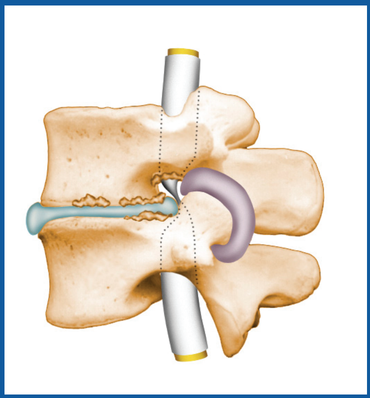
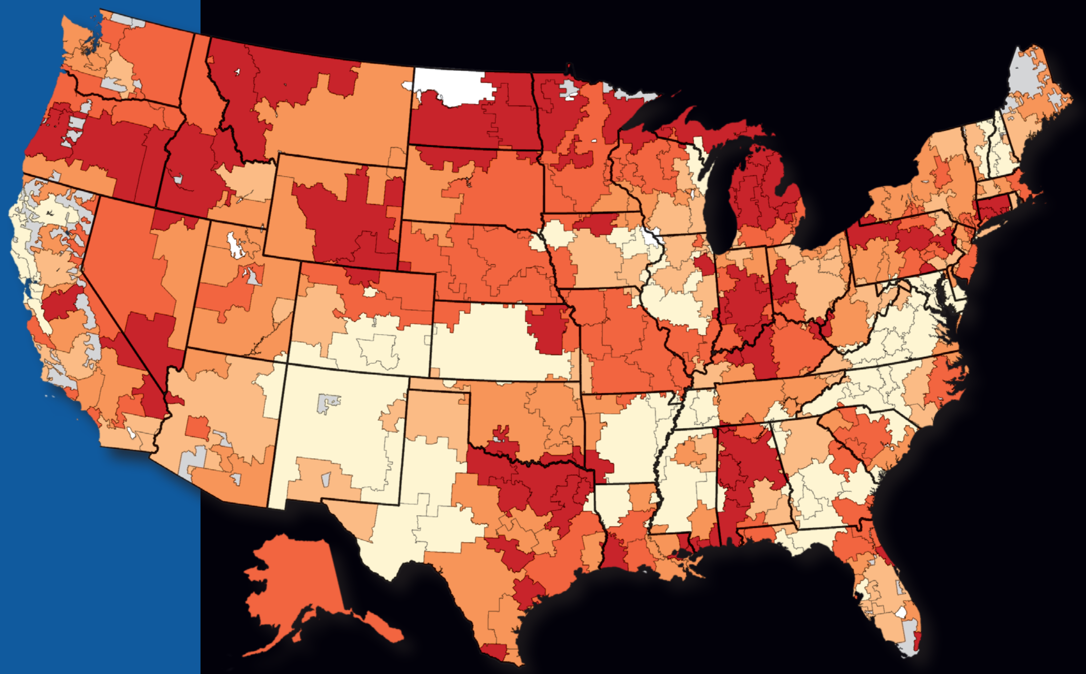


Variation in the Care of Surgical Conditions: Spinal Stenosis

A Dartmouth Atlas of Health Care Series



THE Dartmouth INSTITUTE
FOR HEALTH POLICY & CLINICAL PRACTICE

Variation in the Care of Surgical Conditions: Spinal Stenosis

A Dartmouth Atlas of Health Care Series

The Dartmouth Institute of Health Policy & Clinical Practice and Dartmouth-Hitchcock Medical Center

Brook I. Martin, PhD, MPH
Anna N.A. Tosteson, ScD
Jon D. Lurie, MD, MS
Sohail K. Mirza, MD, MPH

The Dartmouth Institute of Health Policy & Clinical Practice

Philip R. Goodney, MD, MS
Nino Dzebisashvili, PhD
David C. Goodman, MD, MS
Kristen K. Bronner, MA

Dartmouth-Hitchcock
DEPARTMENT OF SURGERY

Dartmouth
GEISEL SCHOOL OF
MEDICINE

Table of Contents

Foreword

The new Dartmouth Atlas series on variation in the care of surgical conditions, including this report on the surgical treatment of back pain resulting from spinal stenosis, raises new questions regarding surgical management of both common and less frequently occurring medical conditions. This report carefully details the issues surrounding spinal stenosis, including the physical and economic burden, the difficulties of obtaining a definitive diagnosis, and patient decision-making, and, as in previous Atlas analyses, emphasizes geographic practice variation in surgical treatment rates. However, the report also takes a more longitudinal view. The changes over time in which procedure is favored to treat back pain and spinal stenosis are particularly fascinating, driven as they appear to be by a mix of clinical evidence—including emerging long-term results—and physicians' opinions and personal experience. Registries and clinical trials should go a long way toward producing the kind of widely applicable data upon which patient decision support tools should be based. Patients want to know procedure and facility-based risks and benefits. Just as the future of medicine is personalization of diagnosis and treatment, so too the future of decision support is to increasingly provide information tailored to the person and his or her health care environment. Ultimately, it is the active participation of fully informed patients that can address the question of "which rate is right," so provocatively posed by the Dartmouth Atlas analyses. I look forward to future analyses targeting other common, preference-sensitive interventions, where reports such as this can highlight opportunities for improvement.

Michael J. Barry, M.D.

President, Informed Medical Decisions Foundation
Clinical Professor of Medicine, Harvard Medical School

Variation in the Care of Surgical Conditions

A Dartmouth Atlas of Health Care Series

Introduction

Twenty-first century surgery is among the great accomplishments of medicine. Surgeons have led some of the most important improvements in care quality, safety, and efficiency. Surgical methods are now highly effective for some of the most serious and previously intractable medical conditions, ranging from arthrosclerosis to obesity to chronic back pain. Today, surgical procedures work better and entail lower risk, less pain, and less time in the hospital.

As the scope and quality of surgical care continues to advance, there is still much that remains to be done to optimize care for patients. For many conditions, surgery is one of several care options, and in some instances, there are several types of surgical procedures available. Research into the effectiveness and adverse effects of a surgical procedure compared to alternatives is often incomplete. While quality has generally improved over time, outcomes can differ across hospitals and surgeons. Too often, treatment options, whether medical or surgical, are recommended without patients fully understanding the choices and participating in the decision; and these recommendations can vary markedly from one physician to the next. Finally, the costs of care continue to rise and often differ across health care systems, even the most reputable and prestigious. Why can the "best" surgical care at one academic medical center cost twice as much as another?

This Dartmouth Atlas of Health Care series reports on unwarranted regional variation in the care of several conditions for which surgery is one important treatment option. Unwarranted variation is the differences in care that are not explained by patient needs or preferences. Each report begins with an examination of the underlying condition, the available treatment options before surgery, and the role of shared decision-making. The care during surgery is then presented, including aspects of quality, risks, and costs. The next section is concerned with the care of patients after surgery, including hospital readmissions and ambulatory care.

The bottom line is that the greatest promise of surgery still lies before us. These reports show that quality is often excellent, but not in all places. Variation in surgical rates is high and represents both gaps in outcomes research and poor patient decision quality. Outcomes differ from place to place even when controlling for patient differences. The opportunities for better and more efficient care are substantial and will require renewed efforts in research and clinical quality improvement.

Variation in decision-making for surgical conditions

Experienced leaders and educators in surgery often emphasize to their trainees and students that performing an operation is easy: choosing the right patients for surgery is much more difficult. Over the last decade, important changes have occurred related to how surgeons and patients decide whether, when, where, and how to best perform surgery. In the past, surgeons commonly played a paternalistic role, and many surgeons made decisions for their patients, relying on their own training and experience.

When surgeons—and more importantly, patients—face a decision regarding surgery, making the "right" choice can be clear and straightforward in certain situations. For example, patients with hip fracture almost always need to undergo surgery. For nearly every patient, surgical repair offers better pain control, improved functional status, and lower mortality when compared to treatment with conservative measures. Further, most patients who experience hip fracture are over the age of 65 and have access to surgical care, as they receive their health care benefits through Medicare. Because of this important constellation of circumstances—the treatment works well, is readily available, and is actively sought by both physicians and patients—hip fracture care is fairly uniform and regional rates vary relatively little, as shown in previous work by the Dartmouth Atlas and others (Figure 1).[1,2]

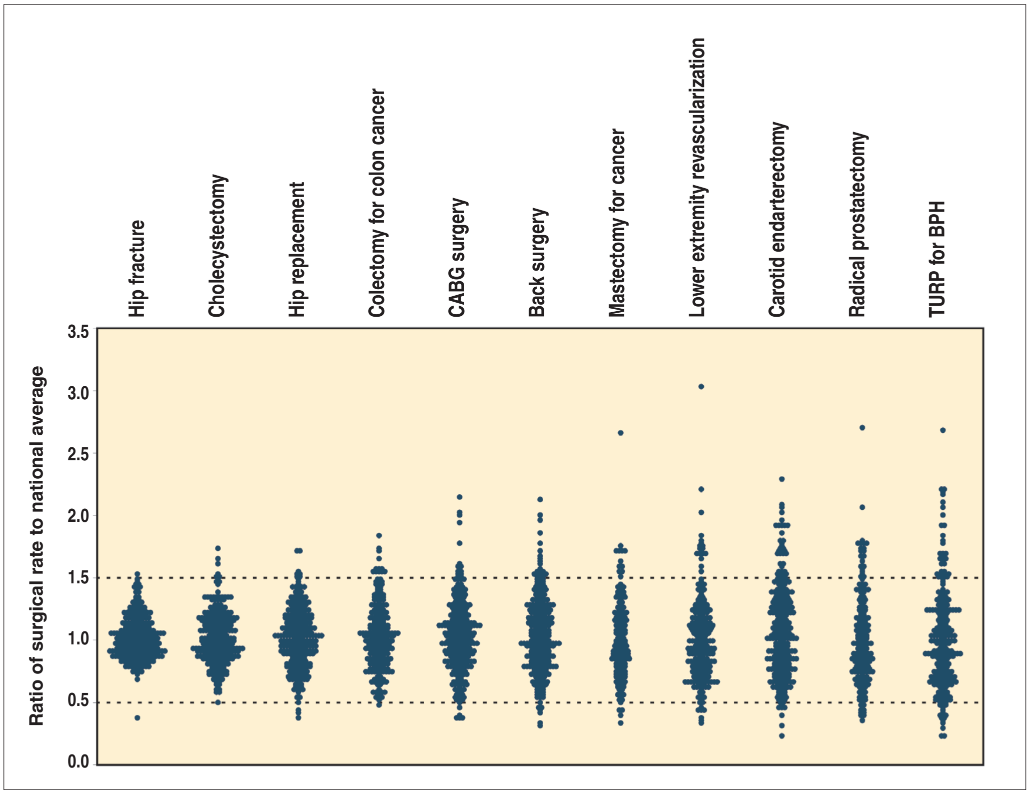
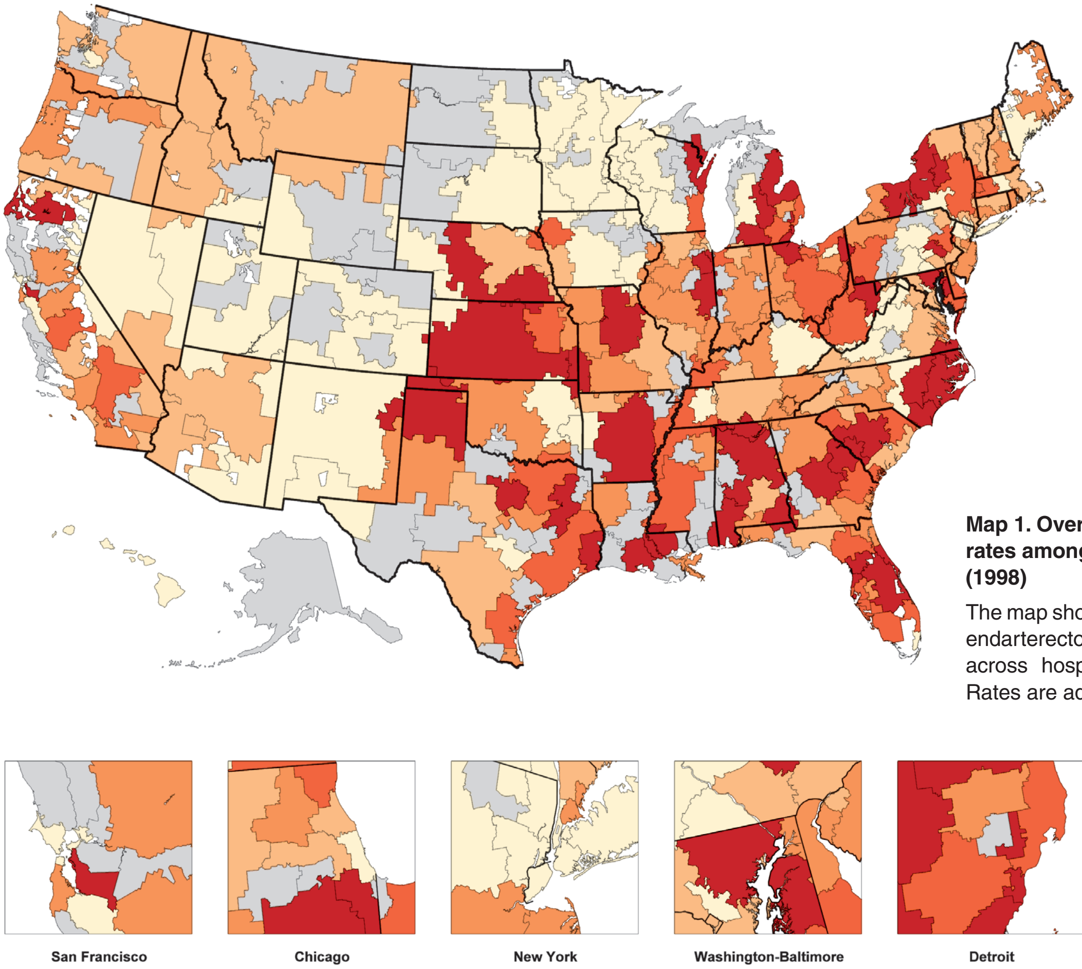


Figure 1. Variation profiles of 11 surgical procedures among hospital referral regions (2010)

Each point represents the ratio of observed to expected (national average) Medicare rates in the 306 U.S. hospital referral regions. Rates are adjusted for age, sex, and race. High and low outlier regions are distinguished by dotted lines.



