Essays in Health Care Economics

Nicholas Benson

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ESSAYS IN HEALTH CARE ECONOMICS

by

Nicholas Miller Benson IV

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy
Major: Economics

The University of Memphis
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Special thanks to my wife Shannon and daughter Emery for being patient and supportive during the long nights and weekends for the last four years.
Abstract
This dissertation comprises two essays. The innovation in the first essay is investigating how spine surgeons respond to reimbursement changes. Spinal fusion is the highest US operating room expense and the performed fusion procedure depends on surgeon preference. Substitutable procedures (one-stage posterior, or 1SF, and two-stage fusions, or 2SF) are studied using 2010-2014 national claims data. Results from a multinomial logit model reveal a significant rise in the volume of 2SF, the procedure with the highest physician fee, following a 13.9% reduction in 1SF fees. Risk ratio analysis indicates that patients were 5.8% more likely to receive the costlier 2SF after the policy change. The -0.512 estimated cross-price elasticity of supply suggests that the procedures are substitutes. This contradicts the standard prediction from the target-income hypothesis. The second essay on rent seeking demonstrates how, at the state-level, Certificate of Need programs (CONP) and the strength of the Corporate Practice of Medicine doctrine (CPMD) could enrich incumbent hospitals by limiting competition. Private practice spine surgeons partner with commercial insurers to move common procedures, e.g. spinal decompressions or anterior cervical fusions (ACDFs), from hospital inpatient to ambulatory surgery centers (ASCs) reducing procedure cost by as much as 65%. This paper used 2009-2015 claims data on 1,018,171 procedures to determine if the CONP or the CPMD strength influence the choice of higher vs lower cost surgical settings. CONPs in 24 states are a barrier to opening ASCs. The common law, CPMD, prevents corporations from practicing medicine by employing physicians. Hypotheses tested are that CONPs and a weak CPMD lead to fewer procedures in lower cost settings. Results confirm that in states with weak CPMDs, patients are 59% less likely to have an ACDF in an ASC and patients in states with a CONP are 40% less likely to have an ACDF in an ASC.
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ESSAYS IN HEALTH CARE ECONOMICS

ESSAY 1: “Do surgeons respond to reimbursement changes for alternative procedures?”

1. Introduction

Spine surgery has been one of the fastest growing surgical interventions of the last 20 years making it one of the largest operating room expenses (Rajaee, 2012); (Weiss, 2014). In recent years, many attempts have been made to curb the rising cost of spine surgery through a variety of cost-containment strategies such as Accountable Care Organizations and bundled payments. The results of these attempts have been largely disappointing (Dummit, 2016). As health plans and policy makers try new incentives to influence both clinical and financial outcomes of spine surgeries, it is critical to explore the relationship between the choice of surgical technique and the financial and non-financial incentives that can influence that choice.

In spine surgery, as with all complex medical decisions, the physician acts as an agent on behalf of the patient to guide treatment. The physician behavior literature (reviewed in section 3) has taught us several important lessons about the principal agent relationship: 1) There is significant information asymmetry between the patient and physician which can be used to influence both the quantity and type of treatment; 2) Physicians are motivated by a complex set of personal, professional and practice environmental factors including altruism (the desire to do good), professional pride and satisfaction; and 3) Physician induce demand in response to changes in reimbursement. The literature on spine surgeon behavior is non-existent which is a gap this paper aims to fill by analyzing the impact of reimbursement changes on substitutable spine surgery procedures and providing the cross-price elasticity of supply.
This paper studies a 2012 policy change affecting one of five substitutable spine procedures using a commercial claims database to test how surgeon response to a reimbursement change corresponds with the familiar target-income hypothesis. The specific research questions researched is when there is a decrease in reimbursement for a specific spine surgical procedure, will surgeons compensate by increasing the quantity of the procedure with the lower reimbursement or will they substitute a procedure with comparatively higher reimbursement. If the latter, the cross-price elasticity of the surgical procedures can be quantified. The research question is important because from 1998 to 2008, spine surgery costs increased 37% faster than US healthcare spending, and the US spends more on spine surgery than any other operating room expense. The spine surgeon is the primary decision maker for costly variable expenses during a surgery and understanding how surgeons respond to incentive changes will help inform policy decisions.

The paper is organized as follows. Section 2 reviews the current situation in spine surgery and section 3 provides some background on the physician agency literature. Section 4 reviews the surgical procedures available to the surgeon and the surgeon reimbursement for each procedure. Section 5 describes the data used for the analysis and how the various procedures and control variables were constructed. Section 6 reviews the methods used to analyze the data and section 7 presents the results. Section 8 discusses the potential implications of the findings and section 9 concludes.

2. Current situation in spine surgery

Lower back and/or leg pain can be a debilitating condition that impairs the sufferer’s ability to work or lead an active life. It has been estimated that 80% of people will experience back pain at some point in their life and, while most pain resolves quickly, up to 20% of people
will go on to develop chronic back pain (chronic is defined as persisting at one year) (NIH, 2015). In some situations, a surgical intervention in the form of a spinal decompression (removing troublesome bone, tissue or disc) and/or spinal fusion (the permanent joining of two or more vertebral bodies) may be required.

Significant advances in the techniques and technologies used for spinal decompression and fusion during the late 90s and early 2000s have improved the surgeon’s ability to perform interventions. Rajaee et al (2012) showed that spinal fusions increased 137% from 1998 to 2008 (174,223 to 413,171) and, during the same period, costs increased from an average of $24,676 to $81,960 (ibid). Among frequently performed surgical procedures, spinal fusion is reportedly the highest aggregate operating room expense for hospitals in the US (Weiss, 2014).

While there is good evidence that a surgical intervention is superior to conservative care for certain aging spine conditions such as spondylolisthesis (a slipping of one vertebral body over another) (Weinstein 2009) and spinal stenosis (a narrowing of the spinal canal) (Weinstein 2008), there are concerns about the benefits of spinal fusion in other pathologies, such as degenerative disc disease, where the evidence is not as robust (Carolina, 2016). Insurance companies have responded to these concerns and the dramatic rise in spinal fusion procedures by tightening their coverage policies (Tarr, 2014).

3. Background on Physician Agency

Health economists are familiar with two theories believed to influence physician behavior. The first, the target income hypothesis states that physicians have a certain income “target” in mind and will adjust the quantity of services up or down to meet this target (Sloan, 2012). The second, physician-induced demand, is complementary to the target income hypothesis because it provides the mechanism for physicians to use their information asymmetry
to drive demand for urgent medical conditions. The origins of physician induced demand are often attributed to Robert Evans’ 1974 paper, Supplier Induced Demand: Some Empirical Evidence and Implications. In this seminal work, Evans states that “the physician can exert direct influence on the demand function of the consumer by altering the patient’s perceptions of his needs and the capacity of medical technology to satisfy them” (Evans, 1974).

The potential ramifications of this information asymmetry with respect to physician and, more specifically, surgeon compensation have been well documented. Fuchs studied the impact that the supply of surgeons had on the rate of surgery in 22 metropolitan areas and found a 10% increase in the number of surgeons, increased surgical procedures by 3% (Fuchs V., 1978). Longitudinal data in New York and Washington has shown a reduction in surgical fees for coronary artery bypass surgeries leads to an increase in volume (Yip, 1998). These and other studies have shown that surgeons can induce demand leading to an increase surgical volume. This fact is so well accepted that increases in volume are factored into the calculation for physician fee reductions (Commission).

An increase in volume to offset payment reductions is an example of the income effect. The other effect, substitution, has been studied much less and is of importance in spine surgery where there are large, surgeon directed variations in techniques and technologies used in a surgical intervention (more on this later). One method of substitution is to increase volumes of specific procedures in more profitable payers. Work by McGuire supports the substitution effect by showing that lower physician fees by different insurance carriers can influence procedure selection (McGuire, 1991). More recent data out of the U.K. has looked at the role of incentives on implant choice with substitutable technology. In 2015, Papanicolas and McGuire used a difference-in-difference approach to show that reimbursement influenced artificial hip implant
selection. Interestingly, this paper showed that the hip implant with higher reimbursement and higher utilization conflicted with the implant recommended by the National Institute for Clinical Excellence (Papanicolas, 2015).

The role of physician-induced demand has been studied in markets where the physicians can freely set prices. Wong and colleagues used longitudinal data from Australia to show that general practitioners (GP) charged a lower price (resulting in lower out of pocket costs) to patients when the GP had an incentive to lower the price. Unfortunately, adverse selection was seen in the population that was omitted from the GP incentive. The group that was unaffected by the incentive had their out of pocket costs rise following the policy change (Wong, 2016).

Physicians are described as utility maximizers instead of profit maximizers. McGuire created a utility maximization model incorporating physician-induced demand (Culyer, 2000).

