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Effects of a Commercial Insurance Policy Restriction on Lumbar Fusion in North Carolina and the Implications for National Adoption

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Abstract

Study design—Analysis of the State Inpatient Database of North Carolina, 2005–2012, and the Nationwide Inpatient Sample, including all inpatient lumbar fusion admissions from non-federal hospitals.

Objective—To examine the influence of a major commercial policy change that restricted lumbar fusion for certain indications, and to forecast the potential impact if the policy were adopted nationally.

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The device(s)/drug(s) is/are FDA-approved or approved by corresponding national agency for this indication.

Summary of Background Data—Few studies have examined the effects of recent changes in commercial coverage policies that restrict the use of lumbar fusion.

Methods—We included adults undergoing elective lumbar fusion or re-fusion operations in North Carolina. We aggregated data into a monthly time series to report changes in the rates and volume of lumbar fusion operations for disc herniation or degeneration, spinal stenosis, spondylolisthesis, or revision fusions. Time series regression models were used to test for significant changes in the use of fusion operation following a major commercial coverage policy change initiated on January 1st, 2011.

Results—There was a substantial decline in the use of lumbar fusion for disc herniation or degeneration following the policy change on January 1st, 2011. Overall rates of elective lumbar fusion operations in North Carolina (per 100,000 residents) increased from 103.2 in 2005 to 120.4 in 2009, before declining to 101.9 by 2012. The population rate (per 100,000 residents) of fusion among those under age 65 increased from 89.5 in 2005 to 101.2 in 2009, followed by a sharp decline to 76.8 by 2012. There was no acceleration in the already increasing rate of fusion for spinal stenosis, spondylolisthesis or revision procedures, but there was a coincident increase in decompression without fusion.

Conclusions—This commercial insurance policy change had its intended effect of reducing fusion operations for indications with less evidence of effectiveness without changing rates for other indications or resulting in an overall reduction in spine surgery. Nevertheless, broader adoption of the policy could significantly reduce the national rates of fusion operations and associated costs.

Keywords

Lumbar Spinal Fusion; Degenerative Disc; Disc Herniation; Coverage and Reimbursement; Blue Cross Blue Shield of North Carolina

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Insurance coverage policies can influence clinical practice and promote appropriate use of interventions. Inappropriate use not only adds cost, it can expose patients to potential iatrogenic harm without a clear increase in benefit. Questions about appropriate use of lumbar fusion in the treatment of low back pain secondary to degenerative disc disease prompted the Medicare Coverage Advisory Committee to initiate a review in 2006.[1] Since then, payers have increasingly implemented policies that scrutinize use of this procedure.[2, 3] Broader coverage for lumbar fusion surgery is associated with more frequent use, greater use of more complex procedures, higher incidence of surgical complications, and more repeat operations.[4] One approach to change practice has been to restrict coverage for surgical indications with weaker evidence of effectiveness. However, empirical data are lacking on the effects of policy changes on use of lumbar fusion.

There is fairly strong evidence that fusion surgery is effective for some widely-accepted surgical indications, such as spondylolisthesis, fractures, and scoliosis.[5, 6] However, for degenerative disc disease (DDD), lumbar fusion is controversial, and may not be more effective than structured non-operative care.[2, 7, 8] For patients with disc herniation (HNP) or spinal stenosis, decompression without fusion is supported by strong evidence, but the addition of fusion has not been shown to improve outcomes.[9, 10] For these conditions, fusion surgery often exposes patients to additional surgical complications with little advantage over decompression alone.[11–13]

Based on this evidence, the dominant commercial insurer in North Carolina, Blue Cross Blue Shield of North Carolina (BCBSNC), initiated a requirement for prior review of lumbar fusion procedures on January 1st, 2011, issuing denials of coverage where the sole indication was disc herniation (HNP), degenerative disc disease (DDD), stenosis in the absence of spondylolisthesis, initial discectomy/laminectomy for neural structure decompression, or facet syndrome.[14]

Though not well-suited for studying treatment efficacy, observational studies using insurance claims are well suited to measure the effect of healthcare policies because they track all patients in a population, wherever they may receive care. Therefore, they are less susceptible to selective referral, surveillance bias, reporting bias, and small sample variability.

Using statewide discharge databases, we examined trends in lumbar fusion operations, by surgical indication, in relation to the policy change implemented on January 1st, 2011 for lumbar fusion in North Carolina. When a fusion procedure is not performed, a common alternative is a decompression alone, so a policy curtailing fusion surgery might be expected to lower overall surgical rates, increase use of decompressions without fusion, or both. We expected the use of fusion to decrease for HNP and DDD indications, but wanted to estimate the magnitude of this “policy effect” and to forecast the potential impact if such a policy were implemented on a national scale. We did not expect to see a similar decrease for fusions used with spinal stenosis, an indication more common among older people covered by Medicare.

Methods

Data sources

We examined the State Inpatient Database (SID) and State Ambulatory Surgery and Services Database (SASD) for North Carolina. The Agency for Healthcare Research and Quality (AHRQ) maintains SID and SASD, which are components of the Healthcare Cost and Utilization Project (HCUP).[15] Data from HCUP has previously been used to study spinal procedures.[16–20] Variables provided by these all-payer inpatient (SID) and ambulatory (SASD) discharge registries include diagnosis and procedure codes, patient demographics, and charges from non-federal hospitals and from hospital-owned and freestanding ambulatory surgical and outpatient surgery facilities. Up to 33 diagnosis and 24 procedures codes from the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM), are listed with each discharge summary in SID; and each SASD visit summary contains up to 30 procedure codes from the American Medical Association’s Current Procedural Terminology (CPT) and up to 33 ICD-9-CM diagnosis codes. Sex- and age-stratified (by 5-year increments) population datum specific to North Carolina, available from the U.S. Census, were used as a denominator for deriving statewide procedure rates. National population data were applied to derive national rate estimates.[21] Hospital cost-tocharge ratios were obtained from HCUP to estimate the trends in aggregated costs for spinal admissions over time.

