Supplemental file

Three patterns of spinal manipulative therapy for back pain and their association with imaging studies, injection procedures, and surgery: A cohort study of insurance claims

Brian Anderson, DC, PhD

W Steve McClellan, MS

STROBE/RECORD methods checklist [1]

Methods	
Study design	Retrospective cohort analysis of insurance claims
Setting	Claims generated by insured members of a single, self-insured fortune 500 company covering approximately 50,000 individuals with a geographic location including various states in the southern US
Participants	Covered individuals aged ≥ 18 with a primary back pain related diagnosis. Patients with diagnoses related to cancer, fracture, infection or inflammatory spondylopathy are not included in the dataset. Included ICD-9 and ICD-10 diagnoses are listed in appendix 1
Variables	1. Episode of care= 90 day claim free period before and after first and last claim, respectively 2. Age= age at first visit of episode 1 3. Gender= male/female 4. Spinal manipulative therapy (SMT) = presence of any CPT code in the range 98940-98942 5. Initial SMT = first procedure provided during episode 1 of back pain was SMT 6. Delayed SMT = SMT was provided at some point during episode 1 in combination with other therapies 7. No SMT = the absence of CPT codes 98940-98942 8. Imaging = CPT codes provided in Appendix 1 9. Injection= CPT codes provided in Appendix 1 10. Surgery= CPT codes provided in Appendix 1 11. Care Escalation = presence of any Imaging, Injection, or Surgery procedure code listed in Appendix 1 12. Retrospective risk score (R.Risk)= proprietary score calculated based on demographics, medical/pharmacy claims for the year prior to initial visit for episode 1. This score can change with additional claims during episode 1, so the mean R.Risk score was used in our modeling 13. Claim count = number of claims present for episode 1 14. Log Allowed = allowed insurance reimbursement for all procedures during episode 1, log transformed
Data sources/management	The dataset was made available via a collaboration with a private healthcare company called Integrative Musculoskeletal Care (IMC) based in Tallahassee FL.
Bias	Misclassification of treatment group is the most likely source of bias in our analysis. Our method of assigning an episode to the spinal manipulation group when evidence of

	this service was present at any time during the episode could potentially bias our results against spinal manipulation; we believe this strengthens the conclusions of our models. Other sources of potential bias are discussed in limitations
Study size	Adequate detail provided in Methods section
Quantitative variables	Binary comparisons between each predictor and the outcome care escalation (yes/no) were made (Table 1). Table 2 reports counts, mean/median values and ranges for each predictor based on care escalation/no escalation as well as treatment group. The model outcomes reported in the manuscript are fully adjusted for all predictors.
Statistical methods	A modified Poisson regression model fit through generalized estimating equations with unstructured covariance matrix was employed for a categorical outcome variable as described by Zou [2-3] to calculate relative risk of care escalation as well as individual procedures.
Data access and cleaning methods	The cleaned dataset population is the study sample. Diagnosis codes (ICD-9, ICD-10) and Procedure code lists reduce the associated claims to those that are in-scope for IMC services provided to their clients (Dislocations, fractures, infections and inflammatory arthropathies are excluded). SM had full access to the deidentified dataset population; BA had access to a slightly more deidentified version of this dataset
Linkage	The data is person level linked by an encrypted unique member identifier. The quality of the linkage is co-verified by independent parties at both IMC and the SIE. Social security number, date of birth and gender are used to generate the encrypted IDs.

1- Benchimol El et al. The Reporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. PLoS Med 2015, 12(10)

2- Zou, G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. American Journal of Epidemiology 2004, 159:7

3- Zou, G & Donner, A. Extension of the modified Poisson regression model to prospective studies with correlated binary data. Stat Methods Med Res 2011, 22:661