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

where \( Y = N(m_1 x_1(i_1) + m_2 x_2(i_2)), \)
\[ I = N(i_1 + i_2). \]

In this model, the physician’s utility depends on income, \( Y \), and inducement, \( I \). The physician sees \( N \) patients and has two procedures to choose from, \( x_i \), and makes margin, \( m \), on each procedure. The total cost of inducement is the sum of \( i_1 \) and \( i_2 \) across all patients. Taking the partial derivatives with respect to the inducement for each procedure yields:

\[ m_1 x_1' = m_2 x_2' = -\frac{U_I}{U_Y} \]

Alternative models of utility maximization have been suggested that include leisure (McGuire, 1991). The inclusion of leisure is reasonable in nearly all utility maximization
models; however, Fuchs has shown that, at the market price, surgeons want to provide more surgery than the quantity demanded (Fuchs V., 2011). This implies that surgeons are consuming more leisure than desired and the binding of any model including leisure can be called into question.

Lastly, physicians have a unique role in the provision of healthcare services because they function as a double agent. Due to the complex nature of medicine and information asymmetry, patients expect physician agents to induce demand for the treatment that will produce a desired outcome. This positive inducement expectation is true in many industries such as medicine, law, finance and many others. The double agent challenge comes when the physician has to balance the financial constraints of the healthcare system with the needs of the patient. Blomqvist has shown that there are conditions, in both fee-for-service and capitated models, where an efficient allocation of resources can be found (Blomqvist, 1991). The healthcare landscape is constantly changing, and we must be vigilant in the assessment of each unique clinical situation.

4. Background of Spinal Fusion Procedures

Spine surgery is unique in that a lack of clear clinical guidelines create variability in the type of surgical procedure performed. This contrasts with hip arthroplasty which is mostly done the same way around the world with some variability in implant type. If a patient has spondylolisthesis and is a candidate for spine surgery, they can receive a decompression or a fusion. If they receive a fusion, there are many approaches and implants types and the patient can get different opinions on surgical approach from surgeons in the same practice. As an example of the variability in spine surgery, two recent randomly controlled trials published in the New England Journal of Medicine came to different conclusions with respect to fusion vs. decompression for spondylolisthesis (Ghogawala, 2016) (Forsth, 2016).
This paper assesses the impact of a policy change resulting in a reimbursement decrease for a specific degenerative (due to aging) spinal procedure. Procedures analyzed are elective spinal fusions that patients undergo for degenerative conditions of an aging spine affecting less than three motion segments.

When a patient elects for a fusion procedure, the surgeon can choose among five procedural options (Figure 1). The first is an Anterior Interbody Fusion (AIF) only. This procedure is when the anterior aspect of the spine is approached from the front or the side and the vertebral bodies are permanently joined by creating a fusion through a spacer (interbody) in the disc space. If the fusion is done from the side, it is called a Lateral Lumbar Interbody Fusion (LLIF) and it is called an Anterior Lumbar Interbody Fusion (ALIF) if the spine is reached through the stomach. The AIF procedure can be identified in the data and has been excluded from the analysis. The second option is when a surgeon approaches the spine from the back and performs a Posterior Lumbar Interbody Fusion (PLIF) through the interbody. The third procedural option is when the surgeon does not place an interbody in the disc space and instead fuses the vertebral segments by laying bone graft over the posterior elements (e.g. transverse processes) of the spine. This procedure is called a Posterior Lumbar Fusion (PLF). The fourth type of procedure that the surgeon can choose is to combine a PLIF with a PLF. During this surgery, the surgeon fuses two areas of the same two vertebral bodies in a single stage operation. As you can imagine, there are economies of scope to be gained by the surgeon with the fourth procedure. We are not able to distinguish between the second, third and fourth procedures and will refer to the collection of these three procedures as one-stage posterior (1SP). The fifth and final type of procedure, called a two-stage fusion (TSF), is when an AIF is combined with a PLF. Given the separate approaches for the Anterior and Posterior fusions, this approach requires two
stages (they are usually completed on the same surgical day). Import to the research, the fourth procedure underwent a one-time reduction in reimbursement on 1/1/2012 while the other 4 procedures experienced the usual across-the-board reimbursement adjustments applied to all procedures.

The US surgeon reimbursement system is a fee for service and each of the procedural options have distinct surgeon payments based on a quantity of surgical points. Hospitals have a separate reimbursement program that remained constant during the study period. 2017 point values from Medicare for each of the 5 procedures are approximately1:

1) AIF is 59.6 points
2) PLIF is 84.1 points
3) PLF is 72 points
4) PLIF + PLF is 93.5 points
   (reduced from 108.7 points)
5) AIF + PLF is 108.1 points

Most lumbar fusions in the US are done from the posterior approach and on January 1st, 2012, the Centers for Medicare and Medicaid Services (CMS) combined two individual Current Procedural Terminology (CPT®) codes for procedure four PLIF (CPT® code 22612) and PLF (CPT® code 22630) into a single code (CPT® code 22633). This combination reduced the points or relative value units (RVU) and associated physician payment for the procedure by 13.9% (or ~15 points) (Medtronic, 2012). RVUs are a resource-based points system where more complex procedures requiring more work have more points. These points are the same for every US

1 Assumes a PEEK interbody spacer and non-segmental instrumentation
surgeon therefore the point reduction had the same effect on all spine surgeons. There are differences in the value of a single point in different regions based on the cost of living, malpractice insurance and market wages.

Given the information asymmetry, the substitutable procedure options and the profit maximizing behavior of rational individuals, economic theory (specifically the theory of target income and supplier induced demand) predicts that physicians will either increase procedural volumes to compensate for the reduction in payment or substitute a procedure with a higher reimbursement, ceteris paribus.

The hypothesis is that surgeons will substitute the procedure with the highest reimbursement (TSF) and there will not be an increase in procedural volumes of the procedure that received the reimbursement cut (1SP). As already mentioned, surgeons want to provide more procedures than the market demands (Fuchs V., 2011) making an increase in volume difficult. Due to the required insurance approval and invasive nature of spine surgery, demand inducement for a new surgical procedure is much more complex than substituting a procedure that has higher reimbursement

5. Methods and Data

The methods section will describe the statistical models and how the variable on interest was used to test our hypothesis. The data selection will outline the dataset used for analysis and how the variable of interest was created.

5.1 Methods

The question of how surgeons react to a reimbursement reduction was explored in three groups of models. First came an analysis of the impact of the policy change on the procedures of interest. A multinomial logistic regression was used where the dependent variable was either a
ISP procedure or a TSF procedure. For analysis, the ISP procedure was set as the baseline and state clustered errors were used. To test for robustness, the model was run using fake “After” variables to simulate the policy happening a year earlier, in 2011, or a year later, in 2013.

\[
\Pr Y_{it} = \alpha + \beta_{After} + \gamma_{Smoker} + \zeta_{Hypertension} + \rho_{Morbid} + \delta_{Obesity} + \theta_{Cannabis} \\
+ \tau_{Female} + \pi_{Age} + \varphi_{Age^2} + \psi_{MCC} + \varepsilon
\] (5)

The next model investigated whether a decrease in reimbursement for procedure 4 (one of the ISP procedures) led to an increase in ISP procedures using a probit model. The variable of interest throughout the paper was a dummy variable was created for procedures occurring after the reimbursement change in 2012 and labeled “After”. To test for robustness, smoking status, hypertension, obesity, morbid obesity, cannabis use, sex, age, and MCC were controlled for using dummy variables. The dependent variable in this specification is a dummy variable equal to one if a ISP fusion was performed (2-PLF, 3-PLIF, or 4-PLIF+PLF).

\[
Posterior Procedures = \alpha + \beta_{After} + \gamma_{Smoker} + \zeta_{Hypertension} + \rho_{Morbidobe} + \delta_{Obesity} + \\
\theta_{Cannabis} + \tau_{Female} + \pi_{Age} + \varphi_{Age^2} + \psi_{MCC} + \varepsilon
\] (6)

Finally, a probit model was used to look for a substitution effect. We expected this effect to be present if an increase in the fifth procedure (a two-stage fusion) following the reimbursement change was detected. As with the posterior procedure analysis, we controlled for smoking status, hypertension, obesity, morbid obesity, cannabis use, sex, age and MCC using robust standard errors.
\[ TSF = \alpha + \beta \text{After} + \gamma \text{Cigsmoke} + \zeta \text{hypertension} + \rho \text{Morbidob} + \delta \text{Obesity} + \theta \text{Cannsmoke} + \\
\tau \text{Female} + \pi \text{Age} + \varphi \text{Age}^2 + \psi \text{MCC} + \epsilon \]

(7)

It has been reported that probit, logit and linear probability model (LPM) show similar results (Currie, 1996). A LPM and logit model were used as robustness checks. Because of the potential sex related complications, a likelihood-ratio test was done for the one-stage posterior and two-stage procedures to determine the goodness of fit. In both situations, the null hypothesis could be rejected, and we decided to keep a dummy variable for sex in the model. In addition, a Hosmer-Lemeshow test has been described as a robustness test for goodness of fit (Lemeshow, 1982) and was used in our approximation. In each specification, the null hypothesis could not be rejected.