The 2005–2012 National Inpatient Sample (NIS), available through AHRQ, was used to estimate the potential impact of a broader implementation of a non-coverage policy on a national scale. The National Inpatient Sample is a nationally representative sample of discharge summaries from non-federal hospitals in the United States commonly used to track trends in inpatient procedures. As with the state data, participating hospitals submit uniform patient demographics, discharge disposition, hospital charges, and diagnosis and procedure codes to AHRQ's central distributor. Survey weighting and sampling design variables are included with the data to produce national estimates of utilization. We applied the revised 2012 longitudinal weights created for trend analyses.

Study population

We identified adults (age 20 or older) who had a thoracolumbar, lumbar, or lumbosacral fusion for degenerative spinal conditions in North Carolina from 2005 through 2012. We included all fusion operations reported by non-Federal facilities in North Carolina (n = 57,813), including 2,360 (4.1%) that derived from the ambulatory database (SASD). Patients were selected using a validated algorithm based on ICD-9-CM and CPT diagnosis and procedure codes, with 98% sensitivity and 99.1% specificity for correctly identifying fusion cases.[22, 23]

We excluded patients with non-degenerative spinal pathology such as vertebral fractures, spinal cord injury, intraspinal abscess, or inflammatory spondylopathy. We also excluded patients with admissions coded for accidents, neoplasm, immune deficiency, osteomyelitis, and cervical or thoracic procedures. Lumbar fusion operations combined with decompressions were included, as were patients with codes implying previous spine operation (e.g., "refusion"). However, patients undergoing artificial disc replacement, corpectomy, osteotomy, or kyphectomy were excluded. Admissions involving an insertion of spinal spacers or dynamic stabilizing devices were only included if co-coded with a fusion operation.

Classifying surgical indications

All diagnosis and procedure codes available for each admission were used to designate surgical indication. This was accomplished by using a previously published hierarchical coding algorithm, grouping cases as: revision spine operations (top of hierarchy), scoliosis, spondylolisthesis, stenosis, disc herniation (with and without myelopathy), and disc degeneration (e.g. spondylosis).[22] Admissions for disc herniation or degenerative disc disease were combined into a common variable since these were the primary indications targeted by the policy restriction. To further simplify the presentation, we also combined admissions related to spondylolisthesis or scoliosis.

Decompression procedures

We examined combined trends for laminectomy, laminotomy, and discectomy procedures (herein "decompression without fusion") in North Carolina over the same period. For this analysis, we included all inpatient admissions and outpatient operations for decompression without fusion, but otherwise applied the same inclusion and exclusion criteria used to define the fusion cohort.

Covariates

Because changes in patient characteristics could explain changes in fusion (and decompression) procedure rates over time, we described changes in age, sex, comorbidity, previous surgery, and surgical indication in our cohorts. An “enhanced” version of the Charlson index was used to measure comorbidity, grouped as “none”, “one”, or “two or more”.[24]

Costs

Trends in the hospital costs for inpatient fusion operations excluded professional fees and non-covered services. The medical component of the Consumer Price Index was used to adjust costs from earlier years to their 2012 equivalents.[25]

Analysis

Differences in patient characteristics, comorbidity, diagnoses, and operative features were summarized, with chi-square or t-test comparisons between the years before and after the policy change was implemented on January 1st, 2011.

We then aggregated the volume of fusion procedures into a monthly time series. A smoothing function was used to examine trends in the crude (unadjusted) rates and volume of fusion operations over time. To test whether there was a significant change in using fusion after the policy was implemented, we used Autoregressive Integrated Moving Average (ARIMA) adjusting for the monthly proportional changes in the distributions of sex, mean age, and mean comorbidity index. An ARIMA is a regression model for time series data that incorporates both a smoothing function to eliminate idiosyncratic variability (“moving average”) and a function to improve the estimate for each month based on its correlation with the estimate from the previous month (“auto-regressive” component). The outcomes for our models were the month-to-month change (i.e. the first difference) in the rate and volume of lumbar fusion operations, adjusting for the monthly proportional change in mean age, percent female, and mean comorbidity. To understand the policy effect, we separately documented changes in procedure rates by surgical indication and by insurance type (public and private payers). We also examined whether there was a coincident increase in use of decompression without fusion. Hypothesis testing was based on significance of the difference in the regression coefficient for each outcome before-versus-after implementation of the policy on January 1st, 2011, using a two-sided alpha level of 0.05.

Mean admission costs were estimated using generalized linear regressions, adjusting for age, sex, comorbidity, previous surgery, and diagnosis.

We applied the “policy effect” from North Carolina to the observed fusion operation rates in the Nationwide Inpatient Sample in order to estimate the potential impact of a national policy change. The estimated “policy effect” from North Carolina is the indication-specific ratio of the observed fusion volume to the expected volume if there were no change in the coverage policy, estimated by forecasting the monthly pre-policy trend through 2014. The ratio of observed-to-expected volume serves as a measure of the potential "policy effect". Applying this ratio to the national data allowed us to estimate the number of fusion operations that might have been avoided by a national policy change, along with associated hospital costs reduction. Separate estimates were created for only those over age 65 and based on whether decompression without fusion serves as a substitute procedure.

All analyses were performed using StataMP, version 13 (College Station, TX). A waiver of human subjects review for publicly available data was obtained from the Committee for the Protection of Human Subjects at Dartmouth College.

Results

Study population

We identified 67,783 lumbar spinal fusion operations for degenerative or revision diagnoses in North Carolina from 2005 through 2012. We excluded 9,970 procedures (14.7%; Table 1), leaving 57,813 eligible, including 11,145 (19.3%) for patients who had a previous lumbar spine operation.

