PRACTICE VARIATION IN SPINE SURGERY

ACCORDING TO PAYER

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LIST OF ABBREVIATIONS

A/P – Anterior/Posterior

AHRQ – Agency for Healthcare Research and Quality

ALIF – Anterior Lumbar Interbody Fusion

APG – Appendectomy patient group

CI – Confidence Interval

d.f. – Degrees of freedom

DHS – Department of Human Services

FMSG – Foreign Medical School Graduate

HCUP – Healthcare Utilization Project

IRB – Institutional Review Board

LF – Lumbar fusion

NIH – National Institutes of Health

NS – Not statistically significant

OHDDS – Oregon Hospital Inpatient Discharge Database

OHPG – Oregon hospitalized patient group

OHPR – Oregon Office of Healthcare Policy and Research

OHSU – Oregon Health Sciences University

OR – Odds Ratio

OSPG – Oregon state population group

Ore - Oregon

RR – Relative Risk

SID – State Inpatient Databases

SPORT – Spine Patient Outcomes Research Trial

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ABSTRACT

Study Design: Secondary analysis of Oregon Hospital Discharge Database (OHDDS).

Objective: To explore the relationship between payer status and practice variation in lumbar spine surgery in Oregon.

Methods: Lumbar fusion patients were extracted from the OHDDS, and payer for each patient was determined. Payer mix was then compared to the state population, the state hospitalized population, and an additional control group of appendectomy patients. Within the group of fusion patients, associations were evaluated between payer and diagnosis, procedure, and instrumentation status.

Results: For a lumbar fusion patient, in comparison with a state resident, the crude odds ratio of being insured vs. uninsured is 9.06 (4.73-19.94); the crude odds ratio of having private as opposed to public insurance is 0.54 (0.44-0.65). Compared to an Oregon hospitalized patient, the age-adjusted odds ratio that a lumbar fusion patient has insurance is 3.97 (2.10-7.64); the age-adjusted odds ratio of the fusion patient having private instead of public insurance is 1.63 (1.31-2.06). When measured against appendectomy patients and adjusted for age, the odds ratio that a lumbar fusion patient has insurance (vs. no insurance at all) is 10.37 (3.92-27.37); the odds ratio that the insurance is private as opposed to public is 0.85 (0.45-1.62). Controlling for age, there is a statistically significant association between payer and diagnosis among lumbar fusion patients. For a patient who has Medicaid or is uninsured, in contrast to a patient with private insurance or Medicare, the age-adjusted odds ratio that the fusion procedure is associated with an urgent instead of an elective diagnosis is 4.16 (1.45-11.99). After controlling for age and diagnosis, payer does not have a statistically significant association with either procedure or instrumentation status.

Conclusions: The odds that a lumbar fusion patient has insurance vs. being uninsured are significantly higher than in the state population, other hospitalized patients, and appendectomy patients. Compared to the state population, lumbar fusion patients have a greater ratio of public vs. private insurance, because of the older age of the fusion group and the resultant predominance of Medicare. But among fusion patients, the overall proportion of private insurance is higher than would be expected and higher than in other hospitalized patients. Regarding the reasons for lumbar fusion surgery, the diagnoses are more often urgent among patients who are uninsured or have Medicaid, compared to those with private insurance or Medicare. But, there is no apparent association between payer and the type of procedure or the use of instrumentation; the diagnosis leading to fusion is the main predictor of these latter variables. These findings have implications in public policy, particularly with regard to the construction of public insurance and questions of privatization.

I. INTRODUCTION

BACKGROUND

Back pain is a significant public health issue.

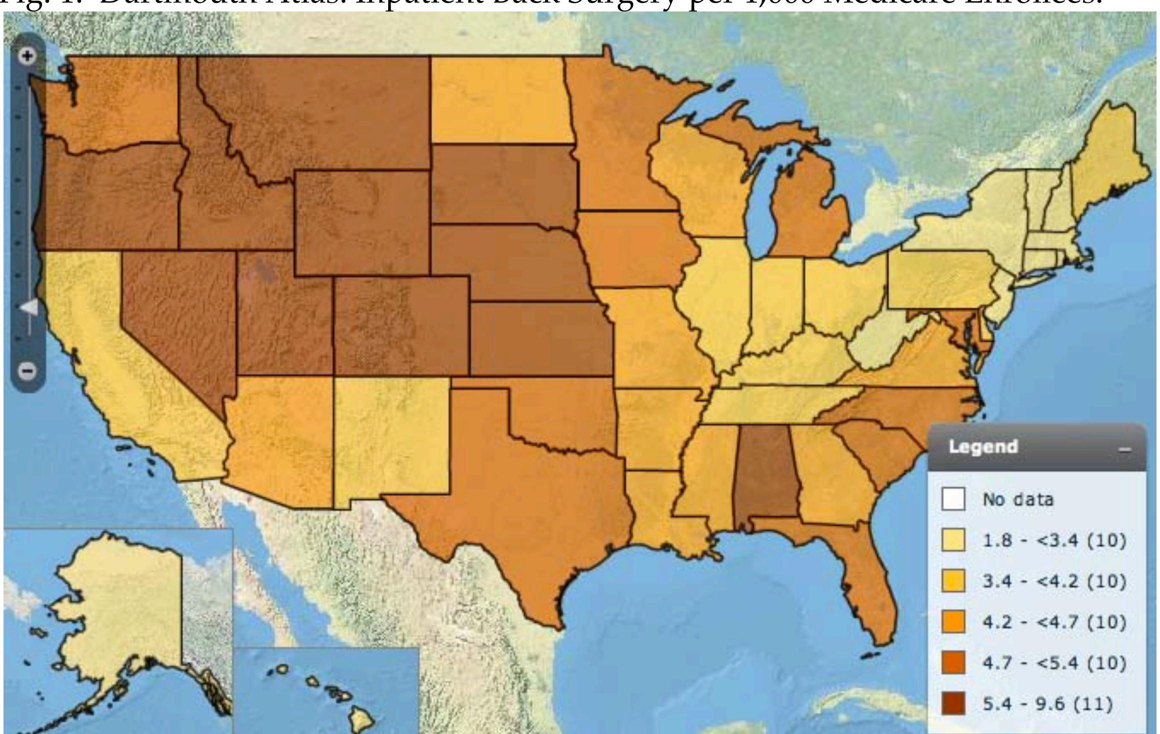
Lumbar spine problems are conditions of great significance in the United States. In the American working age population, low back and leg pain is the number one cause of disability. Across the US, there are almost 10,000 ER visits for back problems each day. (Owens PL & al., 2008) For Americans aged 18-55, low back related societal costs exceed the costs for AIDS, cancer, and heart disease combined. (Deyo RA & al., 1994) Direct medical costs related to back pain have been estimated at $25 billion per year, and the costs to society are even higher. (Carey TS & al., 1995)

There is increasing pressure to improve the treatments for these problems, especially since so many patients are affected. Currently, operations to treat spinal conditions are among the most commonly performed inpatient procedures in the United States. (Atlas SJ & al., 1996) In fact, this is the 9th most expensive condition treated in American hospitals. (Owens PL & al., 2008) Lumbar diskectomy, for instance, which is only one of many different lumbar procedures, is performed approximately 200,000 times per year. (Cherkin DC & al., 1994)

The treatment of back pain is highly variable.