The two indications with the best literature supporting and intervention were run separately with probit models to see if there was a difference for patients with the sole diagnosis of spondylolisthesis or spinal stenosis.

The method for calculating the arc cross-price elasticity is described in Table 1. Again, it is important to point out that there are two components of physician reimbursement, the RVU or points and dollar value associated with each point. The policy change was a reduction in points which only affected the PLIF+PLF procedure (Medtronic, 2012). There are annual changes to the RVU fee schedule, but these changes happen across all procedures reimbursed by Medicare. The 15.16 point reduction represents a 13.9% less points for the procedure affected by the policy. This percent change was used as the change in price for the cross-price elasticity.
### Table 1: Arc cross-price of elasticity

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1SP</td>
<td>Price</td>
<td>Natural progression</td>
<td>Natural progression</td>
</tr>
<tr>
<td></td>
<td>Policy Change</td>
<td>Policy Change</td>
<td>Policy Change</td>
</tr>
<tr>
<td>2SF</td>
<td>Quantity</td>
<td>Natural progression</td>
<td>Natural progression</td>
</tr>
<tr>
<td></td>
<td>Policy Change</td>
<td>Policy Change</td>
<td>Policy Change</td>
</tr>
</tbody>
</table>

**Arc Cross Price Elasticity of Supply**

\[
\text{Percent change in quantity supplied of 2SF} = \frac{\text{Percent change in price of 1SP}}{\text{Percent change in quantity supplied of 2SF}} \quad (8)
\]

### 5.2 Data

Data used for the analysis were derived from the Truven Health MarketScan® 2010 to 2014 Commercial Claims and Encounters and Medicare Supplemental and Coordination of Benefits Databases (Truven Health Analytics, Ann Arbor, Michigan). These databases represent the health services of approximately 170 million employees, dependents, and retirees in the US with primary or Medicare supplemental coverage through privately insured fee-for-service, point-of-service, or capitated health plans. The sample size for this paper based on the years and procedures of interest is 121,207. The Commercial and Medicare Supplemental Databases are generally representative of the surgical population in the US in terms of gender (46% male). All enrollment records and inpatient, outpatient, ancillary, and drug claims were collected. The use of the MarketScan® databases has been well established in the literature resulting in more than 1,100 peer-reviewed publications (Analytics, 2016). The database has also been used for research in spine surgery and in 2015 it was used to compare the outcome differences between anterior and posterior interbody fusion surgery (Huang, 2015). The Huang paper looked at the exact same procedures studied in this paper. The Truven database includes important variable categories such as Medicare Severity-Diagnosis Related Group (MS-DRG) codes, International Classification of Diseases, Ninth Revision (ICD-9) procedure (ICD-9P) and diagnosis (ICD-9D)
codes, Current Procedural Terminology (CPT®) codes, as well as other patient specific data such as sex and age. The analysis was done using the following MS-DRG codes; 459 - Spinal fusion except cervical with a major complication or comorbidity (MCC), 460 - Spinal fusion except cervical without a MCC, 453 - Combined anterior/posterior spinal fusion with MCC, 454 - Combined anterior/posterior spinal fusion with a complication or comorbidity (CC) and 455 - Combined anterior/posterior spinal fusion without CC/MCC. The years analyzed were from 2010-2014.

MS-DRG codes 459 and 460 specify that they are for non-cervical indications, however MS-DRGs 453, 454 and 455 can be used for cervical and thoracolumbar procedures. To control for this, procedures were removed when an ICD-9D or ICD-9P codes for a cervical procedure or diagnosis occurred. Specifically, encounters using ICD-9D codes 7211, 7210, 7230 or 7231 or ICD-9P codes 8103 or 8102 were identified as cervical and removed from the data set. The remaining 121,207 encounters are thoracolumbar procedures that would have been impacted by the reimbursement change.

The data were analyzed to see if there were difference with procedures amenable to LLIF by creating procedure specific dummy variables for spondylolisthesis and stenosis (ICD-9D 75612, 75611, 7384 or 72402 and 72403 respectively). TSF procedures have been reported to have higher complications and because of the potential for adverse effects in at-risk patients dummy variables were created for patients with MCC using MS-DRG 459 or 453. Dummy variables for obesity were created using ICD-9D codes 27800 and 27801 because the AIF procedures approach the spine from the front of the patient which may not be preferred by surgeons in obese patients. A dummy variable was created for sex because a rare but significant complication of an AIF procedure is retrograde ejaculation which can leave males infertile.
Lastly, ICD-9D codes were used to create dummy variables for important medical conditions that would not be picked up by a MCC label such as the use of tobacco (3051), cannabis (30520), a diagnosis of hypertension (4019) and depression (311).

To identify a substitution effect, it is important to isolate TSF procedures (procedure 5). This was done using a dummy variable for procedure where the MS-DRG was 453, 454 or 455. While the data do not allow us to isolate PIF + PLF procedure for analysis, it is possible to look at 1SP (procedures 2, 3 and 4) fusions in aggregate. To do this, AIF procedures were identified and removed from the dataset using a dummy variable if the ICD-9P code was 8106 and the MS-DRG was 459 or 460. The remaining procedures, after removing both anterior approaches are posterior fusions. The summary statistics of tested variables can be found in table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>121,207</td>
<td>50.61575</td>
<td>10.70812</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>MCC</td>
<td>121,207</td>
<td>0.0514631</td>
<td>0.2209411</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Female</td>
<td>121,207</td>
<td>0.5578695</td>
<td>0.4966414</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cannabis</td>
<td>121,207</td>
<td>0.0006554</td>
<td>0.0255928</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hypertension</td>
<td>121,207</td>
<td>0.3110534</td>
<td>0.4629261</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Smoker</td>
<td>121,207</td>
<td>0.1080539</td>
<td>0.3104495</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Depression</td>
<td>121,207</td>
<td>0.0707767</td>
<td>0.2559494</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Obesity</td>
<td>121,207</td>
<td>0.0680349</td>
<td>0.2518066</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Morbid Obesity</td>
<td>121,207</td>
<td>0.0366327</td>
<td>0.1878589</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
7. Results

A feel for the impact of the change can be seen in the graph of the means of one and two-stage procedures. Figure 2 shows a change in 1SP growth rates following the reimbursement change. A different trend can be seen in the TSF graph (figure 3) where the procedure trend moves from decline to growth following the change. The dotted line represents the year of the policy change.

![Figure 2](image1.png)  
![Figure 3](image2.png)

The results of the first set of analysis to determine whether there was a significant impact of the reimbursement change are in Table 3. The variable of interest (policy year) was positive and significant for the true year of the policy change. This was not true for the fake policy year of 2011 or the fake policy year of 2013.
Table 3: Multinomial Logits comparing fake policy years

<table>
<thead>
<tr>
<th></th>
<th>2012 (true year)</th>
<th>2011 (fake year)</th>
<th>2013 (fake year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy year</td>
<td>0.056**</td>
<td>0.030912</td>
<td>0.038795</td>
</tr>
<tr>
<td></td>
<td>(0.026299)</td>
<td>(0.032456)</td>
<td>(0.041505)</td>
</tr>
<tr>
<td>Age</td>
<td>0.021024**</td>
<td>0.020907**</td>
<td>0.020959***</td>
</tr>
<tr>
<td></td>
<td>(0.010528)</td>
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<td>(0.041688)</td>
<td>(0.041888)</td>
<td>(0.042152)</td>
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* p<0.10, ** p<0.05, *** p<0.01

The base procedure is one-stage posterior (1SP)

The results of the next model that investigated whether a decrease in reimbursement led to an increase in procedures, as predicted by the target income hypothesis, was negative and significant for all three models (Table 4). Surgeons did not increase posterior procedure volumes in response to the reduction in reimbursement. The data for TSF showed a very different story. In these models, the change in procedures was positive and significant for each model. A multinomial logistic risk ratio model found the policy increased the probability a TSF by 5.8% implying that the reimbursement change led to the substitution of the procedure with the higher
reimbursement. An odds ratio of 0.955 and 1.519 following the policy change were calculated for the 1SP and TSF procedures respectively.

