimate the impact of fees on utilization. Alternatively, states that increase reimbursement rates may also have more generous welfare programs that incentivize Medicaid beneficiaries to utilize more medical care. More generally, state-by-year economic shocks may bias the estimates by influencing Medicaid eligibility, demand for health care, or the number of people in the states who qualify and enroll for Medicaid (Dehejia and Lleras-Muney 2004).

I address concerns of policy endogeneity and omitted state-level factors by including covariates that proxy state economic conditions, enrollment effects, and other welfare program generosity. These state-by-year controls include state unemployment rate, Medicaid eligibility threshold, and percent state revenue from the federal government[17]. I note here that the estimates are not sensitive to inclusion or exclusion of state-level controls. I also provide evidence that variation in Medicaid fees for imaging services are plausibly random and uncorrelated with other state-level factors that may influence the provision of the exams. Following the method

[17] Data on state unemployment rate and percent state revenue from the federal government comes from the U.S. Bureau of Census, Department of Labor, Employee Standards Administration's Local Area Unemployment Statistics and State Government Finance Reports.

presented in Chen et al. 2019, I regressed Medicaid-to-Medicare fee ratio on state FE and year FE and the listed state covariates. Appendix Table 2.1 shows that none of the coefficients statistically significant across modalities. This shows that the relative Medicaid payment for diagnostic radiology services are not systematically predicted by state-level covariates. However, the estimates may still be biased due to time-varying unobservables not accounted by the empirical model, such as changing underlying health conditions.

In the extended analysis, I focus on patient groups with specific clinical conditions to narrow down underlying health conditions that may affect imaging use. The outcomes in the main analysis likely capture both appropriate and inappropriate use of imaging services. To examine the effect of financial incentives on wasteful imaging, I focus on a set of low-value imaging services among patients with specific clinical conditions. By analyzing low-value services, I examine how physicians exercise undue influence, against the interest of the patient, as regulated fee changes. The low-value services include:

- X-ray, CT, and MRI imaging of spine among back pain patients
- CT and MRI of head or brain among uncomplicated headache patients

These two cases represent low-value diagnostic imaging relevant to the Medicaid population and are selected from the list of low-value diagnostic imaging procedures in Schwartz et al. (2014). Many studies have shown that these services provide little benefit and, in some cases, have the potential to harm patients (Clemens and Gottlieb 2014; MNAPCD 2017; Schwartz et al. 2014). Take low back imaging as an example. Spinal disorders are sixth most common reason for outpatient visits and 80% of adults see a physician for low back pain at some point in their lives.

It is estimated that low back pain may cost the healthcare system about $85 billion each year. When physicians evaluate back pain, they decide whether to image. Clinical studies show that acute back pain resolves spontaneously in most cases. Guidelines recommend against imaging unless there are known or suspected cancer, fevers, or acute neurologic findings. Despite this, 36% of family practitioners and 13% of general internists order imaging procedures for back pain patients (Litkowski et al. 2016). In another study, close to 30% of Medicare patients with low back pain were imaged within 28 days of diagnosis (Pham et al. 2009).

These two cases are also chosen for the ease of distinguishing the appropriate use of service from wasteful use using Medicaid claim's procedural, diagnostic does, and beneficiary demographic information. For each selected service, an operational definition of low-value occurrence is developed using CPT codes ICD-9 diagnostic codes, timing of care, site of care, and demographic information. I construct a dichotomous variable for whether the beneficiary with a specific set of clinical condition has received the imaging service within 30 days of the first diagnosis. Detailed sample selection and outcome construction method are discussed in Appendix C and D.

## 2.6 Data

In this study, I use Medicaid claims data from the Medicaid Analytic eXtract (MAX) files in years 2003, 2004, 2008, 2009, and 2010. MAX is an annual, state-specific claims data for every individual enrolled in Medicaid for at least one day during the year. I use the MAX Personal Summary (PS) file to obtain enrollee's monthly eligibility and demographic data, such as race, age, and blind and disability status. I also use MAX Other Therapy (OT) file, a beneficiary level claims data for physician, OPD, and other services to construct fee and utilization measures for radiology services. OT file contains records for both FFS (FFS) and managed care encounter records. For each enrollee, the FFS claims data show what service he received from which provider and how much the provider was reimbursed for the service. The encounter records identify who received what service under which managed care organization and from which provider. While a patient may be enrolled in both FFS and managed care plans, I limit my analysis to FFS claims because the encounter records in MAX are of varying quality and completeness across states (Ruttner et al. 2015). Focusing on FFS claims, I calculate Medicaid payment on a per-service basis and utilization measure that responds to this payment level[18].

To assess the extent of each state's Medicaid enrollment under FFS plan, I calculate the share of Medicaid enrollees on full benefit FFS payment plan by state and year. The denominator is the number of Medicaid beneficiaries on full benefit program under any payment plan (e.g. capitation) for at least 11 months in a year in each state (vast majority are enrolled for the full year). The numerator is the number of beneficiaries that are under FFS for at least 11 months in a year. This FFS share measure represents the extent of Medicaid enrollees whose services are reimbursed under per-service basis during majority of the year in each state. Then, I selected 12 states with FFS share greater than 10% across all five years: California, Colorado, Florida, Illinois, Indiana, Louisiana, Minnesota, Missouri, New York, Texas, Washington, and Wisconsin. Appendix Table 2.2 shows FFS share by state across the years. In 2003, Louisiana had 100% of their full benefit Medicaid beneficiaries on FFS plan. On the lower end,

[18] Medicaid pays providers by FFS or capitation. Capitation is a fixed payment from Medicaid to the provider for each enrollee-month, irrespective of services used. Capitated payments include fees to non-physicians and extent of service coverage is specific to each state. Thus, capitated payments may be a poor proxy for the generosity of payments for services (Decker 2009). This study focuses on FFS payments, which are prices paid directly to physicians for each procedure they render and capture variation in payment across states for the identical procedure.

Minnesota's FFS share was 31% in 2003. On average, 58% of full benefit Medicaid enrollees enrolled for 11-12 months were under FFS plan. Despite not including encounter records, FFS claims provide a comprehensive utilization data among a large share of Medicaid beneficiaries.

Moreover, imposing the FFS share criteria ensures that there are enough observations in each state to reliably calculate Medicaid fee index[19]. I also selected enrollees under full benefit program (as opposed to limited benefit scope) so that utilization measures reflect yearly use of imaging services per beneficiary that is not restricted by benefit scope. I include FFS share in the analysis to account for the changing composition of Medicaid patients in a state that could affect fee level and utilization. Inclusion or exclusion of FFS share measures does not significantly alter the estimates.

The analysis sample includes adult Medicaid beneficiaries between ages 19 and 64. The data is in an unbalanced panel form, where patients who have used Medicaid services over time can be tracked if they remained enrolled in the full benefit, FFS program in each state. The sample includes 8,692,852 Medicaid beneficiaries between 2003-2004 and 2008-2010 in 12 states. Table 2.2 presents the descriptive statistics of sample Medicaid beneficiaries in 2003. Over 60% are female, which reflects the Medicaid eligibility expansion during 2003-2010 among parents of dependent children, who are more likely to be female. It is also consistent with the fact that the women generally have lower income than men and thus are more likely to qualify for Medicaid programs. The average age is about 40. Overall, more than half of the sample are minorities, including African Americans (25%), Hispanic (15%), Asian (2%), and other races (14%). About 60% are also blind or disabled based on their Medicaid basis of

[19] States that met the FFS share criteria but did not have enough observations to calculate Medicaid fee index reliably were further excluded from the analysis. See Appendix C for the list of excluded states.

eligibility. On average, 30% of state's revenue comes from the federal government. The federal share of state revenue reflects how much states receives in funding from the federal government to help pay for public services, such as health care. The indicator measures the combined effects of swings in state and federal funds that may influence the generosity of state welfare programs (Stauffer et al. 2019). Appendix C provides details on sample selection criteria.

### 2.6.1 Construction of Medicaid-to-Medicare Fee Ratio

This paper uses Medicaid FFS reimbursement rates derived from Medicaid claims data to measure the generosity of physician payment levels for imaging services. The fee index is calculated using the average state Medicaid fee for a set of imaging procedures weighted by the relative frequency of use for each imaging procedure within a modality. Since Medicare fees are readily available, Medicaid fee indices were divided by Medicare fee indices (created using Medicaid weights for the same bundle of services). Average Medicare fees proxy the fees that providers would receive from treating non-Medicaid patients. The resulting Medicaid-to-Medicare ratio measures the generosity of state Medicaid payment relative to Medicare or private prices. Since Medicare fees are lower on average compared to those of private payers, the fee ratio may represent a low estimate of the generosity of Medicaid fees compared to non-Medicaid payment (Decker 2009).

Data on Medicaid reimbursement schedule for specific procedures is not readily available as federal agencies do not collect state-specific Medicaid fees in detail. Kaiser Family Foundation and the Urban Institute conduct surveys on Medicaid reimbursement rates for the 30 most common procedures every 4-5 years. However, each state changes their Medicaid fee schedule each year, and there is no readily available information on state-specific Medicaid reimbursement rates for various imaging tests during the study period. Thus, I construct Medicaid fee indices using the detailed Medicaid claims data that captures the variability of Medicaid payments across time and state.

The fee index is a weighted average of mean Medicaid reimbursement rate for imaging procedures (identified by Current Procedure Terminology (CPT) codes) within modalities (e.g. head CT scan within the modality of CT scans). Fee index for modality *j*, state *s*, year *t* in office[20] is

$$Medicaid\ Fee\ Index_{jst} = w_{jst}^{(1)} \cdot p_{jst}^{(1)} + w_{jst}^{(2)} \cdot p_{jst}^{(2)} + \cdots + w_{jst}^{(n)} \cdot p_{jst}^{(n)},$$

The right-hand side components consist of the mean Medicaid reimbursement rates and the weight for each CPT[21]. The superscript corresponds to a specific imaging service, represented by a CPT code (e.g., 70460: Head CT with contrast). The weight, $w^i$, is specific to each procedure *i* and is the proportion of claims with CPT code *i* out of total claims across procedures within the imaging modality *j* within a year and state in office:

$$w^{(i)} = \frac{number\ of\ claims\ for\ CPT\ i}{total\ number\ of\ claims\ across\ CPTs\ witin\ a\ modality}.$$

[20] I use office-based FFS claims to calculate the Medicaid fee index because OPD-based radiology procedures are often not reimbursed on a fee schedule as in office-setting. States sometimes follow other payment method, such as bundling ancillary and other services provided in the same visits. Also, often the global payment or technical component were not used in Medicaid claims with OPD codes, but only professional components were reported. Thus, I only use imaging FFS claims with place of service code = 11 (office) to calculate the fee index. Appendix G provides details on Medicaid OPD payment policies for radiology services in each state.

[21] I use mean fee based on claims with global payment scheme since there are more claims with global payment scheme than claims with technical component alone. The two prices (global and technical) move together since global price approximately the same as the combined price of professional and technical components.

The CPT specific weight represents how frequently an imaging service was used relative to other types of procedures within a modality. These weights differ by modality, state, and year. I multiply the average reimbursement rate and the weights for the corresponding CPT. Since each claim is reimbursed on a FFS basis, the payment rate for each service represents a per-unit price of the service[22]. The reimbursement rates have been deflated to 2010 dollars using the Gross Domestic Product deflator. Appendix E lists CPT codes used in the study for each modality.