Despite the common nature of lower back problems, the treatment for these conditions is far from standardized. The rates of lumbar spine surgery have been noted to vary from five to fifteen-fold in different areas – from state to state, and even within the same state. (Volinn E & al., 1994) (Volinn E & al., 1997) (Cherkin DC & al., 1994) (Loeser JD & al., 1993)

Fig. 1. Dartmouth Atlas: Inpatient Back Surgery per 1,000 Medicare Enrollees.



From:http://www.dartmouthatlas.org/data/map.aspx?ind=73&loc=2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52&loct=2&tf=6&fmt=98&ch=32

Fig. 1, above, shows the Dartmouth Atlas map of US rates of spine surgery. The highest rate is in Wyoming, at 9.6; the lowest is in Hawaii, at 1.8. The study was limited to Medicare, and the results are per 1,000 Medicare enrollees, from 2005 data. Oregon is above the 90th percentile, with 6.7. (Dartmouth Atlas, 2005) This magnitude of variation exceeds expected variation in the frequency of disease, so it is unlikely that patient population differences can account for the variation. (Volinn E & al., 1994)

Variability is a prominent feature of modern U.S. health care.

Geographic variability in health care delivery systems was noted as early as 1938, when widely varying rates of tonsillectomy throughout England were reported. (Mulley AG, 2009) (Glover JA, 1938) Interest in this phenomenon was rekindled by the observation that the rates of many different surgical procedures are so enormously divergent across the United States and beyond. (Wennberg J & al., 1973) (McPherson & al., 1982) (Wennberg J & al., 1987) Other investigators have extrapolated from the surgical arena to medical care in general – and it turns out that the variability is a pervasive feature of American health care. For example, test ordering is quite diverse, referral practices vary, and profound regional differences have been documented in end-of-life hospitalizations. (Song Y & al. 2010) (Phelan SM & al., 2009) (Bederman SS & al., 2010) (O'Donnell CA, 2000) (Grytten J & al., 2003) (O'Neill L & al., 2006) (Weinstein JN & al., 2000) It should be noted that the variation in medical care is not uniquely American; similar findings have been reported worldwide. (Bolin K & al., 2009) (Grytten J & al, 2003) (Loeser & al., 1993)

Over the past thirty years or so, increasing attention has been directed towards elucidating the reasons behind the observed variability and in understanding its implications. (Fisher S, et al. 2003) Geographic variation has been attributed to three general areas: patient factors, physician factors, and system factors. Complicating the analysis is the fact that there are most certainly interactions between the factors. (O'Neill L & al., 2006) For example, the outcome of any given physician/patient encounter is determined not only by the specific system, physician, and patient factors, but also by the way in which those three aspects influence and modify each other.

Patient factors in health care variability.

Patient variables can be directly health related, such as age, gender, and co-morbidities. Most studies on variation have controlled for at least some of these factors, and found that they explain relatively little. (Weinstein JN & al., 2000) (Forte ML & al., 2008) Of course, co-morbidity lends itself less well to accurate measurement, quantification, and representation - but the findings are robust across many studies. (Fisher S & al., 2004) (Bertko JM, 2003) Other likely medical contributors may be still harder to measure or generalize, such as the particular symptomatology, and the severity of the disease. However, some studies have addressed these issues, at least in part. The use of physician surveys with clinical vignettes allows standardization of the medical factors, and such studies – which will be discussed again below – continue to show variation. (O'Neill L & al., 2006) (Lutfey KE & al., 2009) (Veloski J & al., 2005) But there are non-clinical patient considerations as well. Cultural heritage, religion, educational background, family status, or economic situation: all of these potentially impact a patient's presentation, communication, beliefs, and expectations. All are therefore possible influences regarding that person's presentation, preferences, and decision-making. And these factors may cluster geographically. Some have been studied - such as type of occupation (including percentage lifting), education, and income – and they do explain a small amount of the variance. (Hawley ST & al., 2006) But although it is recognized that some degree of variation can be ascribed to unmeasured patient variables such as beliefs and expectations, this has yet to be quantified. (Loeser JD & al., 1993)

The specific diagnosis may also be considered a patient factor. It is well recognized that diagnoses in which there is clinical uncertainty demonstrate larger rate variation. (Lutfey KE & al., 2009) (Irwin ZN & al., 2005) (Griggs JJ & al., 2009) (Eddy FM, 1984) Presumably, there is more room for accommodation of patient preferences when no one particular option is known to be superior. Furthermore, clinical uncertainty expands the role of the physician's opinion, which varies more when a standard is undefined.

Physician factors in health care variability.

The majority of the geographical variation has been attributed to physician factors. This is logical, in the sense that measuring the delivery of health care is largely measuring the activities of those who provide it. Physician factors can be as simple as age or gender, or as complicated as personality type. Most authors have lumped everything together in a nebulous factor called "physician practice style." (Loeser JD & al., 1993) However, O'Neill and Kuder have created a framework from which one can approach the physician decision-making pathway, which is astonishingly complex. They divide the components of decision making into three groups. The first, the "Clinical Baseline Heuristic," includes training and experience: US vs. FMSG, practice specialty, and fellowship training. This component also includes the physician's own personal preferences, such as general strategic approach and philosophy. The second component, the "Practice-Specific Heuristic," comprises aspects of the physician's current practice, such as solo/group, community/academic, availability of technology, and the local standard of care. This second component expresses the physician's adaptation to his or her particular environment. Together, the first two components help explain a physician's overall approach to the practice of medicine. The last group is the "Patient-Specific Strategy," which includes the factors that differ amongst patients, such as diagnosis, disease severity, co-morbidity, and travel distance. (O'Neill L & al., 2006) This categorization is useful in approaching the topic, and there are many other factors that could be included. Other authors have identified these additional components: 1) the doctor's weighing of, and degree of influence over the patient's preferences; 2) membership in various medical societies, or subscription to specific journals; or even 3) the physician's desire for income, or 4) desire to use "new" technologies or stay current with the latest procedures. (Loeser JD & al., 1993) Some investigators have considered the physician's degree of practice satisfaction, number of patients, and "cognitive load." (Keating NL & al., 2004) (Burgess DJ, 2010) As with the patient variables, some physician variables are difficult to measure – especially the highly individual factors such as personality or aggressiveness, training and practice experiences, and desire to use the latest procedures. Other variables, such as society membership or journal subscription, are more discrete and therefore easier to measure, but they have not been formally evaluated in this context.

A few investigators have attempted to address components of physician practice style. One group of Norwegian investigators who were evaluating practice variation took advantage of the fact that some of the doctors relocated to different municipalities during the course of the study. They questioned whether or not practice style, as determined by resource utilization, changed when the physicians relocated – in essence, testing the relative impact of the "Clinical Baseline Heuristic" and the "Practice-Specific Heuristic." Practice style did not change with relocation. (Grytten J & al., 2003) Various other studies have followed interventions designed to alter physician practice style. To some extent spurred by the findings of geographical variation, there have been efforts to standardize care, with the development of an increasing number of clinical guidelines. But physician practice style has proven resistant to change, and there is a growing body of research directed towards understanding this resistance and developing more effective techniques to influence physicians' practice. (Cabana MD & al., 1999) (Griggs JJ & al., 2009) (Lutfey KE & al., 2009) (Bederman SS & al., 2010)

System factors in health care variability.