Table 4: Models comparing 1SP and TSF after the reimbursement change

<table>
<thead>
<tr>
<th>Variable</th>
<th>1SP (Probit)</th>
<th>1SP (Probit)</th>
<th>1SP (Logit)</th>
<th>TSF (Probit)</th>
<th>TSF (Probit)</th>
<th>TSF (Logit)</th>
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<td>After</td>
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<td>(0.0223)</td>
<td>(0.0269)</td>
<td>(0.0146)</td>
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<tr>
<td>Hypertension</td>
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<td>-0.0414**</td>
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<tr>
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<td>(0.0090)</td>
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<td>(0.0039)</td>
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<tr>
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<td>MCC</td>
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<td>(0.2927)</td>
<td>(0.1631)</td>
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<td>0.0886***</td>
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<td></td>
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<tr>
<td></td>
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<td>(0.0138)</td>
<td>(0.0160)</td>
<td>(0.0088)</td>
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<tr>
<td>Pseudo R2</td>
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<td>0.0001</td>
<td>0.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
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<td>121207</td>
<td>121207</td>
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<td></td>
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</table>

* p<0.10, ** p<0.05, *** p<0.01

Multinomial logistic models were run on the sole diagnosis of spondylolisthesis or stenosis and yielded different results. In the model with stenosis only, there was a statistically significant positive change in TSF procedures following the reimbursement change. There was a
The data show that surgeons did not increase the volumes of the procedure with the reimbursement cut and instead substituted a procedure with higher reimbursement. The arc
cross-price elasticity was calculated to determine the magnitude of the substitution. Table 5 shows that for every 1% decrease in points for the one-stage posterior fusions, the number of two-stage fusions increases by 0.51%. The calculation was performed by estimating the natural progression with a ration of TSFs to the total procedures for each year. This ratio was found to be 0.1679 in 2011, which was a 2% decline from 2010. Extrapolating this 2% decline to 2012 leads to a ratio of 0.1645 in 2012. The total number of procedures in 2012 was 24,568 of which 4,042 were expected to be TSF procedures – there were 4,336. The difference represents a 7% increase over what would have been expected without the police change. Using the 7% increase in quantity and a 13.9% decrease in reimbursement for the substitutable procedure, the arc cross-price elasticity of supply was calculated to be -0.5122.

Table 6: Arc cross-price elasticity calculations

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
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<tbody>
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<td>1SP</td>
<td>N/A (RVU)</td>
<td>N/A (RVU)</td>
<td>0</td>
</tr>
<tr>
<td>Price</td>
<td>69.95</td>
<td>54.79</td>
<td>13.9%</td>
</tr>
<tr>
<td>2SF</td>
<td>0.167897</td>
<td>0.17649</td>
<td>5.12%</td>
</tr>
</tbody>
</table>

\[
\text{Arc Cross Price Elasticity of Supply} = \frac{7.12\%}{-13.9\%} = -0.5122
\] (7)

8. Discussion

The change in surgeon reimbursement appears to have had an impact on procedural selection in spine surgery favoring the procedure with the greatest reimbursement. This is consistent with previous reported results in oncology where the decrease in reimbursement for certain chemotherapy drugs resulted in the substitution of chemotherapy drugs with more favorable reimbursement (Jacobson, 2010). The timing of this change was, for all intents and
purposes, a natural experiment and, to our knowledge, there are not any other factors that would have contributed to the procedural shift. The findings are potentially significant given the high costs of spine surgery. This study is the first time the impact of a change in physician payment has been studied in spine surgery and the first time a cross-price elasticity of supply has been calculated for spine surgery.

Lab experiments have shown that the variations in the type of payment model (fee-for-service, capitated and mixed) can influence the quantity and quality of service provided (Brosig-Koch, 2015). The elasticity of the quantity of services supplied is particularly important in a fee-for-service reimbursement model than incentivizes volume over value. The fee-for-service aspect of physician service has been widely described as a market failure due to information asymmetry, the fact that healthcare is a credence good, and the principal-agent problem. The spine surgeon agents performing the procedures analyzed in this paper have the highest compensation of any medical specialty (Rosin, 2014). This finding suggests that there may not be an income ceiling to the physician induced demand theory. The results presented in this paper will be important to consider as Medicare transitions to a bundle payment model and policy decisions are made on physician gain-sharing.

The statistically significant TSF increase is particularly significant given the potential externalities of the shift. As mentioned, there is a lack of clear evidence pointing to the clinical superiority of any one technique and there is some evidence that the TSF procedure has higher complications (Epstein, 2016). In addition, recall that the TSF procedure is two procedures – there are two separate skin incisions with the patient staged in two different positions. This two-in-one procedure has been shown to result in longer operative times and higher costs than the posterior procedure that had the reimbursement decrease (Andres, 2012). An analysis of the data
in this paper found that a TSF increased hospital stay by 15.1%. As the US government looks to achieve its goals of improving care while reducing cost and enhancing quality, the way surgeons respond to changes in incentives are important to consider.

There are important criticisms to this paper. The first is that the evidence is retrospective in nature and there is not an untreated population to use as a control. The second is that technical innovation moves faster than the evidence. The modern LLIF procedure was commercialized just over 10 years ago and while there is no evidence of superiority, there is also not quality evidence of inferiority. Another criticism is that there is a significant aging of the U.S. population and this older population is living longer with greater quality of life expectations. Our data described the working age population which omitted this important age group. Finally, this evidence only includes data from the US and no conclusions of external validity can be drawn.

Most importantly is to note that the decision to undergo any surgical intervention is multifaceted and is a joint decision between the patient, the patient’s friends/family, the surgeon, and many other healthcare professionals. It is impossible to fully appreciate and, therefore, measure all the factors that go into care delivery. More research is needed to investigate the correlations identified in this study.

9. Conclusion

This paper looked at the impact a random change in physician reimbursement had on the type of spinal fusion procedure performed. A decrease in reimbursement for a single stage posterior fusion was correlated with a shift in the mix of procedures toward a two-stage anterior/posterior approach where higher surgeon reimbursement remained unchanged. The procedure favored by the change may have negative externalities that we not considered when the policy was set. The cross-price elasticity calculation provides important insight to policy
makers as decisions are made on the best reimbursement strategies to decrease the cost of care while improving quality.
ESSAY 2: “Rent seeking in surgical care: A look at the impact of Certificate of Need programs and the Corporate Practice of Medicine doctrine.”

1. Introduction

The U.S. spent 17.9 percent of its Gross Domestic Product (GDP) on healthcare in 2016 (CMS.gov, 2017), a share projected to reach 20.1% by 2025 (CMS.gov, 2017). Relieving this financial burden will require experimentation and close collaboration between payers, patients and providers. The Patient Protection and Affordable Care Act (PPACA) created the Center for Medicare and Medication Innovation (CMMI) to encourage experimentation on new and innovative health care models involving multiple payers, providers and other stakeholders. Among the goals of the CMMI is investigating different types of innovative payment models that link reimbursement to quality outcomes. These quality-based payment models are in contrast to the existing fee for service payment model that is based on diagnostic tests run or procedures performed. Many of these quality-based reimbursement experiments were quickly embraced by hospital systems that volunteered to participate.

But what if a solution already exists? What if, in pursuit of higher profits, one group of private market stakeholders has figured out how to provide high quality spine care at a fraction of the price? This is the case with routine spine surgery performed in outpatient settings, but it comes at an expense to incumbent hospitals who have strong incentives to resist change. This paper investigates rent seeking behavior (actions to make a profit without producing wealth or social welfare) by analyzing the frequency of low cost setting spine surgery in states with different policies and laws that can potentially affect hospital market power.

The research questions this paper addresses are whether a state-level policy, the Certificate of Need (CON) program, or a weak Corporate Practice of Medicine (CPM) doctrine,
2. Background

Spine surgery is expensive. Weiss et al. (2014) found that spine surgeries accounts for more than 6% operating room procedures and more than 8% of the operating room expenses with more than $15b spent in 2011 alone. The frequency with which spine surgeries are performed, and the cost of these interventions have risen significantly over the last 15 years (Rajaee, 2012). Bernstein et al (2017) found that these procedures are invariant with respect to economic downturns. Moreover, the vast majority of spinal decompressions (the removal of bone or tissue from an impinged nerve) and fusion (the permanent joining of two vertebral bodies) are performed as expensive inpatient procedures (e.g. procedures with at least one overnight stay).

Spine procedures can be performed in three different types of facilities: 1) hospital inpatient (INP) facility, 2) hospital outpatient (OUTP) facility, and 3) ambulatory surgery center (ASC). These facilities have substantially different cost structures and have distinctly different reimbursement levels for the same procedure. Hospitals treating all types of health conditions, have more than 250 beds, staffs an ER 24/365, and care for indigent patients have a much higher cost structure than ambulatory surgical centers that provides same day surgical care for a very limited set of indications. Recognizing these differences, the Centers for Medicare & Medicaid Service (CMS) and private insurance carriers provide the highest reimbursements for hospital inpatient procedures.
For a qualifying spine procedure, the site of surgery decision is made jointly by the surgeon and patient with passive participation by the payer who provides reimbursement. The site of surgery decision can depend on a variety of factors such as patient health, patient preference or procedure complexity, but should not vary based on non-medical considerations. A state-level CON program or the state specific strength of the CPM doctrine should not have an impact on site of surgery.

2.1 Policy review

Certificate of Need (CON)

In 1964, New York was first state to institute a CON regulation. The program was expanded nationally to all states except Louisiana in 1974 after the National Health Planning and Development Act was passed. The Act, passed at a time when CMS reimbursement used a cost-plus model and was an attempt to decrease healthcare costs by limiting the number of community health care facilities. Economic theory posits that the consumption of healthcare services can be induced by the supplier (e.g. gate keeping physicians), and the induced demand would then increase the need for expensive medical care, equipment and services. CON programs could act as a constraint by limiting the supply of facilities requiring expensive medical equipment in a region. Fewer medical equipment can, theoretically, limit physician-induced demand.