Map 1. Overall carotid revascularization rates among hospital referral regions (1998)

The map shows the combined rate for carotid endarterectomy and carotid artery stenting across hospital referral regions for 1998. Rates are adjusted for age, sex, and race.

For many other illnesses, the choice of surgery is much less clear. For example, patients with asymptomatic carotid artery stenosis have a small but measurable risk of stroke as a result of narrowing within the carotid artery (the blood vessel in the neck that supplies the brain).[3] For certain patients with carotid disease, the risk of surgery to remove the plaque is fairly low, and removal of plaque can reduce the patient's risk of stroke over time. However, in patients with other illnesses, the chance of complications from surgery may be higher than the risk of stroke from the plaque itself.[4]

Because of this uncertainly about who should undergo carotid revascularization, treatment decisions vary considerably. Unlike hip fracture treatment, carotid surgery varies dramatically across the United States, as the Dartmouth Atlas has previously shown.[5] Carotid procedures are performed commonly in some regions, but rarely in others, resulting in marked regional differences in the use of revascularization. Many of these differences appear to be explained by differences in local medical opinion of the value of surgical care (Map 1).

New developments that have influenced surgical decision-making

How can surgeons and patients make the best decisions? In the past, many investigators reasoned that the surgeons who achieved the best results were likely to have the largest practices, and using this seemingly simple metric would ensure that patients received good surgical care. However, this assumption ignored the fact that it is difficult for surgeons to know who really achieves the "best" results. Many outcomes (such as death after carotid surgery) occur uncommonly, and a single surgeon has little ability to compare his or her results to those of other surgeons.

Given this challenge, over the last two decades, efforts to organize, measure, and improve results in surgical practice via quality improvement initiatives have developed, despite substantial obstacles. Patterns of surgical practice vary broadly across different regions of the United States, making it challenging to study and compare patients and outcomes. Further, the process of collecting, studying, and improving surgical outcomes represented a formidable challenge a decade ago, when most medical information lived in paper records, arranged in leaning stacks of bulging charts.

One important development in measuring care has been the development of clinical registries. These registries are used to study the clinical characteristics and outcomes of patients undergoing surgery and have supported many quality improvement initiatives, such as those shown in Table 1.

Table 1. Surgical registries and quality improvement organizations

Quality Improvement Initiative	Organization	Surgical Specialty	Focus	Funding
American College of Surgeons National Surgical Quality Improvement Initiative (ACS-NSQIP)	American College of Surgeons	Many	Measuring and reporting patient characteristics and outcomes	Hospitals
Veterans Affairs National Surgical Quality Improvement Program	Veterans Affairs	Many	Measuring and reporting patient characteristics and outcomes	Federal
Society of Thoracic Surgeons National Database (STS)	Society of Thoracic Surgeons	Thoracic surgery	Limiting risk with cardiac and thoracic procedures	Surgeons
Vascular Quality Initiative (VQI)	Society for Vascular Surgery	Vascular surgery	Improving care of patients with vascular disease	Surgeons and hospitals

Surgeons interested in measuring and improving their surgical results collaborated by systematically tracking patient outcomes. In many ways, these new efforts represented an important and novel strategy toward reducing variation by using clinically derived information to improve surgical decisions and care (Figure 2). As information for surgeons and patients increased (the green arrow), uncertainty for patients decreased (the red arrow). This simple but effective approach helped to limit variation in surgical treatments.

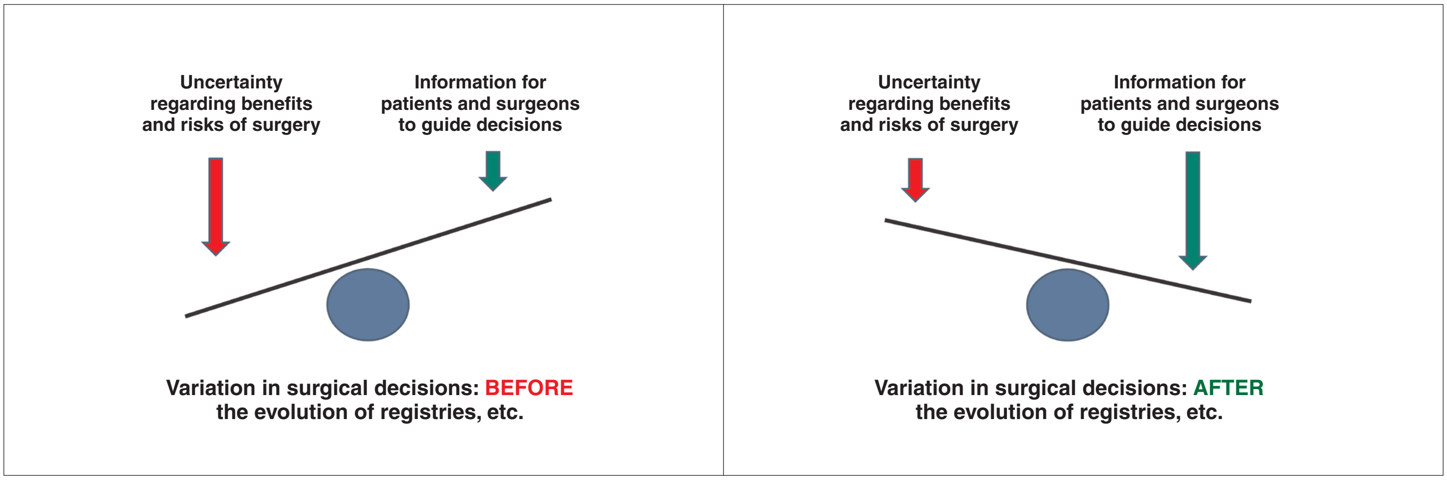


Figure 2. How information and uncertainty can affect variation in surgical care

Three other changes occurred during this time that helped create a spirit of engagement and excitement for quality improvement efforts and surgical outcomes research. While there were some differences, these general changes are outlined below:

1. Less invasive methods became commonly available in surgery. In recent years, across nearly every surgical specialty, rapid advances in surgical technology have helped offer patients the ability to undergo major surgery without the need for a major recovery. Several examples illustrate this trend. Working inside body cavities no longer requires large abdominal or chest incisions, and surgeons instead use video cameras and small instruments in laparoscopic and endoscopic surgery. In vascular surgery, the blood vessels themselves are often the pathway to perform procedures (i.e., endovascular techniques). And finally, with the development of radiofrequency ablation, locally acting chemotherapeutics, and laser thermablation, the key objectives of a surgical procedure can be accomplished using a much less invasive approach. Patients rapidly learned about many of these approaches and sought out these less invasive procedures, and surgeons retrained to offer these new approaches.

2. Surgeons learned about data management and quality improvement. In places like Northern New England,[6,7] the Veterans Administration,[8] and others,[9] leaders in surgical outcomes assessment built the systems necessary to study and improve surgical care. These regional and national quality improvement efforts grew to become the infrastructure that allowed surgeons and patients to know when, how, where, and why surgical procedures were being performed. These initiatives set the stage for an emphasis on achieving the best outcomes.

3. Surgeons, patients, and payers put a new emphasis on measuring and reporting. Armed with gigabytes of data and advanced analytic systems, surgeons were now able to quickly analyze their outcomes. The ability to determine the structural and process measures associated with the best outcomes allowed surgeons new insights into what works and what does not. For example, surgeons used information from studies based on registries to demonstrate the benefits of processes of care, such as perioperative antibiotic administration, or of evolving procedures, such as bariatric surgery for patients with morbid obesity. Payers' and patients' expectations grew; they demanded the best operation, at the right time, with the highest quality.

Challenges to improving surgical decision-making and the goals of this series

Of course, several challenges accompanied these new developments. Who will pay for continued efforts to organize and measure surgical practice? How should results be shared and compared, especially among competitors? Would efforts to use the newest, latest, or most profitable device win out over the goal of improving quality and efficiency? Would surgeons, a group steeped in tradition and often slow to change, adopt these new approaches?

These questions have different answers in different settings. In some cases, such as in coronary bypass surgery, cardiac surgeons adopted outcomes assessment and quality improvement broadly, quickly, and enthusiastically. However, in other settings, such as surgery for prostate cancer or lower extremity vascular disease, efforts toward quality measurement and outcomes assessment have been taken up more slowly, and the impact of these initiatives remains less striking.

Why might some surgeons improve their decisions using these new strategies while other surgeons choose not to try these approaches? In this series of reports, we will use several examples to illustrate the challenges. We will describe, across a broad spectrum of conditions, advances in surgical decision-making, including shared decision-making, which have resulted in less variation in care, improved patient satisfaction, and better outcomes. We will also describe settings wherein these strategies have been less successful, and variations in surgery rates and surgical decision-making remain. In these latter cases, we will outline the potential to improve surgical practice by refining the methods we use to select patients for intervention.

This series will study these conditions and their challenges in much the same way that surgeons approach these problems: by considering the challenges in care that occur before surgery, during surgery, after surgery, and beyond surgery. Within each condition, we will follow the patient along these choices and decisions and learn where the greatest challenges, most important uncertainties, and best evidence lie in making decisions about surgery. Further, we will examine the implications of these uncertainties and identify settings where more effective choices surrounding surgical care could result in healthier populations and potentially even lower costs.

Table 2. Structure of each report

Before surgery	Determinants of condition and treatment decisions
	Incidence of condition
	Regional variation in condition/covariates related to the condition
	Treatment options - effectiveness, trade-offs, and knowledge gaps
	Issues related to decision quality and shared decision-making
	Examples of quality improvement efforts or attempts to limit variation in treatments for condition
During surgery	Technical quality and outcomes
	Variation in procedure rates
	Cross-sectional rates of competing treatments
	Technical quality and results (short-term outcomes related to treatments)
	Example where regional quality improvement efforts may hold potential benefits in improving care
After surgery	Post-procedure care and long-term outcomes
	Downstream effects of treatment on condition
	Readmission or re-interventions after treatments for condition
Beyond surgery	Implications for surgeons, patients, and society
	How variation in treatments for the condition reflects opportunities for quality and efficiency gains
	How, why, and where efforts to limit variation are needed and might help
	How to move ahead in limiting variation or improving care in surgical treatments for condition

Influencing the key decision-makers: Patients, primary care physicians, surgeons, and policymakers

In the past, when it came to making a decision about surgery, the surgeon's recommendation was considered the most important opinion. His or her perspective was often critical in determining the use of a particular surgical procedure, especially for "preference-sensitive" care: care for conditions where there is no single "right" rate for every population or patient.

Current models of care suggest that better outcomes occur when full information about treatment options is shared with patients, who are then assisted in sharing the decision with the physician. This information often needs to come not only from surgeons, but also from primary care physicians who help patients choose among the different options, each with their likely outcomes and trade-offs. (For more information about patient-centered medical decision-making, please visit the Dartmouth Center for Informed Choice at http://tdi.dartmouth.edu/research/engaging/informed-choice and the Informed Medical Decisions Foundation at www.informedmedicaldecisions.org). In addition to reaching patients, the best information needs to reach policymakers who make decisions about how we spend our health care dollars, such that our resources provide the most effective care for patients with surgical conditions.

Shared Decision-Making

Dale Collins Vidal, MD

Professor of Surgery, Geisel School of Medicine; Director, Center for Shared Decision Making, Dartmouth-Hitchcock

Much of the striking variation in the use of surgical procedures reported in this Dartmouth Atlas series can be attributed to differing physician opinions about the value of one surgery over another, or a single surgical option compared to other treatments such as medication, active surveillance, or physical therapy. Each option can have different potential benefits as well as short and long-term side effects. For a given condition, any of the options may be a reasonable alternative. The decision is often further complicated by incomplete evidence regarding both benefit and harm.

It is particularly important to note that many informed patients have different perspectives than their physicians about the benefits and trade-offs of treatment options. The final choice of treatment should be made by patients who have been informed about the choices, including the pros and cons of each approach and any uncertainty about the evidence that supports each option. In addition, the health care team needs to help patients clarify their own goals and partner with patients to make joint decisions.

This process of engaging patients in decisions about their care is known as shared decision-making. Shared decision-making is a collaborative process that allows patients and their providers to make health care treatment decisions together, taking into account the best scientific evidence available, as well as the patient's values and preferences. The right choice for one patient may not be the same as the next. In this series, Dartmouth Atlas investigators will consider many clinical situations where there is no single "right" choice and highlight areas where shared decision-making may have an important role for patients with surgical conditions.

In summary, this series of Atlas reports is intended to help patients, physicians, and policymakers recognize where improvements in science have helped to limit variation and improve surgical care; but more importantly, for each of the surgical conditions we study, we hope to identify specific clinical settings and situations where variation in the treatment of surgical condition remains, and outline the best opportunities for improvement in surgical care that lie ahead.

References

1. Wennberg DE, Birkmeyer JD, eds. The Dartmouth Atlas of Cardiovascular Health Care. American Hospital Press, Chicago, IL: 1999.

2. Birkmeyer JD, Sharp SM, Finlayson SR, Fisher ES, Wennberg JE. Variation profiles of common surgical procedures. *Surgery*. 1998;124:917-923.

3. Endarterectomy for asymptomatic carotid artery stenosis. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. *JAMA*. 1991;273:1421-1428.

4. Wallaert JB, De Martino RR, Finlayson SR, Walsh DB, Corriere MA, Stone DH, Cronenwett JL, Goodney PP. Carotid endarterectomy in asymptomatic patients with limited life expectancy. *Stroke*. 2012;43:1781-1787.