Table 2.3 shows Medicaid-to-Medicare fee ratios in 2003 and 2010 by modality. Medicaid fees for imaging services are lower than Medicare fees in most states in the sample. Across the four imaging modalities, the average fee ratio is about 0.70 – Medicaid paid about 70% of what Medicare paid for the same set of services. In some states, Medicaid fees were substantially lower. In 2003, New York and Washington had fee ratio of about 0.40 for CT – Medicaid paid less than half of what Medicare paid. In a few states, Medicaid paid higher than or paid about the same as Medicare – Minnesota and Wisconsin. This reflects the fact that the states have considerable latitude in setting fees, and some states set Medicaid reimbursements much higher compared to other states. Both fee ratio and pattern of change in fees between 2003 and 2010 varied considerably by state. For example, fee ratio in 2003 for X-ray ranged from 0.42 to 1.19. Also, for X-ray, the fee ratio fell between 2003 and 2010 for five states and increased for the rest of the states. Similarly, in other modalities, the changes in fee ratio during the study period varies widely. On average, fee ratio increased by 9% for X-ray, decreased by less than 1% for diagnostic ultrasound, increased by 8% for CT, and increased by 26% for MRI.

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[22] 2003 is used as the base year for the weights. Weights calculated using 2003 data represents how often a procedure code was used in 2003. 2003 weight is used for constructing price indices in years 2004, 2008, 2009, and 2010.

To obtain a more detailed picture of changes in Medicaid-to-Medicare fee ratio, Figures 2.1-2.4 plot the ratios by state over time for each modality. Once again, the fee ratio varies noticeably across states and while some states experience large changes, other states experience smaller changes in fee ratios. To assess the variation in fees across states and over time, I regressed Medicaid-to-Medicare fee ratio on state FE, year FE, and various state-level covariates. In Appendix Table 2.1, I present the adjusted R-squared statistics from this regression. The adjusted R-squared value ranges from 0.87 to 0.95. This indicates that about 5-13% of the total variation in the fee-ratio is within state over time. This paper tests the effect of these changes on the utilization of imaging exams and the site of care among Medicaid beneficiaries.

Medicaid-to-Medicare fee ratios for low-value imaging services are created in a similar manner described above. The weights are calculated for each imaging modality (e.g. CT imaging of spine) for the bundle of CPT codes that falls within that modality. Appendix Tables 2.3 and 2.4 present changes in the fee ratio by state and by imaging modality (spine and brain imaging). Like the fee ratios created for the main analysis, the average fee ratio is about 0.70. While states like Minnesota and Wisconsin have fee ratio greater 1, for most states, Medicaid payments is substantially lower than Medicare payments. Once again, the pattern of change in fees between 2003 and 2010 varied considerably by state. For example, Appendix Table 2.4 shows that fee ratio in 2003 for Brain CT ranged from 0.52 to 1.28. For Brain CT, the fee ratio fell for two states and increased for the rest of the states. The change ranged from -4.3% in Illinois to 59.5% in New York. On average, fee ratio increased by 3% for Spine X-ray, 9% for Spine CT, 23% for Spine MRI, 12% for Brain CT, and 37% for Brain MRI.

### 2.6.2 Construction of Utilization Measure

Utilization is measured at the beneficiary level. For each imaging modality, I count the total number of procedures performed in office or OPD per beneficiary annually. Patients who were enrolled in full benefit program under FFS payment scheme for at least 11 months during the year but did not use one of the four imaging procedures in office or OPD are assigned zero quantity. I additionally construct a dichotomous variable for rather a beneficiary had any imaging tests in a year separately by modality and place of service. More details on constructing the utilization measures for the main analysis are outlined in Appendix D.

Table 2.4 presents summary statistics of utilization measures in 2003. Out of the four imaging modalities studied in this paper, X-ray is the most frequently used imaging test. About 10% of the sample beneficiaries received at least one X-ray in office in a year and 16% in OPD. Diagnostic ultrasound is the next common diagnostic radiology procedure in this sample with about 7% of the beneficiary receiving at least one exam in a year either in office or OPD. CT and MRIs are less common with 2-5% of the beneficiaries receiving at least one CT or MRI in either office or OPD. Tests are generally performed more frequently in OPD setting, except for diagnostic ultrasound exams, which are more commonly administered in office setting.

For low value services, I first identify the patients who meet the diagnosis and exclusion criteria described in Appendix F – back pain patients for low back imaging and headache patients for brain imaging. Then I locate all their claims in the MAX OT file for 30 days following the date of the diagnosis in the same state of the diagnosis. The outcomes are specified based on the Medicaid billing code in the ensuing claims. I construct a dichotomous variable for whether the beneficiary with the clinical condition has received the imaging service within 30 days of the first diagnosis. Measuring utilization of low-value services can be sensitive to the claims-based definition applied to the data (MNAPCD 2017). For example, reducing the number of exclusion criteria in a measure can affect the observed utilization rate. I use the base definition (more sensitive, less specific) provided in Schwartz et al. (2014) to include or exclude patients for the study sample based on their diagnosis in the Medicaid claims during the measurement year. I also note that variation in the generation or processing of Medicaid claims may cause measurement error.

Bottom rows in each panel of Tables 2.6 and 2.7 present summary statistics of utilization of low-value imaging services in 2003. Among low-back patients, Spine X-rays (7-11%) are the most performed out of the three low-value spine imaging services, followed by Spine MRI (4%) and Spine CT (1%). The rate of performance is roughly similar in office and OPD across modalities. Among uncomplicated headache patients, Brain CT scans are more frequently performed than Brain MRIs within 30 days of the first diagnosis, and OPD is the more common place of service than office for both procedures. On average, about 2-3% of uncomplicated headache patients in the same had received brain CT or MRI in office.

### 2.7. Results

I test the implication of the model that physician's decision to supply care depends on the marginal benefit of care. The model predicts that increase in Medicaid fee for imaging services will have an ambiguous effect on the quantity of imaging tests performed depending on the strength of income and substitution effects. The quantity response for imaging tests administered in office may be stronger than in OPD since providers get reimbursed directly for the performing of the exams. The financial link between performance of imaging tests in OPD setting and physician inducement for services is less clear because physicians are often contracted with the hospitals and the hospitals receive direct payments. Increasing the Medicaid fee to Medicare level is associated with a positive and large increase in use of X-ray, diagnostic ultrasound, and CT scans. The effects tend to be larger in office for X-ray while the opposite is true for diagnostic ultrasound and CT scans. On the other hand, increase in fee ratio results in less MRI use in office and a small and positive increase in OPD. However, none of the estimates are statistically distinguishable from zero at the 5%-level or precisely estimated. Among low-back pain patients, the probability of receiving a back imaging generally increases with increase in fee ratio, except for spine MRI, which is associated with a decrease in probability. The effect tends to be stronger in OPD than in office. The result is similar for headache patients receiving brain imaging. An increase in fee ratio is associated with an increase in the probability of receiving a brain CT scan and a decrease in the probability of receiving a brain MRI. Once again, I cannot make conclusive statements due to lack of statistical precision.

Table 2.5 contains coefficients from models analyzing the effects of the fee ratio on utilization measures by imaging modality and site of service. Control variables include age, sex, race dummies, state unemployment rate, state's percent revenue from federal government, Medicaid income eligibility thresholds for pregnant women, and FFS share, state FE, and year FE. First consider Panel A, utilization of X-ray. From the preferred model with state-controls (column 2), an increase of 0.30 in the Medicaid-to-Medicare fee ratio (for example, increasing the fee ratio from 2003 mean of 0.70 to 1, indicating that Medicaid pays the same as Medicare) would increase the number of X-rays received in office by about 0.027 units (0.30*0.089). This is equivalent to an increase of 127% relative to the mean number of office-based X-rays in 2003 of 0.021. The probability of receiving any exam in a year is also positively correlated with the fee ratio. An increase of 0.30 in the fee ratio would increase the probability of receiving an X-ray in office by about 1.9 percentage points (0.30*0.064), equivalent to an increase of 19% relative to the average probability of receiving an office-based X-ray exam in 2003 of 0.10. The results for OPD-based utilization are also positive. An increase of 0.30 in the fee ratio would increase the number of X-rays received in OPD by about 0.18 units (0.30*0.591). This is equivalent to an increase of 49% relative to the average number of OPD-based X-rays in 2003 of 0.36. Lastly, an increase of 0.30 in the fee ratio would increase the probability of receiving an X-ray in OPD by about 4.2 percentage points (0.30*0.142), an increase of 27% relative to the average probability of receiving an OPD-based X-ray in 2003 of 0.16. However, none of the estimates across specifications are statistically significant or precisely estimated based on the wild-cluster bootstrap procedure. The estimates are similar with and without state-level controls.

Similar calculations to adjust the estimates so that each coefficient represents the effect of increasing the Medicaid-to-Medicare fee ratio by 0.30 have been repeated across panels and preferred specification (model that include state controls). I present the summarized results in Table 2.8. The effect of fee ratio increase is positive and practically large for X-ray, diagnostic ultrasound, and CT scans. For example, increasing the fee ratio from 0.7 to 1 increases the number of CTs administered in OPD by 0.04 units on average per beneficiary per year. Relative to the average number of OPD-based CTs in 2003 of 0.10, this is equivalent to a 43% increase. To put the numbers in context, this is equivalent to increasing the rate of CT scan per 1,000 Medicaid beneficiaries from 100 to 140.

For MRI scans, however, fee ratio increase is associated with large and negative changes in office and relatively small and positive changes in OPD. For example, increasing Medicaid fees to match Medicare fees across procedures within MRI modality results in a 0.6 percentage point decrease in the probability of receiving an MRI in office. This is equivalent to decreasing the probability of receiving an MRI in office from 2% to 1.4%. In terms of number of MRIs received in office, fee ratio increase results in 0.01 less exams in office. While the point estimate is small, this effect seems sizeable relative to the average number of MRIs received in office in 2003 of 0.03, which is a 36% decrease. On the other hand, fee ratio increase has negligible effect on volume (2% increase) and probability of receiving MRI scans (3% increase) in OPD. However, none of the estimates from the main analysis is statistically significant at the 5%-level or precisely estimated based on based on the wild-cluster bootstrap standard errors. Thus even though I find that increase in Medicaid-to-Medicare fee ratio results in practically large increase or decrease of imaging usage across the four modalities, I cannot make any conclusive statement on its effects.

Tables 2.6 and 2.7 present unadjusted estimates for low-value imaging services, spine imaging for low-back patients and brain imaging for unspecified headache patients. The dependent variable is an indicator whether a Medicaid beneficiary has received at least one of the low-value imaging services during the year in office or OPD (presented separately in each panel and column). Like the main analysis results, an increase in fee ratio is generally associated with positive, but statistically insignificant effect on the probability of low-value imaging services. The estimates are also imprecisely measured as shown in 95%-confidence intervals reported with the estimates.