CMS replaced the cost-plus reimbursement model with a prospective payment system in 1983. This substantial change to the payment model had significant implications and legislation passed for a reimbursement system that no longer exists should be revisited (e.g. CON program). Of the 49 states that initially had a CON regulation, the law has been fully repealed in 15 states with New Hampshire the latest to do so in 2016. Importantly, just because a state has a CON program, it does not imply constraints on all facilities and services in the state. A state-level
CON program can broadly or narrowly apply to nursing homes, medical office buildings, organ transplants, radiation therapy and a wide variety of other areas.

The CON program of interest to the research question is the limitation on ASCs in 24 states and the District of Columbia (ACFAS, 2017). The impact of this regulation is observed by comparing the number of ASCs in a state with a CON program like New York (132) with the less populous neighboring state of New Jersey (268 ASCs) or a state with a similar population like Florida (409 ASCs) (ASCA, 2017). An exception to this general trend is the state of Georgia where Tom Price, an Orthopedic surgeon and the former U.S. Secretary of Health and Human Services, was a board member of an entity that performed surgery in ASCs.

There is evidence that CON programs may not have the desired cost constraining intent (Granderson, 2011). As early as 1976, it was shown that CON programs “did not reduce the volume of investment”, but instead “altered its composition” by substituting investment in response to “financial factors and organizational pressures for expansion” (Salkever, 1976). Conover and Sloan (1998) used a time series model to show that CON programs led to a 2% reduction in the supply of beds, but higher hospital costs and higher hospital profits. They concluded that “[t]here is no evidence of a surge in acquisition of facilities or in costs following the removal of CON regulations.” There is also CON research on the impact to complex surgical procedures. For Coronary Artery Bypass Grafting (CABG) procedures, the lack of a CON program has been correlated with lower procedures per institution and a higher mortality rate (Vaughan-Sarrazin, 2002). In summary, the literature states that CON programs do not necessarily contain costs as originally intended, but there may be a positive, unintended consequence of lower complications when the presence of a CON program concentrates CABG

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2 The US states are: AL, AK, CT, GA, HI, IL, IA, KY, ME, MD, MA, MI, MS, MT, NV, NY, NC, RI, SC, TN, VT, VA, WA
procedures to a few hospitals. The first hypothesis is that CON programs act as bureaucratic barriers to hospital competition potentially enriching the incumbent hospital by reducing the frequency of procedures performed in lower cost settings.

Corporate Practice of Medicine (CPM) Doctrine

The history of the CPM doctrine is long and complex. The process started with the American Medical Association (AMA), which was founded in 1847 to improve the quality of health care by distinguishing “licensed” and “trained” physicians from those who were not. The origins of the CPM doctrine and the AMA began in early 20th century as a response to physician employment by railroads and consumer clubs (Starr, 1984). Central the CPM doctrine is the belief that only physicians are trained to make complex healthcare decisions, and the employment of a physician by a corporation would negatively impact the decision-making autonomy of that physician. The opinion that physician employment “undermines the physician-patient relationship and the physician’s exercise of independent medical judgment in the sole interest of the patient” (Garcia v. Texas State Bd. Of Med. Exam’rs, 348 F. Supp. 435, 437 W.D. Tex. 1974; AHLA, 2017) remained largely intact until the emergence of health maintenance organizations (HMOs) in the 1970s.

Legislation that authorized HMOs preempted many state laws (including some of those associated with the CPM doctrine) to allow employment of physicians by organizations whose goal was to use capitated payments to constrain healthcare spending. The research community has expressed support for CPM doctrine modification given the extensive changes to healthcare delivery in the 100” years since conception (Mars, 1997). A detailed review of court opinions pertaining to the CPM doctrine is beyond the scope of this paper, but there are a few states where state law has been tested and the prohibition of physician employment has been upheld (Kusserow, 1991). One of those, California, has a long history of case law supporting the
doctrine. In 1935, the supreme court of California declared “[t]hat a corporation may not engage in the practice of the law, medicine or dentistry is a settled question in this state” (PAINLESS PARKER V. BOARD OF DENTAL EXAM, 1932). For such a broad sweeping doctrine and increasing concerns about the hospital acquisition of physician private practices, the CPM doctrine has had remarkably little national exposure.

Today, the Medical Board of California interprets the CPM doctrine in two sections of state law governing the practice of medicine, the Medical Practice Act. The first, section 2052, says it is unlawful to practice medicine without a license and requires anyone who “diagnoses, treats, operates for or prescribes for any ailment” to have a license. The second, section 2400, states that corporations have “no professional rights, privileges, or powers.” In other words, a corporation cannot earn a license to practice medicine. Even with legal support for the CPM doctrine, California has created exceptions for teaching institutions, medical/charitable foundations, and clinics. California is also the home of Kaiser Permanente, the largest managed care organization in the US. This organization does not employ physicians but creates an exclusive arrangement between medical groups that are responsible for staffing and care delivery within the fixed budget of the Kaiser Foundation Health Plan (Kim, 2007). California is a clear example of how health care innovation can exist alongside the CPM doctrine.

The CPM doctrine is important to the research question because surgeons in private practice are vertically integrating and it is this segment that are investing in ASCs. Surgeons that are employed by hospitals or other corporations do not choose to compete with their employer by opening their own ASC. Our experience is that few surgeons are aware of the doctrine and, when the opportunity is substantial enough, large hospital systems have enough resources to find ways to employ surgeons. As a result of this information asymmetry, we chose to look for states with
case law or other authority allowing CPM, or exceptions to the doctrine permitting relatively unfettered physician employment. The hypothesis is that states with unencumbered surgeon employment would have fewer private practice spine surgeons to open up ASCs and would therefore have less procedures performed in ASCs. Weak CPM doctrine states identified by expert legal opinion were Tennessee, Ohio, Louisiana, Mississippi and Alabama.

2.2 Reimbursement overview

This third background section is to provide a brief description of the differences in reimbursement for the three sites of surgery. Differences in reimbursement exist for both the type of procedure performed (more complex procedures are reimbursed at a higher rate) as well as the site of surgery. These differences are important for the reader to appreciate as they define the magnitude of the potential rent seeking behavior. We study two surgical procedures where there is consensus and literature supporting them in the outpatient setting (inclusive of both ASC and outpatient): Anterior Cervical Discectomy Fusion (ACDF) and spinal decompression (Adamson, 2016; McGirt, 2015; Kurd, 2015; Natalie, 2007).

The 2017 CMS reimbursement for an inpatient ACDF was $13,710. This is 43% higher than an outpatient facility ($9,561) and 95% more expensive than an ASC ($7,047). Importantly, this reimbursement is a facility fee (covering room, board, surgical supplies, etc.) paid to the facility owners. All sites of surgery have the same professional fees paid to the surgeon for performing the surgery. For a spinal decompression, inpatient facility reimbursement is $7,349, outpatient reimbursement is $5,199, and reimbursement is $2,682 for an ASC. These reimbursement amounts are for a procedure covered by Medicare. The data used for this analysis came from commercial payers where the spread between the facility fees for a given procedure is
much wider. The revenue gain for a hospital when a single ACDF surgery is performed in the inpatient setting instead of an ASC is at least $6,663.

3. Conceptual Framework

This section reviews how the various stakeholders function in the system and their economic motivations. The framework will provide context for the a priori hypothesis that incumbent hospital systems may have financially benefitted from the presence or enforcement of a state-level policy and weak CPM doctrine. If the hypothesis is true, fewer procedures will have been performed in lower cost sites of surgery in states where policy or law favor the hospital. The higher cost of surgical intervention manifests as a wealth transfer from the private or public insurance payer and the private practice ASC owning surgeon, to the incumbent hospital system. Section 3.3 presents an empirical model of how differing economic interests interact with the policies from section 2 and present in the market. The final part of this section will review complex initiatives under way from CMS to reduce the cost of complex surgical interventions. This final section is important because if the a priori hypothesis is true, a simpler and better (in terms of payer cost reduction) solution to the problem may already exist.

3.1 Private insurance companies

Private insurance companies are profit maximizers who earn most of their revenues from investments and policy premiums charged for covered lives. Health insurers seek to minimize payout ratios. They have variable expenses when a covered life engages in healthcare consumption.

Outside of certain spinal trauma and tumor conditions, insurance companies in the US typically mandate a conservative care period of at least 6 months. During this period, all reasonable, non-operative care options are explored. If the patient does not respond to
conservative treatment, a surgical intervention may be authorized. Assuming there is no
difference in outcome quality, private insurance companies want the procedure done on the right
patient (one who will respond to treatment) in the lowest cost facility.