5. Goodney PP, Travis LL, Malenka D, Bronner KK, Lucas FL, Cronenwett JL, Goodman DC, Fisher ES. Regional variation in carotid artery stenting and endarterectomy in the Medicare population. *Circ Cardiovasc Qual Outcomes.* 2010;3:15-24.

6. O'Connor GT, Plume SK, Olmstead EM, Coffin LH, Morton JR, Maloney CT, Nowicki ER, Tryzelaar JF, Hernandez F, Adrian L, et al. A regional prospective study of in-hospital mortality associated with coronary artery bypass grafting. The Northern New England Cardiovascular Disease Study Group. *JAMA*. 1991;266:803-809.

7. Cronenwett JL, Likosky DS, Russell MT, Eldrup-Jorgensen J, Stanley AC, Nolan BW. A regional registry for quality assurance and improvement: The Vascular Study Group of Northern New England (VSGNNE). *J Vasc Surg.* 2007;46:1093-1101.

8. Khuri SF, Daley J, Henderson W, Hur K, Demakis J, Aust JB, Chong V, Fabri PJ, Gibbs JO, Grover F, Hammermeister K, Irvin G, 3rd, McDonald G, Passaro E, Jr., Phillips L, Scamman F, Spencer J, Stremple JF. The Department of Veterans Affairs' NSQIP: The first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. National VA Surgical Quality Improvement Program. *Annals of Surgery.* 1998;228:491-507.

9. Flum DR, Fisher N, Thompson J, Marcus-Smith M, Florence M, Pellegrini CA. Washington state's approach to variability in surgical processes/outcomes: Surgical Clinical Outcomes Assessment Program (SCOAP). *Surgery.* 2005;138:821-828.

Back pain in the United States

Back pain is a leading cause of morbidity and disability in the United States.[1] It is estimated that up to 80% of people will experience low back pain at some point during their lifetimes.[2,3] At any given point in time, about 26% of U.S. adults have low back pain, and 14% have neck pain.[4,5] Back pain that lasts at least two weeks occurs in 13.8% of the U.S. population annually, accounting for 2-3% of all physician visits, and is the second most common reason for hospitalizations.[4,6-8]

About 30 million people in the United States receive professional medical care for a spine problem each year.[9] The prevalence of back pain under treatment remained stable from 1997 to 2005 and then declined slightly between 2006 and 2008, possibly due to a decrease in the use of elective procedures during the economic recession.[9,10] However, while the prevalence of back pain has remained fairly stable over time, the percentage of patients who describe their back pain as "chronic" has increased, from less than 5% in 1992 to more than 10% of all patients with back pain in 2006.[11,12]

Economic burden of low back pain

Low back pain is a leading cause of both lost productivity and medical expenditures. In 2004, over $100 billion was spent in the United States on medical care associated with spine problems—approximately the same amount spent treating cancer, diabetes, or arthritis.[9] On average, patients with back pain have 73% higher health care expenses than patients without back pain (Figure 3).

Wide regional variation in back surgery rates has been reported previously by the Dartmouth Atlas Project.[13] More recently, marked variation in Medicare costs for an average episode of care (a series of health care encounters related to an occurrence of back pain) has been reported across the United States. Much of the variation was explained by the type of operation chosen; for example, admissions involving a spinal fusion operation were more expensive than those involving a decompression alone. Decisions about how to treat patients in the short period of time after they were discharged were also highly variable. Whether patients were discharged to skilled nursing facilities, referred to home health agencies, sent home with instructions for self-care, or used rehabilitation services was an important factor in explaining differences in costs.[14]

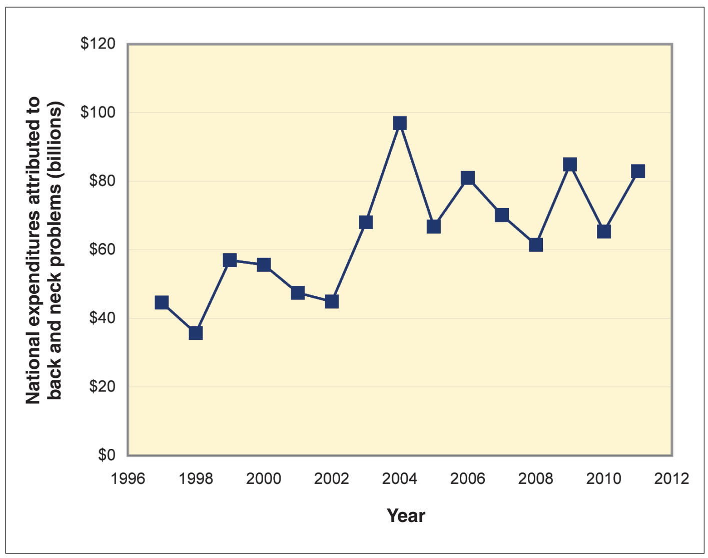


Figure 3. National expenditures attributed to back and neck problems, 1997-2011

Source: Medical Expenditure Panel Survey (MEPS).

A focus on lumbar spinal stenosis

Back pain is a complex problem, but a specific type of back pain, lumbar spinal stenosis, provides a good example that helps to summarize the treatment options, epidemiology, and evidence of effectiveness of treatment. Simply defined, lumbar spinal stenosis is a narrowing of the space within the vertebrae (backbone) where spinal nerves pass. This is caused by an abnormal thickening of the tissues surrounding the spinal cord and vertebral bodies (Figure 4). The hallmark of this condition is neurogenic claudication—pain in the leg that occurs while walking—which is relieved by sitting down or bending forward. Symptoms due to stenosis typically progress slowly. However, unlike pain from a disc herniation, symptoms from stenosis rarely resolve, but typically wax and wane over time.[15] Among older adults, spinal stenosis is common, thought to affect about 30% of people age 60 and over.[16]

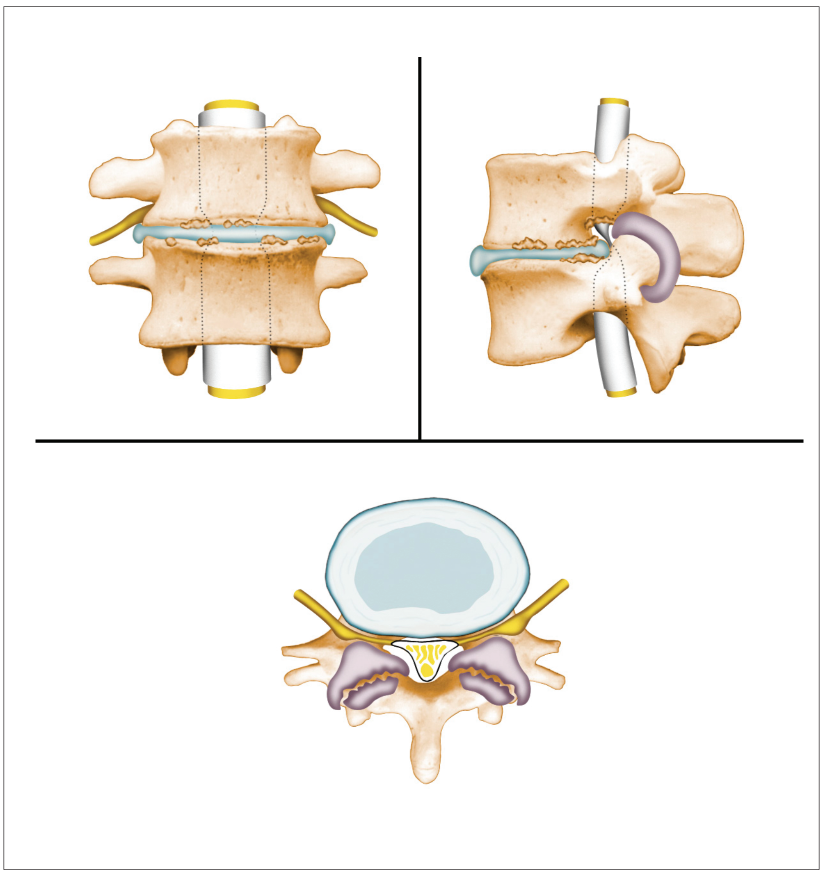


Figure 4. Spinal stenosis

Thickening of the tissue surrounding the spinal cord is shown in purple.

The role of imaging: too much or too little?

Spinal stenosis can be difficult to diagnose definitively, in part because there is no reliable test. The diagnosis requires consideration of clinical symptoms, as well as imaging that shows a narrow spinal canal. However, in some patients, a narrow spinal canal causes no symptoms. When combined with a clinical evaluation, imaging studies, such as magnetic resonance imaging (MRI), may help diagnose spinal stenosis. However, radiographic and clinical definitions of stenosis lack consensus,[17-19] and these classifications often correlate poorly with patient reports of pain and disability.[20-22] In fact, spinal abnormalities revealed by imaging are surprisingly common even among asymptomatic people; studies have shown that, among patients without symptoms of back pain, 21% had spinal stenosis, 17% had spine joint problems, and 19% had other abnormalities of the bones and tissues of the spinal canal.[23,24] Although the narrowing of the spinal canal can be measured with imaging, the degree of constriction predicts poorly which patients will benefit from surgery.

Before surgery

Patient decisions about back pain: challenges in treatment choices

There are multiple treatment options for people with lumbar spinal stenosis, including medication and physical therapy, steroid injections, and surgery. While the use of tests and treatments for spinal stenosis has grown in recent years, this increase does not appear to be caused by higher prevalence of the disease;[25] rather, patients are receiving higher intensity care.

Given the many different treatment options for spinal stenosis, many patients would benefit from shared decision-making, a formal process of educating patients about the risks and benefits of treatment options and engaging them in decisions that promote care consistent with their values and preferences. The Spine Center at Dartmouth-Hitchcock Medical Center and Dr. James Weinstein led a National Institutes of Health-funded trial, the Spine Patient Outcomes Research Trial (SPORT), that studied ways to give patients the best information possible about the different treatments for back pain and which decisions were associated with the best outcomes (www.dartmouth-hitchcock.org/spine/sport.html). Similar efforts to help patients make the best, most informed decisions—even in the context of a brief clinic visit—have been undertaken by The Decision Laboratory, led by Dr. Glyn Elwyn (www.optiongrid.org). These decision support tools aim to help patients and providers compare alternative treatment options, even with complex conditions such as back pain and spinal stenosis (Figure 5).

As outlined in this report, patients with spinal stenosis often suffer from chronic pain and disability. While successfully navigating these health problems is difficult, resources are available at:

The American Academy of Orthopaedic Surgeons: orthoinfo.aaos.org/topic.cfm?topic=A00575

National Institute of Arthritis and Musculoskeletal and Skin Diseases: www.niams.nih.gov/Health_Info/Back_Pain/

Anthem BlueCross BlueShield: www.anthem.com/wps/portal/ahpprovider?content_path=provider/noapplication/f1/s0/t0/pw_b156442.htm&state=in&rootLevel=1&label=Low%20Back%20Pain%20Tools%20for%20Patients%20and%20Providers

Dartmouth-Hitchcock Medical Center: www.dartmouth-hitchcock.org/medical-information/health_encyclopedia/aa121240#zx3768 option grid®

Spinal stenosis

Use this grid to help you and your healthcare professional talk about how best to treat spinal stenosis. It is for people diagnosed with spinal stenosis who have experienced leg weakness, numbness, or pain that worsens with standing and walking and improves with sitting. It is not for people with loss of bowel and urine control due to pinched nerves in their lower back.

Frequently asked questions	Managing without injections or surgery	Injections (epidural steroids)	Surgery
What does the treatment involve?	Being as active as possible to improve blood flow and taking medicine to relieve pain and swelling around the nerves.	Injection of a local anesthetic and steroid where the nerves are under pressure. This takes around 20 minutes.	A small piece of bone is removed to make a larger space for the nerve(s) in your back. This takes about 2 hours and most people spend 1-2 days in the hospital afterwards.
How soon will I feel better?	6 weeks after the problem starts, about 20 in every 100 people (20%) say they are better.	Studies have had mixed findings. At best, between 15 to 30 in every 100 people (15 to 30%) experience relief. Of those, most feel better in a week or so.	6 weeks after surgery, about 75 in every 100 people (75%) say they feel better.
Which treatment works best in the long-term??	4 years after treatment, about 48 in every 100 people (48%) who manage without surgery say they are better.	It is hard to say. Some studies have shown benefits from steroid injections but others have not.	4 years after surgery, around 59 in every 100 people (59%) say they are better.
What are the main risks/side effects?	The side effects will depend on which pain reliever you use.	Fewer than 1 in every 100 people (>1%) have problems, such as bleeding, headache, and infection.	2 in every 100 people (2%) will get an infection. 1 in every 100 people (1%) will get blood clots. Less than 1 in every 100 people (>1%) will get nerve damage.
How will this treatment impact my ability to care for myself?	You should go about your normal daily activities as much as you are able to.	You will need someone to drive you home after the injection. Most people resume regular activities the day after the injection.	Most people need some help from family and/or friends for 1-2 months following a simple operation. More complex operations require longer healing.
Will I need any other treatment?	No, but you may be asked to see a physical therapist to start an exercise program.	You should take pain relievers as needed and keep active. The injection may be repeated in the future, but usually no more than 2 or 3 times in total.	Most people use pain relievers after the operation. Some need physical therapy after their operation and 15 in every 100 people (15%) need a short stay in a nursing home. Longer term, 6 in every 100 people (6%) need more back operations within 1 year of surgery, 13 in every 100 (13%) within 4 years; and 25 in every 100 (25%) within 10 years.

Editors: Thom Walsh, Ben Dropkin, Sohail Mirza, Michael Lewis, Glyn Elwyn.
Evidence document: http://www.optiongrid.org/resources/spinalstenosis_evidence.pdf
Last update: 7 October 2014 **Next update:** 1 November 2015 **ISBN:** 978-0-9926733-1-4
Download the most current version from: http://www.optiongrid.org

Figure 5. Option grid for spinal stenosis

Source: The Option Grid Collaborative (www.optiongrid.org).