There has been significant attention research focused on system variables, such as the availability of resources – hospitals, surgeons, physical therapy, etc.

(Keller RB & al. 1990) But studies have proved contradictory to one another. Some investigators have found that a high number of spine surgeons correlates with higher rates of spine surgery, and the number of facilities has also been positively associated with high surgery rates. However, individual factors such as bed availability and surgeon density have not correlated, and researchers have questioned the significance of the association, as it has been documented that many patients evidently travel to major centers regardless of where they reside. (Loeser JD & al., 1993)

Other investigators have considered the role of the system structure, comparing variability between countries. However, in these cases many variables are different and it is difficult to isolate the effects of particular components. (Bolin K & al., 2009) (Lutfey & al., 2009)

SIGNIFICANCE

There are several reasons why it is important to further characterize practice variation – in general, in the practice of spine surgery, and specifically regarding the significance of different types of payers.

Practice variation studies can help foster standardization of care.

First, an understanding of practice variation is important as a prerequisite to the standardization of care. There is increasing demand for standardization, evidenced by the proliferation of practice guidelines. (Woolf SH, 1990) (Woolf SH, 2000) Standardization of care is widely perceived as an important goal for several reasons. (Kurtin P & al., 2009) Probably most importantly, if the standardized care is "best practice," then standardization would bring everyone up to that level. Substandard care would be reduced. Ideally, guidelines describe best practices and serve as a link between research and implementation – a means to standardize care at a high quality level. In other high-risk industries, such as aviation, guidelines have been shown to reduce error and improve quality and safety. In health care, studies have been mixed. (Bahtsevani C & al., 2004) (Marshall JK, 2000) Guidelines can be - and are - produced by governmental agencies, medical associations, hospitals, insurance companies, physician groups, and so on. Different organizations may have divergent goals in the creation of guidelines – such as lowering costs or reducing litigation risk – and those goals can potentially conflict with the delivery of quality care. Also, an organization lacking the appropriate experience, skills, judgment, or resources can still produce guidelines; even if the intent is good, the guidelines may be poor. There is growing recognition of the importance of the quality of the guidelines, and increasing focus on the process of guideline development and evaluation. (Cecamore C & al., 2010) Furthermore, implementation is clearly an essential step if guidelines are to have any effect, but this stage has proven very tricky. There is clearly more work to be done in defining the goals of standardized care and in identifying the best methods of implementation An understanding of practice variation in general can help identify issues that might allow further insight into standardizing medical practice across all specialties.

Clearly, in order to foster the development of guidelines and the standardization of care, it is necessary to identify the "best practices" for dissemination. But for many spine conditions, attempts to produce satisfactory and accepted guidelines have been unsuccessful. This is particularly true with regard to spinal surgery. The NIH has created guidelines for the management of acute back pain. (Chou R & al., 2007) However, except in very rare specific situations, surgery is not part of the protocol. For surgical care – indications for surgery, specific surgical procedure, and even post-operative management – there is a rather glaring lack of standardization. The level of concordance among spine surgeons differs according to the diagnosis. For instance, the surgical treatment of cauda equina syndrome secondary to a herniated lumbar disc is practically universally agreed upon. In fact, this situation even appears in the NIH guidelines. But at the other end of the spectrum is chronic back pain. For that condition, issues of whether and when to operate, what procedure to use, and how to follow the patient, are all highly individualized.

Some of this pronounced variability undoubtedly relates to the lack of evidence necessary to recommend specific treatments. Therefore, whatever factors are responsible for practice variation appear to be operating to a greater degree. That is, within the realm of acceptable care, there is more room for influence by surgeon practice style and patient preferences. This means that the treatment of back pain may serve as a good subject for considering the evaluation of practice variation in general.

Practice variation studies can help direct outcomes research to improve quality of care.

However, an understanding of practice variation among spine surgeons has another benefit: because some of the variation likely relates to insufficient outcomes information, characterization of the differences in care can help identify specific topics in need of further research.

Assuming that the rate variation is not caused by patient population differences, as the literature suggests, then some patients are receiving unnecessary surgery or others are receiving insufficient surgery (or both). (Wennberg, JE & al., 1987) On its own, a study limited to identifying and characterizing practice variation cannot determine which surgeries might be either unnecessary or insufficient. Determination of whether or not the rate is appropriate requires knowledge of the patients' outcomes. Assuming the populations are similar, substantially better outcomes in a high rate group might suggest that the procedure is underutilized in other areas. On the other hand, if outcomes are no different, it suggests that the increased number of surgeries does not produce added benefit, and therefore may be superfluous.

Without clinical outcome data, it is impossible to tell whether a rate is too high or too low. However, understanding practice variation will uncover the particular areas of high variation which need focused clinical study. This knowledge will ultimately provide insight into the treatment of spine problems.

For instance, if any group of patients is found to undergo surgery at a particularly high or low rate, this group can be targeted for further analysis to determine outcomes relative to the group at the other end of the spectrum. The same line of reasoning applies to the choice of procedure. It may be the case that the different surgical procedures available for back pain are distributed randomly. However, if certain factors can be identified in association with certain procedures, this will suggest an avenue for follow-up in comparing outcomes.

Clinical outcome data are required in order to determine the best treatment paradigms. However, there may be a gap between the results of carefully controlled clinical trials, and the same treatments as they are administered in ordinary treatment situations, when there are many more variables. Evaluating actual practice variation begins to allow parsing out the various other variables that may affect outcome. Once these variables have been identified, evaluation of their correlation with outcomes can proceed. Then, appropriate interventions can be designed and implemented.

Identifying any component of practice variation specifically related to payer has additional value in the evaluation and creation of public policy.

The particular role of the payer is of contemporary relevance. There is widespread agreement that reforms in the American system of healthcare delivery are necessary. Of central importance is the drive to expand "coverage" for the many individuals who are currently uninsured. That leads directly to the question of how to finance the changes. However, the quality of the care is of concern also. It may be the case that different payers are associated with variations in the type and quality of care delivered. Eventually, outcomes studies will be needed to determine whether or not different payers are linked with variations in the quality of care. However, the first step requires evaluation of whether or not payer-associated differences are even present. The presence of potential payer-associated differences in health care delivery will need to be considered in the reorganization of the health care system.

REVIEW OF LITERATURE

Practice variation in spine surgery.

There have been several investigations regarding the role of physician specialty in spine surgery. One study compared practices of orthopedic surgeons, primary care physicians, and chiropractors in the evaluation of acute low back pain. Orthopedic surgeons ordered more tests, and the costs were highest for the orthopedists and chiropractors. Patient satisfaction was roughly equivalent in all groups. There was no evaluation of surgery rates or procedures since surgery was not performed during this study (surgery is rarely indicated for acute low back pain.) (Carey TS & al., 1995) Another study reported similar findings based on a survey of practicing surgeons in the two specialties. (Irwin ZN & al., 2005) Interestingly, both within and across these studies, there appears to be some evolution over time, with a trend towards convergence of the two specialties. In the past it was common for orthopedic and neurological surgeons to both participate in a single procedure, with the neurosurgeon performing the decompression and the orthopedic surgeon adding the fusion. But as more neurosurgeons receive training in fusion techniques, they are performing these procedures themselves.