Table 2.9 presents the point estimates in relation to a 0.30 increase in Medicaid-to-Medicare fee ratio and relative to the average probability of receiving an exam per year for each modality by place of service. Among back pain patients, increase in Medicaid-to-Medicare fee ratio is associated with positive changes in probability of receiving spine X-ray and CT exams but associated with negative changes for spine MRIs. An increase in fee ratio increases the probability of receiving any spine X-ray exam by 1 percentage point in office (15% increase) and 6 percentage points in OPD (61% increase). For spine CT, increase in fee ratio is associated with 0.1 percentage point increase in office (12% increase) and 0.8 percentage point in OPD (84% increase). On the other hand, increase in fee ratio is associated with a decrease in the probability of MRI use in office of 0.3 percentage points (9% decrease), like the main analysis results, and decrease of 0.6 percentage points (14% decrease). While the point estimates are small, the effect size relative to the average probability of receiving an exam seems sizeable.

Among headache patients, increase in Medicaid-to-Medicare fee ratio is also associated with large positive changes in the probability of receiving brain CT scans in office and in OPD. Increasing the fee ratio results in a 9-percentage point increase in office (31% increase) and a 12.6 percentage point increase in OPD (105% increase). Like the main analysis result and the result for back pain patients, use of brain MRI decreases in office by 0.6 percentage points (33% decrease) while utilization in OPD is minimally affected with 0.1 percentage point increase (4% increase). While the results are robust to controlling for state-level covariates, the estimates are once again not statistically distinguishable from zero at the 5%-level and are imprecisely measured.

A study closest to this paper is by Clemens and Gottlieb (2014), who estimate the effect of Medicare reimbursement changes (because of geographic consolidation of Medicare payment regions) on courses of treatment for back pain from 1993 to 2004. In response to an average of 2% increase in payment rates, they find minimal change in the overall provision of MRIs to Medicare beneficiaries with back pain within a year after diagnosis. It’s difficult to compare the effect sizes since the results from this study lacks sufficient statistical precision to make conclusive statements on the relationship between Medicaid fee increase and utilization of imaging services.

### 2.8 Conclusion

This study is motivated by the growth in utilization of diagnostic imaging procedures and the question of whether financial incentive is a possible driver behind this growth. In Medicaid setting, the paper explores the relationship between FFS reimbursement rate and utilization for four widely used diagnostic radiology services in two major outpatient setting– X-ray, diagnostic ultrasound, CT, and MRI administered in office and OPD. Overall, increasing the Medicaid reimbursement rates to equal Medicare rates is associated with economically large changes in the utilization and probability of receiving imaging exams across the four imaging modalities. For X-ray, diagnostic ultrasound, and CT scans, the effect is positive with the magnitude of the effect being larger in OPD than in office. MRI use in office tends to be negatively respond to Medicaid fee increases while the fee change has very small effect of MRI use in OPD. Among low-value services, fee ratio increase is associated with an increase in use of spine X-ray and CT scans in office and in OPD and decrease in use of spine MRI in both office and OPD among back pain patients. Across services, the effect size is also larger in OPD than in office. For headache patients, fee ratio increase results in greater probability of receiving brain CT in office and OPD and decrease in probability of receiving brain MRI in office and a small effect in OPD. While the estimates are robust to controlling for state-level covariates, none of the estimates discussed above are not statistically significantly and are precisely estimated.

While the results from this study generally points to a positive relationship between increase in Medicaid reimbursement rates and use of services, the results from this study are not conclusive due to lack of statistical precision. Despite the limitation, this study provides a framework to analyze the use of lucrative imaging services among Medicaid patients in terms of strength of income and substitution effects. Cutting or increasing Medicaid fees is a common means by which states respond to fiscal pressures or address patient access problems (Smith et al. 2004). Thus, it is important to understand the implications of changes in Medicaid reimbursement rates on the utilization of care among Medicaid patients, who make up a small proportion in most physician's patient panel. As overutilization of expensive diagnostic radiology services continue to be observed, future work should better account for physician and patient characteristics to investigate the effects of changes in payment generosity on service utilization and health outcomes.

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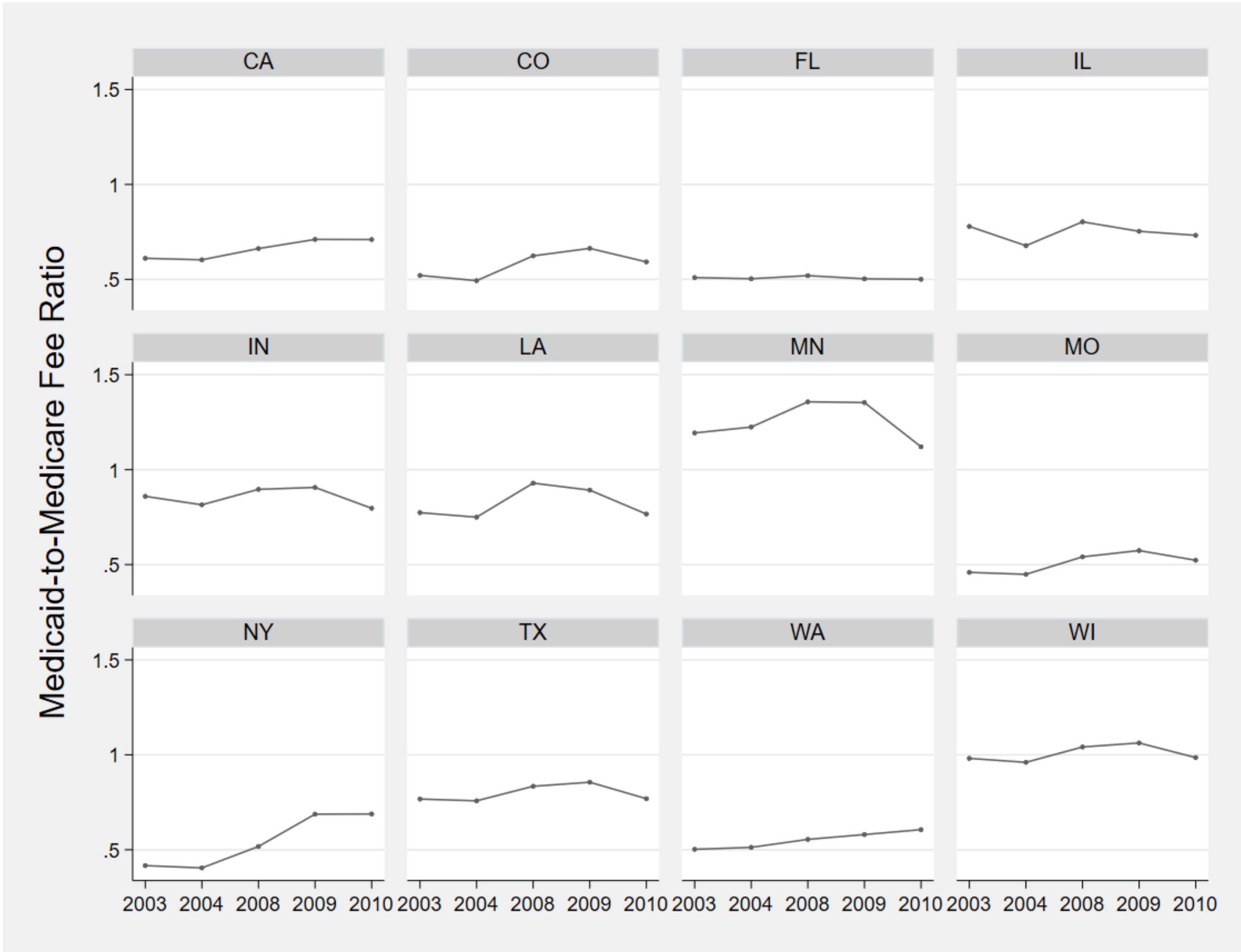
## 2.10 Tables and Figures

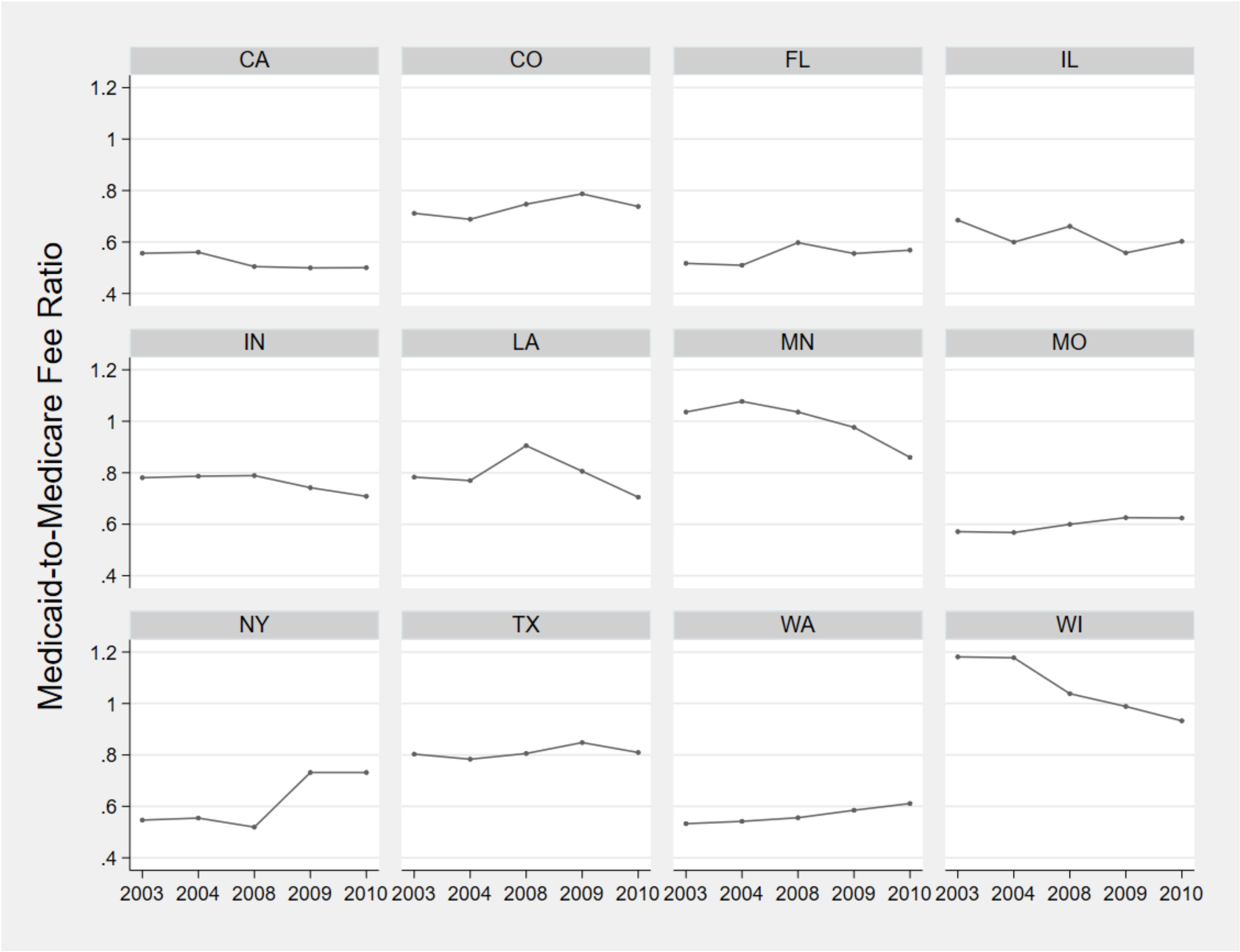
***Figure 2.1***

*Time Series of Medicaid-to-Medicare Fee Ratio: X-ray*




*Notes*: Data are from MAX OT files 2003-2004 and 2008-2010. Medicaid-to-Medicare fee ratio is created by dividing Medicaid fee index (the weighted average of mean Medicaid reimbursement rates for X-ray services in each state) by Medicare fee index (constructed in a similar manner as Medicaid fee index but using Medicare fees). Weight reflects the relative frequency of service use within the state and year among full benefit, FFS Medicaid enrollees. The mean Medicaid reimbursement rate is calculated for office-based imaging services among adults (19-64).