Non-surgical options for the treatment of spinal stenosis

Medical management: Medications are commonly used as initial therapy for common spinal problems, including spinal stenosis. Typical medications include non-steroidal anti-inflammatory drugs (NSAIDs), analgesics, COX-2 inhibitors, muscle relaxants, certain anticonvulsants (e.g., Neurontin), and certain anti-depression medications (e.g., Cymbalta). Systematic reviews highlight a moderate short-term benefit of most of these drugs to relieve pain, but, like nearly all medications, they also have risks.[26-28]

Although the use of opioids (also referred to as narcotics) in the treatment of back pain has been discouraged in clinical guidelines, there was a 423% increase in opioid use among people with back problems from 1997 to 2005.[25] The availability of more potent opioid analgesics since 1997 has been accompanied by higher rates of opioid-related complications, leading to emergency department visits, psychiatric conditions, and death.[26,29-31] It is unclear why these treatment patterns have occurred, as the wide geographic variation in opioid use does not appear to reflect disease prevalence, injury, or surgical procedures.[32] Opioid use for the long-term management of chronic spinal problems is not supported by scientific evidence of safety and effectiveness.[33,34] While more than half of "regular" prescription opioid users have back pain,[35] a report from the Cochrane collaboration states that "… opioids for long-term management of chronic [low back pain] remains questionable" and guidelines from the American College of Physicians and the American Pain Society have called for reassessing patients who fail to respond to a time-limited course of opioids.[26,33,36]

Non-operative therapy: The benefits of medical care, chiropractic care, physical therapy, and other non-surgical interventions to treat spinal stenosis have not been demonstrated.[16,37,38] There is some evidence that exercise improves leg pain and functioning compared to no treatment, but these measures do not alter the natural progression of stenosis.[39] Nevertheless, one-third of the patients in the Spine Patient Outcomes Research Trial (SPORT) study's unstructured non-operative treatment group reported significant improvements in symptoms at four years.[40] This may be as due to "tincture of time" as any treatment offered.

Epidural steroid injections: Wide geographic variation in epidural steroid injections has also been reported in the United States. Their use does not correlate to evidence-based indications of sciatica or radiculopathy;[41,42] does not reduce the rate of subsequent surgery;[43-48] and does not appear to obviate the need for opioids, surgery, or medical visits among the elderly U.S. population.[42,49] One recent large randomized trial found no short-term benefit of epidural steroid injection relative to injection with lidocaine, a short-term anesthetic, in treating patients with lumbar spinal stenosis.[50]

During surgery

Older treatments or newer methods? Trends and geographic variation in surgical treatments for spinal stenosis

Surgical interventions have evolved from traditional decompression—where the tissue compressing the spinal nerves is removed—to include both more invasive types of operations such as spinal fusion, where the spine bones are fixed together, and less invasive procedures such as minimally invasive or percutaneous (through the skin) decompression. Over 94,000 inpatient operations for lumbar stenosis were performed in the United States in 2011, with national hospital costs exceeding $2.3 billion (according to unpublished data from the Healthcare Cost and Utilization Project). There are no recent studies documenting the rate of ambulatory or outpatient decompression operations for spinal stenosis in the United States.

Figure 6 shows the rates of initial (incident) inpatient decompression and fusion operations for lumbar spinal stenosis among Medicare fee-for-service beneficiaries age 65 and over. These estimates exclude patients who had other spine problems, such as spinal fractures, or a diagnosis of cancer. The rate of spinal fusion operations for stenosis increased 67%, from 31.6 per 100,000 Medicare beneficiaries in 2001 to 52.7 per 100,000 Medicare beneficiaries in 2011.

Surgical decompression of the spinal canal, such as laminectomy (removing the rear piece of the vertebrae), eliminates pressure on the spinal nerve roots. A variety of surgical techniques is used, with recent advances toward minimally invasive and microscopic techniques.[51,52] The rates of inpatient decompression among older adults have declined as fusion operations have increased and as decompression is increasingly performed as an outpatient procedure (Figure 6).

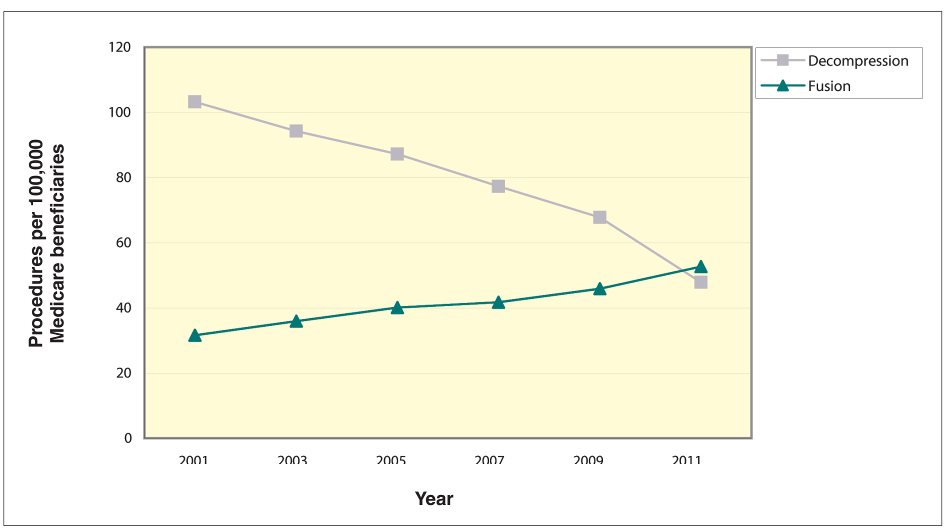
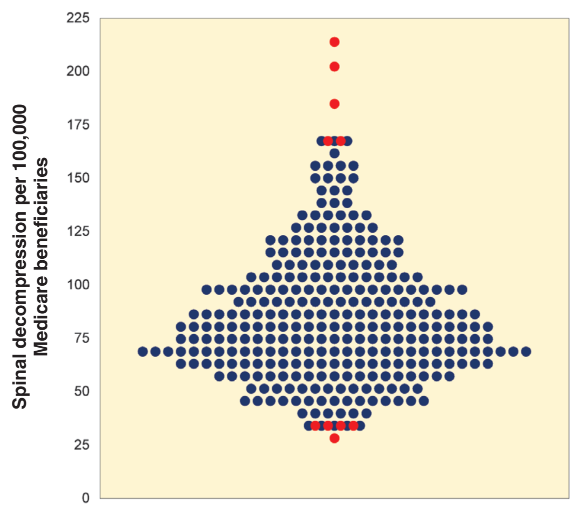


Figure 6. Trends in rates of spinal decompression and fusion, 2001 to 2011

The rates shown in the figure represent decompression and fusion procedures for patients with a diagnosis of lumbar spinal stenosis among all Medicare fee-for-service beneficiaries.

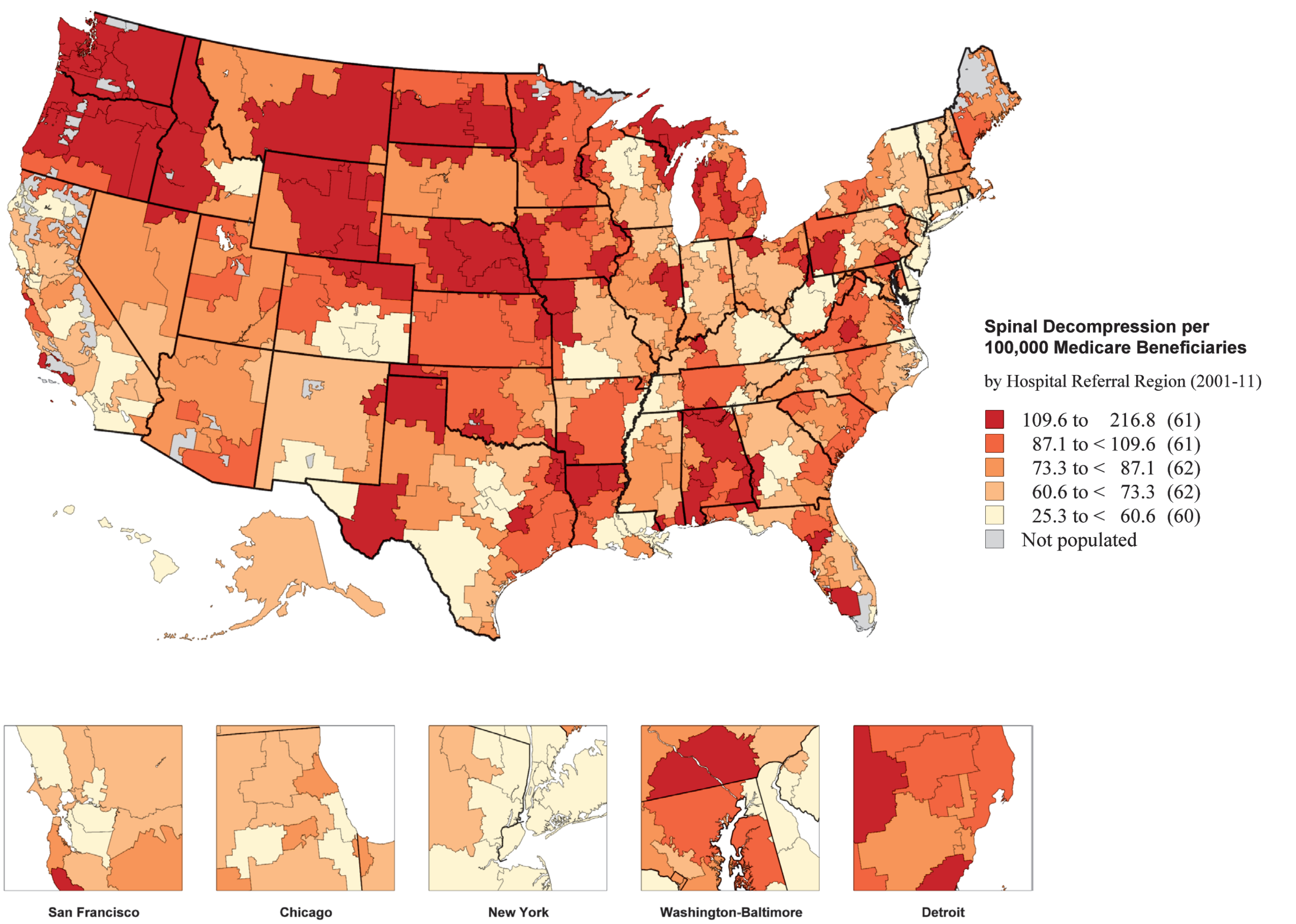
During the period comprising 2001 through 2011, inpatient spinal decompressions for lumbar spinal stenosis were performed at a rate of 80.0 per 100,000 Medicare beneficiaries across the United States. The rate varied more than eight-fold among hospital referral regions, from fewer than 35 procedures per 100,000 in the Bronx, New York (25.3), Miami, Florida (31.8), and South Bend, Indiana (34.8) to more than 180 per 100,000 in Mason City, Iowa (216.7), Tacoma, Washington (200.7), and Bloomington, Illinois (186.6) (Figure 7). Rates of spinal decompression were generally higher in the Pacific Northwest and northern Mountain states than in other parts of the country (Map 2).



Mason City, IA	216.7
Tacoma, WA	200.7
Bloomington, IL	186.6
Slidell, LA	167.3
Monroe, LA	166.8
Newark, NJ	35.8
Manhattan, NY	35.6
South Bend, IN	34.8
Miami, FL	31.8
Bronx, NY	25.3

Figure 7. Inpatient spinal decompression per 100,000 Medicare beneficiaries among hospital referral regions (2001-11)

Each blue dot represents the rate of spinal decompression for lumbar spinal stenosis in one of 306 hospital referral regions in the U.S. Red dots indicate the regions with the 5 lowest and 5 highest rates.

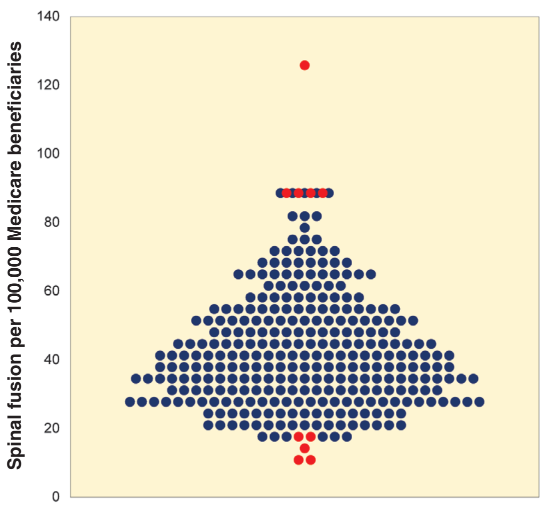


Map 2. Inpatient spinal decompression per 100,000 Medicare beneficiaries (2001-11)

Rates are adjusted for age, sex, and race. The average was created based on odd-numbered years from 2001 to 2011.