3.2 Private practice surgeon

The private practice surgeon is assumed to be utility maximizing economic agent who
gains utility from income and has disutility from any demand inducement required to increase
patient consumption. The surgeon gets income from professional fees for office visits (minimal)
and surgical procedures (substantial). A potential third source of surgeon income is based on the
profit at an ASC where she has an ownership stake. This revenue is paid as a fixed ownership
distribution and is not a per-procedure kick back. In a spine procedure, facility fees are often
double or triple the amount of the professional fees making ASC ownership a profitable
endeavor. Assuming no difference in outcome quality, the private practice surgeon wants the
procedure done on the right patient, in an ASC where they have an ownership stake.

3.3 Hospital

Hospitals tend to behave as cost minimizers. They earn most revenues from procedure-
based reimbursement in the operating room, and they have a fixed reimbursement amount based
on the procedure performed. The reimbursement amount is based on a hospital contract with a
private insurance company, or with CMS in accordance with the facility fee schedule. Hospital
fixed and variable expenses are paid out of the procedural reimbursement. Fixed expenses
include capital, rent/lease, utilities, indirect labor and insurance. Variable expenses include direct
labor, medical supplies, medical implants, room, board and medications. The hospital has a
financial incentive to maximize the number of procedures, maximize the per-procedure
reimbursement and minimize the variable expenses associated with each procedure. When there
is subjectivity in the site of surgery, the hospital has a strong incentive for the procedure to be done inpatient.

3.4 Empirical model

The reviewed economic theory predicts that agents seek to maximize or minimize their respective objective functions. In a free market, private insurance company’s incentives are aligned with the ASCs and private practice surgeons. They have an incentive to exploit advances in healthcare technology and migrate the appropriate spine procedures to the facility with the lowest fee. Patients who are responsible for a percentage of surgical expense also benefit from the procedure being performed in the low-cost setting. ASC migration is in direct conflict with the hospital, which is heavily incented to resist any shift away from performing procedures in an inpatient (INP) facility. Bureaucratic CON programs disrupt the free market by creating a barrier to ASC construction. The regulation imposes an indirect tax on ASC ownership that raises the price to anyone opening an ASC. States with a weak CPM doctrine have a market distortion that removes friction from surgeon employment thereby decreasing the supply of private practice surgeons. This distortion in surgeon employment aligns the hospital and surgeon’s incentives. Surgeon employment could work against the interests of private insurance companies (and, potentially, CMS) by decreasing the number of private practice surgeons that could open an ASC.

3.5 Public insurance initiatives from CMS

In an effort to control the rising cost of surgical procedures, the U.S. government initiated opt-in pilots with CMMI called the Bundle Payments for Care Improvement. These pilots were solely focused on select inpatient procedures and reimbursed facilities with a bundle payment that covered all costs within a defined episode of time (typically 90 days). The centers
participating in bundle payment initiatives were then compared to similar centers that were not part of the pilot to determine the impact of the program. Complex orthopedic bundles saved on an average of $864 and, surprisingly, spine bundles were more expensive by an average of $3,477 (Group, 2016). Based on the results of this pilot, CMS announced the Comprehensive Care for Joint Replacement (CJR) Model that made bundle payments mandatory in 67 metropolitan areas on April 1, 2016 (CMS.gov, 2017). CMS has, understandably, not initiated a mandatory bundle for spine surgery. A bundle payment model adds risk and complexity to the bundle holder (usually a hospital) because the holder has to administer payments to all facilities (rehab, skilled nursing facilities, etc.) and healthcare professionals that are owed compensation within a given episode of care. The bundle holder assumes the payment risk and keeps whatever money is remaining from the payment after all the expenses have been paid for the episode.

A free market solution to the rising cost problem has emerged where expensive procedures are migrating to lower cost settings (specifically ASCs) with surgeon ownership. The stakeholders in this free market solution are private insurance carriers, and private practice Orthopedic and Neurosurgeons. Private insurance carriers are free to make policy decisions independent from CMS guidelines. This independence allows them to react faster to improvements in healthcare technology that enables surgical procedures, such as an ACDF, to be done in a lower cost facility. Private practice surgeons, as compared to surgeons employed directly by an academic center or a corporation, are free to make decisions that maximize their utility without the constraints or biases imposed by a corporation. This surgeon group has partnered with private insurers to take appropriate spine patients to lower cost facilities. The savings from performing a surgery in a lower cost setting dwarfs the savings from a BPCI
program. Recall the ASC reimbursement for an ACDF was 49% cheaper than inpatient and the $864 savings realized in the Orthopedic pilot was less than 6% of the CMS facility fee.

4 Methods and Data

This section will describe how each hypothesis was tested. The Methods section will review how each hypothesis by describing the question, the dependent variable, the variable of interest and the statistical approach selected. The Data section specifies the data set used and details how the variables were constructed.

4.1 Methods

To test the hypothesis that a CON program acts as a bureaucratic barrier to hospital competition leading to fewer procedures performed in lower cost settings, a multinomial logistic regression was used. The dependent variable was able to take three forms based on the site of surgery: inpatient, outpatient or ASC. The inpatient site of surgery was used as the base for comparison. Advances in medical technology create macro level trends over time and these trends were accounted for by using time fixed effects. There are also state level variations in government policy and healthcare preferences that were controlled for with dummy variables for each state and robust standard errors clustered by state. Discussions with ASC owners found that age, obesity, high blood pressure (hypertension) and the inability to stop smoking could all impact the site of surgery decision. These factors were controlled for in equation 1. The binary variable of interest is CON. By using inpatient as the base for comparison, a negative coefficient would signal that the hypothesis is true.

\[
\Pr \text{Site of Surgery}_{it} = \alpha + \beta \text{CON}_{it} + \gamma \text{Smoker}_{it} + \xi \text{Hypertension}_{it} + \delta \text{Obesity}_{it} + \pi \text{Age}_{it} + \phi \text{Age}^2_{it} + e_{it} \tag{9}
\]
The analysis was first run on both procedures together (ACDF and decompression) followed by each procedure separately. Risk ratios were then calculated to determine the magnitude of CON effect for each procedure and in each site of surgery. To test for differences in health seeking behavior, an analysis was run for males and females separately.

The hypothesis that states with unencumbered surgeon employment would have less private practice spine surgeons to open up ASCs and therefore less procedures performed in ASCs was tested in a similar way. The dependent variable was able to take the same three forms based on the site of surgery. The inpatient site of surgery was again used as the base for comparison. Variations between states and over time were controlled for using time and state fixed effects. Age, obesity, hypertension and the inability to stop smoking were additional covariates and the binary variable of interest is CPMD (equation 2). A negative CPMD coefficient compared to inpatient would make the hypothesis true.

\[
\Pr \text{Site of Surgery}_{it} = \alpha + \beta \text{CPMD}_{it} + \gamma \text{Smoker}_{it} + \zeta \text{Hypertension}_{it} + \delta \text{Obesity}_{it} + \pi \text{Age}_{it} + \phi \text{Age}_{it}^2 + e_{it} \tag{10}
\]

The analysis was first run on both procedures together followed by each procedure separately. Risk ratios were then calculated to determine the magnitude of CPMD effect for each procedure and in each site of surgery. To test for differences in health seeking behavior, an analysis was run for males and females separately.

4.2 Data

Data used for the analysis were derived from the Truven Health MarketScan® 2009 to 2015 Commercial Claims and Encounters and Medicare Supplemental and Coordination of Benefits Databases (Truven Health Analytics, Ann Arbor, Michigan). These databases represent the health services of approximately 170 million employees, dependents, and retirees in the
United States with primary or Medicare supplemental coverage through privately insured fee-for-service, point-of-service, or capitated health plans. The sample size for this paper based on the years and procedures of interest is 1,018,171. The Commercial and Medicare Supplemental Databases are generally representative of the surgical population in the United States in terms of gender (53% female). All enrollment records and inpatient, outpatient, ambulatory surgery center, ancillary, and drug claims were collected. The use of the MarketScan® databases has been well established in the literature resulting in more than 1,100 peer-reviewed publications (Analytics, 2016). There are in-patient and outpatient MarketScan® databases. Both were used for this paper, however the site of surgery explicitly listed in observation was taken as the location of the procedure, instead of the database that housed the procedure. In addition, both the location of Office and ASC were consolidated to form the ASC location. The spinal procedures analyzed require general anesthesia which is not appropriate for an office setting. Furthermore, private practices can add rooms to their office and perform ambulatory surgery through a physician office practice exemption. Due to macro level fluctuations, there will be variations in the total number of procedures done in each year, however, the relative frequency of the procedures done at each facility should be consistent, ceteris paribus. We used a multinomial logit model to assess any changes in the relative frequency of the site of surgery for ACDF or spinal decompressions. A multinomial probit model has previously been used to show how differences in incentives can impact the care decision and we chose a logit model to allow the calculation of risk and odds ratios (Bolduc, 1996) (Akin, 1995).