Lumbar ICD-9 (10)	
721.2 (M478.14)	Thoracic spondylosis without myelopathy
721.3 (M478.14)	Lumbosacral spondylosis without myelopathy
721.4 (M471.4, M471.6)	Thoracic or lumbar spondylosis with myelopathy
721.5 (M482.0)	Kissing spine; Baastrup's syndrome
721.6 (M481.0)	Ankylosing vertebral hyperostosis
721.7 (M483.0)	Traumatic spondylopathy
721.8 (M489)	Other allied disorders of spine
721.9 (M489.19; M471.0)	Spondylosis of unspecified site
722.1 (M512.6,-.7; M512.4-.5)	Displacement of thoracic or lumbar disk w/o myelopathy
722.2 (M519)	Displacement of disk, site unspecified, w/o myelopathy
722.5 (M513.4-.7)	Degeneration of thoracic or lumbar intervertebral disk
722.6 (M513.4-.7)	Degeneration of intervertebral disk, site unspecified
722.7 (M519, M500.0, M510.4-.7)	Intervertebral disk disorder with myelopathy
722.8 (M961)	Postlaminectomy syndrome
722.9 (*)	Other and unspecified disk disorder
724.2-.9 (**)	Other and unspecified disorders of back
738.4 (M4300, M4310)	Acquired spondylolisthesis
738.5 (M9983, M9984)	Other acquired deformity of back or spine
739.2 (M9902)	Non-allopathic lesion- Thoracic region
739.3 (M9903)	Non-allopathic lesion- Lumbar region
739.4 (M9904)	Non-allopathic lesion- Sacral region
839.2 (S33101A, S23101A)	Dislocation- Thoracic and lumbar vertebra, closed
839.3 (S31000A,S33101A,S21209A,S23101A)	Dislocation- Thoracic and lumbar vertebra, open
839.4 (S2320XA, S332XXA, S3339XA)	Dislocation- Other vertebra, closed
846.0-.3 (S338XXA, S336XXA, S339XXA)	Sprains and strains of sacroiliac region
847.1 (S23XXA, S238XXA)	Sprains and strains of thoracic
847.2 (S335XXA)	Sprains and strains of lumbar region
847.3 (S338XXA)	Sprains and strains of sacrum region
847.4 (S338XXA)	Sprains and strains of coccyx region
Diagnostic codes are provided in both ICD-9 & (ICD-10) since the claims database contained both	
* M464.0, M51.9, M508.0, M509.0, M464.5, M518.4, M518.5, M464.7, M518.6, M518.7	
** M480.0, M480.4, M480.6, M480.8, M546, M543.0, M541.4-.7, M548.9, M54.9, M432.7-.8, M532X7, M53.3, M532X8, M540.8, M438X9, M53.9	