NC Policy Effect

We observed marked differences in rates and volume of fusion operations in North Carolina following the January 1, 2011 implementation of the policy change (Figure 1). The annualized age-, sex-, and comorbidity-adjusted rate of lumbar fusion (all indications) per 100,000 residents of North Carolina increased from 103.2 in 2005 (6,173 fusion procedures) to a peak of 120.4 in 2009 (8,189 fusion procedures), before decreasing to 101.9 (7,555 fusion procedures) in 2012. The volume of fusion operations increased, on average, by 36 cases per year prior to the policy change. This was followed by a decrease of 94 cases per year after the policy was implemented ($p<0.001$).

In contrast to the trends for fusion surgery, the rate of lumbar decompression significantly increased in North Carolina following the policy change on January 1st, 2011 (Figure 1, $p=0.004$). In absolute volume, the increase in decompression was approximately equivalent to the decrease of fusion operations. The annualized population rate of decompression procedures in North Carolina decreased from 185.9/100,000 in 2005 (11,265 procedures) to 144.1/100,000 (10103 procedures) in 2010, followed by an increase to 150.7/100,000 (10973 procedures) in 2012.

The decrease in lumbar fusion combined with the corresponding increase in decompression without fusion resulted in an overall slight decrease in the rates of spine surgery that did not achieve statistical significance ($p = 0.346$; table 3).

The mean age of patients undergoing lumbar fusion following the initiation of the policy change was 58.7 years, compared to 55.9 among those in the previous years (Table 2, $p < 0.001$). There was no pre-post difference in the distribution of sex ($p=0.560$). There was a slightly, but statistically significantly, greater proportion of Blacks and Asians undergoing fusion surgery in the years following the policy change (p=<0.001). Patients undergoing fusion operations after the initiation of the policy had more comorbidity (p=0.001) and were more likely to be receiving public insurance (p=<0.001), compared to those before the policy change.

A smaller proportion of fusion admissions after the policy change was initiated had a length of stay of four or more days (Table 2). In addition, the proportion of fusion operations involving combined surgical approaches, stabilizing instrumentation, and 4 or more vertebrae (3 or more disc levels) were all slightly greater after initiation of the policy change. Use of Bone Morphogenetic Protein was lower in the post policy period than in the pre-policy period.

Changes in the volume of fusion operation following the policy change varied by surgical indication (Figure 2). Table 3 provides the corresponding results of the ARIMA time-series regression models. Separate fusion models were estimated for each surgical indication. The beta coefficients for each parameter represent the average monthly change in volume, controlling for other factors included in the model. For example, a one percent increase in the proportion of females undergoing a fusion is associated with one additional lumbar fusion of any diagnosis per month (coef 1.047, not significant). The change in the monthly volume of fusions (any diagnosis) decreased by nearly 8 procedures per month after the policy change was initiated (coef −7.86, p<0.001). After controlling for age, sex and comorbidity, there was a significant decrease in fusion for HNP or DDD following the non-coverage policy (p<0.001). The policy effect was similar for these two surgical indications. On average, fusions procedures for these indications increased by 11 cases per year prior to the policy change, followed by a decrease of 71 cases per year following the policy. There was no change in fusion rates for spinal stenosis, revisions operations, or spondylolisthesis and scoliosis (combined) following the policy change.

By 2012, a greater volume of fusion operations was being performed among publicly insured patients. While the annualized population rate of fusion increased among those 65 or older, from 168.1/100,000 in 2005 to 221.0/100,000 in 2012, the rate decreased among those under age 65, from 89.5/100,000 in 2005 to 76.8/100,000 in 2012 (after peaking at 101.2/100,000 in 2009). Trends in the use of fusion following the policy change were more pronounced for those covered by commercial insurers than those covered by public insurers (Figure 3). In addition, the decrease in fusion operations following the initiation of the policy was slightly more pronounced among those covered by BCBSNC than those covered by other commercial policies.

Hospital cost

The reduction in the volume of fusion operations in North Carolina following the policy change resulted in a significant decrease in the trends in aggregate hospital costs (Figure 4). Prior to the January 1st, 2011 policy change, the total annual hospital costs for fusion operations in North Carolina increased 96%, from $149.7 Million in 2005 to $292.7 Million in 2010. Hospital cost then decreased in 2011 before stabilizing by 2012.

Estimated National Policy Impact

In examining U.S. trends from the National Inpatient Sample, we found that following several years of steady increases, the population rates of fusion surgery for HNP and DDD in the United States have decreased since 2010 (Figure 5). The estimated impact of a policy change if scaled to a national level, shown in Figure 5, displays both the observed and hypothetical "expanded policy" trends in the United States. A policy adopted on January 1, 2011 might have resulted in 3,712 fewer fusion operations by the end of 2013 (Table 4). If the policy change were scaled to a national level, we estimate a potential hospital cost reduction of $270 Million during the first three years (or $185 million if decompression procedures increased proportionally). This represents approximately 3% of total hospital costs for elective fusion.

Discussion

Lumbar fusion operations for HNP or DDD indications decreased precipitously in North Carolina following the initiation of a commercial policy change that targeted these select indications. While there was no evidence of acceleration in the ongoing rise of fusions for spondylolisthesis, scoliosis, or spinal stenosis, there was a concomitant increase in decompression without fusion during the study period. The overall effect of these trends was a slight, non-significant, decrease in overall volume of spine operations.

Decreasing rates of lumbar fusion operations for HNP or DDD, without a commensurate increase for other indications, suggests that the policy change had its intended effect of reducing the use of fusion for these indications. The effect of the policy change on fusion operations was greater among those covered by commercial insurers than for those covered by public insurance, and greater for those covered by BCBSNC than for other commercial insurers. From a payer perspective, the policy change had its intended effect of increasing the proportion of fusion procedures performed for indications supported by stronger evidence. Broader adoption of the policy targeting select indications could significantly reduce the national rates of inpatient fusion admissions and corresponding hospital costs, even if decompression without fusion simultaneously increased.