Variables used in this paper were either present in the data base or constructed using the Medicare Severity-Diagnosis Related Group (MS-DRG) codes, International Classification of Diseases, Ninth Revision (ICD-9) procedure (ICD-9P) and diagnosis (ICD-9D) codes or Current
Procedural Terminology (CPT®) codes. All MS-DRG codes associated with Decompression surgery (028, 029, 030, 518, 519, 520) and single stage Cervical Fusion (471, 472, 473) were included. In addition, CPT® codes were used to identify Cervical Fusion (22551) and Decompression (63047, 63030) in the outpatient database which does not use MS-DRG codes.

Co-morbidities of obesity (obesity), hypertension (hypertens) and tobacco use (smoker) were created based on the presence of a corresponding ICD-9D code. These co-morbidities were selected because they may lead the surgeon to suggest an inpatient surgical site. Codes used to identify obesity were 27800 or 27801 capturing patients reported to be both obese and morbidly obese. In addition to these codes, it is recognized that patients with other types of comorbidities would not be good candidates for surgery in an outpatient facility or ASC. There are specific MS-DRG codes (028, 029, 471, 472, 518, 519) for these patients and they were excluded from the analysis. Dummy variables for each year and each state were created to control for macro level variations over time and for any state-specific differences. The dependent variable was created based on the three different sites of surgery. The variable of interest CON was created based on the existence of a ASC specific CON as defined in section 2. The CPMD variable of interest was created for Tennessee, Ohio, Louisiana, Mississippi and Alabama based on expert legal opinion.

5. Empirical Results

Summary statistics of the data are in Table 7. There were 1,018,171 ACDF or decompression procedures used in the analysis that the patients had an average age of 54. Thirty-seven percent of procedures were performed in a state that had CON regulations and 26% of procedures were performed in states with a weak CPM doctrine. The frequency of patients
with identified diagnosis of obesity, depression, hypertension and smoking cigarettes can be observed.

Table 7: Summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1,018,171</td>
<td>53.961</td>
<td>13.569</td>
</tr>
<tr>
<td>Smoker</td>
<td>1,018,171</td>
<td>0.0739</td>
<td>0.262</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1,018,171</td>
<td>0.195</td>
<td>0.396</td>
</tr>
<tr>
<td>Obesity</td>
<td>1,018,171</td>
<td>0.044</td>
<td>0.205</td>
</tr>
<tr>
<td>Depression</td>
<td>1,018,171</td>
<td>0.044</td>
<td>0.205</td>
</tr>
<tr>
<td>CON program</td>
<td>1,018,171</td>
<td>0.37</td>
<td>0.483</td>
</tr>
<tr>
<td>Weak CPMD</td>
<td>1,018,171</td>
<td>0.26</td>
<td>0.439</td>
</tr>
</tbody>
</table>

The results are presented in the order of the hypothesis tested. The first set of tables present the results for the CON hypothesis followed by a second set of tables for the CPM doctrine. The first table for each tested hypothesis presents the empirical findings of policy impact and the second table will show a risk ratio calculation to quantify the magnitude of the policy impact.

The hypothesis that a CON program acts as a bureaucratic barrier to hospital competition leading to fewer procedures performed in lower cost settings was found to be true (Table 8). The three columns of the CON coefficient are for an analysis run on ACDF and decompression (column 1), ACDF alone (column 2) and decompression alone (column 3). The variable of interest is presented in the CON rows (there is one for each site of surgery as compared to inpatient) and the negative significant coefficients confirm the a priori hypothesis.
Table 9 presents the relative risk ratios in a similar manner. The relative risk ratios for the variable of interest were negative for both procedures combined (column 1) and for each procedure run separately (columns 2 and 3). Patients undergoing an ACDF procedure in a state with a CON program were 93% less likely to have the procedure performed in a hospital outpatient setting and 40% less likely to have the procedure performed in an ASC.
Table 10 shows the hypothesis that states with unencumbered surgeon employment would have less procedures performed in ASCs was found to be true. The variable of interest in this analysis was CPMD and the two rows of negative values show that fewer procedures were performed in hospital outpatient and ASC surgical sites as compared to the inpatient setting. The three columns show that the results were true for both procedures in aggregate (column 1) and
each procedure separately (columns 2 and 3). A difference in the healthcare preferences of males and females was present in the data.

Table 10: MLOGIT for the Corporate Practice of Medicine doctrine

<table>
<thead>
<tr>
<th>Site of Surgery: Outpatient</th>
<th>(1) ACDF/Dec</th>
<th>(2) ACDF</th>
<th>(3) Decomp</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPMD</td>
<td>-1.29920***</td>
<td>-1.02409***</td>
<td>-1.31867***</td>
</tr>
<tr>
<td>(0.04969)</td>
<td>(0.12194)</td>
<td>(0.04081)</td>
<td></td>
</tr>
<tr>
<td>Cigarette smoker</td>
<td>0.28245</td>
<td>0.56364</td>
<td>0.09665</td>
</tr>
<tr>
<td>(0.24615)</td>
<td>(0.36238)</td>
<td>(0.35668)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.16664</td>
<td>0.28099</td>
<td>0.01468</td>
</tr>
<tr>
<td>(0.15705)</td>
<td>(0.29787)</td>
<td>(0.21036)</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>-0.58838**</td>
<td>0.07181</td>
<td>-1.16140***</td>
</tr>
<tr>
<td>(0.24252)</td>
<td>(0.45896)</td>
<td>(0.29679)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.06416***</td>
<td>-0.11376***</td>
<td>-0.02511</td>
</tr>
<tr>
<td>(0.01717)</td>
<td>(0.03406)</td>
<td>(0.02083)</td>
<td></td>
</tr>
<tr>
<td>Age^2</td>
<td>0.00040**</td>
<td>0.00080**</td>
<td>0.00004</td>
</tr>
<tr>
<td>(0.00020)</td>
<td>(0.00035)</td>
<td>(0.00023)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site of Surgery: ASC</th>
<th>(1) ACDF/Dec</th>
<th>(2) ACDF</th>
<th>(3) Decomp</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPMD</td>
<td>-0.89261***</td>
<td>-0.89335***</td>
<td>-0.45359***</td>
</tr>
<tr>
<td>(0.04404)</td>
<td>(0.07989)</td>
<td>(0.0402)</td>
<td></td>
</tr>
<tr>
<td>Cigarette smoker</td>
<td>-0.38535**</td>
<td>-0.40280**</td>
<td>-0.41680*</td>
</tr>
<tr>
<td>(0.18019)</td>
<td>(0.19304)</td>
<td>(0.23111)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>-0.07854</td>
<td>0.07351</td>
<td>-0.27431**</td>
</tr>
<tr>
<td>(0.07675)</td>
<td>(0.12399)</td>
<td>(0.10803)</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>-0.36485*</td>
<td>-0.53722**</td>
<td>-0.44994*</td>
</tr>
<tr>
<td>(0.20278)</td>
<td>(0.26077)</td>
<td>(0.25053)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.04844***</td>
<td>-0.16334***</td>
<td>0.0128</td>
</tr>
<tr>
<td>(0.01218)</td>
<td>(0.01543)</td>
<td>(0.01806)</td>
<td></td>
</tr>
<tr>
<td>Age^2</td>
<td>0.00022</td>
<td>0.00124***</td>
<td>-0.00033</td>
</tr>
<tr>
<td>(0.00016)</td>
<td>(0.00017)</td>
<td>(0.00023)</td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>1018171</td>
<td>740550</td>
<td>277621</td>
</tr>
</tbody>
</table>

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level

Note: MLOGIT models with state and year fixed effects. CPMD indicates the procedure occurred in a state with a weak CPM policy. ACDF indicates an Anterior Cervical Discectomy Fusion. Decomp indicates a Decompression surgery.

The relative risk ratios in table 11 are presented in the same format as the previous tables. The negative coefficient for the variable of interest quantifies the magnitude of the impact in each surgical setting and for the different procedural combinations. For a decompression procedure, the risk ratio for outpatient was 0.2675. The ratio translates into a 73% decreased chance of having an outpatient decompression in a state with a weak CPM doctrine. The chance of having a decompression performed in an ASC is reduced by 34%. The risk ratios for an
ACDF are 0.359 for outpatient (64% less likely) and 0.410 for an ASC (59% less likely). All risk ratio values were statistically significant.