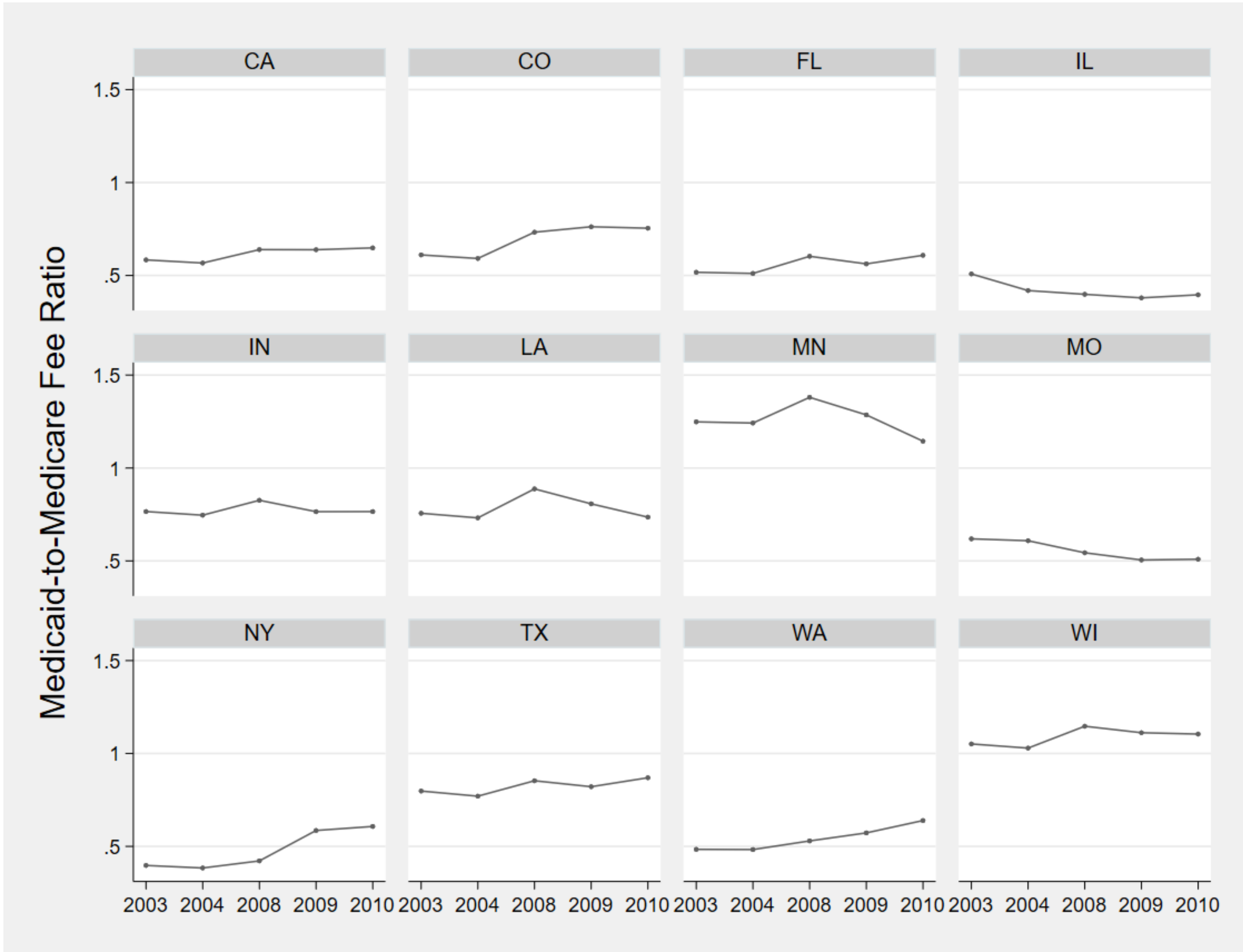
***Figure 2.2***
*Time Series of Medicaid-to-Medicare Fee Ratio: Diagnostic Ultrasound*




*Notes*: Data are from MAX OT files 2003-2004 and 2008-2010. Medicaid-to-Medicare fee ratio is created by dividing Medicaid fee index (the weighted average of mean Medicaid reimbursement rates for diagnostic ultrasounds in each state) by Medicare fee index (constructed in a similar manner as Medicaid fee index but using Medicare fees). Weight reflects the relative frequency of service use within the state and year among full benefit, FFS Medicaid enrollees. The mean Medicaid reimbursement rate is calculated for office-based imaging services among adults (19-64).

***Figure 2.3***

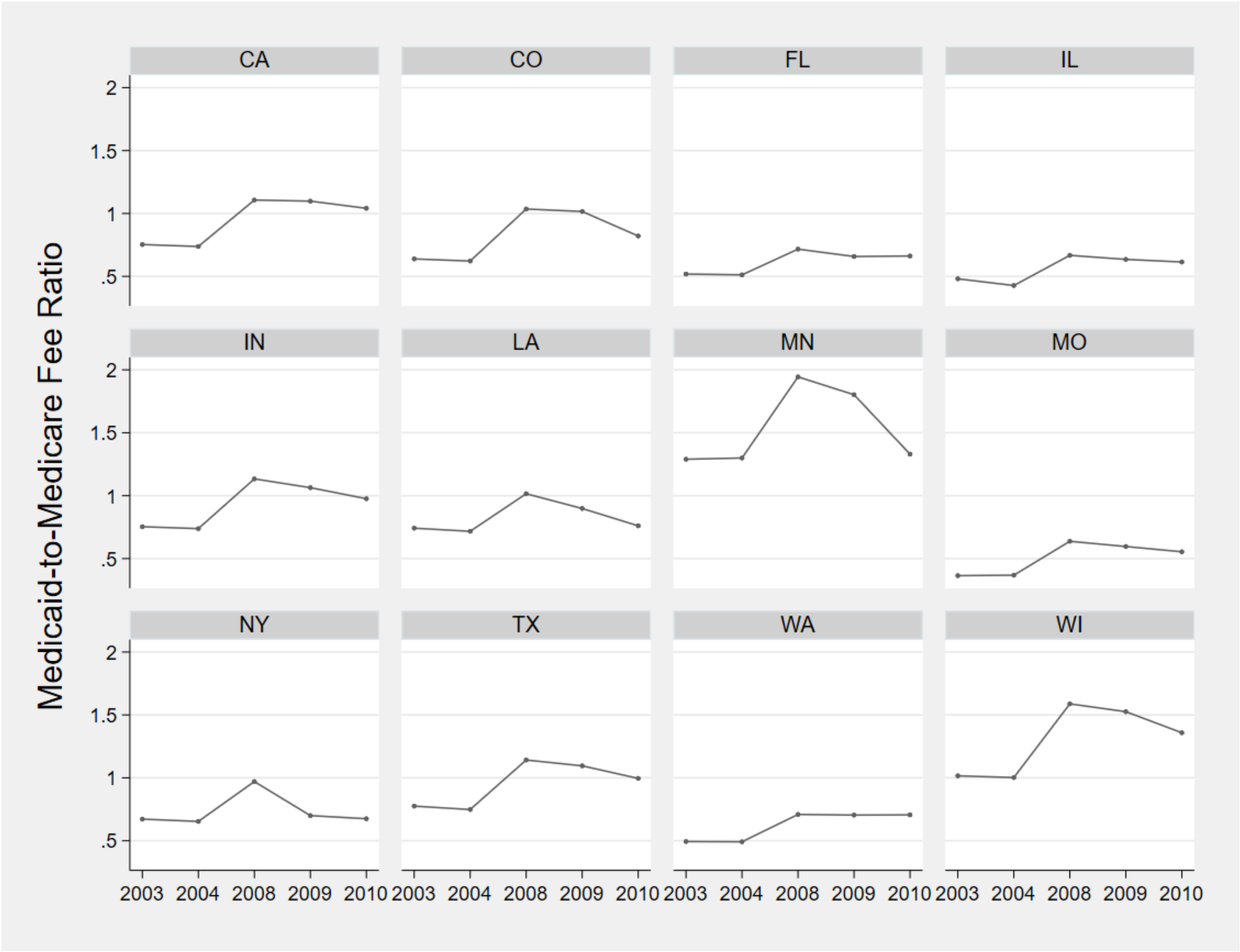
*Time Series of Medicaid-to-Medicare Fee Ratio: CT*




*Notes*: Data are from MAX OT files 2003-2004 and 2008-2010. Medicaid-to-Medicare fee ratio is created by dividing Medicaid fee index (the weighted average of mean Medicaid reimbursement rates for CT scans in each state) by Medicare fee index (constructed in a similar manner as Medicaid fee index but using Medicare fees). Weight reflects the relative frequency of service use within the state and year among full benefit, FFS Medicaid enrollees. The mean Medicaid reimbursement rate is calculated for office-based imaging services among adults (19-64).

***Figure 2.4***

*Time Series of Medicaid-to-Medicare Fee Ratio: MRI*




*Notes*: Data are from MAX OT files 2003-2004 and 2008-2010. Medicaid-to-Medicare fee ratio is created by dividing Medicaid fee index (the weighted average of mean Medicaid reimbursement rates for MRIs in each state) by Medicare fee index (constructed in a similar manner as Medicaid fee index but using Medicare fees). Weight reflects the relative frequency of service use within the state and year among full benefit, FFS Medicaid enrollees. The mean Medicaid reimbursement rate is calculated for office-based imaging services among adults (19-64).

***Table 2.1***

*Places of Service by Modality in 2003*

| | Xray | Diagnostic Ultrasound | CT | MRI |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Office | 0.24 | 0.48 | 0.15 | 0.40 |
| Hosp. Outpatient Dept. | 0.45 | 0.38 | 0.52 | 0.47 |
| Hosp. Inpatient Dept. | 0.14 | 0.08 | 0.15 | 0.09 |
| Emergency Room | 0.15 | 0.04 | 0.17 | 0.03 |
| Other places | 0.02 | 0.02 | 0.01 | 0.01 |

*Notes*: Data are from MAX OT files 2003. The claims are restricted to imaging services reimbursed under FFS plans only. Also, the table shows place of service for global or technical components, therefore represents performing of the exams rather than reading (professional component). The sample of beneficiaries consists of full benefit, FFS Medicaid beneficiaries enrolled for at least 11 months out of the year. States included in the sample are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI. Other places of service include patient's home, rural health clinic, ambulatory surgery center, nursing facility, and other unknown places.