While we observed a clear reduction in the use of fusion surgery for HNP and DDD, the lack of change in the use of fusion surgery for spinal stenosis may be because stenosis is more common in an older, publicly insured population, or because of diagnostic overlap between stenosis and spondlylolisthesis.

We used population-based data to document the effects of a policy change that targets the use of fusion operations for selected indications. Our longitudinal study complements previous cross-sectional comparisons that have found similar coverage and reimbursement policies to be influential, explaining a large proportion of practice variation in fusion operations.[4] The BCBSNC policy change covers fusions that it defines as "medically necessary" and instituted an appeal process for non-covered fusions. Some have argued that the development of this policy was not transparent and that it failed to cite clinical evidence to support the coverage decision.[26] However, the new policy is similar to that previously initiated in Washington State, which has had similar effects.

Our findings have several limitations. Our analysis only shows a decrease in utilization of fusion, and does not provide any information on outcomes for patients. Because HCUP data do not enable us to identify patients who were either denied a fusion or were never considered for fusion as a consequence of the policy change, we cannot know what alternative treatment(s) they received. HCUP data lack clinical detail such as patient reported pain and function, image findings, and specific vertebral level(s) operated on. Future comparative effectiveness and policy research is needed to consider the clinical implications and patient-reported outcomes among patients undergoing spinal operations. Of particular interest is the need to document the rate at which these patients have additional operations. Additional operations could potentially lessen the long-term cost savings, although the rates of reoperation following an initial fusion appear higher than decompression alone, and are more costly. Our reliance on an observational research design precludes a direct inference that the changes in use of fusion operation for HNP and DDD were caused by the policy change, or that decompression without fusion served as a substitute procedure. Factors other than the implementation of the policy could have driven the changes we observed, although this seems unlikely given the specificity of the effect on targeted surgical indications and the specific insurance carrier that implemented the policy change. It is also unlikely there was a sudden change in the underlying pathology of patients undergoing spinal operations coincident with the initiation of the policy change, especially given several preceding years of stable increases in volume.

Insurers have increasingly initiated policies intended to reduce the use of lumbar fusion for disc herniation and degenerative disc disease.[14, 27] From a payer perspective, these policies appear to have the intended effect of making the use of lumbar fusion more concordant with clinical evidence, but did not reduce the overall rate of lumbar spine surgery or potential “overuse” of surgery in general. Despite an initial decrease, hospital costs for fusion started to increase again in 2012. Longer term data are necessary to determine whether the policy effect on procedure rates and cost will be sustained.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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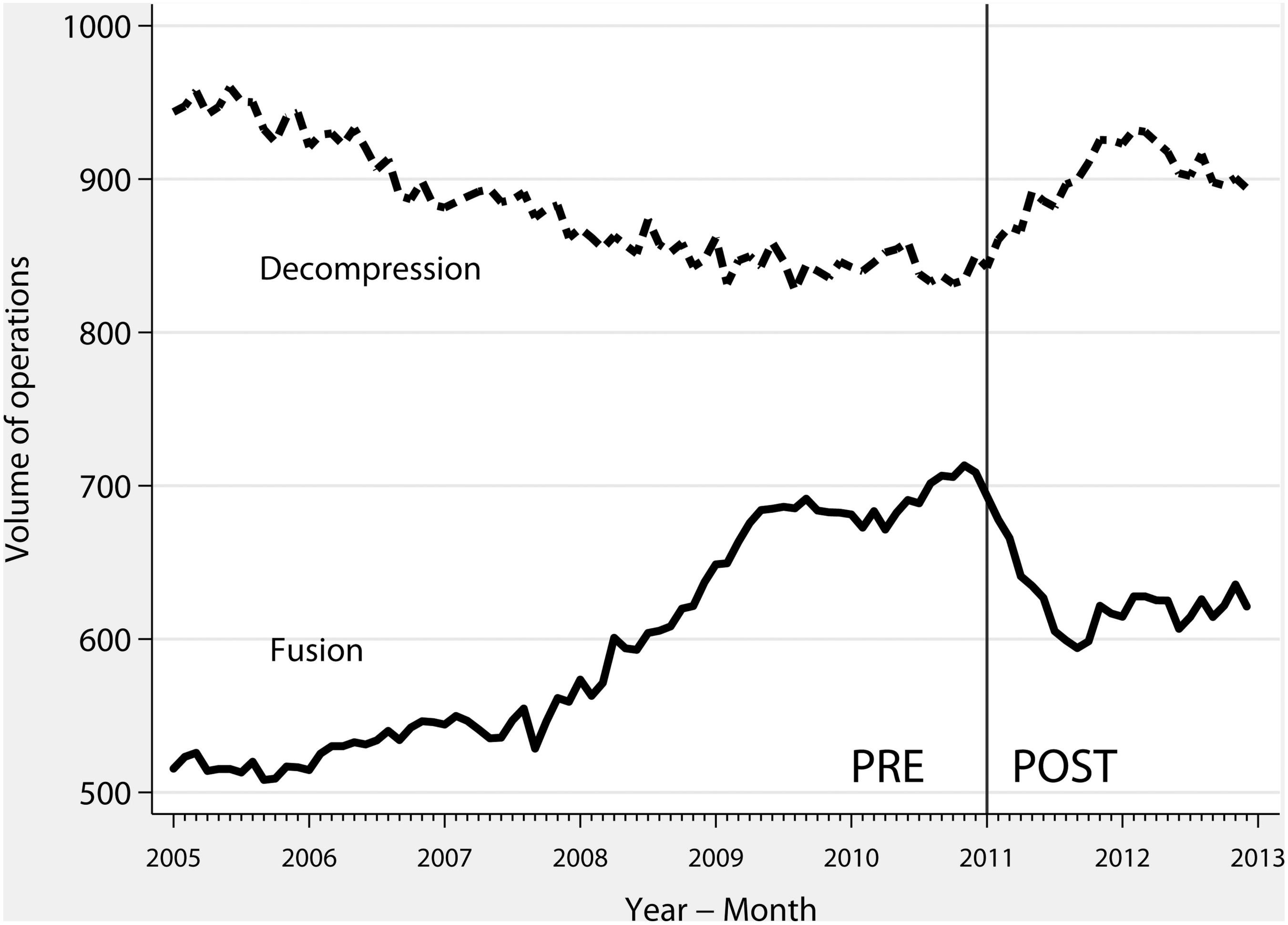

Figure #1.
Monthly trends in volume of lumbar spine surgery in North Carolina, before and after commercial coverage policy change.