While decompression procedures are well established for treating stenosis, fusion operations are an increasingly popular, but controversial, treatment option (Figure 6).[53] Spinal fusion is intended to eliminate back pain by joining together two or more adjacent vertebrae under the theory that stabilization will reduce symptoms. The procedure frequently involves implanting cages, rods, or other instrumentation to join vertebrae together. The evidence of the effectiveness of lumbar fusion surgery for treating spinal stenosis (in the absence of significant curvature, called scoliosis, or slipping of a vertebra, called spondylolisthesis) has not been fully established.[54] A meta-analysis by Turner et al was among the first to find little evidence supporting fusion surgery for spinal stenosis, reporting large variation in satisfactory results.[55] On the other hand, a European cohort study found that fusion operations led to better patient-reported outcomes compared to decompression alone, although fusion increased the risk for surgical complications and repeat operations.[56]

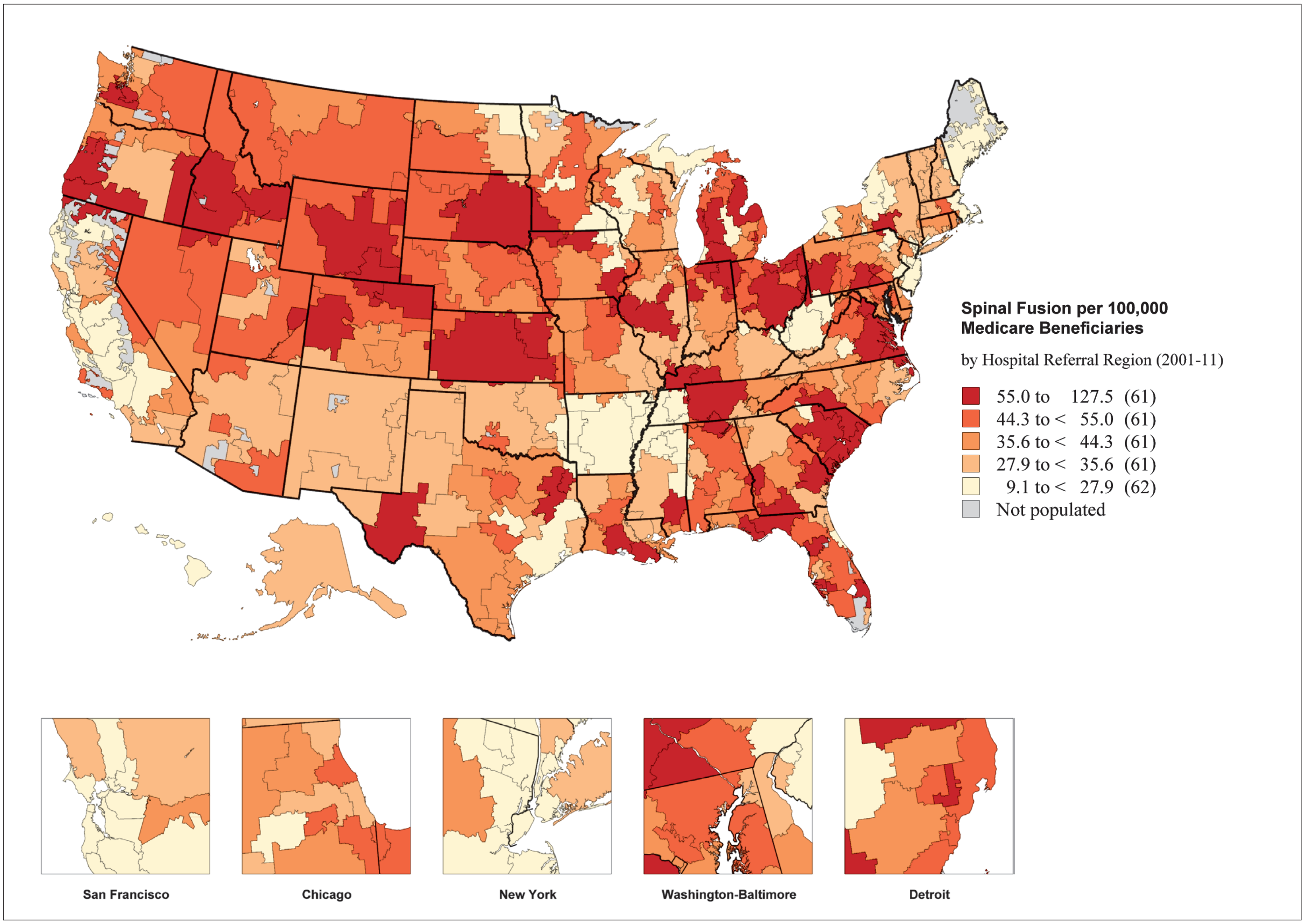
The average rate of inpatient spinal fusion for lumbar spinal stenosis during the period from 2001 to 2011 in the United States was 41.1 per 100,000 Medicare beneficiaries. The fusion rate varied by a factor of more than fourteen across hospital referral regions, from 9.2 procedures per 100,000 in Bangor, Maine to 127.5 per 100,000 in Bradenton, Florida (Figure 8). Regions with relatively low fusion rates included Fresno, California (12.5), Alameda County, California (14.9), and Scranton, Pennsylvania (17.1). More than 80 procedures per 100,000 were performed in Grand Rapids, Michigan (89.9), Mason City, Iowa (89.2), and Tyler, Texas (88.5) (Map 3).



Bradenton, FL	127.5
Grand Rapids, MI	89.9
Mason City, IA	89.2
Tyler, TX	88.5
Newport News, VA	87.4
Bronx, NY	17.5
Scranton, PA	17.1
Alameda County, CA	14.9
Fresno, CA	12.5
Bangor, ME	9.2

Figure 8. Inpatient spinal fusion per 100,000 Medicare beneficiaries among hospital referral regions (2001-11)

Each blue dot represents the rate of spinal fusion for lumbar spinal stenosis in one of 306 hospital referral regions in the U.S. Red dots indicate the regions with the 5 lowest and 5 highest rates.



Map 3. Inpatient spinal fusion per 100,000 Medicare beneficiaries (2001-11)

Rates are adjusted for age, sex, and race. The average was created based on odd-numbered years from 2001 to 2011.

After surgery

Two small randomized trials have demonstrated that, on average, surgical decompression improves patient-reported measures of pain, disability, and quality of life compared to non-operative treatments.[57,58] Other comparative effectiveness studies examining the potential benefits and harms of surgery for spinal stenosis have helped to provide further guidance. Surgical patients with spinal stenosis in the Maine Lumbar Spine Study (MLSS) had greater improvements in patient-reported measures of pain and function through a ten-year follow-up compared to non-surgical patients; however, the surgical advantage narrowed over time.[59] The SPORT study reported better pain relief and functional recovery with surgical treatment than with non-surgical treatment for patients with spinal stenosis.[40] Overall, decompression procedures appear to have moderate efficacy for stenosis, but these results lessen with time,[53] and many patients still have significant problems. At a median four years of follow-up in one cohort study, 17% of patients had undergone a repeat operation, and 30% reported severe pain.[14]

Complications

Compared to decompression procedures alone, complex fusion operations (defined as those involving combined surgical approaches or multiple vertebral levels) are associated with greater risks of life-threatening complications, mortality, and increased health care utilization.[60] After adjustment for age, comorbidity, previous spine surgery, and other features in a Medicare population, the likelihood of a life-threatening complication with complex fusions compared to decompressions was almost three times higher. Rehospitalizations within 30 days occurred for 7.8% of patients undergoing decompression compared to 13.0% having a complex fusion. Among Medicare patients undergoing any type of spine surgery for lumbar stenosis, with or without spondylolisthesis, the two-year reoperation rate was 17%. In addition, 25% were readmitted to the hospital due to a surgery-related complication.[61]

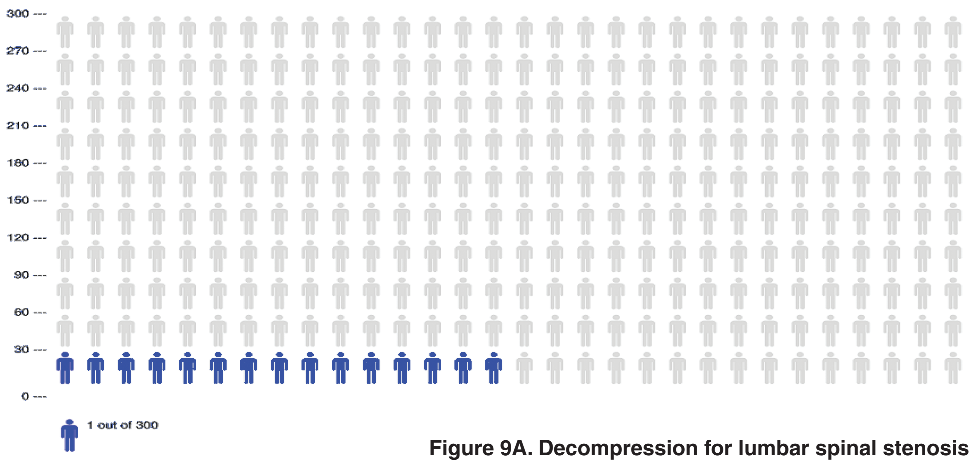


Figure 9A. Decompression for lumbar spinal stenosis
15 out of 300 (5.1%).

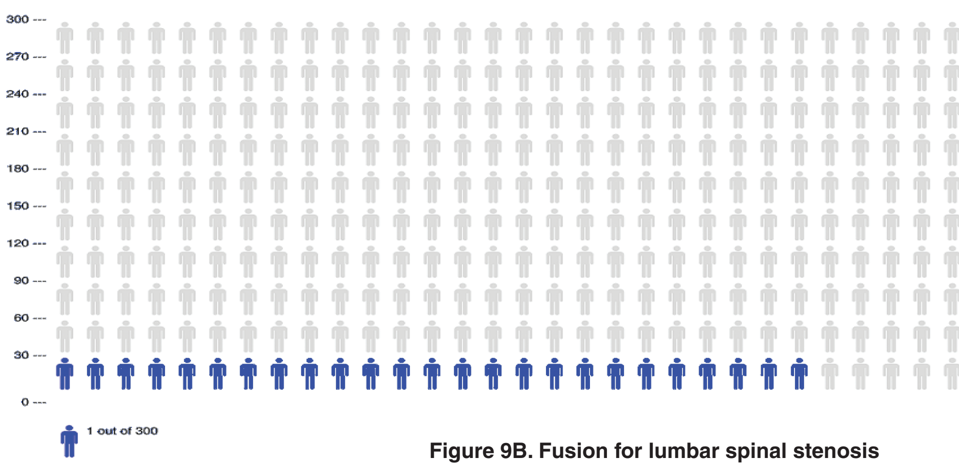


Figure 9B. Fusion for lumbar spinal stenosis
25 out of 300 (8.4%).

Figure 9. Risk of death after inpatient surgical procedure for lumbar spinal stenosis

Table 3. Surgical safety outcomes following inpatient operation for lumbar spinal stenosis among Medicare beneficiaries

Outcome	Decompression	Fusion
Life-threatening complications	1.7%	2.8%
Wound problems	1.9%	3.4%
All-cause readmission	6.8%	8.8%
Reoperation (1 year)	5.2%	4.7%
Reoperation (5 year)	14.0%	16.0%
Reoperation (10 year)	17.9%	20.7%

Adjusted for age group, sex, comorbidity, and previous hospitalization. Analysis based on approach reported in: Deyo RA et al. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA.* 20:303(13);1259-65. Updated with additional years of combined data.

Table 3 and Figure 10 show the rates of postoperative surgical complications and repeat spine surgeries among Medicare beneficiaries undergoing an initial inpatient lumbar spine operation for spinal stenosis (without spondylolisthesis or scoliosis). On average, during the five-year period after surgery, 16% of patients required a second operation among those with fusion and 14% among those with decompression, even after adjusting for differences in patient age, sex, comorbidity, and hospitalizations in the previous year. Fusion operations were associated with greater risk of wound problems and life-threatening complications within 30 days, as well as a significantly higher rate of all-cause repeat hospitalizations.

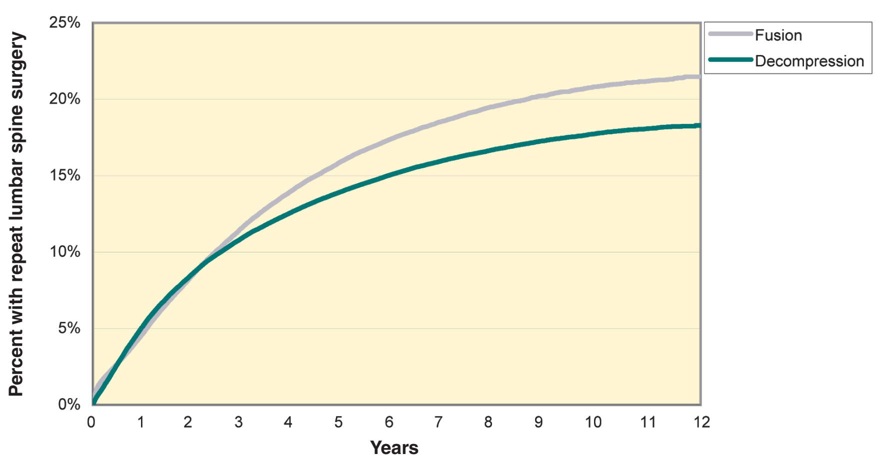


Figure 10. Cumulative incidence of repeat lumbar spine operations following initial inpatient decompression or fusion for lumbar spinal stenosis among Medicare fee-for-service beneficiaries, 2000-11

Source: CMS MedPAR. Estimates based on Kaplan-Meier Failure, following methods reported in: Deyo RA et al. Revision surgery following operations for lumbar stenosis. *J Bone Joint Surg Am.* 2011 Nov 2;93(21):1979-86. Updated with additional years of data.

Can less invasive alternatives help? New technology, but what evidence?

Interspinious process devices (such as the X-Stop© device, approved by the FDA in late 2005) have recently emerged as a less invasive alternative to decompression procedures. These devices are inserted between the spinous processes of adjacent vertebrae and spread the vertebrae apart to prevent the nerve canals from pressing on the nerves. While industry-sponsored randomized trials suggest an advantage over non-surgical treatments, there are only a few clinical trials comparing them to decompression.[62-64] While these devices can be placed using only local anesthetics, their use is associated with a higher incidence of reoperation. Interspinous distraction procedures appear to have fewer life-threatening complications at the time of the operation, but lead to more subsequent revision operations.[65,66] Other minimally invasive decompression techniques are under development, but the evidence necessary to support their use remains limited.