Table 11: MLOGIT risk ratios for the Corporate Practice of Medicine doctrine

<table>
<thead>
<tr>
<th>Site of Surgery: Outpatient</th>
<th>(1) ACDF/Dec</th>
<th>(2) ACDF</th>
<th>(3) Decompr</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPMD</td>
<td>0.2728***</td>
<td>0.359***</td>
<td>0.2675***</td>
</tr>
<tr>
<td>(0.0136)</td>
<td>(0.0438)</td>
<td>(0.0109)</td>
<td></td>
</tr>
<tr>
<td>Cigarette smoker</td>
<td>1.326</td>
<td>1.757</td>
<td>10.105</td>
</tr>
<tr>
<td>(0.3265)</td>
<td>(0.6367)</td>
<td>(0.3929)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.181</td>
<td>1.3244</td>
<td>1.015</td>
</tr>
<tr>
<td>(0.1855)</td>
<td>(0.3945)</td>
<td>(0.2135)</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>0.555**</td>
<td>1.0745</td>
<td>0.313***</td>
</tr>
<tr>
<td>(0.1347)</td>
<td>(0.4931)</td>
<td>(0.0929)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.938***</td>
<td>0.8925***</td>
<td>0.975</td>
</tr>
<tr>
<td>(0.0161)</td>
<td>(0.0304)</td>
<td>(0.0203)</td>
<td></td>
</tr>
<tr>
<td>Age^2</td>
<td>1.000**</td>
<td>1.0001**</td>
<td>1.000</td>
</tr>
<tr>
<td>(0.0002)</td>
<td>(0.0003)</td>
<td>(0.0002)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site of Surgery: ASC</th>
<th>(1) ACDF/Dec</th>
<th>(2) ACDF</th>
<th>(3) Decompr</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPMD</td>
<td>0.410***</td>
<td>0.409***</td>
<td>0.6353***</td>
</tr>
<tr>
<td>(0.0180)</td>
<td>(0.0327)</td>
<td>(0.0255)</td>
<td></td>
</tr>
<tr>
<td>Cigarette smoker</td>
<td>0.680**</td>
<td>0.668**</td>
<td>0.6592*</td>
</tr>
<tr>
<td>(0.1226)</td>
<td>(0.1290)</td>
<td>(0.1523)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.924</td>
<td>1.076</td>
<td>0.7607*</td>
</tr>
<tr>
<td>(0.0710)</td>
<td>(0.1334)</td>
<td>(0.0821)</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>0.694*</td>
<td>0.584**</td>
<td>0.6377*</td>
</tr>
<tr>
<td>(0.1408)</td>
<td>(0.1524)</td>
<td>(0.1598)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.953***</td>
<td>0.849***</td>
<td>1.013</td>
</tr>
<tr>
<td>(0.0116)</td>
<td>(0.0131)</td>
<td>(0.0183)</td>
<td></td>
</tr>
<tr>
<td>Age^2</td>
<td>1.000</td>
<td>1.001***</td>
<td>0.9997</td>
</tr>
<tr>
<td>(0.0002)</td>
<td>(0.0002)</td>
<td>(0.0002)</td>
<td></td>
</tr>
</tbody>
</table>

| Sample size                 | 1045171      | 740550   | 277621      |
| R2                          | 0.0506       | 0.006    | 0.0405      |

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level

Note: MLOGIT models with state and year fixed effects. CPMD indicates the procedure occurred in a state with a weak CPMP policy. ACDF indicates an Anterior Cervical Discectomy Fusion. Decompr indicates a Decompression surgery.

6. Discussion

The find that patients were less likely to have common spinal procedures performed in a lower cost setting when the state participates in a CON program has significant cost implications. Recall that ACDF procedures performed in the outpatient facility or ambulatory surgery center cost taxpayers (through Medicaid) 51 to 70 cents on the dollar - the savings for commercial payers are higher. The less expensive sites of surgery have been shown to have equivalent or
superior outcomes for the procedures studied (McGirt, 2015; Adamson, 2016; Tally, 2013) and for many other surgical procedures (Munnich, 2018). The data show that CON programs may enable rent seeking by incumbent hospital systems. Similar findings were present for spinal decompression.

There are important policy timing differences between the two procedures. CMS publishes an annual list of procedures that are only approved to be performed as a hospital inpatient. This so-called inpatient only list, contained the CPT® code for an ACDF until 2012. Once a CPT® code is removed from the inpatient only list, there is a period of time before the procedure appears on CMS’ ASC Payment list. Reimbursement for the ACDF CPT® code (22551) began in 2015 (CMS.gov). The ACDF coverage is in contrast to the CPT® codes for spinal decompression that were allowed by CMS in all of the facility types for the entire study period. Again, the procedures studied in this paper were from commercial payers that are not bound to follow the CMS guidelines, however surgeons see patients with a wide variety of insurance policies. The heterogeneity of patients makes identifying patients who are covered by a commercial payer that allows an ACDF in an ASC a complex task. The difference in results between a procedure that was in the process of migrating to outpatient facilities (ACDF) as compared to a procedure that has already migrated (decompression) is a topic for additional research.

The data contain 2,355 ACDF procedures that were done on patients over the age of 65 but were still working and covered by commercial insurance. Had the patients not been working, CMS’ inpatient only list would have made them ineligible to undergo the procedure in any setting other than an inpatient facility. Using a conservative assumption that all 2,355 patients would have been treated in an outpatient facility, Medicaid would have spent an addition $9
million for a similar outcome. Another example of unintended consequences with the inpatient only list includes a plate that is used in most US ACDF procedures. The plate is billed using CPT® code 22845. This CPT® code remained on the inpatient only list until 2017 - even though the fusion code was approved years earlier – which prevented many surgeons from performing the procedure in a lower cost setting. The inpatient only list has significant cost implications and the benefits of such a list is an area for additional research.

States with case law or other authority allowing the corporate practice of medicine, or exceptions to the doctrine permitting relatively unfettered physician employment had fewer procedures in low cost facilities. This finding applies to both ACDF and decompression procedures. Again, the hypothesis is that a weak doctrine leads to fewer private practice surgeons which decreases the supply of surgeons who would own an ASC. The data show a significant relationship and further research is needed to prove or disprove the theoretical mechanism.

The market for surgeon employment has transitioned from one where most physicians were in private practice to one of hospital employment (Charles, 2013). There are many factors driving these trends and it has become a controversial topic. Proponents of physician employment highlight the improvements in alignment that comes from a common “boss” and many physicians enjoy being able to focus on patient care instead of all the complexity that comes from running a business. Detractors of physician employment frequently cite traditional monopoly power concerns such as lower quality and higher prices that come from reduced competition. It is not clear that traditional measures of market concentration such as the Herfindahl-Hirschman Index (HHI) are considered when a hospital system buys the two cardiology groups in a town effectively giving it a monopoly on cardiac care.
Other than the indirect mechanism of action required for a true hypothesis, there are further limitations of this study. First, while the CON program is well known by the spine surgeon community, our experience is that very few surgeons are aware of the CPM doctrine. Attempts were made to avoid information asymmetry challenges by identifying states with a weak doctrine, but the fact that surgeons are generally unaware of the doctrine means that it does not factor into the decision making of a critical stakeholder. In addition, the analysis was retrospective in nature and relied on private payer claims data that omits many variables – such as patient outcomes, patient education, marital status, etc. Marital status and the patient’s level of education have been collected in randomized clinical trials comparing inpatient and outpatient procedures and could be important omitted variables (Krywulak S, 2005). The data also excluded the largest payers in the US, Medicare and Medicaid. Further studies with a more complete dataset will be needed to validate the CPM results.

There are also important limitations with the CON analysis in this paper. The first is that the study was retrospective in nature. The second is that larger private practices are more likely to vertically integrate and own ambulatory surgery centers. Large private practices also have bargaining power with payers and hospitals and are often too profitable to be realistic acquisition targets for a hospital. We are not aware of any method to objectively quantify the strength of private practices in each state and had no such metric in the analysis. Finally, as mention in the CPM section, the claims data set was limited in the variables collected and excluded Medicare and Medicaid. Further studies are required to validate the findings.

7. Conclusion

For the years 2009-2015, data analysis of more than one million procedures using commercial payer data shows that states that still have a CON program have less ACDF and
decompression procedures performed in lower cost settings. Patients who underwent an ACDF in CON states were 93% less likely to have that procedure performed in a hospital outpatient facility and 40% less likely to have the procedure performed in an ASC. Policy makers in states with an active CON program should review the merits of the policy and those making national policy decisions on facility reimbursement should consider the potential cost savings of lower cost settings, such as an ASC, when setting fee schedules. Similar trends were found in states with a weak CPM doctrine.

The monopoly power and potential rent seeking in large hospital systems should be a topic for open debate. This is especially true in situations with specialty providers, such as spine surgeons, where control of the referral path by hospital systems employing primary care physicians can determine the market outcome.

Lastly, there are common, expensive operations such as spine and orthopedic procedures where improvements in healthcare technology can reduce cost and regulation stymies progress. The inpatient only list is an example of a regulation that may have more costs than benefits. The 2017 inpatient only list has the CPT® codes for hip (27130) and knee (27447) arthroplasty even though both procedures have been performed in outpatient facilities for more than 10 years (Berger, 2005) (Bertin, 2005). Bertin (2005) found that hip arthroplasty was $4,000 cheaper in the outpatient setting and the CJR program was rolled out national based on a per procedure pilot savings of $864.
References


PAINLESS PARKER V. BOARD OF DENTAL EXAM, 216 Cal. 285 (Court of Appeal of California 1932).