Practice variation and insurer.

In a survey in Minnesota, the cost of care for back injuries was 130% higher for workers' compensation compared to group health. The cost difference was partly due to differences in treatment, reported as over-utilization of imaging, surgery, and other treatment modalities. However, the analysis also included costs of time out of work, which was also increased in the workers' compensation group. The cost component that was due to treatment differences vs. work differences was not specified. (Katz JN, 1995) Thus, although treatment differences existed here in comparing workers' compensation to other payers, the differences are not characterized.

In a study of spine practice variation in Australia, the unemployment rate was the only variable that was found to be a determinant of the rate of lumbar spine surgery. (Loeser JD & al., 1993) This contrasted with a prior study by the same authors that was done in Washington DC. (Volinn E & al., 1992) While in Australia unemployment was associated with higher rates of spine surgery, in Washington the correlation was opposite as well as lesser in degree. The authors thought that this reflected differing insurance coverage, insofar as the unemployed in Australia maintain Medicare coverage, while unemployment in Washington usually leads to the loss of health care coverage. (Loeser JD & al., 1993) However, insurance status was not measured directly.

A more direct example resulted from comparing spine surgery rates between countries. Profound rate differences have been identified, and because some countries regulate access to surgeons, this has been postulated to be a relevant factor. To evaluate that possibility, rates of spine surgery were evaluated in US HMOs in which access to surgeons is tightly controlled. The rates of spine surgery within the HMOs were half of the overall rates of the states in which the HMOs were located. (Cherkin DC & al., 1994) Some authors interpreted that finding as meaning that "financial incentives may be more powerful determinants of surgical rates than are cultural differences." (Whang PG & al., 2008)

In this regard, it has been asserted in the lay press that spine surgeons are inappropriately influenced to perform fusion procedures over decompressions, because of the greater reimbursement for the former. However, an economic study contested this view. Fusions take longer to perform and require extra pre- and post-operative care, all included in the surgical fee. The authors found that payment per minute of surgeon time is actually lower for fusions. (Katz JN, 1995)

II. MATERIALS AND METHODS

RESEARCH QUESTION, HYPOTHESES, AND OBJECTIVES

Research Question.

The specific goal of this project was to address the following question: Do patients with back pain and a public payer receive different surgical treatment than those with back pain and a private payer? There are many components of surgical care, and myriad ways to look at it. This study addressed the question by testing the following specific hypotheses:

Primary Hypothesis.

Among patients undergoing lumbar fusion surgery, the ratio of private to public payers is higher than in the population.

Secondary Hypotheses.

Among patients undergoing lumbar fusion surgery, the age-standardized ratio of private to public payers is higher than in a control group of patients undergoing appendectomy.

Among patients undergoing instrumented lumbar fusion, the ratio of private to public payers is higher than that among patients undergoing un-instrumented lumbar fusion.

<u>Specific aims and objectives.</u>

In turn, the hypotheses were addressed by seeking the following specific aims and objectives:

Primary Hypothesis Objectives:

1) To determine, from Oregon state data, the proportion of state residents in each insurance category.

2) To determine, from hospital discharge data, the number of patients who underwent lumbar fusion in a calendar year, and the insurance status of those patients.

3) To compare the ratio of private to public payer patients in the lumbar fusion group with the same ratio in the state population.

If the null hypothesis could be rejected, it was reasoned that this could suggest that the private group was more likely than the public group to receive surgical treatment as opposed to nonsurgical care.

Secondary Hypothesis (1) Objectives:

1) To determine the number of hospitalized patients in Oregon who underwent inpatient appendectomy, and the insurance status of those patients.

2) Using the same information from the primary hypothesis, to

compare the ratios of private to public-payer patients between the two groups: those who underwent lumbar fusion, and those who underwent appendectomy.

It was reasoned that study results supporting the first secondary hypothesis would support the position that the private group was more likely than the public group to receive surgical treatment as opposed to nonsurgical care. It is possible that the insurance status of the population at large is different from the population of hospitalized patients. Furthermore, it is also possible that the insurance status of patients hospitalized for surgery differs from that of those hospitalized for medical reasons. Therefore, appendectomy patients were chosen to serve as a control group that was also a surgical inpatient population.

Appendectomy was further chosen because it is a procedure with little clinical uncertainty. Therefore, little variation was expected for this procedure, although rates across the US have not been analyzed in the Dartmouth Atlas. Furthermore, coding of this procedure is relatively simple, and therefore less prone to error. And finally, appendectomy is often performed in otherwise healthy individuals. As the majority of lumbar fusions are elective procedures, these patients are also relatively healthy, most of the time. Of course, in some situations both appendectomy and fusion patients could have serious co-existing diseases. However, choosing similarly healthy groups minimizes the potential confounding caused by co-morbidity.

Secondary Hypothesis (2) Objectives:

1) To separate the lumbar fusion patients according to payer status, and perform descriptive analysis of the two groups. Variables to explore included age and gender.

2) To describe the distribution of individual diagnoses in the different groups.

These objectives were intended to explore potential confounders. However, they were also included to help characterize the two populations, particularly with regard to diagnosis. It is possible that patients with different payers undergo fusion procedures for different reasons. This finding would be interesting on its own, but characterizing the diagnoses also allows the possibility of controlling for this variable.

3) To separate the group of lumbar fusion patients into those who received instrumentation and those who did not, and to identify the insurance status distribution in each sub-group.

4) To determine whether or not payer group is correlated with instrumentation status, after adjusting for potential confounding variables, such as diagnosis.

These objectives focus on the question of whether or not payer group is associated with different types of procedures. To some extent this is addressed by the fusion code (e.g. anterior, posterior, or both). However, the use of instrumentation within those procedures is also a matter of clinical debate, and therefore up to the surgeon's discretion. So instrumentation use itself is potentially subject to significant variability.

DATA SOURCES

Oregon Hospital Inpatient Discharge Database.

The dataset of lumbar fusion patients and appendectomy patients was extracted from the Oregon Hospital Inpatient Database (OHDDS). All Oregon hospitals are required to report to this database, which is maintained by the Office for Oregon Health Policy and Research (OHPR) Research and Data Unit. The purpose of this unit is to provide "impartial, non-partisan policy analysis, research and evaluation, and (…) technical assistance, (…) in an advisory capacity to Oregon Health Policy Board, the Oregon Health Authority, the Governor and the Legislature." (Office for Oregon Health Policy and Research, 2010) The hospital discharge database is part of this role, and it is also submitted to the U.S. Agency for Healthcare Research and Quality (AHRQ) for use in federal policy making.

Since its implementation in 1988, the database has become increasingly comprehensive. It includes patient demographics, admission and discharge data including diagnoses, procedures, and other characteristics of treatment, as well as payer information and other financial data.

The state provides extracts of the OHDDS to the public for a fee. However, access to identifying information is restricted. (Office for Oregon Health Policy and Research, 2010) Oregon Health Sciences University also has access to the OHDDS, and the extract used in this study was provided by OHSU.

Statewide data.