Beyond surgery

Trends and variation in treatments for lumbar spinal stenosis likely reflect an aging population, a lack of consensus about the best treatment options, and changes in surgical technologies. While decompression may remain the gold standard for patients for whom non-operative treatments have failed, it is increasingly performed on an outpatient basis, using minimally invasive techniques, and incorporating spinal spacers. Additionally, some patients may seek to undergo lumbar fusion operations. Some have viewed fusion as obviating the need for additional treatments. Sadly, this does not bear out in observation of readmissions, complications, and repeat spine surgery rates.

The need for shared decision-making

The complex and changing treatment options highlight the need for the development of better tools to help patients to make the best, most informed treatment choices. Prior work by the Dartmouth Atlas Project has shown that the marked regional variation in surgery for back pain reflects the local practice styles of spine surgeons. For the individual patient, there is often not a single "right" treatment choice. Each has the potential to benefit the patient, but benefit is not certain. Each also entails the possibility of harm or the need for further surgery. In ideal settings, patients should be informed about these options and given the opportunity to participate in shared decision-making, allowing their values and preferences to guide them to the best decision for them.

Treatment Options	Decision Support Tool Components			Patient Outcomes
	Patient Needs	Decision Support	Decision Quality	
Medication Physical therapy Steroid injections Surgery - Decompression - Fusion	Clarification of individual values and preferences Knowledge of procedure risks, benefits, and other considerations	**Continuously updated, patient-specific data regarding risks and benefits** Guidance for the patient/surgeon interaction Other considerations	Assessment of patient knowledge and understanding Assessment of congruence with pre-specified values and preferences	Measurement of: Pain reduction Quality of life Surgical complications 30-day readmission Need for repeat surgery

Figure 11. Conceptual model for decision support process

Procedures such as spinal fusion have become increasingly common in recent years. These operations, unfortunately, can result in complications, some requiring readmission to the hospital. These findings point to significant opportunities to improve safety and effectiveness in treating back pain. Long-term surveillance of safety measures and patient-reported outcomes are rare in spine surgery but are critically important for informing patients and other stakeholders about the value of spinal procedures.

Conclusions

Surgery for back pain, especially for patients with spinal stenosis, has changed dramatically in recent years but continues to vary from one region to the next. While surgical outcomes research has provided information about when and how these changes have occurred over time, patients are still subject to the accident of geography. In one region, patients are more likely to be offered decompression; in another, fusion; and in a third, medical management may be more common. We know very little about how the variation in care patterns has affected patients and their lives. While more needs to be done to improve the treatments for spinal stenosis and back pain, there is a more immediate opportunity to improve care by implementing shared decision-making. A higher quality decision-making process would help patients find the choice best aligned with their values and preferences.

Methods

Data sources and cohort formation: We examined the 100% sample of the Medicare Provider Analysis and Review (MedPAR) file for patients undergoing an initial inpatient lumbar spinal fusion or decompression operation for spinal stenosis from 2001 to 2011. Each MedPAR claim is coded with up to ten diagnosis and six procedure codes. We searched all of these codes to identify patients with spinal stenosis undergoing decompression or fusion operations. Population data for estimating population-based rates came from the Medicare Denominator file and was stratified by five-year increments of age, sex, and race (black/non-black). We combined data from 2001 through 2011 to estimate age-, sex-, and race-adjusted trends in the rates of decompression and fusion operations for spinal stenosis per 100,000 Medicare beneficiaries.

We identified inpatient admissions among beneficiaries age 65 and older, excluding those who were on social security disability insurance, had eligibility for end-stage renal disease, or were enrolled in Medicare HMO programs (e.g., Medicare Advantage). Admissions associated with the surgical indication of spinal stenosis were identified using a previously published and validated hierarchical coding algorithm (www.researchgate.net/publication/257631899_SPINEDEF_%28Version_6%29_Coding_definitions_for_characterizing_spine-related_medical_encounters). All inpatient admissions that involved an initial (incident) thoracolumbar, lumbar, or lumbosacral fusion or decompression operation for spinal stenosis from 2001 through 2011 were included. However, admissions that included codes for refusion, artificial disc replacement, corpectomy, osteotomy, and kyphectomy were excluded. We further excluded admissions that contained codes for non-degenerative lumbar spinal admissions, such as spinal fracture, vertebral dislocation, spinal cord injury, cervical or thoracic conditions, and inflammatory spondylopathy. Finally, we excluded admissions associated with codes for accidents, neoplasm, HIV or immune deficiency, intraspinal abscess, or osteomyelitis.

Surgical complications: Orthopaedic device complications, wound problems, life-threatening medical complications, and repeat surgery were ascertained for each patient. To calculate the rate and difference in surgical risk between fusion and decompression, we performed a logistic regression for each type of complication, including variables for patient age, sex, race, comorbidity, and previous hospitalizations. Similarly, we examined differences in long-term rates of repeat spine operation between decompression and fusion. We used a Cox proportional hazard regression model to examine differences in the time until a first reoperation between patients undergoing initial decompression and fusion operations.

Economic analyses: For the economic analyses presented in this report, we updated our previously published analysis of the Medical Expenditure Panel Survey[9] with data through 2012 to estimate the treated prevalence and the economic burden of back and neck problems in the United States. MEPS is a household survey of medical expenditures weighted to represent national estimates. We focused on adults (> 17 years) with self-reported neck and back problems mapped to spine-related codes from the International Classification of Disease (ICD-9-CM). Inflation-adjusted, survey-weighted generalized linear regression models, adjusting for age, sex, and Charlson comorbidity, were used to calculate the incremental difference in health care costs between patients with and without spine problems.

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Birmingham	AL	1,398,742	124.6	44.7
Dothan	AL	282,577	121.3	50.0
Huntsville	AL	402,264	118.5	65.4
Mobile	AL	464,724	119.6	44.8
Montgomery	AL	272,362	96.2	37.2
Tuscaloosa	AL	167,593	82.2	28.0
Anchorage	AK	254,882	63.5	35.5
Mesa	AZ	398,308	74.9	34.2
Phoenix	AZ	1,324,677	76.6	31.9
Sun City	AZ	267,810	93.1	50.0
Tucson	AZ	572,030	97.6	49.7
Fort Smith	AR	250,102	62.8	24.1
Jonesboro	AR	174,688	100.3	24.6
Little Rock	AR	1,130,527	109.5	27.6
Springdale	AR	292,036	61.0	22.5
Texarkana	AR	194,169	128.0	27.4
Orange County	CA	1,061,288	46.7	30.8
Bakersfield	CA	372,840	63.1	18.4
Chico	CA	237,544	80.5	29.7
Contra Costa County	CA	332,781	52.5	25.0
Fresno	CA	465,467	37.0	12.5
Los Angeles	CA	3,308,910	61.7	22.8
Modesto	CA	366,226	74.3	26.1
Napa	CA	183,811	67.6	25.4
Alameda County	CA	480,509	48.3	14.9
Palm Springs/Rancho Mirage	CA	220,793	66.1	36.9
Redding	CA	275,138	54.1	18.9
Sacramento	CA	978,357	67.9	28.9
Salinas	CA	219,866	108.5	39.3
San Bernardino	CA	664,846	54.2	23.0
San Diego	CA	1,205,041	57.7	29.2
San Francisco	CA	611,589	62.2	19.9
San Jose	CA	577,960	60.8	17.6
San Luis Obispo	CA	170,941	63.9	21.2
San Mateo County	CA	327,617	82.8	26.1
Santa Barbara	CA	234,230	153.9	45.0
Santa Cruz	CA	127,842	140.4	21.6
Santa Rosa	CA	214,000	47.6	28.5
Stockton	CA	224,961	63.1	40.2
Ventura	CA	361,823	121.1	45.9
Boulder	CO	101,347	110.6	68.4
Colorado Springs	CO	381,179	47.9	41.1
Denver	CO	848,970	89.6	46.1
Fort Collins	CO	168,987	120.5	59.8

Rates are adjusted for age, sex, and race. Blank cells indicate that the rate was suppressed due to a small number of events occurring in the region during the study period. The averages were created based on odd-numbered years from 2001 to 2011.

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Grand Junction	CO	159,589	91.0	64.3
Greeley	CO	185,433	146.8	64.0
Pueblo	CO	103,911	44.0	42.5
Bridgeport	CT	419,634	82.7	24.0
Hartford	CT	1,039,959	70.0	39.5
New Haven	CT	965,608	54.7	34.8
Wilmington	DE	500,184	40.6	30.7
Washington	DC	1,441,278	81.3	39.6
Bradenton	FL	261,124	85.5	127.5
Clearwater	FL	385,591	84.7	48.6
Fort Lauderdale	FL	1,715,571	68.2	65.9
Fort Myers	FL	1,053,852	112.7	47.7
Gainesville	FL	373,306	104.7	49.5
Hudson	FL	349,227	100.8	45.1
Jacksonville	FL	854,278	84.6	35.6
Lakeland	FL	229,025	79.4	43.2
Miami	FL	1,068,243	31.8	31.5
Ocala	FL	637,897	134.9	60.0
Orlando	FL	2,222,114	65.6	54.2
Ormond Beach	FL	301,636	53.9	27.7
Panama City	FL	157,359	46.8	64.6
Pensacola	FL	527,166	102.0	41.5
Sarasota	FL	547,740	77.2	80.5
St. Petersburg	FL	278,090	118.1	36.4
Tallahassee	FL	420,477	69.0	61.2
Tampa	FL	542,844	67.1	30.5
Albany	GA	125,218	53.0	52.9
Atlanta	GA	2,441,602	65.7	32.8
Augusta	GA	396,573	66.7	47.9
Columbus	GA	195,141	125.0	81.7
Macon	GA	435,234	58.7	39.6
Rome	GA	188,040	87.1	35.6
Savannah	GA	488,566	97.3	58.7
Honolulu	HI	576,993	40.3	26.8
Boise	ID	401,406	120.2	86.9
Idaho Falls	ID	110,210	59.6	70.9
Aurora	IL	111,932	43.7	21.5
Blue Island	IL	572,392	59.9	51.9
Chicago	IL	1,238,208	46.4	28.4
Elgin	IL	364,742	68.5	39.1
Evanston	IL	756,091	86.9	51.9
Hinsdale	IL	249,779	73.5	48.0
Joliet	IL	372,502	65.4	36.9
Melrose Park	IL	777,643	69.6	35.0

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Peoria	IL	500,641	73.3	33.7
Rockford	IL	503,483	60.6	42.0
Springfield	IL	725,016	77.7	79.9
Urbana	IL	293,657	147.7	33.7
Bloomington	IL	106,732	186.6	72.5
Evansville	IN	523,772	83.3	32.0
Fort Wayne	IN	521,594	67.8	83.5
Gary	IN	357,341	64.4	53.1
Indianapolis	IN	1,729,082	69.9	36.2
Lafayette	IN	120,404	71.7	68.1
Muncie	IN	133,807	98.4	71.7
Munster	IN	221,961	82.2	53.9
South Bend	IN	463,173	34.8	74.3
Terre Haute	IN	141,641	49.9	32.9
Cedar Rapids	IA	199,297	74.4	20.4
Davenport	IA	379,339	107.5	54.3
Des Moines	IA	785,272	101.8	40.6
Dubuque	IA	87,363	139.2	32.9
Iowa City	IA	232,634	118.3	56.8
Mason City	IA	149,020	216.7	89.2
Sioux City	IA	206,199	112.6	48.3
Waterloo	IA	159,472	88.0	44.8
Topeka	KS	321,952	98.3	66.6
Wichita	KS	974,015	92.7	58.4
Covington	KY	200,691	83.3	18.0
Lexington	KY	915,667	50.0	27.9
Louisville	KY	1,098,043	68.9	39.8
Owensboro	KY	107,837	116.0	32.0
Paducah	KY	324,320	63.7	60.4
Alexandria	LA	204,932	106.4	49.7
Baton Rouge	LA	370,119	38.0	30.6
Houma	LA	145,992	73.8	56.4
Lafayette	LA	378,712	48.9	60.4
Lake Charles	LA	165,315	94.8	43.1
Metairie	LA	207,018	53.7	29.3
Monroe	LA	201,108	166.8	38.5
New Orleans	LA	235,393	48.6	37.2
Shreveport	LA	486,473	124.0	35.0
Slidell	LA	92,030	167.3	42.1
Bangor	ME	343,868	83.6	9.2
Portland	ME	813,159	91.6	27.0
Baltimore	MD	1,598,239	91.3	48.9
Salisbury	MD	393,863	54.0	38.8
Takoma Park	MD	440,271	70.0	50.4

Rates are adjusted for age, sex, and race. Blank cells indicate that the rate was suppressed due to a small number of events occurring in the region during the study period. The averages were created based on odd-numbered years from 2001 to 2011.