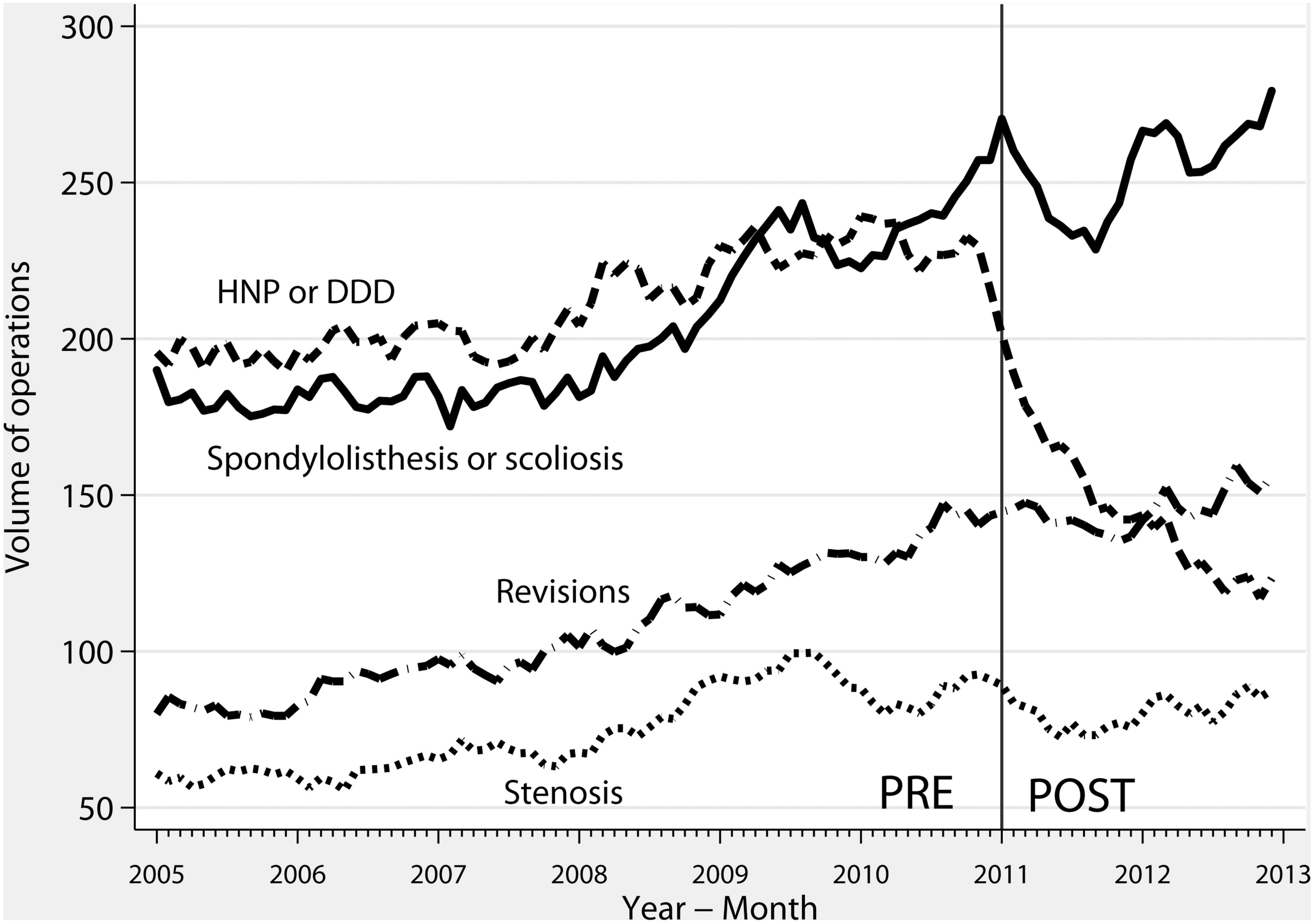

Figure #2.
Monthly trend in volume of lumbar fusion surgery in North Carolina by surgical indication, before and after commercial coverage policy change.