Besides allowing access to OHDDS, the OHPR publishes reports and summary statistics on its own. The OHPR receives reports from many state agencies and other sources, so it is not limited to the hospital inpatient sample in the OHDDS. The statewide data for this study came from a report prepared for the legislature by the Department of Human Services Office (DHS), a part of the OHPR. The available information was limited to statewide 2008 frequency counts for each payer group, as well as 2008 population statistics. (DHS, 2010)

Additional data regarding Oregon hospitalizations were obtained from AHRQ. The AHRQ collects abstracts of inpatient discharges from participating states, including Oregon. This collection is called the SID (State Inpatient Databases). The Oregon SID data, provided by the OHPR, is extracted from the OHDDS. The AHRQ collects other data as well – for example, regarding Emergency Department visits, Ambulatory Surgery, and Pediatric care, among others. Together, these datasets are part of the Health Care Utilization Project (HCUP), which the AHRQ describes as a "family of health care databases and related software tools (…) sponsored by the AHRQ (to) bring together data collection efforts (…and) to create a national information resource." (AHRQ, 2010) Like the OHPR, the AHRQ publishes various reports; however, the public can also directly query the SID online at http://hcupnet.ahrq.gov/HCUPnet. Because this is a public resource, all identifying information has been stripped and only aggregate information is available. For this study the author obtained the Oregon hospitalized patient data via SID query as described above.

SUBJECT SELECTION

Lumbar Fusion.

This data set was limited to hospitalizations occurring over a one-year period (2010). Cases were selected from the OHDDS according to the procedure codes for lumbar fusion (listed in Appendix A). Patients under 16 were excluded.

The specific data fields obtained included demographic factors (age, gender), all diagnoses, all procedures, and payer identification codes. The demographic factors were obtained in stratified form to avoid any personally identifiable information. Age was provided in 5-year increments, starting with 16-20. A complete list of the data fields used for this study can be found in Appendix B.

Appendectomy.

Controls were selected according to the procedure codes for appendectomy, listed in Appendix B. Again, patients under 16 were excluded. The same data fields were obtained as listed for lumbar fusion. However, sample size calculations during study planning dictated the need to use a two-year sample for this group (2009 and 2010).

Oregon state population and Oregon hospitalized patients.

The Oregon state population data was restricted to the 2008 count of individuals in each payer group, as reported by the OHPR. (DHS, 2010)

Information about Oregon hospitalized patients was obtained in addition to the appendectomy and Oregon state data, because of the age of the appendectomy patients. The appendectomy patients were intended to serve as a control group of other hospitalized patients. But because these patients were young, additional information was obtained about the entire population of hospitalized patients. A query of the Oregon SID was performed at HCUPnet, including all Oregon inpatient hospitalizations in 2009. Overall frequency counts in each payer group were obtained, broken down by age group. (AHRQ, 2010)

It should be noted that, although age group counts were thus available for all of the study groups, the groups were defined differently by each source. While the age groups from OHDDS were in 5-year increments, the OHPR data were in 10-year increments, and the AHRQ adult data were in 20-year increments. This necessitated combining OHDDS age groups for certain comparisons.

DATA ANALYSIS

Data preparation.

First, cases were reviewed to ensure that they met inclusion criteria. The file was examined for missing or incomplete data. Twenty of the 461 lumbar fusion cases had a birth day and month listed, instead of an age category. These patients were excluded when analyses included age.

The original data file provided the information in vertical format. That is, there were separate entries for each procedure code and all diagnoses were repeated for each procedure code. Because most spine operations consist of more than one code, and because the diagnosis list included anything applicable during the hospitalization, there were between three and about 200 entries per patient. The first manipulation was to convert the data into a horizontal format, with one entry per patient. The conversion to horizontal format retained all diagnoses and all procedures, but instead of displaying them as separate entries, the reformatting listed them across each patient's entry.

Several new variables were then created. String variables were converted into numeric form. A variable was created for payer, which classified each case as private, Medicare, Medicaid, uninsured, or other. The "private" payer group included fee-for-service, managed care, and commercial payers. The "Medicare" and "Medicaid" groups consisted of their respective enrollees. "Uninsured" denoted the absence of any type of coverage. The "other" category included payers that could not be assigned to another group. As needed for the particular analysis, other variables were created with different payer combinations. For example, a "public" payer consisted of Medicaid and Medicare; "insured" denoted the assignment of either private, Medicare, or Medicaid coverage. Additional variables were created to encode other information. One variable was created to encode the type of procedure, and another to indicate whether or not instrumentation was used. All diagnoses listed in the database were extracted, and the relevant diagnoses that appeared most commonly were coded into groups: trauma, tumor, infection, disc displacement, spinal stenosis, spondylolisthesis, back pain, and spondylosis. The list of ICD-9 codes in each group can be found in Appendix C. However, it is worth noting that, because of low numbers, spondylolisthesis included both the degenerative form (the majority) as well as cases with spondylolysis.

Initial data review.

As an initial step, all of the descriptive characteristics were examined. Where appropriate, data were graphed to visualize relationships and identify potential confounders. The initial data review disclosed the need for age adjustment.

Age adjustment techniques.

Because of the known association between diagnosis and age, and age and insurance status, when possible the confounding effect of age was assessed by stratified analyses. Stratified analysis was possible in the comparisons between lumbar fusion and the Oregon Hospitalized population, as well as the appendectomy patients. However, age stratified data were not available for the Oregon state population.

Given Medicare age requirements, stratifying into age under 65 and 65 and over would have been logical. However, individual ages were not available, and the lumbar fusion and appendectomy study datasets categorized age differently. Although age groups were in 5 year increments, the age brackets were 16-20, 21-25, etc. Extrapolating upward, that categorization classified the seventh decade as 61-65 and 66-70. The 65-year-olds, therefore, were sub-optimally classified with the younger group, so that this specific age bracket (61-65) was particularly heterogeneous with respect to payer status; 60-64 and 65-69 would have better represented the population. The Oregon hospitalized patient data did allow grouping by that approach, however, because the data for that population were provided for ages 18-44, 45-64, 65-84, and 85+. On the other hand, in comparing the lumbar fusion patients with the Oregon hospitalized patients, it was not possible to align the age groups exactly. Although the configuration was not perfectly precise, the groups were matched as closely as possible. By combining groups within the study dataset, it was possible to make the groupings quite similar. Patients under 18 were excluded from the Oregon population and the Oregon hospitalized patients, but the fusion group pediatric limit was 16. However, the difference was not felt to be of great significance, as only approximately 1% of the fusion patients fit into that age grouping. Between the fusion and control groups, all other age strata differed by one year in the 20+ span. Thus, for fusion patients vs. Oregon hospitalized patients, the groupings were: 16-45 vs. 18-44, 46-65 vs. 45-64, 66-85 vs. 65-84, and 86+ vs. 85+.

Within the study data, odds ratio estimates were evaluated in 5-year and 10-year increments, as well as in categories corresponding to the Oregon hospitalized patient data (described above). The stratified results were tabulated, examined, and compared to the crude results to detect differences suggestive of confounding or interaction. Specific tests used included the Breslow-Day (Woolf) test of homogeneity of odds ratios, for assessment of interaction, and the Cochran-Mantel-Haenszel test of conditional independence. Also, the stratified results were used to calculate variance weighted, age-adjusted odds ratios (Appendix D). The age-adjustments were done using the Mantel-Haenszel method. In comparison with the Oregon hospitalized patients, the strata described in the paragraph above were used (i.e. approximately 20-year intervals). For the comparisons within the fusion group, or between fusion and appendectomy, the decade strata were used to compute the age-adjusted results. Age stratified data was not available for the Oregon population, so these comparisons were computed as unadjusted odds ratios.