Imaging CPT codes

72110 X-RAY EXAM OF LOWER SPINE

72100 X-RAY EXAM L-S SPINE 2/3 VWS

73510 X-RAY EXAM OF HIP

73522 X-RAY EXAM HIPS BI 3-4 VIEWS

72170 X-RAY EXAM OF PELVIS

72020 X-RAY EXAM OF SPINE

72114 X-RAY EXAM L-S SPINE BENDING

72010 X-RAY EXAM OF SPINE

72202 X-RAY EXAM SACROILIAC JOINTS

76140 X-RAY CONSULTATION

72120 X-RAY EXAM OF LOWER SPINE

72265 CONTRAST X-RAY LOWER SPINE

72082 X-RAY EXAM ENTIRE SPI 2/3 VW

72220 X-RAY EXAM SACRUM TAILBONE

72080 X-RAY EXAM THORACOLMB 2/> VW

73523 X-RAY EXAM HIPS BI 5/> VIEWS

72270 CONTRAST X-RAY SPINE

73501 X-RAY EXAM HIP UNI 1 VIEW

72090 X-RAY EXAM OF TRUNK SPINE

72148 MRI LUMBAR SPINE W/O DYE

72158 MRI LUMBAR SPINE W/O & W/DYE

76800 US EXAM SPINAL CANAL

72131 CT LUMBAR SPINE W/O DYE

76377 3D RENDERING W/POSTPROCESS

76942 ECHO GUIDE FOR BIOPSY

72132 CT LUMBAR SPINE W/DYE

76376 3D RENDER W/O POSTPROCESS

76000 FLUOROSCOPE EXAMINATION

72275 EPIDUROGRAPHY

72133 CT LUMBAR SPINE W/O & W/DYE

74176 CT ABD & PELVIS

72195 MRI PELVIS W/O DYE

72149 MRI LUMBAR SPINE W/DYE

74150 CT ABDOMEN W/O DYE

74176 CT ABD & PELVIS W/O CONTRAST

74170 CT ABDOMEN W/O & W/DYE

76937 US GUIDE VASCULAR ACCESS

72197 MRI PELVIS W/O & W/DYE

72193 CT PELVIS W/DYE

Injection CPT codes

96372 THER/PROPH/DIAG INJ SC/IM

62311 INJECT SPINE L/S (CD)

64483 INJ FORAMEN EPIDURAL L/S

64484 INJ FORAMEN EPIDURAL ADD-ON

27096 INJECT SACROILIAC JOINT

64493 INJ PARAVERT F JNT L/S 1 LEV

64494 INJ PARAVERT F JNT L/S 2 LEV

20553 INJECT TRIGGER POINTS 3/>

64495 INJ PARAVERT F JNT L/S 3 LEV

20552 INJ TRIGGER POINT 1/2 MUSCL

20553 INJECT TRIGGER POINTS =/> 3

62290 NJX PX DISCOGRAPHY LUMBAR

62304 MYELOGRAPHY LUMBAR INJECTION

62323 NJX INTERLAMINAR LMBR/SAC

62284 INJECTION FOR MYELOGRAM

64490 INJ PARAVERT F JNT C/T 1 LEV

64491 INJ PARAVERT F JNT C/T 2 LEV

62322 NJX INTERLAMINAR LMBR/SAC

64640 INJECTION TREATMENT OF NERVE

64445 N BLOCK INJ SCIATIC SNG

64450 N BLOCK OTHER PERIPHERAL

96374 THER/PROPH/DIAG INJ IV PUSH

62273 INJECT EPIDURAL PATCH

62327 NJX INTERLAMINAR LMBR/SAC

62319 INJECT SPINE W/CATH L/S (CD)

62305 MYELOGRAPHY LUMBAR INJECTION

96365 THER/PROPH/DIAG IV INF INIT

96375 TX/PRO/DX INJ NEW DRUG ADDON

Surgical CPT codes

63030 LOW BACK DISK SURGERY

22558 LUMBAR SPINE FUSION

22853 INSJ BIOMECHANICAL DEVICE

460 SPINAL FUSION EXCEPT CERVICAL

22612 LUMBAR SPINE FUSION

22840 INSERT SPINE FIXATION DEVICE

63042 LAMINOTOMY SINGLE LUMBAR

63035 SPINAL DISK SURGERY ADD-ON

64635 DESTROY LUMB/SAC FACET JNT

64636 DESTROY L/S FACET JNT ADDL

22633 LUMBAR SPINE FUSION COMBINED
22851 APPLY SPINE PROSTH DEVICE
22830 EXPLORATION OF SPINAL FUSION
63047 REMOVE SPINE LAMINA 1 LMBR
63048 REMOVE SPINAL LAMINA ADD-ON
520 BACK & NECK PROC EXC SPINAL FUSION
20930 SP BONE ALGRFT MORSEL ADD-ON
22842 INSERT SPINE FIXATION DEVICE
63056 DECOMPRESS SPINAL CORD
63057 DECOMPRESS SPINE CORD ADD-ON
518 BACK & NECK PROC EXC SPINE FUSION
22845 INSERT SPINE FIXATION DEVICE
519 BACK & NECK PROC EXC SPINAL FUSION
20937 SP BONE AGRFT MORSEL ADD-ON
22849 REINSERT SPINAL FIXATION
22852 REMOVE SPINE FIXATION DEVICE
22585 ADDITIONAL SPINAL FUSION
22614 SPINE FUSION EXTRA SEGMENT
455 COMBINED ANT/POST SPINAL FUSION
69990 MICROSURGERY ADD-ON
20931 SP BONE ALGRFT STRUCT ADD-ON
22533 LAT LUMBAR SPINE FUSION
22534 LAT THOR/LUMB ADDL SEG
64714 REVISE LOW BACK NERVE(S)
63044 LAMINOTOMY ADDL LUMBAR
22634 SPINE FUSION EXTRA SEGMENT
63655 IMPLANT NEUROELECTRODES
63685 INSRT/REDO SPINE N GENERATOR
63012 REMOVAL OF SPINAL LAMINA
22899 SPINE SURGERY PROCEDURE
63012 REMOVE LAMINA/FACETS LUMBAR
22850 REMOVE SPINE FIXATION DEVICE
459 SPINAL FUSION EXCEPT CERVICAL W MCC
22630 LUMBAR SPINE FUSION
63650 IMPLANT NEUROELECTRODES
20936 SP BONE AGRFT LOCAL ADD-ON
63267 EXCISE INTRASPINAL LESION
454 COMBINED ANT/POST SPINAL FUSION
27279 ARTHRODESIS SACROILIAC JOINT
63661 REMOVE SPINE ELTRD PERQ ARAY

63688 REVISE/REMOVE NEURORECEIVER
22102 REMOVE PART LUMBAR VERTEBRA
63045 REMOVAL OF SPINAL LAMINA
63017 REMOVAL OF SPINAL LAMINA
63664 REVISE SPINE ELTRD PLATE
22632 SPINE FUSION EXTRA SEGMENT
63090 REMOVAL OF VERTEBRAL BODY
22846 INSERT SPINE FIXATION DEVICE
64772 INCISION OF SPINAL NERVE
64999 NERVOUS SYSTEM SURGERY
22214 REVISION OF LUMBAR SPINE
22848 INSERT PELV FIXATION DEVICE
22843 INSERT SPINE FIXATION DEVICE
63709 REPAIR SPINAL FLUID LEAKAGE
22810 FUSION OF SPINE