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Boston	MA	2,905,066	85.4	26.8
Springfield	MA	469,764	72.0	33.7
Worcester	MA	307,221	77.4	50.2
Ann Arbor	MI	771,202	83.7	41.1
Dearborn	MI	342,156	73.3	52.1
Detroit	MI	1,108,678	95.1	54.3
Flint	MI	339,333	88.1	39.9
Grand Rapids	MI	605,380	106.3	89.9
Kalamazoo	MI	432,238	96.4	55.4
Lansing	MI	388,435	134.8	27.1
Marquette	MI	171,068	116.6	19.6
Muskegon	MI	178,442	131.9	57.9
Petoskey	MI	153,544	74.0	52.3
Pontiac	MI	239,421	102.5	53.8
Royal Oak	MI	459,439	84.0	69.4
Saginaw	MI	555,906	100.3	68.1
St. Joseph	MI	109,088	100.3	22.4
Traverse City	MI	206,670	117.3	54.6
Duluth	MN	257,760	96.9	36.8
Minneapolis	MN	1,434,362	102.2	45.9
Rochester	MN	298,010	104.1	21.1
St. Cloud	MN	130,611	166.7	20.4
St. Paul	MN	400,552	123.4	41.9
Gulfport	MS	114,522	104.0	41.6
Hattiesburg	MS	195,547	60.6	69.4
Jackson	MS	666,746	75.4	33.3
Meridian	MS	149,597	79.0	20.5
Oxford	MS	97,154	79.6	23.0
Tupelo	MS	269,844	66.5	17.9
Cape Girardeau	MO	218,620	85.5	34.4
Columbia	MO	520,521	70.2	54.2
Joplin	MO	292,890	89.7	50.3
Kansas City	MO	1,338,356	112.7	40.2
Springfield	MO	594,758	56.1	41.7
St. Louis	MO	1,977,157	68.5	32.6
Billings	MT	394,864	125.9	54.7
Great Falls	MT	113,357	79.8	40.5
Missoula	MT	274,625	78.6	48.7
Lincoln	NE	445,555	123.5	43.5
Omaha	NE	847,677	119.1	45.3
Las Vegas	NV	694,803	68.3	40.6
Reno	NV	419,773	81.8	44.9
Lebanon	NH	346,236	71.0	32.3
Manchester	NH	576,524	81.2	35.1

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Camden	NJ	2,018,098	48.4	24.7
Hackensack	NJ	855,222	43.5	27.2
Morristown	NJ	657,767	64.8	35.7
New Brunswick	NJ	609,813	48.5	23.7
Newark	NJ	828,334	35.8	18.6
Paterson	NJ	242,770	63.4	20.0
Ridgewood	NJ	276,298	60.0	21.6
Albuquerque	NM	798,793	72.0	33.5
Albany	NY	1,232,672	65.9	33.8
Binghamton	NY	297,971	55.2	55.1
Bronx	NY	447,503	25.3	17.5
Buffalo	NY	692,313	71.0	26.9
Elmira	NY	266,299	61.9	20.4
East Long Island	NY	2,629,006	38.5	30.9
Manhattan	NY	2,320,335	35.6	23.2
Rochester	NY	499,889	100.2	37.5
Syracuse	NY	729,887	83.0	27.7
White Plains	NY	712,135	57.6	31.5
Asheville	NC	578,469	74.7	47.2
Charlotte	NC	1,270,661	72.4	65.2
Durham	NC	845,359	91.7	37.1
Greensboro	NC	315,613	84.0	28.3
Greenville	NC	560,227	69.9	31.9
Hickory	NC	203,696	88.7	51.9
Raleigh	NC	938,652	83.1	36.4
Wilmington	NC	306,199	82.7	50.2
Winston-Salem	NC	610,810	66.0	39.2
Bismarck	ND	184,179	130.2	44.4
Fargo/Moorhead MN	ND	375,347	110.3	33.7
Grand Forks	ND	123,966	95.8	25.0
Minot	ND	104,868	88.9	37.3
Akron	OH	376,023	142.0	76.4
Canton	OH	385,753	108.1	54.7
Cincinnati	OH	879,493	73.4	41.9
Cleveland	OH	1,340,774	76.0	57.2
Columbus	OH	1,636,441	64.6	55.5
Dayton	OH	711,358	72.9	51.4
Elyria	OH	163,416	95.1	31.7
Kettering	OH	255,125	64.4	65.1
Toledo	OH	607,040	131.7	51.0
Youngstown	OH	448,648	78.9	55.4
Lawton	OK	138,559	112.7	47.6
Oklahoma City	OK	1,176,503	95.7	29.3
Tulsa	OK	788,484	76.9	29.3

Rates are adjusted for age, sex, and race. Blank cells indicate that the rate was suppressed due to a small number of events occurring in the region during the study period. The averages were created based on odd-numbered years from 2001 to 2011.

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Bend	OR	121,059	154.2	33.1
Eugene	OR	391,361	149.8	57.2
Medford	OR	323,665	107.2	60.1
Portland	OR	898,954	149.0	42.3
Salem	OR	100,701	127.5	47.3
Allentown	PA	824,563	89.5	33.5
Altoona	PA	179,896	54.3	50.4
Danville	PA	360,304	70.1	41.6
Erie	PA	512,378	93.6	37.5
Harrisburg	PA	696,969	85.8	64.6
Johnstown	PA	113,991	93.3	44.8
Lancaster	PA	423,965	159.3	54.4
Philadelphia	PA	1,955,482	64.7	27.1
Pittsburgh	PA	1,504,518	111.1	59.1
Reading	PA	394,268	61.5	40.6
Sayre	PA	155,201	67.7	37.5
Scranton	PA	270,765	89.8	17.1
Wilkes-Barre	PA	219,944	47.4	25.2
York	PA	297,112	136.1	62.4
Providence	RI	615,563	55.2	43.1
Charleston	SC	651,793	98.6	71.9
Columbia	SC	726,297	85.9	58.5
Florence	SC	241,915	103.3	74.7
Greenville	SC	564,871	98.0	36.4
Spartanburg	SC	246,860	100.2	26.0
Rapid City	SD	151,118	77.4	51.8
Sioux Falls	SD	652,940	86.3	73.0
Chattanooga	TN	451,315	50.7	31.8
Jackson	TN	267,675	67.5	24.0
Johnson City	TN	174,303	48.5	37.5
Kingsport	TN	307,496	57.8	29.9
Knoxville	TN	846,740	70.6	35.8
Memphis	TN	1,021,060	59.4	23.5
Nashville	TN	1,446,374	88.1	67.9
Abilene	TX	246,124	71.2	39.3
Amarillo	TX	302,164	132.0	32.8
Austin	TX	635,194	79.8	50.0
Beaumont	TX	298,469	96.8	32.7
Bryan	TX	121,785	155.7	35.1
Corpus Christi	TX	278,392	70.5	44.2
Dallas	TX	1,913,948	70.3	40.3
El Paso	TX	543,167	57.5	35.1
Fort Worth	TX	812,985	55.8	47.5
Harlingen	TX	266,872	85.5	40.8

Appendix Table. Rates of inpatient lumbar decompression and fusion for lumbar spinal stenosis among hospital referral regions (2001-11)

HRR Name	State	Number of Medicare beneficiaries	Lumbar decompression per 100,000 Medicare beneficiaries	Lumbar fusion per 100,000 Medicare beneficiaries
Houston	TX	2,405,919	103.3	27.7
Longview	TX	144,511	118.0	67.9
Lubbock	TX	444,739	81.9	34.5
McAllen	TX	255,625	73.2	37.9
Odessa	TX	206,455	110.9	62.3
San Angelo	TX	125,445	85.5	34.7
San Antonio	TX	1,184,382	55.4	39.6
Temple	TX	156,536	36.8	27.8
Tyler	TX	434,016	106.3	88.5
Victoria	TX	119,113	78.1	38.0
Waco	TX	219,028	44.2	43.8
Wichita Falls	TX	163,689	74.3	42.8
Ogden	UT	183,192	94.4	29.2
Provo	UT	161,789	89.9	30.8
Salt Lake City	UT	836,139	80.9	45.7
Burlington	VT	449,412	59.1	30.0
Arlington	VA	866,789	52.5	66.5
Charlottesville	VA	400,815	99.2	48.5
Lynchburg	VA	197,415	151.0	27.9
Newport News	VA	362,626	104.5	87.4
Norfolk	VA	726,543	56.0	67.9
Richmond	VA	1,016,211	82.0	64.3
Roanoke	VA	547,605	95.6	29.0
Winchester	VA	278,536	89.6	44.8
Everett	WA	281,257	110.0	28.9
Olympia	WA	206,427	126.0	57.5
Seattle	WA	1,322,823	112.4	44.3
Spokane	WA	932,111	145.0	52.3
Tacoma	WA	353,221	200.7	63.5
Yakima	WA	168,224	116.0	44.4
Charleston	WV	616,385	45.6	21.1
Huntington	WV	267,118	62.6	19.6
Morgantown	WV	276,451	59.0	25.3
Appleton	WI	179,914	77.3	50.9
Green Bay	WI	344,975	121.8	32.1
La Crosse	WI	216,541	85.9	19.4
Madison	WI	643,338	66.1	35.6
Marshfield	WI	272,431	50.0	27.0
Milwaukee	WI	1,528,985	69.1	33.3
Neenah	WI	142,774	78.4	47.7
Wausau	WI	145,152	40.9	33.8
Casper	WY	145,133	155.8	73.4
United States	US	165,390,225	80.0	41.1

Rates are adjusted for age, sex, and race. Blank cells indicate that the rate was suppressed due to a small number of events occurring in the region during the study period. The averages were created based on odd-numbered years from 2001 to 2011.

References

1 Deyo RA, Phillips WR. Low back pain. A primary care challenge. *Spine*. 1996 Dec 15;21(24):2826-32.

2 Biering-Sørensen F. A prospective study of low back pain in a general population. III. Medical service--work consequence. *Scand J Rehabil Med.* 1983;15(2):89-96.

3 Frymoyer JW, Pope MH, Clements JH, Wilder DG, MacPherson B, Ashikaga T. Risk factors in low-back pain. An epidemiological survey. *J Bone Joint Surg Am.* 1983 Feb;65(2):213-8.

4 Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: estimates from U.S. national surveys, 2002. *Spine*. 2006 Nov 1;31(23):2724-7.

5 Lawrence RC, Felson DT, Helmick CG, Arnold LM, Choi H, Deyo RA, Gabriel S, Hirsch R, Hochberg MC, Hunder GG, Jordan JM, Katz JN, Kremers HM, Wolfe F; National Arthritis Data Workgroup. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum.* 2008 Jan;58(1):26-35.

6 Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain. Frequency, clinical evaluation, and treatment patterns from a U.S. national survey. *Spine*. 1995 Jan 1;20(1):11-9.

7 Deyo RA, Cherkin D, Conrad D, Volinn E. Cost, controversy, crisis: low back pain and the health of the public. *Annu Rev Public Health.* 1991;12:141-56.

8 Deyo RA, Tsui-Wu YJ. Descriptive epidemiology of low-back pain and its related medical care in the United States. *Spine*. 1987 Apr;12(3):264-8.

9 Martin BI, Deyo RA, Mirza SK, Turner JA, Comstock BA, Hollingworth W, Sullivan SD. Expenditures and health status among adults with back and neck problems. *JAMA*. 2008 Feb 13;299(6):656-64.

10 Is the growth in spine procedures in the United States finally beginning to tail off? *The Back Letter.* 2012 Aug;27(8):85-93.

11 Freburger JK, Holmes GM, Agans RP, Jackman AM, Darter JD, Wallace AS, Castel LD, Kalsbeek WD, Carey TS. The rising prevalence of chronic low back pain. *Arch Intern Med.* 2009 Feb 9;169(3):251-8.

12 Martin LG, Freedman VA, Schoeni RF, Andreski PM. Trends in disability and related chronic conditions among people ages fifty to sixty-four. *Health Affairs.* 2010 Apr;29(4):725-31.

13 Weinstein JN, Lurie JD, Olson PR, Bronner KK, Fisher ES. United States' trends and regional variations in lumbar spine surgery: 1992-2003. *Spine*. 2006 Nov 1;31(23):2707-14.

14 Schoenfeld AJ, Harris MB, Liu H, Birkmeyer JD. Variations in Medicare payments for episodes of spine surgery. *Spine* J. 2014 Jul 11. [Epub ahead of print]

15 Johnsson KE, Rosén I, Udén A. The natural course of lumbar spinal stenosis. *Clin Orthop Relat Res.* 1992 Jun;(279):82-6.

16 Kalichman L, Cole R, Kim DH, Li L, Suri P, Guermazi A, Hunter DJ. Spinal stenosis prevalence and association with symptoms: the Framingham Study. *Spine* J. 2009 Jul;9(7):545-50.

17 Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J; Lumbar Spinal Stenosis Outcome Study Working Group Zurich. Radiologic criteria for the diagnosis of spinal stenosis: results of a Delphi survey. *Radiology*. 2012 Jul;264(1):174-9.

18 Suri P, Rainville J, Kalichman L, Katz JN. Does this older adult with lower extremity pain have the clinical syndrome of lumbar spinal stenosis? *JAMA*. 2010 Dec 15;304(23):2628-36.

19 Steurer J, Roner S, Gnannt R, Hodler J; LumbSten Research Collaboration. Quantitative radiologic criteria for the diagnosis of lumbar spinal stenosis: a systematic literature review. *BMC Musculoskelet Disord.* 2011 Jul 28;12:175.

20 Haig AJ. Correlation between disability and MRI findings in lumbar spinal stenosis. *Acta Orthop.* 2011 Oct;82(5):637; author reply 637-8.

21 Haig AJ, Tong HC, Yamakawa KS, Quint DJ, Hoff JT, Chiodo A, Miner JA, Choksi VR, Geisser ME, Parres CM. Spinal stenosis, back pain, or no symptoms at all? A masked study comparing radiologic and electrodiagnostic diagnoses to the clinical impression. *Arch Phys Med Rehabil.* 2006 Jul;87(7):897-903.

22 Geisser ME, Haig AJ, Tong HC, Yamakawa KS, Quint DJ, Hoff JT, Miner JA, Phalke VV. Spinal canal size and clinical symptoms among persons diagnosed with lumbar spinal stenosis. *Clin J Pain.* 2007 Nov-Dec;23(9):780-5.

23 Jarvik JJ, Hollingworth W, Heagerty P, Haynor DR, Deyo RA. The Longitudinal Assessment of Imaging and Disability of the Back (LAIDBack) Study: baseline data. *Spine.* 2001 May 15;26(10):1158-66.

24 Boden SD, McCowin PR, Davis DO, Dina TS, Mark AS, Wiesel S. Abnormal magnetic-resonance scans of the cervical spine in asymptomatic subjects. A prospective investigation. *J Bone Joint Surg Am.* 1990 Sep;72(8):1178-84.

25 Deyo RA, Mirza SK, Turner JA, Martin BI. Overtreating chronic back pain: time to back off? *J Am Board Fam Med.* 2009 Jan-Feb;22(1):62-8.