In the "Results: Tables and Figures" section of this paper, all of the results are tabulated and reported: the age-adjusted overall odds ratio, the unadjusted crude odds ratio, and the stratum-specific odds ratios, including all the different stratum groupings. However, in discussing the odds ratios – either in the "Results" section or other portions of this paper – the most appropriate results are presented. The results are then accompanied by specification of the type, whether adjusted, unadjusted, or stratum-specific.

Comparison between lumbar fusion and other control groups: descriptive analysis.

Basic descriptive statistics were calculated, such as gender proportion, and counts in the payer categories, diagnostic groups, and procedure types. Since age was provided in grouped format and individual age was not available mean age was figured using weighted averages of the medians in each age grouping.

Comparison between lumbar fusion and other control groups: inferential analysis.

For the primary and secondary hypotheses, the data for the relevant category were counted and plugged into a 2x2 table for computation of the odds ratio (the specific arrangement of the tables can be seen in Appendix D.) 95% confidence intervals were calculated for all odds ratios.

Since the lumbar fusion dataset included all lumbar fusion patients in Oregon in a one-year period, and the Oregon state data and Oregon hospitalized patient data were also actual frequency counts, it was possible to calculate the incidence rate ratio or relative risk for these groups. The number in the appendectomy group was a two-year sample, so the average rate was determined.

The study hypotheses involved comparison of the ratio of private to public payers among different groups. Similar comparisons, such as between insured and uninsured, were likewise accomplished with contingency tables and the calculation of odds ratios. With larger contingency tables and comparisons involving more than two groups, analysis was performed using Chi^2 or Fisher's exact tests or logistic regression.

Comparisons within the lumbar fusion population: descriptive analysis.

The lumbar fusion cases were looked at in additional detail. Basic descriptive statistics were derived for each payer group, such as gender proportion and age (calculated as described above). The distribution of diagnoses was tabulated according to payer group.

An approximate incidence of lumbar fusion in the different payer groups was calculated with the number of study cases in the payer group as the numerator, and the total number of Oregon patients in that payer group as the denominator. Since the denominator is from the state data, which is not the same year, the resultant value is only approximate.

Within the fusion group, the numbers of patients within the various diagnosis categories were tabulated according to payer. Column and row percentages were calculated, reflecting the proportion of patients in each payer group with a given diagnosis (column percentage), and the proportion of patients with a given diagnosis category contributed by each payer (row percentage). Because the row percentage was strongly influenced by the total number of patients in the payer group, approximate incidences of each diagnosis category were calculated to aid in interpretation. Diagnosis incidence was calculated per 100,000 using the method described above, i.e. with the Oregon state data providing the denominator.

The distribution of diagnoses was compared between the payers using the Chi^2 test and multiple logistic regression. Age stratified testing was performed also. Effect magnitude was gauged by calculation of odds ratios comparing the diagnoses that are often urgent with the diagnoses that are usually non-urgent. The diagnoses considered urgent were trauma, tumor, and infection. The non-urgent group consisted of the following, typically degenerative diagnoses: disc displacement, spinal stenosis, spondylolisthesis, back pain, and spondylosis.

The relationship between diagnosis and age was also examined. For each payer group, diagnoses were tabulated according to age. Chi^2 testing and multiple logistic regression were used to test the association. To reduce the number of cells for the Chi^2 test, age was grouped into two categories: ≤ 65 and >65.

Finally, the lumbar fusion patients were divided into two groups: those who received instrumentation, and those who did not. The incidence of instrumentation was calculated, and the demographic characteristics of the two groups were tabulated and compared.

Comparisons within the lumbar fusion population: inferential analysis.

To address the third hypothesis, a 2x2 contingency table was set up tabulating instrumentation status against payer status, private or public (Medicare plus Medicaid). To include the other payer groups, Chi^2 testing was done. As described above, stratified testing was performed, and Mantel-Haenszel age adjustment was carried out. Decade strata were used to calculate the adjusted odds ratios. Using logistic regression, a formal test for interaction between age and payer was assessed. Although the unadjusted, adjusted, and stratum-specific results were tabulated for reporting, the overall age-adjusted result was selected in the absence of interaction. The stratum-specific results were selected in the presence of age-interaction. The simplest representative stratification was chosen.

Associations among certain other variables were tested when, based on clinical rationale, there was reason to suspect potential confounding. Procedure, diagnosis, and age were all viewed as potential confounders. The procedures were tabulated, and patients who had combined procedures were excluded from the analysis because they were infrequent. The potential associations between procedure and instrumentation, payer, and age were explored using Chi^2 tests. Logistic regression was utilized to investigate in further detail; that is, to gauge effect magnitude and control for confounding factors. In the model for instrumentation, instrumentation status was the dependent variable. The reference group was the uninstrumented category. Independent variables were age, payer status, diagnosis, and procedure.

METHODS OF DATA INTERPRETATION

Results were considered statistically significant if $p < 0.05$, or in the case of odds ratios, if the 95% confidence interval did not include the value 1.

ETHICAL CONSIDERATIONS

The study was approved by the OHSU Institutional Review Board. The dataset was obtained as an extract without personally identifying information.

III. RESULTS

LUMBAR FUSION COMPARED WITH OTHER CONTROL GROUPS

Descriptive analysis: demographics.

Table 1 (page 45) summarizes the demographic factors and payer distribution in the various study populations. Age distributions differ in all the study populations. On average, the lumbar fusion patients are the oldest, with a mean and standard deviation of 56.88 ± 0.71 years. Next are the Oregon hospitalized patients, who have a mean (± σ) age of 46.93 ± 0.04 years, followed by Oregon state residents at 37.10 ± 0.01 years. The appendectomy group has the youngest age mean (± σ), 33.19 ± 1.04 years. The number of appendectomy patients decreases considerably with age, presumably reflecting a lower incidence of appendicitis in older patients. The Oregon state population displays two peaks: 45-54 and 5-14. The Oregon hospitalized population shows a peak for newborns and then approximately even distribution between the 45-64 and 65-84 segments. Age among the lumbar fusion patients is closer to a normal distribution, peaking in the 60-70 range. Age-adjusted and/or stratified results are reported throughout the following paragraphs.

Regarding other demographics, the gender proportions differ slightly as well, in so far as females comprise 59% of the OR hospitalized group, but are closer to 50% in all the others; presumably this reflects maternity admissions. However, the gender distribution of the appendectomy and lumbar fusion groups is not significantly different (lumbar fusion patient's odds of being male, compared to appendectomy patient's odds of being male: age-adjusted OR = 0.77; 95% CI 0.50-1.21).

Descriptive analysis: payer groups.

The percentages in each payer group are presented in Table 1 (page 45); for additional clarity, a graphic representation is displayed in Figure 2 (page 46).

Private payers account for the largest proportion in all the groups. Medicare makes up a substantial portion of the lumbar fusion and Oregon hospitalized patient groups (37.53% and 34.45%, respectively). There are very few Medicare appendectomy patients.