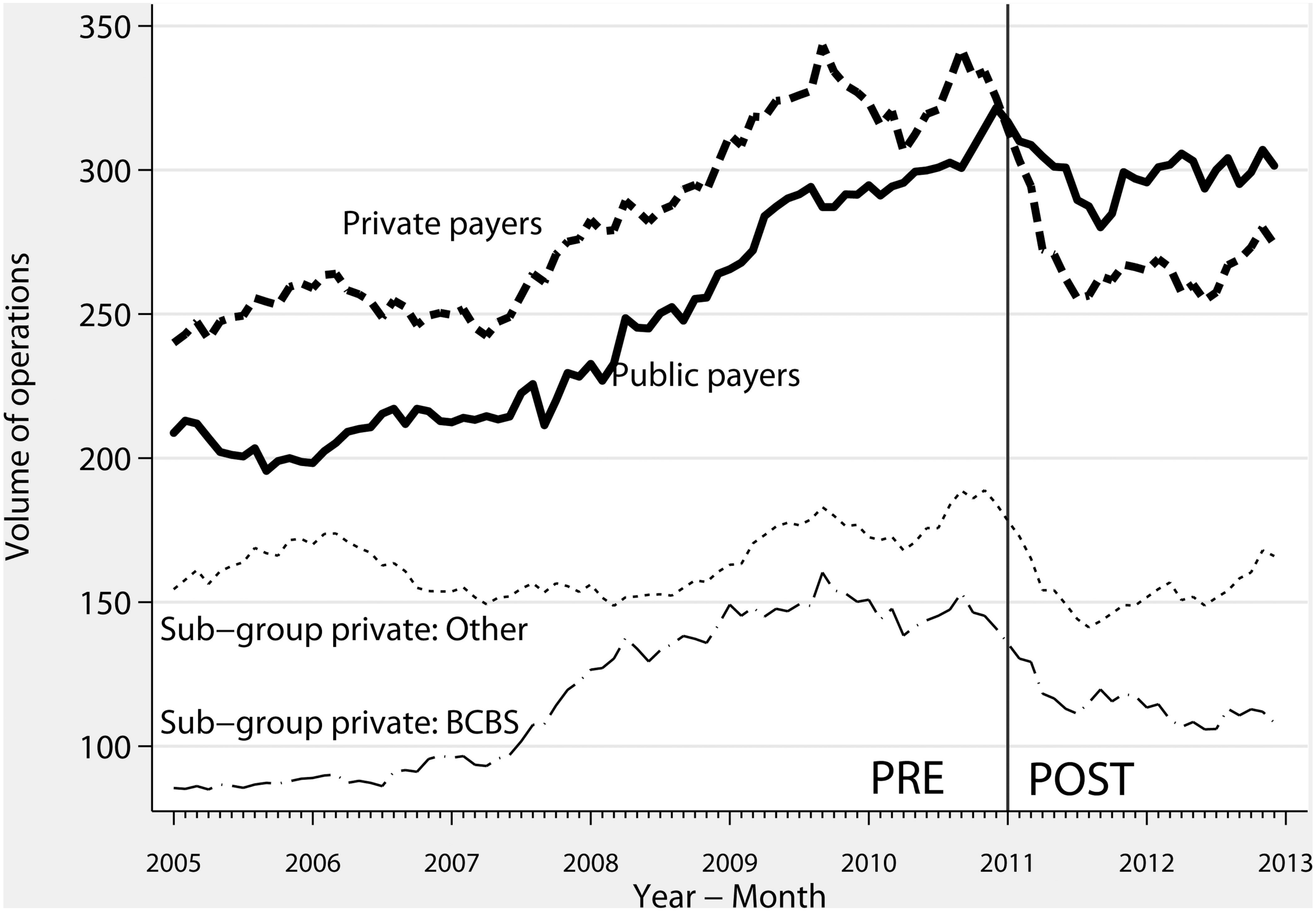

Figure #3.
Monthly trend in volume of lumbar fusion surgery in North Carolina by insurance type, before and after commercial coverage policy change.