***Table 2.2***

*Descriptive Statistics of Sample Medicaid Beneficiaries in 2003*

| Variables | |
|---|---|
| Female | 0.64 |
| Age | 40.51 |
| White | 0.44 |
| Black or African American | 0.25 |
| Hispanic or Latino | 0.15 |
| Asian | 0.02 |
| Other races | 0.14 |
| Blind or disabled | 0.63 |
| State unemployment rates | 0.06 |
| Share state revenue from the federal government | 0.28 |
| Medicaid income eligibility limits (%) for pregnant women | 202.75 |
| FFS Share | 0.58 |
| Number of States | 12 |
| Observation | 1,790,552 |

*Notes*: Data are from MAX OT files 2003. The sample consists of full benefit, FFS Medicaid beneficiaries enrolled for at least 11 months out of the year. States included in the sample are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI. Medicaid income eligibility limits for pregnant women are calculated as a percent of the Federal Poverty Level in each state and year. FFS share is calculated as the share of beneficiaries on FFS Medicaid program each year out of all full-benefit beneficiaries enrolled for at least 11 months during the year on any type of plan.

***Table 2.3***

*Changes in Medicaid-to-Medicare Ratio by State (2003-2010)*

| | A. X-ray | | | B. Diagnostic Ultrasound | | |
|---|---|---|---|---|---|---|
| | 2003 | 2010 | % Change | 2003 | 2010 | % Change |
| California | 0.61 | 0.71 | 16.17 | 0.56 | 0.50 | -10.1 |
| Colorado | 0.52 | 0.59 | 13.66 | 0.71 | 0.74 | 3.71 |
| Florida | 0.51 | 0.50 | -1.81 | 0.52 | 0.57 | 9.94 |
| Illinois | 0.78 | 0.73 | -6.01 | 0.68 | 0.60 | -12.04 |
| Indiana | 0.86 | 0.80 | -7.31 | 0.78 | 0.71 | -9.28 |
| Louisiana | 0.77 | 0.77 | -0.92 | 0.78 | 0.70 | -9.97 |
| Minnesota | 1.19 | 1.12 | -6.09 | 1.04 | 0.86 | -17.02 |
| Missouri | 0.46 | 0.52 | 13.88 | 0.57 | 0.62 | 9.28 |
| New York | 0.42 | 0.69 | 65.23 | 0.55 | 0.73 | 33.82 |
| Texas | 0.77 | 0.77 | 0.28 | 0.80 | 0.81 | 0.78 |
| Washington | 0.50 | 0.61 | 20.62 | 0.53 | 0.61 | 14.69 |
| Wisconsin | 0.98 | 0.99 | 0.45 | 1.18 | 0.93 | -21.04 |
| Average | 0.70 | 0.73 | 9.01 | 0.73 | 0.70 | -0.60 |
| | C. CT | | | D. MRI | | |
| | 2003 | 2010 | % Change | 2003 | 2010 | % Change |
| California | 0.58 | 0.65 | 11.05 | 0.75 | 1.04 | 38.27 |
| Colorado | 0.61 | 0.75 | 23.53 | 0.64 | 0.82 | 28.53 |
| Florida | 0.52 | 0.61 | 17.68 | 0.52 | 0.66 | 27.68 |
| Illinois | 0.51 | 0.40 | -22.1 | 0.48 | 0.61 | 27.82 |
| Indiana | 0.77 | 0.77 | -0.04 | 0.75 | 0.98 | 29.56 |
| Louisiana | 0.76 | 0.74 | -2.75 | 0.74 | 0.76 | 2.52 |
| Minnesota | 1.25 | 1.14 | -8.33 | 1.29 | 1.33 | 3.15 |
| Missouri | 0.62 | 0.51 | -17.7 | 0.36 | 0.55 | 52.04 |
| New York | 0.40 | 0.61 | 52.81 | 0.67 | 0.68 | 0.46 |
| Texas | 0.80 | 0.87 | 8.98 | 0.78 | 1.00 | 28.41 |
| Washington | 0.48 | 0.64 | 32.08 | 0.49 | 0.71 | 42.98 |
| Wisconsin | 1.05 | 1.10 | 5.06 | 1.02 | 1.36 | 33.68 |
| Average | 0.69 | 0.73 | 8.36 | 0.71 | 0.87 | 26.26 |

*Notes*: Data are from MAX OT files 2003 and 2010. For each modality, global payment rate reimbursed for office setting (place of service code 11) is for adults (19-64) is used to calculate the Medicaid fee index. Medicaid-to-Medicare fee ratios are constructed as the ratio between Medicaid fee index (a weighted average of the mean reimbursement fees for service within each imaging modality administered in office) and Medicare fee index (calculated similarly but using Medicare reimbursement rates for the same bundle of services).

***Table 2.4***

*Descriptive Statistics of Utilization by Imaging Modality in 2003*

| | X-ray<br>(1) | Diagnostic Ultrasound<br>(2) | CT<br>(3) | MRI<br>(4) |
|---|---|---|---|---|
| A. Utilization in Office | | | | |
| Share of sample with qty >0 | 0.10 | 0.07 | 0.02 | 0.02 |
| Mean (sd) | 0.21 (0.84) | 0.13 (0.61) | 0.03 (0.29) | 0.03 (0.24) |
| Range | (0, 41) | (0, 41) | (0, 27) | (0, 16) |
| B. Utilization in OPD | | | | |
| Share of sample with qty >0 | 0.16 | 0.06 | 0.05 | 0.02 |
| Mean (sd) | 0.37 (1.23) | 0.10 (0.53) | 0.10 ((0.59) | 0.04 (0.28) |
| Range | (0, 82) | (0, 46) | (0, 114) | (0, 17) |
| Observations | 1,790,552 | 1,790,552 | 1,790,552 | 1,790,552 |

*Notes*: Data are from MAX OT files 2003. The sample consists of full benefit, FFS Medicaid beneficiaries enrolled for at least 11 months out of the year. States included in the sample are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI.

## *Table 2.5*

*Estimates of the Effect of Fee Ratio on Utilization*
*Dependent Variable: Utilization of Imaging Services by Modality and Place of Service*

| | Office | | | OPD | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | No. of Exams | No. of Exams | Any | No. of Exams | No. of Exams | Any |
| A. X-ray | | | | | | |
| Medicaid-to-Medicare Fee Ratio | 0.080 | 0.089 | 0.064* | 0.414 | 0.591 | 0.142 |
| | (0.106) | (0.084) | (0.033) | (0.463) | (0.519) | (0.147) |
| | [-0.415, 0.474] | [-0.223, 0.272] | [-0.067, 0.128] | [-1.935, 2.215] | [-1.018, 2.305] | [-0.492, 0.579] |
| State-level Controls | | Yes | Yes | | Yes | Yes |
| Mean of D.V. in 2003 (sd) | 0.021 (0.84) | 0.021 (0.84) | 0.10 | 0.37 (1.23) | 0.37 (1.23) | 0.16 |
| B. Diagnostic Ultrasound | | | | | | |
| Medicaid-to-Medicare Fee Ratio | 0.038 | 0.032 | 0.029 | 0.136 | 0.142 | 0.072 |
| | (0.056) | (0.043) | (0.019) | (0.083) | (0.112) | (0.064) |
| | [-0.047, 0.275] | [-0.029, 0.195] | [-0.009, 0.097] | [-0.157, 0.421] | [-0.183, 0.610] | [-0.141, 0.310] |
| State-level Controls | | Yes | Yes | | Yes | Yes |
| Mean of D.V. in 2003 (sd) | 0.13 (0.61) | 0.13 (0.61) | 0.07 | 0.10 (0.53) | 0.10 (0.53) | 0.06 |
| C. CT | | | | | | |
| Medicaid-to-Medicare Fee Ratio | 0.014 | 0.025 | 0.018** | 0.114 | 0.146 | 0.163 |
| | (0.021) | (0.022) | (0.007) | (0.319) | (0.291) | (0.122) |
| | [-0.040, 0.076] | [-0.040, 0.088] | [-0.006, 0.037] | [-1.065, 0.892] | [-0.996, 0.924] | [-0.227, 0.497] |
| State-level Controls | | Yes | Yes | | Yes | Yes |
| Mean of D.V. in 2003 (sd) | 0.03 (0.29) | 0.03 (0.29) | 0.02 | 0.10 (0.59) | 0.10 (0.59) | 0.05 |
| D. MRI | | | | | | |
| Medicaid-to-Medicare Fee Ratio | -0.033 | -0.036 | -0.020 | 0.004 | 0.003 | 0.002 |
| | (0.024) | (0.031) | (0.019) | (0.042) | (0.037) | (0.026) |
| | [-0.094, 0.027] | [-0.132, 0.055] | [-0.083, 0.034] | [-0.072, 0.137] | [-0.112, 0.119] | [-0.078, 0.091] |
| State-level Controls | | Yes | Yes | | Yes | Yes |
| Mean of D.V. in 2003 (sd) | 0.03 (0.24) | 0.03 (0.24) | 0.02 | 0.04 (0.28) | 0.04 (0.28) | 0.02 |
| Num. of States | 12 | 12 | 12 | 12 | 12 | 12 |
| Observations | 8,692,852 | 8,692,852 | 8,692,852 | 8,692,852 | 8,692,852 | 8,692,852 |

*Notes:* Data are from MAX OT files 2003-2004 and 2008-2010. For columns 1-2 and 4-5 the dependent variable is the number of each imaging modality a Medicaid beneficiary received in office or OPD in a year. For columns 3 and 6, the dependent variable is an indicator for whether the patient received any imaging exam (within modality) in office or OPD during the year. All regressions control for age, race, sex, and blind and disability status indicator, state FE and year FE. State-level controls include unemployment rates, poverty rates, Medicaid eligibility thresholds for infant and pregnant women, and share of state revenue from the federal government, and FFS share. States included are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI. Robust standard errors clustered at the state level are shown in parentheses. I also report 95% confidence interval obtained using the wild-cluster bootstrap procedure of Cameron and Miller (2015). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Table 2.6***

*Estimates of the Effect of Fee Ratio on Utilization of Spine Imaging*
*Dependent Variable: Any Spine Imaging by Modality and Place of Service*

| | Office | | OPD | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Any | Any | Any | Any |
| A. Spine X-ray | | | | |
| Medicaid-to-Medicare Fee Ratio | 0.028 | 0.036 | 0.213** | 0.224** |
| | (0.033) | (0.040) | (0.079) | (0.083) |
| | [-0.109, 0.107] | [-0.116, 0.172] | [-0.051, 0.484]* | [-0.019, 0.460] * |
| State-level Controls | | Yes | | Yes |
| Mean of D.V. in 2003 (sd) | 0.07 | 0.07 | 0.11 | 0.11 |
| B. Spine CT | | | | |
| Medicaid-to-Medicare Fee Ratio | 0.007 | 0.004 | 0.036** | 0.028** |
| | (0.004) | (0.002) | (0.012) | (0.010) |
| | [-0.003, 0.021] | [-0.003, 0.012] | [-0.001, 0.059]* | [-0.004, 0.049] |
| State-level Controls | | Yes | | Yes |
| Mean of D.V. in 2003 (sd) | 0.01 | 0.01 | 0.01 | 0.01 |
| C. Spine MRI | | | | |
| Medicaid-to-Medicare Fee Ratio | -0.009 | -0.012 | -0.002 | -0.019 |
| | (0.026) | (0.027) | (0.053) | (0.036) |
| | [-0.072, 0.059] | [-0.082, 0.073] | [-0.122, 0.142] | [-0.150, 0.073] |
| State-level Controls | | Yes | | Yes |
| Mean of D.V. in 2003 (sd) | 0.04 | 0.04 | 0.04 | 0.04 |
| Num. of States | 12 | 12 | 12 | 12 |
| Observations | 515,503 | 515,503 | 515,503 | 515,503 |