However, the appendectomy group has the largest proportion of uninsured patients (24.26%) - even higher than the Oregon population (15.17%). Only 5.95% of the Oregon hospitalized group is uninsured. Among the fusion patients, the uninsured portion is lower yet – 1.95%.

The Medicaid pattern is slightly different. As with the uninsured, the smallest proportion is found in the fusion group (6.07%). But the percentage is highest among Oregon hospitalized patients (18.41%) instead of the appendectomy group (8.42%). The percentage of appendectomy patients with Medicaid is near the Oregon population value of 11.28%.

Hypothesis tests.

The primary and first secondary hypotheses can be tested using the results presented so far. Among patients undergoing lumbar fusion surgery, the percentage of private payers (out of private + public payers) is 0.55. This same proportion is 0.70 in the state of Oregon; 0.42 among all patients hospitalized in Oregon, and 0.80 among appendectomy patients in Oregon.

The result of testing the primary hypothesis: for a lumbar fusion patient, compared to a state resident, the odds of having private as opposed to public insurance are about half (0.54; 0.44 - 0.65).

The results from comparison with the Oregon hospitalized population are reported in Table 2 (page 47). As described in the "Methods" section, testing is stratified. Overall, the fusion patient's age-adjusted odds of having private vs. public insurance are 1.63 times the odds for a hospitalized patient.

Table 3 (page 48) displays the results of the first secondary hypothesis, comparison with the appendectomy group. As with the Oregon hospitalized patient comparison, the results are stratified. Without age adjustment, the overall point estimate of the odds ratio is 0.31 (0.20 - 0.49). The overall, age-adjusted OR is 0.85, but this OR does not reach statistical significance. In this case stratification and age-adjustment reduce the precision of the estimate (OR = 0.85; 95% CI 0.45 - 1.62). However, there is an interaction with age, so the overall values – adjusted or not – are rejected in favor of stratum-specific results. For a lumbar fusion patient 65 or under, the odds of having private instead of public insurance, when compared to an appendectomy patient are 0.47 (0.26 - 0.82.) The same odds in those over 65 are not statistically significant (3.10; 0.42 - 137.38).

In terms of relative risk, the situation is as follows: The chance that a lumbar fusion patient has private insurance is about 20% less than in the Oregon population in general (RR, 0.79) but about 30% more than in the Oregon hospitalized population (RR, 1.31). The chance that a lumbar fusion patient has private insurance is about 30% less than an appendectomy patient (RR, 0.69).

Additional inferential analyses.

The odds ratios detailed above address the specific hypotheses, comparing the ratios of private to public payers between the different study populations. The following paragraphs describe additional comparisons, including uninsured patients and other payer group combinations.

Accounting for all the payer groups with Chi^2 testing does confirm that there is a significant difference in payer distribution between lumbar fusion patients and all the other control groups. Compared to the Oregon population, Pearson chi^2 (3 d.f.) = 237.04, exact p-value < 0.001. Compared to the Oregon hospitalized population and to the appendectomy group, there are significant differences in payer distribution only for patients under 65 (OHPG: Pearson chi^2 (3 d.f.) = 79.73, exact p-value < 0.001; APG: Pearson chi^2 (4 d.f.) = 81.64, exact p-value < 0.001). But as before, the association does not reach significance in the older groups (Pearson chi^2 (3 d.f.) = 3.38; exact p-value = 0.26).

The odds of being insured vs. uninsured, in comparison with the different control populations, follow. The lumbar fusion patient has about 9 times the odds of being insured, when compared to an Oregon state resident (OR = 9.06; 4.73 - 19.94). As detailed earlier, this is an unadjusted result due to the lack of stratified data for this control group. In comparison with the other two control groups, there is an interaction with age. The unadjusted, age-adjusted, and stratum-specific results for comparisons with the Oregon hospitalized patients and appendectomy patients are tabulated in Tables 4 and 5, respectively (pages 49, 50). There is no statistically significant difference between fusion patients and either control group in patients over 65, consistent with general Medicare coverage (OHPG: OR = .0.23; 0.04-9.49; APG: OR = 7.27; 0.11-146.48). For fusion patients ≤65, in comparison with hospitalized Oregonians <65, the odds of being insured vs. uninsured are 4.20 (2.10-9.81). And compared to appendectomy patients <65, the fusion patients have 12.38 times higher odds of having some type of insurance (95% CI 5.59-30.92).

Looking at the same issue provides the following numbers in terms of the relative risk of being *uninsured*: the risk that a lumbar fusion patient would be uninsured is about 11% of the state population risk. The chance of being uninsured is only 7% compared to an appendectomy patient. Relative to all patients hospitalized in Oregon, the fusion patient's risk of being without healthcare coverage is 29%.

In further evaluation of the lumbar fusion and appendectomy patients, logistic regression provides additional information for the individual payer groups and adds insight into the effect magnitude. When compared to the appendectomy patient, the lumbar fusion patient 65 or under has 7.8 times the odds of having Medicare (95% CI 2.75 - 21.97); is about as likely to have Medicaid (OR = 0.78; 0.40 - 1.51); and has about 11 times the odds of having insurance of some kind (OR = 10.64; 5.00 – 25.00. Computed as 1/(OR, CI uninsured) = 1/(0.094, 0.04 - 0.20.) For the model, LR=-338.79; p< 0.0001).

COMPARISONS WITHIN THE LUMBAR FUSION POPULATION

Descriptive analysis: demographics.

The demographic data within the lumbar fusion population is displayed in Table 6 (page 51). As expected, the Medicare group is older, and age is significantly different between the payer groups (Pearson chi^2 (14 d.f.) = 146.61; Pr < 0.001).

The incidence of lumbar fusion (per 100,000) is 11.28 for private payer patients (29 if over 65), 31.63 for Medicare, 6.54 for Medicaid, and 1.38 for the uninsured.

Descriptive analysis: diagnosis and payer.

Table 6 (page 51) also displays the frequency count in each diagnosis group for each payer, along with column percentages that describe the proportion that each diagnosis contributes to the number of lumbar fusions within a payer group. A graphic representation of the diagnosis composition of each payer group is shown in Figure 3 (page 53). Table 7 (page 52) presents the diagnosis incidence calculations and the row percentages, i.e. the proportion that each payer group contributes to the number in each diagnosis group. Amongst these results, a number of observations are worth describing.

In both the private and Medicare groups, most fusions are performed for degenerative conditions (68.41% and 70.52%, respectively). Of lumbar fusions on Medicaid and uninsured patients, only 39.29% and 37.50% are for diagnoses usually considered degenerative. The converse is not true, however; 11.33% of private, 7.52% of Medicare, 17.85% of Medicaid, and 25.00% of uninsured lumbar fusions are associated with the diagnoses usually deemed urgent. The "other" category makes up the difference (private, 20.24%; Medicare, 21.97%; Medicaid, 42.86%; uninsured, 37.50%).

The difference between the distributions of diagnoses among the payer groups is statistically significant (Pearson chi^2 (28 d.f.) = 47.62, Pr = 0.01). However, due to the low rates of some diagnoses, just over half of the cells have expected frequencies <5. Age stratified analysis presents the same problem, but the results are: ≤65: Pearson chi^2 (28 d.f.) = 38.14, Pr = 0.096; >65: Pearson chi^2 (14 d.f.) = 25.69, Pr = 0.03. The results are confirmed with multiple logistic regression. The strongest correlations are between Medicare and tumor, spinal stenosis, spondylolisthesis, back pain, and spondylosis (for the model, LR chi^2 (28 d.f.) = 52.07, p = 0.0038). Stratifying the logistic regression by age again produces results that are statistically significant only in the older age stratum (≤65: LR chi^2 (28 d.f.) = 40.98, p = 0.054; >65: LR chi^2 (13 d.f.) = 23.52, p = 0.036).