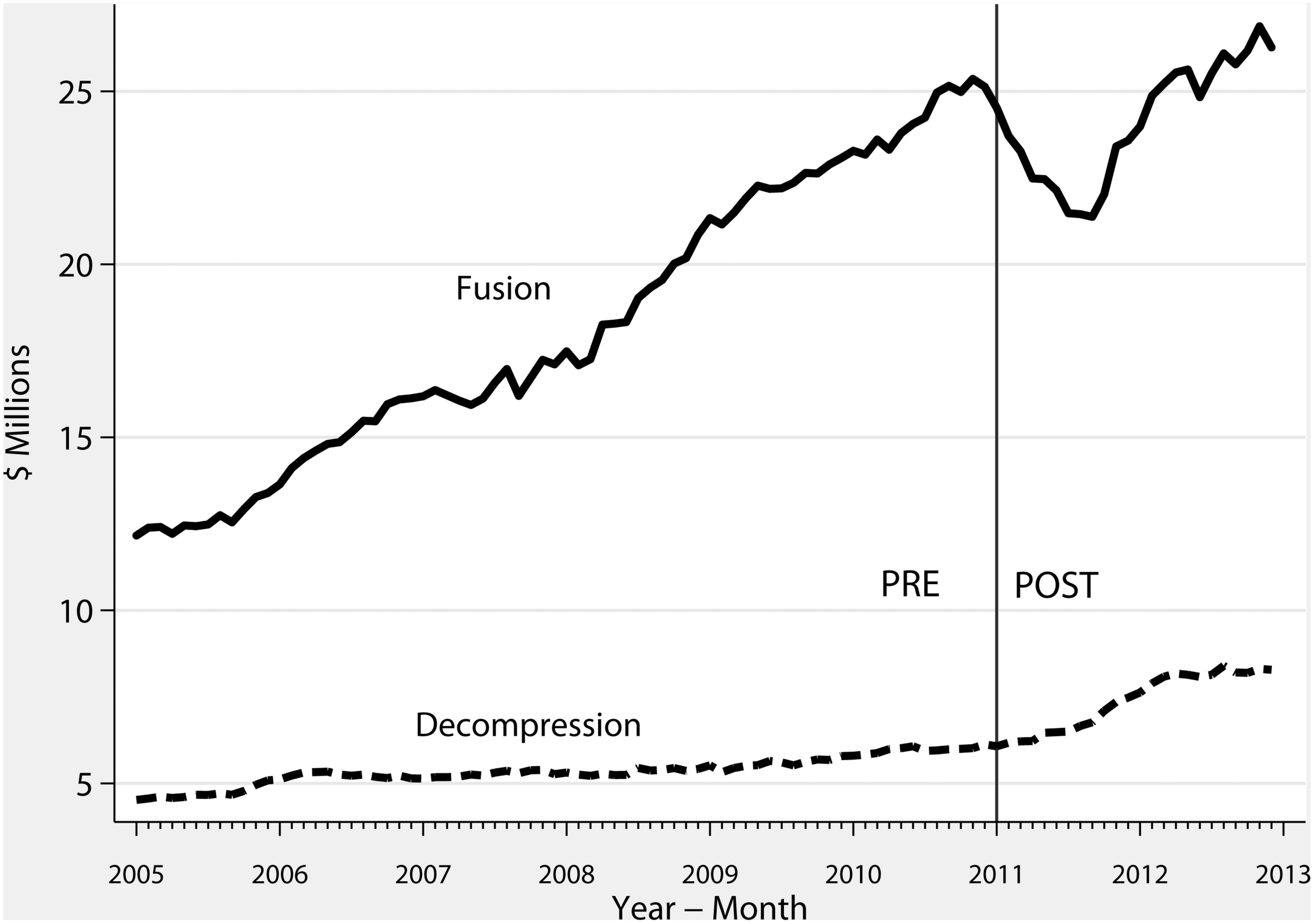

Figure #4.
Monthly trend in hospital costs for spine surgery in North Carolina by type of surgery, before and after commercial coverage policy change.

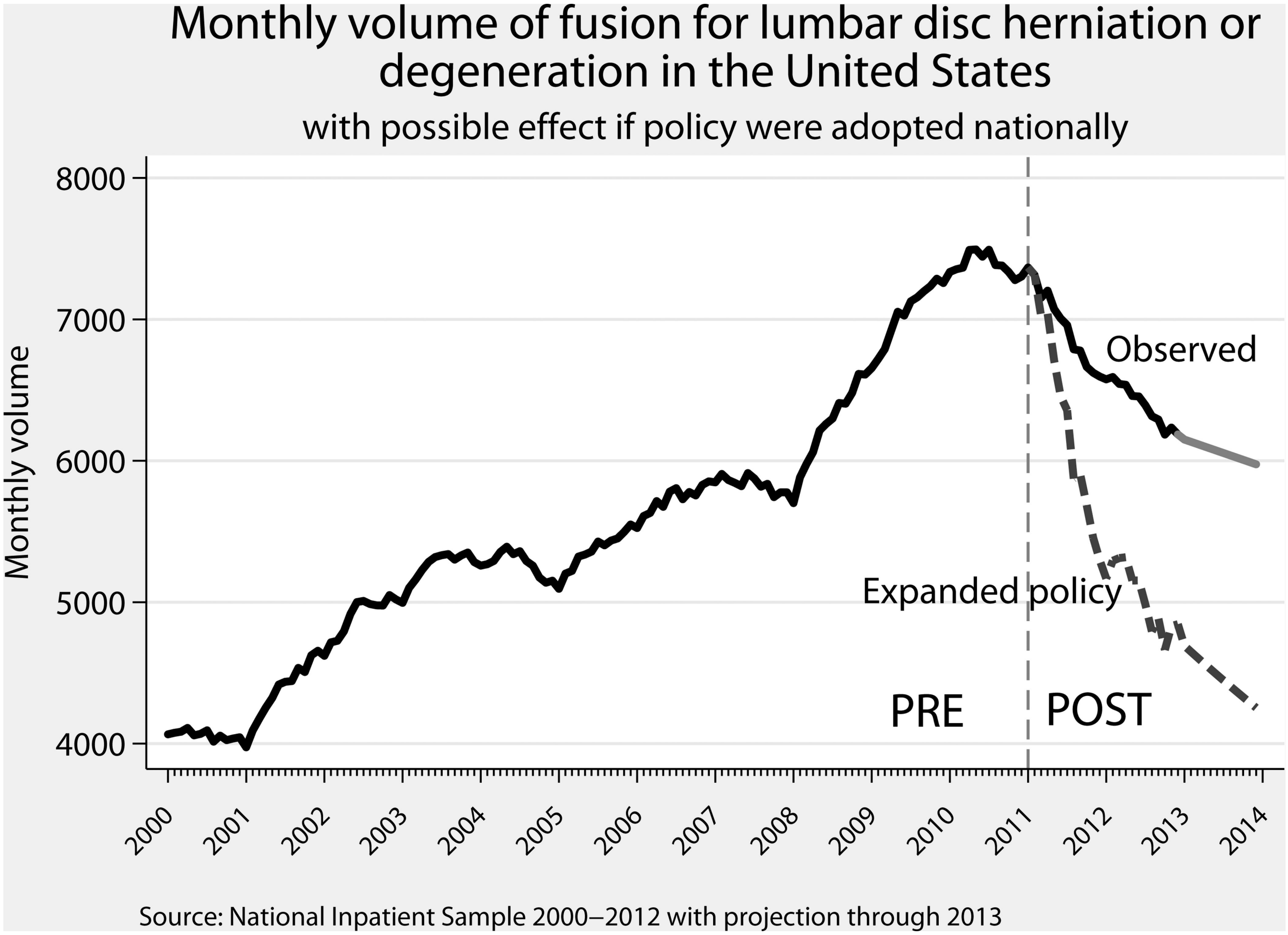

Figure #5.
Monthly trends in volume of fusion for disc herniation or decompression in the United States, with possible effects of expanding the policy change

Table 1

Inclusion and exclusion summary

	Pre Policy	Post Policy	All
Included admissions			
Lumbar fusion for degeneration or revision diagnosis	49610	18173	67783
Excluded Diagnosis			
Fracture or dislocation	1787	782	2569
Spinal Cord Injury	88	57	145
congenital or other anomaly	2074	1146	3220
Inflammatory spondylopathy	112	90	202
Excluded Procedures			
Artificial disc replacement	152	37	189
Open treatment of fracture	458	212	670
Excluded Comorbidity			
Cancer	471	231	702
Neurological impairment	214	194	408
Immune deficiency	50	37	87
Intraspinal Abscess	75	53	128
Osteomyelitis	175	94	269
Pregnancy	*	*	*
Other exclusions			
Trauma	383	167	550
Drug abuse	79	37	116
Age under 20 years	2081	757	2838
Summary Inclusion and Exclusion			
All inclusion criteria	49610	18173	67783
Any exclusion	6823	3147	9970
Final cohort size	42787	15026	57813

Source: Agency for Healthcare Research & Quality's SID and SASD from North Carolina, 2005–2012.