*Notes:* Data are from MAX OT files 2003-2004 and 2008-2010. The dependent variable is an indicator for whether the patient received any spine imaging (within modality) in office or OPD during the year. All regressions control for age, race, sex, and blind and disability status indicator, state FE and year FE. State-level controls include unemployment rates, poverty rates, Medicaid eligibility thresholds for infant and pregnant women, and share of state revenue from the federal government, and FFS share. States included are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI. Robust standard errors clustered at the state level are shown in parentheses. I also report 95% confidence interval obtained using the wild-cluster bootstrap procedure of Cameron and Miller (2015). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Table 2.7***

*Estimates of the Effect of Fee Ratio on Utilization of Brain Imaging*
*Dependent Variable: Any Brain Imaging by Modality and Place of Service*

| | Office | | OPD | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Any | Any | Any | Any |
| A. Brain CT | | | | |
| Medicaid-to-Medicare Fee Ratio | 0.025** | 0.031* | 0.398* | 0.421** |
| | (0.011) | (0.015) | (0.182) | (0.185) |
| | [-0.001, 0.051] * | [-0.022, 0.094] | [-0.366, 0.834] | [-0.146, 0.980] |
| State-level Controls | | Yes | | Yes |
| Mean of D.V. in 2003 (sd) | 0.03 | 0.03 | 0.12 | 0.12 |
| B. Brain MRI | | | | |
| Medicaid-to-Medicare Fee Ratio | -0.021 | -0.022 | 0.007 | 0.004 |
| | (0.018) | (0.019) | (0.030) | (0.025) |
| | [-0.089, 0.010] | [-0.109, 0.032] | [-0.092, 0.074] | [-0.110, 0.077] |
| State-level Controls | | Yes | | Yes |
| Mean of D.V. in 2003 (sd) | 0.02 | 0.02 | 0.03 | 0.03 |
| Num. of States | 12 | 12 | 12 | 12 |
| Observations | 426,438 | 426,438 | 426,438 | 426,438 |

*Notes:* Data are from MAX OT files 2003-2004 and 2008-2010. The dependent variable is an indicator for whether the patient received any brain imaging (within modality) in office or OPD during the year. All regressions control for age, race, sex, and blind and disability status indicator, state FE and year FE. State-level controls include unemployment rates, poverty rates, Medicaid eligibility thresholds for infant and pregnant women, and share of state revenue from the federal government, and FFS share. States included are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI. Robust standard errors clustered at the state level are shown in parentheses. I also report 95% confidence interval obtained using the wild-cluster bootstrap procedure of Cameron and Miller (2015). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Table 2.8***

*Summary of Main Analysis Results (Table 2.5): Adjusted Estimates*

| | Office | | OPD | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | No. of Exams | Any Exam | No. of Exams | Any Exam |
| X-ray | 0.03 units | 1.9 ppt | 0.18 units | 4.2 ppt |
| | (127%) | (19%) | (49%) | (27%) |
| Diagnostic Ultrasound | 0.01 units | 0.9 ppt | 0.04 units | 2.0 ppt |
| | (7%) | (12%) | (43%) | (36%) |
| CT | 0.08 units | 0.5 ppt | 0.04 units | 5 ppt |
| | (25%) | (27%) | (44%) | (98%) |
| MRI | -0.01 units | -0.6 ppt | 0.001 units | 0.06 ppt |
| | (-36%) | (-30%) | (2%) | (3%) |

*Notes:* This table summarizes the point estimates from Table 2.5 interpretable as the effect of increase in Medicaid-to-Medicare ratio of 0.30 (from 0.70 to 1) on either volume of imaging exams or the probability of receiving any exam in office (columns 1-2) or in OPD (columns 3-4). Also presented in parentheses are effect sizes relative to the average of the dependent variable in 2003. None of the estimates are statistically significant at the 5-percent level based on wild-cluster bootstrap standard errors. All regressions control for age, race, sex, and blind and disability status indicator, state FE, year FE, and state-level controls including unemployment rates, poverty rates, Medicaid eligibility thresholds for infant and pregnant women, and share of state revenue from the federal government, and FFS share. States included are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI.

***Table 2.9***

*Summary of Low-Value Service Analysis Results (Tables 2.6 and 2.7): Adjusted Estimates*

| | Office | OPD |
|---|---|---|
| | (1) | (2) |
| | Any Exam | Any Exam |
| Spine X-ray | 1 ppt | 6 ppt |
| | (15%) | (61%) |
| Spine CT | 0.1 ppt | 0.8 ppt |
| | (12%) | (84%) |
| Spine MRI | -0.3 ppt | -0.6 ppt |
| | (-9%) | (-14%) |
| Brain CT | 9 ppt | 12.6 ppt |
| | (31%) | (105%) |
| Brain MRI | -0.6 ppt | 0.1ppt |
| | (-33%) | (4%) |

*Notes:* This table summarizes the point estimates from Tables 2.6 and 2.7 interpretable as the effect of increase in Medicaid-to-Medicare ratio of 0.30 (from 0.70 to 1) on the probability of receiving any exam in office (column 1) or OPD (column 2). Also presented in parentheses are effect sizes relative to the average of the dependent variable in 2003. None of the estimates are statistically significant at the 5-percent level based on wild-cluster bootstrap standard errors. All regressions control for age, race, sex, and blind and disability status indicator, state FE, year FE, and state-level controls including unemployment rates, poverty rates, Medicaid eligibility thresholds for infant and pregnant women, and share of state revenue from the federal government, and FFS share. States included are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI.

## *Appendix Table 2.1*

*Correlation between Medicaid-to-Medicare Fee Ratio and State Covariates*
*Dependent Variable: Medicaid-to-Medicare Fee Ratio*

| | X-ray | Diagnostic Ultrasound | CT | MRI |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| FFS Share | -0.027 | 0.067 | -0.049 | 0.024 |
| | (0.156) | (0.181) | (0.174) | (0.167) |
| State Unemployment Rate | -0.011 | -0.001 | -0.010 | 0.015 |
| | (0.015) | (0.014) | (0.017) | (0.026) |
| Percent Revenue from Federal Government | -0.048 | -0.079 | -0.013 | 0.086 |
| | (0.061) | (0.046) | (0.052) | (0.094) |
| Medicaid Eligibility Threshold for Pregnant Women | 0.0001 | -0.001 | 0.001 | 0.001 |
| | (0.0003) | (0.001) | (0.001) | (0.001) |
| Adjusted R-squared | 0.95 | 0.87 | 0.95 | 0.94 |
| Observations | 60 | 60 | 60 | 60 |

*Notes:* All regressions control for state fixed effects and year fixed effects. State-level controls are from Kaiser Family Foundation and U.S. Bureau of Census. Medicaid-to-Medicare fee ratios are constructed as the ratio between Medicaid fee index (a weighted average of the mean reimbursement fees for service within each imaging modality administered in office) and Medicare fee index (calculated similarly but using Medicare reimbursement rates for the same bundle of services). States included are CA, CO, FL, IL, IN, LA, MN, MO, NY, TX, WA, and WI. Robust standard errors clustered by state are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

***Appendix Table 2.2***

*FFS Share by State Across Years*

| | 2003 | 2004 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| California | 0.33 | 0.34 | 0.35 | 0.35 | 0.31 |
| Colorado | 0.61 | 0.72 | 0.85 | 0.85 | 0.87 |
| Florida | 0.58 | 0.40 | 0.44 | 0.40 | 0.46 |
| Illinois | 0.90 | 0.89 | 0.63 | 0.91 | 0.91 |
| Indiana | 0.63 | 0.57 | 0.36 | 0.36 | 0.38 |
| Louisiana | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Minnesota | 0.31 | 0.31 | 0.28 | 0.23 | 0.22 |
| Missouri | 0.58 | 0.59 | 0.65 | 0.67 | 0.66 |
| New York | 0.44 | 0.38 | 0.20 | 0.15 | 0.14 |
| Texas | 0.74 | 0.74 | 0.55 | 0.49 | 0.52 |
| Washington | 0.54 | 0.52 | 0.53 | 0.51 | 0.49 |
| Wisconsin | 0.35 | 0.36 | 0.17 | 0.13 | 0.15 |

*Notes:* Data are from MAX Personal Summary files 2003-2004 and 2008-2010. FFS share measures the proportion of Medicaid beneficiaries on full-benefit problem under FFS payment scheme for at least 11 months of the year among all Medicaid enrollees on any type of plan, including managed care plans.

***Appendix Table 2.3***

*Changes in Medicaid-to-Medicare Ratio by State (2003-2010)*

*Low-value service: Spine Imaging*

| A. Spine X-ray | 2003 | 2010 | % Change |
|---|---|---|---|
| California | 0.71 | 0.72 | 2.49 |
| Colorado | 0.75 | 0.80 | 7.28 |
| Florida | 0.50 | 0.53 | 4.24 |
| Illinois | 0.83 | 0.71 | -15.23 |
| Indiana | 0.91 | 0.80 | -12.48 |
| Louisiana | 0.77 | 0.70 | -8.81 |
| Minnesota | 1.22 | 1.02 | -16.31 |
| Missouri | 0.43 | 0.47 | 10.79 |
| New York | 0.41 | 0.61 | 49.33 |
| Texas | 0.80 | 0.78 | -2.01 |
| Washington | 0.71 | 0.72 | 2.49 |
| Wisconsin | 0.75 | 0.80 | 7.28 |
| Average | 0.73 | 0.72 | 3.27 |
| B. Spine CT | 2003 | 2010 | % Change |
| California | 0.62 | 0.73 | 17.33 |
| Colorado | 0.61 | 0.76 | 24.96 |
| Florida | 0.51 | 0.59 | 14.78 |
| Illinois | 0.25 | 0.25 | 2.13 |
| Indiana | 0.78 | 0.81 | 4.04 |
| Louisiana | 0.78 | 0.72 | -7.10 |
| Minnesota | 1.32 | 1.22 | -7.40 |
| Missouri | 0.67 | 0.53 | -21.46 |
| New York | 0.40 | 0.57 | 43.01 |
| Texas | 0.80 | 0.88 | 9.93 |
| Washington | 0.52 | 0.63 | 20.24 |
| Wisconsin | 1.06 | 1.18 | 11.40 |
| Average | 0.69 | 0.74 | 9.32 |
| C. Spine MRI | 2003 | 2010 | % Change |
| California | 0.83 | 1.11 | 33.27 |
| Colorado | 0.70 | 0.89 | 26.96 |
| Florida | 0.52 | 0.64 | 24.00 |
| Illinois | 0.51 | 0.64 | 24.87 |
| Indiana | 0.76 | 0.96 | 27.14 |
| Louisiana | 0.72 | 0.75 | 4.96 |
| Minnesota | 1.30 | 1.35 | 3.69 |
| Missouri | 0.37 | 0.54 | 43.95 |
| New York | 0.68 | 0.66 | -2.72 |
| Texas | 0.79 | 0.97 | 22.94 |
| Washington | 0.50 | 0.69 | 38.12 |
| Wisconsin | 1.04 | 1.39 | 32.89 |
| Average | 0.72 | 0.88 | 23.34 |

*Notes:* Data are from MAX OT files 2003 and 2010. For each modality, global payment rate reimbursed for office setting (place of service code 11) is for adults (19-64) is used to calculate the Medicaid fee index. Medicaid-to-Medicare fee ratios are constructed as the ratio between Medicaid fee index (a weighted average of the mean reimbursement fees for service within each imaging modality administered in office) and Medicare fee index (calculated similarly but using Medicare reimbursement rates for the same bundle of services).