26 Chou R, Huffman LH; American Pain Society; American College of Physicians. Medications for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. *Ann Intern Med.* 2007 Oct 2;147(7):505-14.

27 Chan AT, Manson JE, Albert CM, Chae CU, Rexrode KM, Curhan GC, Rimm EB, Willett WC, Fuchs CS. Nonsteroidal antiinflammatory drugs, acetaminophen, and the risk of cardiovascular events. *Circulation*. 2006 Mar 28;113(12):1578-87.

28 Kuijpers T, van Middelkoop M, Rubinstein SM, Ostelo R, Verhagen A, Koes BW, van Tulder MW. A systematic review on the effectiveness of pharmacological interventions for chronic non-specific low-back pain. *Eur Spine J.* 2011 Jan;20(1):40-50.

29 Dersh J, Mayer TG, Gatchel RJ, Polatin PB, Theodore BR, Mayer EA. Prescription opioid dependence is associated with poorer outcomes in disabling spinal disorders. *Spine*. 2008 Sep 15;33(20):2219-27.

30 Doverty M, White JM, Somogyi AA, Bochner F, Ali R, Ling W. Hyperalgesic responses in methadone maintenance patients. *Pain*. 2001 Feb 1;90(1-2):91-6.

31 Chu LF, Clark DJ, Angst MS. Opioid tolerance and hyperalgesia in chronic pain patients after one month of oral morphine therapy: a preliminary prospective study. *J Pain.* 2006 Jan;7(1):43-8.

32 McDonald DC, Carlson K, Izrael D. Geographic variation in opioid prescribing in the U.S. *J Pain.* 2012 Oct;13(10):988-96.

33 Eriksen J, Sjøgren P, Bruera E, Ekholm O, Rasmussen NK. Critical issues on opioids in chronic non-cancer pain: an epidemiological study. *Pain*. 2006 Nov;125(1-2):172-9.

34 Chaparro LE, Furlan AD, Deshpande A, Mailis-Gagnon A, Atlas S, Turk DC. Opioids compared with placebo or other treatments for chronic low back pain: an update of the Cochrane Review. *Spine*. 2014 Apr 1;39(7):556-63.

35 Sullivan MD, Edlund MJ, Steffick D, Unützer J. Regular use of prescribed opioids: association with common psychiatric disorders. *Pain*. 2005 Dec 15;119(1-3):95-103.

36 Chou R, Fanciullo GJ, Fine PG, et al.; for the American Pain Society and American Academy of Pain Medicine Opioid Guidelines Panel. Clinical guidelines for the use of chronic opioid therapy in chronic noncancer pain. *J Pain.* 2009;10(2):113–130.

37 Parker SL, Godil SS, Mendenhall SK, Zuckerman SL, Shau DN, McGirt MJ. Two-year comprehensive medical management of degenerative lumbar spine disease (lumbar spondylolisthesis, stenosis, or disc herniation): a value analysis of cost, pain, disability, and quality of life. *J Neurosurg Spine.* 2014 Aug;21(2):143-9.

38 Scientific approach to the assessment and management of activity-related spinal disorders. A monograph for clinicians. Report of the Quebec Task Force on Spinal Disorders. *Spine*. 1987 Sep;12(7 Suppl):S1-59.

39 Ammendolia C, Stuber K, de Bruin LK, Furlan AD, Kennedy CA, Rampersaud YR, Steenstra IA, Pennick V. Nonoperative treatment of lumbar spinal stenosis with neurogenic claudication: a systematic review. *Spine*. 2012 May 1;37(10):E609-16.

40 Weinstein JN, Tosteson TD, Lurie JD, Tosteson AN, Blood E, Hanscom B, Herkowitz H, Cammisa F, Albert T, Boden SD, Hilibrand A, Goldberg H, Berven S, An H; SPORT Investigators. Surgical versus nonsurgical therapy for lumbar spinal stenosis. *N Engl J Med.* 2008 Feb 21;358(8):794-810.

41 Friedly J, Chan L, Deyo R. Increases in lumbosacral injections in the Medicare population: 1994 to 2001. *Spine*. 2007 Jul 15;32(16):1754-60.

42 Friedly J, Chan L, Deyo R.Geographic variation in epidural steroid injection use in Medicare patients. *J Bone Joint Surg Am.* 2008 Aug;90(8):1730-7.

43 Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klaber-Moffett J, Kovacs F, Mannion AF, Reis S, Staal JB, Ursin H, Zanoli G; COST B13 Working Group on Guidelines for Chronic Low Back Pain. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. *Eur Spine J.* 2006 Mar;15 Suppl 2:S192-300.

44 Armon C, Argoff CE, Samuels J, Backonja MM; Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Assessment: use of epidural steroid injections to treat radicular lumbosacral pain: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology*. 2007 Mar 6;68(10):723-9.

45 Arden NK, Price C, Reading I, Stubbing J, Hazelgrove J, Dunne C, Michel M, Rogers P, Cooper C; WEST Study Group. A multicentre randomized controlled trial of epidural corticosteroid injections for sciatica: the WEST study. *Rheumatology*. 2005 Nov;44(11):1399-406.

46 Carette S, Leclaire R, Marcoux S, Morin F, Blaise GA, St-Pierre A, Truchon R, Parent F, Levésque J, Bergeron V, Montminy P, Blanchette C. Epidural corticosteroid injections for sciatica due to herniated nucleus pulposus. *N Engl J Med.* 1997 Jun 5;336(23):1634-40.

47 Cuckler JM, Bernini PA, Wiesel SW, Booth RE Jr, Rothman RH, Pickens GT. The use of epidural steroids in the treatment of lumbar radicular pain. A prospective, randomized, double-blind study. *J Bone Joint Surg Am.* 1985 Jan;67(1):63-6.

48 Wilson-MacDonald J, Burt G, Griffin D, Glynn C. Epidural steroid injection for nerve root compression. A randomised, controlled trial. *J Bone Joint Surg Br.* 2005 Mar;87(3):352-5.

49 Friedly J, Nishio I, Bishop MJ, Maynard C. The relationship between repeated epidural steroid injections and subsequent opioid use and lumbar surgery. *Arch Phys Med Rehabil.* 2008 Jun;89(6):1011-5.

50 Friedly JL, Comstock BA, Turner JA, Heagerty PJ, Deyo RA, Sullivan SD, Bauer Z, Bresnahan BW, Avins AL, Nedeljkovic SS, Nerenz DR, Standaert C, Kessler L, Akuthota V, Annaswamy T, Chen A, Diehn F, Firtch W, Gerges FJ, Gilligan C, Goldberg H, Kennedy DJ, Mandel S, Tyburski M, Sanders W, Sibell D, Smuck M, Wasan A, Won L, Jarvik JG. A randomized trial of epidural glucocorticoid injections for spinal stenosis. *N Engl J Med.* 2014 Jul 3;371(1):11-21.

51 Mobbs RJ, Li J, Sivabalan P, Raley D, Rao PJ. Outcomes after decompressive laminectomy for lumbar spinal stenosis: comparison between minimally invasive unilateral laminectomy for bilateral decompression and open laminectomy. *Neurosurg Spine.* 2014 Aug;21(2):179-86.

52 Nomura H, Yanagisawa Y, Arima J, Oga M. Clinical outcome of microscopic lumbar spinous process-splitting laminectomy. *J Neurosurg Spine.* 2014 Aug;21(2):187-94.

53 Djurasovic M, Glassman SD, Carreon LY, Dimar JR 2nd. Contemporary management of symptomatic lumbar spinal stenosis. *Orthop Clin North Am.* 2010 Apr;41(2):183-91.

54 Resnick DK, Watters WC 3rd, Mummaneni PV, Dailey AT, Choudhri TF, Eck JC, Sharan A, Groff MW, Wang JC, Ghogawala Z, Dhall SS, Kaiser MG. Guideline update for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 10: lumbar fusion for stenosis without spondylolisthesis. *J Neurosurg Spine.* 2014 Jul;21(1):62-6.

55 Turner JA, Ersek M, Herron L, Deyo R. Surgery for lumbar spinal stenosis. Attempted meta-analysis of the literature. *Spine.* 1992 Jan;17(1):1-8.

56 Munting E, Röder C, Sobottke R, Dietrich D, Aghayev E; on behalf of the Spine Tango Contributors. Patient outcomes after laminotomy, hemilaminectomy, laminectomy and laminectomy with instrumented fusion for spinal canal stenosis: a propensity score-based study from the Spine Tango registry. *Eur Spine J.* 2014 May 20. [Epub ahead of print]

57 Malmivaara A, Slätis P, Heliövaara M, Sainio P, Kinnunen H, Kankare J, Dalin-Hirvonen N, Seitsalo S, Herno A, Kortekangas P, Niinimäki T, Rönty H, Tallroth K, Turunen V, Knekt P, Härkänen T, Hurri H; Finnish Lumbar Spinal Research Group. Surgical or nonoperative treatment for lumbar spinal stenosis? A randomized controlled trial. *Spine*. 2007 Jan 1;32(1):1-8.

58 Amundsen T, Weber H, Nordal HJ, Magnaes B, Abdelnoor M, Lilleâs F. Lumbar spinal stenosis: conservative or surgical management?: A prospective 10-year study. *Spine*. 2000 Jun 1;25(11):1424-35; discussion 1435-6.

59 Atlas SJ, Keller RB, Wu YA, Deyo RA, Singer DE. Long-term outcomes of surgical and nonsurgical management of lumbar spinal stenosis: 8 to 10 year results from the maine lumbar spine study. *Spine*. 2005 Apr 15;30(8):936-43.

60 Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA*. 2010 Apr 7;303(13):1259-65.

61 Ong KL, Auerbach JD, Lau E, Schmier J, Ochoa JA. Perioperative outcomes, complications, and costs associated with lumbar spinal fusion in older patients with spinal stenosis and spondylolisthesis. *Neurosurg Focus.* 2014 Jun;36(6):E5.

62 Zucherman JF, Hsu KY, Hartjen CA, Mehalic TF, Implicito DA, Martin MJ, Johnson DR 2nd, Skidmore GA, Vessa PP, Dwyer JW, Puccio ST, Cauthen JC, Ozuna RM. A multicenter, prospective, randomized trial evaluating the X STOP interspinous process decompression system for the treatment of neurogenic intermittent claudication: two-year follow-up results. *Spine*. 2005 Jun 15;30(12):1351-8.

63 Zucherman JF, Hsu KY, Hartjen CA, Mehalic TF, Implicito DA, Martin MJ, Johnson DR 2nd, Skidmore GA, Vessa PP, Dwyer JW, Puccio S, Cauthen JC, Ozuna RM. A prospective randomized multi-center study for the treatment of lumbar spinal stenosis with the X STOP interspinous implant: 1-year results. *Eur Spine J.* 2004 Feb;13(1):22-31.

64 Wu AM, Zhou Y, Li QL, Wu XL, Jin YL, Luo P, Chi YL, Wang XY. Interspinous spacer versus traditional decompressive surgery for lumbar spinal stenosis: a systematic review and meta-analysis. *PLoS One.* 2014 May 8;9(5):e97142.

65 Deyo RA, Martin BI, Ching A, Tosteson AN, Jarvik JG, Kreuter W, Mirza SK. Interspinous spacers compared with decompression or fusion for lumbar stenosis: complications and repeat operations in the Medicare population. *Spine.* 2013 May 1;38(10):865-72.

66 Hong P, Liu Y, Li H. Comparison of the efficacy and safety between interspinous process distraction device and open decompression surgery in treating lumbar spinal stenosis: a meta analysis. *J Invest Surg.* 2014 Jul 15. [Epub ahead of print]

The Dartmouth Atlas Project works to accurately describe how medical resources are distributed and used in the United States. The project offers comprehensive information and analysis about national, regional, and local markets, as well as individual hospitals and their affiliated physicians, in order to provide a basis for improving health and health systems. Through this analysis, the project has demonstrated glaring variations in how health care is delivered across the United States.

The Dartmouth Atlas Project is funded by the Robert Wood Johnson Foundation and the California Healthcare Foundation.

The Dartmouth Atlas

The Dartmouth Institute
for Health Policy and Clinical Practice

Center for Health Policy Research

Contact: Annmarie Christensen
(603) 653-0897
Annmarie.Christensen@dartmouth.edu

www.dartmouthatlas.org

10282014_dap1.2

The Dartmouth Atlas Working Group

Leadership

Elliott S. Fisher, MD, MPH, Dartmouth Atlas Co-Principal Investigator
David C. Goodman, MD, MS, Dartmouth Atlas Co-Principal Investigator
Jonathan S. Skinner, PhD, Senior Scholar
John E. Wennberg, MD, MPH, Founder of the Dartmouth Atlas
Kristen K. Bronner, MA, Managing Editor

Senior Authors and Faculty

John Erik-Bell, MD
Shannon Brownlee, MS
Julie P.W. Bynum, MD, MPH
Chiang-Hua Chang, PhD
Philip P. Goodney, MD, MS
Nancy E. Morden, MD, MPH
Jeffrey C. Munson, MD, MS
Thérèse A. Stukel, PhD
James N. Weinstein, DO, MS

Analytic and Administrative Staff

Thomas A. Bubolz, PhD
Donald Carmichael, MDiv
Julie Doherty, BA
Jennifer Dong, MS
Daniel J. Gottlieb, MS
Jia Lan, MS
Martha K. Lane, MA
Stephanie R. Raymond, BA
Sandra M. Sharp, SM
Jeremy Smith, MPH
Yunjie Song, PhD
Dean T. Stanley, RHCE
Yin Su, MS
Stephanie Tomlin, MPA
Rebecca Zaha, MPH
Weiping Zhou, MS

Design and Production

Jonathan Sa'adah and Elizabeth Adams

THE Dartmouth INSTITUTE FOR HEALTH POLICY & CLINICAL PRACTICE