Pre and post-policy periods defined by policy initiated on January 1st, 2011.

[*] values suppressed based on reporting guidelines for tables with cell counts <= 10 cases

Table 2

Sample characteristics

	Pre Policy	Post Policy	All	p-value
Age				
Age (mean)	55.9	58.7	56.6	<0.001
Age 20 to 65 (%)	70.3	62.5	68.2	<0.001
Age 65 or older (%)	29.7	37.5	31.8	
Sex				
Male (%)	41.1	40.8	41.0	0.560
Female (%)	58.9	59.2	59.0	
Race				
White (%)	86.4	84.9	85.9	<0.001
Black (%)	10.7	12.8	11.5	
Asian (%)	0.2	0.8	0.5	
Other or Multiple (%)	2.6	1.5	2.2	
Comorbidity				
None (%)	65.0	60.9	64.0	<0.001
One (%)	26.7	27.6	26.9	
Two or more (%)	8.2	11.5	9.1	
Insurance				
Medicare (%)	34.3	41.5	36.2	<0.001
Medicaid (%)	6.9	6.9	6.9	
Commercial (%)	48.0	43.2	46.8	
Other or uninsured (%)	10.8	8.3	10.1	
Length of stay				
One day (%)	10.1	10.7	10.3	<0.001
Two days (%)	12.8	16.7	13.8	
Three days (%)	26.0	27.3	26.3	
Four days (%)	22.1	19.5	21.5	
Five or more days (%)	29.0	25.9	28.2	
Diagnosis				
Disc herniation or degeneration (%)	43.1	30.9	39.9	<0.001
Stenosis (%)	16.5	19.2	17.2	
Spondylolisthesis or scoliosis (%)	38.8	48.2	41.3	
Revision without other diagnosis (%)	1.6	1.8	1.6	
Operative characteristics				
Combined surgical approach (%)	13.1	15.7	13.8	<0.001
Stabilizing instrumentation (%)	62.1	68.0	63.7	<0.001
Bone morphogenetic Proteins (%)	29.1	21.4	27.1	<0.001
3+ disc levels fused (%)	17.1	18.8	17.5	<0.001

Source: Agency for Healthcare Research & Quality's SID and SASD from North Carolina, 2005–2012.

Pre and post-policy periods defined by policy initiated on January 1^{st}, 2011.

Table 3

Time series regression model for the monthly volume of lumbar surgey in North Carolina in relationship to the BCBS coverage pollicy

	Any procedure All diagnoses	All diagnoses	HNP/DDD	Fusion Stenosis	Listhesis	Revision	Decompression All diagnoses
Change in monthly volume							
Post BCBS Policy	−2.207 (−0.89)	−7.857*** (−3.64)	−4.946*** (−4.52)	−0.781 (−1.26)	−0.297 (−0.62)	−1.061*** (−3.32)	6.204** (2.83)
Percent change in proportion female	1.531 (0.61)	1.047 (0.85)	0.198 (0.34)	0.0285 (0.09)	−0.0181 (−0.04)	0.280 (0.60)	0.592 (0.39)
Percent change in mean age	21.56* (1.98)	10.37* (2.29)	0.471 (0.28)	1.734 (1.69)	3.903* (2.42)	3.439* (2.55)	5.042 (0.88)
Percent change in charlson score	−1.626 (−0.80)	−1.335 (−1.91)	−0.385 (−1.59)	0.106 (0.56)	−0.812** (−3.18)	−0.129 (−0.66)	−1.144 (−1.20)
Pre BCBS Policy	0.597 (0.45)	3.051** (2.74)	0.593 (1.31)	0.163 (0.50)	1.135*** (4.34)	0.769*** (3.49)	−1.149 (−1.48)
ARMA							
time lag (1 month)	−0.857*** (−11.94)	22120.771*** (−10.48)	22120.682*** (−7.52)	22120.709*** (−6.94)	22120.967*** (−8.16)	22121.000 (−0.23)	22120.847*** (−10.94)
moving average (2 month)	22121.000 (−0.00)	22120.844*** (−9.72)	22120.774*** (−8.00)	22120.673*** (−5.83)	22120.973*** (−5.39)	22121.000 (−0.01)	22121.000 (−0.00)
Sigma							
Pre BCBS Policy	85.70 (0.00)	49.86*** (12.29)	20.88*** (11.80)	10.95*** (12.32)	18.41*** (10.89)	13.92 (0.01)	53.86 (0.00)
Pre vs. post trend p-value	0.346	<0.001	<0.001	0.256	0.006	<0.001	0.004
Number of months	95	95	95	95	95	95	95

t statistics in parentheses

HNP = Herniated nucleus pulposus DDD = degenerative disc disease Estimates based on NC SID and SASD

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$

Table 4

Potential effect of an expanded policy in terms of reduced lumbar fusion operations and hospital costs.

Scope of expanded policy change	Year	N reduced	Cost reduction from fusion	Cost reduction with replaced by decompression
Applied nationally	2011	580	41.7 M	28.2 M
	2012	1414	102 M	70.0 M
	2013	1719	126 M	87.0 M
	3-years combined	3712	270 M	185 M
Applied to Medicare only	2011	216	16.9 M	11.4 M
	2012	534	40.8 M	27.9 M
	2013	661	49.0 M	33.9 M
	3-years combined	1410	107 M	73.2 M