***Appendix Table 2.4***

*Changes in Medicaid-to-Medicare Ratio by State (2003-2010)*
*Low-value service: Brain Imaging*

| A. Brain CT | 2003 | 2010 | % Change |
|---|---|---|---|
| California | 0.65 | 0.73 | 12.37 |
| Colorado | 0.72 | 0.91 | 26.11 |
| Florida | 0.52 | 0.59 | 15.2 |
| Illinois | 1.17 | 1.12 | -4.25 |
| Indiana | 0.77 | 0.81 | 6.11 |
| Louisiana | 0.76 | 0.82 | 7.84 |
| Minnesota | 1.28 | 1.20 | -6.43 |
| Missouri | 0.59 | 0.52 | -12.17 |
| New York | 0.47 | 0.76 | 59.47 |
| Texas | 0.80 | 0.87 | 8.60 |
| Washington | 0.50 | 0.63 | 27.15 |
| Wisconsin | 1.06 | 1.17 | 11.12 |
| Average | 0.77 | 0.85 | 12.59 |
| **B. Brain MRI** | **2003** | **2010** | **% Change** |
| California | 0.74 | 1.13 | 53.19 |
| Colorado | 0.64 | 0.89 | 38.52 |
| Florida | 0.52 | 0.66 | 27.57 |
| Illinois | 0.36 | 0.50 | 40.79 |
| Indiana | 0.76 | 1.10 | 44.16 |
| Louisiana | 0.71 | 0.82 | 14.39 |
| Minnesota | 1.36 | 1.47 | 8.35 |
| Missouri | 0.35 | 0.58 | 63.40 |
| New York | 0.57 | 0.68 | 19.95 |
| Texas | 0.78 | 1.04 | 33.64 |
| Washington | 0.49 | 0.72 | 46.53 |
| Wisconsin | 1.03 | 1.53 | 48.73 |
| Average | 0.69 | 0.93 | 36.60 |

*Notes:* Data are from MAX OT files 2003 and 2010. For each modality, global payment rate reimbursed for office setting (place of service code 11) is for adults (19-64) is used to calculate the Medicaid fee index. Medicaid-to-Medicare fee ratios are constructed as the ratio between Medicaid fee index (a weighted average of the mean reimbursement fees for service within each imaging modality administered in office) and Medicare fee index (calculated similarly but using Medicare reimbursement rates for the same bundle of services).

## 2.11 Appendices

### 2.11.1 Appendix C. Sample Selection

The sample consists of individuals who are enrolled in and are eligibility for full-benefit Medicaid program for at least eleven months a year. They are also under fee-for-service payment plan for their enrollment period. Twelve states included in this study have more than 10% of their Medicaid enrollees under FFS payment scheme over the study period as shown in Appendix Table 2.2 (Some states that met this FFS share criteria were excluded from the analysis because there weren’t enough claims to calculate the Medicaid Fee Index for each four modalities with precision. These states include Arkansas, Massachusetts, Maine, Oregon, and Virginia).

FFS share is the share of Medicaid enrollees on FFS type plan out of all enrollees on any type of plan (e.g. capitation). FFS type plan includes FFS plan, dental plan, behavioral plan, primary-case case-management (PCCM) plan, and some combination of these plans. People in PCCM are included in FFS sample because providers in these plans are paid on FFS basis. Other plan types include Medicaid recipients who have parts of their care delivered by a managed care company, such as comprehensive plan, managed care plan, combination of managed care plan and dental, behavioral, and/or PCCM plans. I use the MAX personal summary (PS) files to calculate the FFS share in each state and year.

Individuals enrolled in both Medicare and Medicaid ("dual eligible") are excluded from the analysis since Medicare rather than Medicaid serves as the primary source of payment for dual eligible. Lastly, those who are deceased during the sample year have been dropped.

### 2.11.2 Appendix D. Constructing Utilization Measure

Utilization is measured at the beneficiary level. For each imaging modality, I count the total number of procedures performed in office or OPD per beneficiary annually. Patients who were enrolled in full benefit Medicaid program under FFS payment scheme for at least 11 months during the year but did not receive one of the four imaging procedures in office or OPD are assigned zero quantity.

Billing for radiology services are usually separated into two components. The technical component covers the cost of the clinical staff, equipment, medical supplies, and other overhead expenses (Timbie et al. 2015). It is usually billed and collected by the healthcare facility. The professional component covers the interpretation of results and is usually billed and collected by the radiologist practice. When two components are performed together, global payment is billed and collected by the provider (Griffin 2009). These components are identified with a modifier associated with each claim.

I use CPT code and modifiers to identify imaging procedures. I first identified all technical component and global service claims with the code for X-ray, CT, MRI, and diagnostic ultrasounds (CPT 70000-79999). Utilization is the combination of claims with technical component and global service as they represent the number of imaging procedures performed on the individual, rather than the reading of the image (which could be done multiple times for a single image).

### 2.11.3 Appendix E. List of CPT Codes within Modality

- X-ray: CPT 70010-70015, 70030, 70100-70110, 70120-70130, 70134, 70140-70150, 70160, 70170, 70190-70200, 70210-70220, 70240, 70250-70260, 70300-70320, 70328-70332, 70350, 70355, 70360, 70370-74210, 74220, 74240-74249, 74260, 74270-74280, 74290-74291, 74300-74320, 74327-74330, 74340, 74355, 74360, 74400-74425, 74430, 74440, 74445, 74450-74455, 74470, 74475, 74480, 74485, 74710, 74740, 74742, 74775, 75600-75630, 75650, 75658, 75660-75680, 75685, 75705, 75710-75716, 75722-75724, 75726, 75736, 75756, 75774, 75790, 75810, 75860, 75880, 75960, 76006, 76010, 76020, 76040, 76080, 76096, 76098, 76140, 76150, 76350, 77071, 75731-75733, 75741-75746, 75801-75803, 75805-75807, 75820-75822, 75825-75827, 75831-75833, 75840-75842, 75870-75872, 75885-75887, 75889-75891, 75893-75898, 75952-75953, 75980-75984, 75992-75996, 76061-76065, 76075-76076, 76085-76088, 76090-76092, 76100-76102, 76120-76125 (77072-77077, 77080-77081, 77055-77057, 77032, 76977, 77051, 77052 for years 2004, 2008, 2009, and 2010)

- Diagnostic Ultrasound: CPT 75945, 75946, 75989, 76490, 76700-76706, 76511-76513, 76516-76519, 76529, 76536, 76604, 76645, 76770-76775, 76778, 76800-76818, 76819, 76825, 76830, 76831, 76856, 76857, 76870, 76872, 76873, 76880, 76885, 76886, 76930, 76932, 76936, 76941, 76942, 76945, 76946, 76948, 76950, 76965, 76970, 76975, 76977, 76986, 76999 (76510, 76940, 76770-76776 for years 2004, 2008, 2009, and 2010)

- CT: CPT 70450, 70460, 70470, 70480-70482, 70486-70488, 70490-70492, 70496, 70498, 71250, 71260, 71270-71275, 72125-72133, 72191-72194, 73200-73206, 73700-

73706, 74150, 74160, 74170-74175, 75635, 75989, 76013, 76070-76071, 76355, 76360, 76362, 76370, 76375, 76380, 76497 (77078, 77079, 77011, 77012, 77014, 72292 for years 2004, 2008, 2009, and 2010)

- MRI: CPT 70336, 70540-70549, 70551-70553, 71550-71552, 71555, 72141-72142, 72146-72159, 72195-72198, 73218-73223, 73225, 73718-73723, 73725, 74181-74183, 74185, 75552-75556, 76093-76094, 76390, 76393, 76394, 76400, 76498, 76499 (77084, 77058, 77059, 77021, 77022, 75557-75564 for years 2004, 2008, 2009, and 2010)

Source: American Medical Association (AMA) CPT Professional 2003, 2004, 2008, 2009, and 2010 codebook (any year-specific codes are notes)

### 2.11.4 Appendix F. Sample Construction of Low-value Service Analysis

1. Identifying Patients with Specified Diagnoses

I identify patients based on the diagnoses associated with their Medicaid claims as defined by one their first claim including one of the diagnoses listed below:

1.1. Back Pain Diagnoses

Following identification of back pain patients in Schwartz et al. (2014), I use the following list of ICD-9 codes as back pain diagnoses:

- Back pain, various causes: 7213, 72190, 72210, 72252, 7226, 72293, 72402, 7242-7246, 72470, 72471, 72479, 7385, 7393, 7394, 8460-8463, 8468, 8469, 8472

I exclude any of the above claims that also record one of the following diagnoses 180 days prior to the first diagnosis. Patients with the following comorbidities are likely to have back pain with more specific causes. Patients with these specific conditions likely need different treatment options, thus the analysis of back imaging may be less appropriate for them.

- Cancer: 14xx–208xx, 230xx-239xx
- Trauma: 800x-839xx, 850xx-854xx, 86xxx, 905xx-909xx, 92611, 92612, 929, 952xx, 958xx-959xx
- IV drug abuse: 3040x-3042x, 3044x, 3054x-3057x
- Neurologic impairment: 34460, 7292x
- Endocarditis: 4210, 4211, 4219
- Septicemia: 038xx
- Tuberculosis: 01xxx
- Osteomyelitis: 730xx
- Fever, weight loss, malaise, night sweats, anemia not due to blood loss: 7806x, 7830x, 7832x, 78079, 7808x, 2859x

1.2. Uncomplicated Headache

Following Schwartz et al. (2014), I use the following list of ICD-9 codes as uncomplicated headache diagnoses:

- Headache or Migraine: 30781, 339xx, 364x, 7840

I exclude any of the above claims that also record one of the following diagnoses:

- Post-traumatic or thunderclap headache: 33920-33922, 33943

- Cancer: 14xx–208xx, 230xx-239xx
- Migraine with hemiplegia or infarction: 3463x, 3466x
- Giant cell arteritis: 4465
- Epilepsy or convulsions: 345xx, 7803x
- Cerebrovascular diseases, including stroke/TIA and subarachnoid hemorrhage: 43xx
- Head or face trauma: 800xx-804xx, 850xx-854xx, 870xx-873xx, 9590x, 910xx, 920xx-921xx
- Altered mental status, nervous and musculoskeletal system symptoms, including gait abnormality, meningismus, disturbed skin sensation, speech deficits: 78097, 781xx, 7845x
- Personal history of stroke/TIA or cancer: V1254, V10xx

2. Outcomes of Interest for Patients with Specific Conditions

After identifying patients who meet the diagnosis criteria, I locate all their claims in the MAX OT file for 30 days following the date of the diagnosis in the same state of the diagnosis. The utilization outcomes are defined based on the Current Procedural Terminology (CPT) codes in the claims following the diagnosis. The relevant procedure codes are listed below.

2.1 Outcomes of Interest for Back Pain Patients

For patients in the back-pain patient sample, as defined above, I measure the following outcomes, following Schwartz et al. (2014) for guidance:

- Radiologic imaging of spine: 72010, 72020, 72052, 72100, 72110, 72114, 72120, 72200, 72202, 72220
- CT imaging of spine: 72131-72133

- MRI imaging of spine: 72141, 72142, 72146-72149, 72156, 72157, 72158

2.2 Outcomes of Interest for Uncomplicated Headache Patients

- CT of head or brain: 70450, 70460, 70470
- MRI of head or brain: 70551-70553

I analyzed 2003-2004 and 2008-2010 claims data for full benefit, FFS plan beneficiaries who are enrolled for at least 11 months during the year. I consider services that have been characterized as low value, services that provide little to no clinical benefit, by Schwartz et al. (2014). From these services, I select a subset of radiology services that is relevant to the Medicaid population and could be detected using Medicaid claims. Specifically, using procedural and diagnostic codes from the date of service, site of care, and beneficiary demographic information in the claims data, I attempt to distinguish the appropriate use of service from wasteful use. For each selected service, an operational definition of low-value occurrence is developed using CPT codes ICD-9 diagnostic codes (International Classification of Diseases, Ninth Revision), timing of care, site of care, and demographic information. I construct a dichotomous variable for whether the beneficiary with the clinical condition has received the imaging service within 30 days of the first diagnosis.

### 2.11.5 Appendix G. Medicaid OPD Payment Policies for Radiology Services

States usually take one of four methods for setting FFS payments for procedures performed in hospital outpatient department setting[23]:

- Fee schedules: A fee schedule lists a state's Medicaid services and the corresponding payment rates. The reimbursement rates are usually set based on the market value or as a percentage of Medicare rate.
- Cost-based reimbursement: Sates may pay a percentage of hospital's reported costs for Medicaid rates.
- Ambulatory patient classification (APC) groups: Adopted by Medicare, the APC system bundles services into one of 833 APC groups determined by clinical and cost similarity. The payment rates differ by APC groups.
- Enhanced ambulatory patient (EAP) groups: Ancillary and other services commonly provided in the same medical visit are bundled under the EAP groups. The payment rates differ based on the complexity of a patient's illness.

[23] Source: https://www.macpac.gov/subtopic/provider-payment/

## 3. Evidence of IRB Exemption

**Exemption Granted**

March 6, 2020

Eunkyung Kim Vandenberghe

Economics

Phone: (775) 527-0155

RE: **Protocol # 2020-0218**

**"Essays on the Impact of Financial Incentives on Medicaid Service Provision and Patient Outcome"**

Dear Dr. Vandenberghe:

Your application was reviewed on **March 6, 2020** and it was determined that your research meets the criteria for exemption as defined in the U.S. Department of Health and Human Services Regulations for the Protection of Human Subjects [45 CFR 46.104(d)]. You may now begin your research.

| | |
|---|---|
| **Exemption Granted Date:** | March 6, 2020 |
| **Sponsor:** | **None** |

**Please contact the UIC Office of Sponsored Programs (OSP) for assistance or questions related to the Data Use Agreement (awards@uic.edu / 312-996-2862).**

The specific exemption category under 45 CFR 46.104(d) is: 4

The Board determined that this research meets the regulatory requirements for waiver of authorization as permitted at 45CFR164.512(i)(1)(i)(A).

You are reminded that investigators whose research involving human subjects is determined to be exempt from the federal regulations for the protection of human subjects still have responsibilities for the ethical conduct of the research under state law and UIC policy.

Please remember to:

- → Use your research protocol number (2020-0218) on any documents or correspondence with the IRB concerning your research protocol.
- → Review and comply with the policies of the UIC Human Subjects Protection Program (HSPP) and the guidance ***Investigator Responsibilities***.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact me at (312) 996-0865 or the OPRS office at (312) 996-1711. Please send any correspondence about this protocol to OPRS via OPRS Live.

Sincerely,

Camonie J. Johnson
IRB Coordinator, IRB #7

Office for the Protection of Research Subjects

cc: Steven G. Rivkin, Economics, M/C 144

Darren Lubotsky, Faculty Sponsor, Economics

**4. Vita**

**EUNKYUNG VAN DEN BERGHE**

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**Education**

University of Illinois at Chicago, 2014 to present
Ph.D. Candidate in Economics
Thesis Title: *"Essays on the Impact of Financial Incentives on Medicaid Service Provision and Patient Outcome"*
Expected Completion Date: June 2020

B.A., Economics (minor in Mathematics), Brigham Young University – Provo, 2010-2013

***References***

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**Teaching and Research Fields**: Health Economics, Applied Microeconomics

**Research Experience:**

| | |
|---|---|
| 2015-2017 | University of Illinois at Chicago,<br>Research Assistant for Professor Robert Kaestner |
| 2012-2013 | Brigham Young University – Provo,<br>Research Assistant for Professor Joe Price |
| 2013 | Brigham Young University – Provo,<br>Research Assistant for Professor Lars Lefgren |

**Teaching Experience:**

| | |
|---|---|
| Winter 2013 | Intermediate Price Theory, Brigham Young University – Provo,<br>Teaching Assistant for Professor Rulon Pope |

| | |
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| Fall 2013 | Introduction to Economics, Brigham Young University – Provo, Teaching Assistant for Professor James Karl |

**Honors and Scholarships:**

| | |
|---|---|
| 2014-2020 | Board of Trustees Full-Tuition Waiver, University of Illinois at Chicago |
| 2018 | Elizabeth Bass Award (for academic excellence among mothers of young children), University of Illinois at Chicago |
| 2010-2013 | Merit Scholarship, Brigham Young University – Provo |

**Seminar Presentations:**

| | |
|---|---|
| July 2019 | Departmental Seminar at University of Illinois at Chicago |
| April 2017 | Departmental Seminar at University of Illinois at Chicago |

**Research Papers:**

**"The Effect of Physician-Hospital Integration on Medicaid Access to Care and Utilization: Findings from Louisiana's Medicaid Market"**

The U.S. healthcare market has seen a rapid increase of physician-hospital integration with share of hospital-employed physicians increasing from 26% to 44% during 2012-2018. However, it is largely unknown how this trend affects the Medicaid population. This study intends to bridge that gap by relating county/parish-level measures of physician-hospital integration to patient-level measure of access to care and Medicaid service utilization. It focuses on Louisiana, where the entirety of the Medicaid population is under a Fee-for-service payment scheme during the study period of 2008-2010. Among 64 counties, county-level physician-hospital integration increased from 2008 to 2010 by a mean of 1.5 percentage points, with considerable variation in changes across counties (interquartile range, -4 to 29 percentage points). I find no statistically significant relationship between greater physician-hospital integration in a county on overall access to physician services for Medicaid beneficiaries. However, I find that where Medicaid patients see physicians changes following greater availability of integrated physicians in an area, namely from office to hospital outpatient department. This suggests that greater physician integration could imply a decrease in quality of care for Medicaid patients in terms of continuity of care and patient satisfaction. Greater integration also leads to a large increase (140%) in use of imaging procedures among children. On the other hand, I find minimal impacts on use of lab tests. These results on the use of ancillary services suggest that joining providers of complementary services may lead to increase in the use of lucrative procedures. I also estimate a precise zero impact on the use of inpatient services. Lastly, I find that greater physician-hospital integration results in reduced emergency department service usage (-85%) among adults, which may suggest that there may be some efficiency gain following integration. As the trend toward integration intensifies, it will be important for policy makers to consider the consequences of greater integration that may be unique to the Medicaid population.

**"Is Primary Care A Substitute or Complement for Other Medical Care? Evidence from Medicaid"** *Forum for Health Economics and Policy (2019)* (with Jiajia Chen and Robert Kaestner)

It is widely believed that Medicaid reimbursement for primary care is too low and that these low fees adversely affect access to healthcare for Medicaid recipients. In this article, we exploit changes in Medicaid physician fees for primary care to study the response of primary care visits and services that are complements/substitutes with primary care, including emergency department, hospitalization, prescription drugs, and imaging. Results from our study indicate that higher Medicaid fees for primary care have modest effects. Among non-blind and non-disabled adults, we find that a 25% (or $10) increase in Medicaid fees for primary care is associated with approximately a 5% of a standard deviation increase in the number of primary care visits. For the same group, we also find that the fee increase is associated with an increase in the probability of having any primary care visits of approximately 3 percentage points. For children, changes in Medicaid fees are not significantly related to the number of primary care visits. In terms of other types of care, we find some evidence that Medicaid fees for primary care are associated with prescription drug use, and no evidence that primary care fees are associated with the use of emergency department, inpatient services, or imaging. Overall, our evidence provides, at best, limited support for the large effects of Medicaid fees on service provision sometimes asserted in policy discussions.

**"How Do Changes in Fee-for-Service Payment Impact the Utilization of Imaging Exams? Evidence from Medicaid"**

Diagnostic imaging services are expensive, and overutilization of the imaging exams contribute to increasing medical expenditure in the U.S. I test whether the Fee-for-service (FFS) payment scheme drives the utilization of these lucrative services using detailed Medicaid claims data in twelve states over a five-year period (2003-2004 and 2008-2010). Using a difference-in-differences design, I find that increasing Medicaid-to-Medicare fee ratio from 0.7 to 1 is generally associated with a large and positive effect on utilization of X-ray, diagnostic ultrasound, and CT scans and a negative effect on MRI use. The effect sizes tend to be larger in outpatient hospitals than in office. I also examine whether low-value imaging services, spine imaging among back pain patients and brain imaging among headache patients, are impacted by the fee change. I also find that the fee increase is associated with a positive probability of receiving the low-value imaging services, except for spine and brain MRIs. However, none of the estimates are statistically significant at the 5%-level or precisely measured. While this study does not provide conclusive evidence on the relationship between Medicaid FFS reimbursement rates and utilization response, it offers a perspective on how to think about physician's decision to supply care to patients in terms of income and substitution effects in a unique Medicaid environment.

**Other Employment and Volunteer Activities:**

| | |
|---|---|
| 2016-2017 | Graduate Student Council Representative, University of Illinois at Chicago |
| 2010-2012 | Freshman Mentoring, Brigham Young University – Provo |
| 2010-2013 | Volunteer art teacher (Paint a Wish), Brigham Young University – Provo |
| 2011-2012 | Volunteer English teacher (Women of the World), Brigham Young University – Provo |

**Computer Skills and Languages:**

Computer Skills: Stata, R, LaTex/Beamer
Languages: English (fluent), Korean (native)

**Citizenship:** South Korea (U.S. permanent resident)