The effect magnitude can be partly demonstrated as follows: for a lumbar fusion patient with private insurance or Medicare, the age-adjusted odds that the surgery is being done for an emergent diagnosis are 0.24 (0.09 - 0.69), compared to a lumbar fusion patient who is uninsured or has Medicaid; stated alternatively, a fusion patient with Medicaid or without insurance has 4.16 times the age-adjusted odds of having an emergent diagnosis, compared to a fusion patient with Medicare or private insurance (95% CI 1.45 – 11.99).

Descriptive analysis: diagnosis and age.

Table 8 (page 54) presents the diagnoses among lumbar fusion patients broken down by age and payer. The age distributions of the diagnoses appear similar regardless of payer. In all payer groups, trauma is relatively evenly distributed across the age groups. Disc displacement, back pain, and spondylosis are spread across the middle range. Tumor, spinal stenosis, infection, and spondylolisthesis all appear increased in the older patients.

Statistical tests confirm the relationship between diagnosis and age. Testing this correlation with multiple logistic regression produces a statistically significant result (LR chi^2 (7 d.f.) = 47.48; $p < 0.0001$); this is in agreement with using a contingency table to test the association between diagnosis and age ≤65 or age >65 (Pearson chi^2 (7 d.f.) = 14.28, exact p-value = 0.045).

COMPARISON OF INSTRUMENTED AND UNINSTRUMENTED GROUPS

Descriptive analysis.

Table 9 (page 55) summarizes the salient characteristics of the instrumented and uninstrumented lumbar fusion patients. Overall, a little over half of the patients (55.10%) received implanted instrumentation during their spinal procedure.

The age means of the instrumented and uninstrumented patients are very similar. However, gender differs between instrumented and uninstrumented patients in this study. A man has less than 2/3 the odds of receiving instrumentation as a part of his spinal surgery, compared to a woman (age-adjusted OR = 0.59, 0.40 - 0.87). Phrased in relative risk terms, the chance that a man's surgery includes instrumentation is about 80% of a woman's (RR=0.81). Diagnosis does not appear different between the genders (Pearson chi^2 (7 d.f.) = 9.39, exact p-value = 0.22). Age is similar as well: mean age ± σ is 57.19 ± 0.92 for women and 56.57 ± 1.08 for men (two-tailed test, t = 0.44, p = 0.67).

The percentages of instrumented patients for each payer group are displayed graphically in Fig. 4 (page 57) and are as follows: private, 55.47%; Medicare, 56.65%; Medicaid, 42.86%; uninsured, 37.50%; and other, 80.00%. (The corresponding uninstrumented rates are: private, 44.53%; Medicare, 43.35%; Medicaid, 57.14%; uninsured, 62.50%; other, 20.00%.) For the group that is over 65, 20.00% of private payer patients and 52.94% of Medicare patients are found to have instrumentation (there are no uninsured over 65.)

Hypothesis Tests.

The third hypothesis can be addressed from the data in Table 9 (page 55). The overall age-adjusted odds for a private payer patient to receive instrumentation are about the same as the odds for a public payer patient (OR = 0.83; 95% CI 0.51 – 1.36). Results from the individual strata are presented in Table 10 (page 56). There is an interaction with age, with no statistically significant difference in the younger patients, but lower odds of instrumentation for the privately insured 65 and older. Logistic regression also produces similar results (overall LR chi^2 (4 d.f.) = 4.23; p = 0.378; <65: LR chi^2 (4 d.f.) = 3.22, p = 0.52; >65: LR chi^2 (1 d.f.) = 12.63; p = 0.0004). However, a formal test for interaction between payer group and age does not reach statistical significance (chi^2 (4 d.f.) = 4.32; p = 0.36). Furthermore, the chi^2 test of homogeneity does not support the interpretation that there is a true difference amongst the strata (chi^2 (7 d.f.) = 7.25; p = 0.40).

Additional analyses.

Diagnosis and instrumentation status. Testing this association produces Pearson chi^2 (7 d.f.) = 43.97, Pr < 0.001 (2/16 cells with low expected frequencies). Logistic regression also suggests a significant association across age strata (overall LR chi^2 (7 d.f.) = 47.01, p < 0.0001; stratified, ≤65: LR chi^2 (7 d.f.) = 34.85, p < 0.0001; stratified, >65: LR chi^2 (6 d.f.) = 17.66, p = 0.0071). All of the diagnoses have a significant correlation except infection. The individual odds ratios are listed in Table 11 (page 58).

Procedure and instrumentation status. Testing the association between the type of procedure and instrumentation status also produces significant results across the age strata: Pearson chi^2 (4 d.f.) = 71.37, exact p-value < 0.001; ≤65 Pearson chi^2 (4 d.f.) = 43.81, exact p-value < 0.001; >65 Pearson chi^2 (3 d.f.) = 23.68, exact p-value < 0.001.

Procedure and payer status. Table 12 (page 59) lists the different lumbar fusion procedures that were performed within each payer group. In the association between procedure and payer status there is an interaction with age, and the test is statistically significant only in the older age group (overall Pearson chi^2 (16) = 17.29, exact p-value = 0.25; stratified, ≤65: Pearson chi^2 (16 d.f.) = 16.73, exact p-value = 0.32; stratified, >65: Pearson chi^2 (6 d.f.) = 16.62, exact p-value = 0.004).

Procedure and age. Procedure and age are also statistically associated. The multiple logistic regression result is LR chi^2 (11 d.f.) = 35.66, p = 0.0002.

RESULTS: TABLES & FIGURES

Table 1.

Demographic and Insurance Coverage Distributions Among the Four Comparison Groups

		Study Patients		Population Data	
		Cases	Controls	**Oregon Hospitalized Patients***	**Oregon Population****
		Lumbar Fusion	**Append-ectomy**		
Demographics					
Age (Years) Mean ± σ		56.88 ±0.71	33.19 ±1.04	46.93 ±0.04	37.10 ±0.01
Gender	Female	52.28%	48.02%	58.76%	50.30%
	Male	47.72%	51.98%	41.22%	49.70%
Insurance Coverage					
Private		247 (53.58%)	121 (60.40%)	140,901 (37.65%)	2,189,000 (57.67%)
Public	Medicare	173 (37.53%)	14 (6.93%)	128,939 (34.45%)	547,000 (14.41%)
	Medicaid	28 (6.07%)	17 (8.42%)	68,914 (18.41%)	428,000 (11.28%)
Uninsured		8 (1.95%)	50 (24.26%)	21,912 (5.85%)	576,000 (15.17%)
Other		5 (0.87%)	0	13,595 (3.63%)	56,000 (1.47%)
Total Number		**461** (100%)	**202** (100%)	**374,261** (100%)	**3,796,000** (100%)

*Data from AHRQ **Data from OHPR

Figure 2.

Distribution of Payers Among the Four Comparison Groups

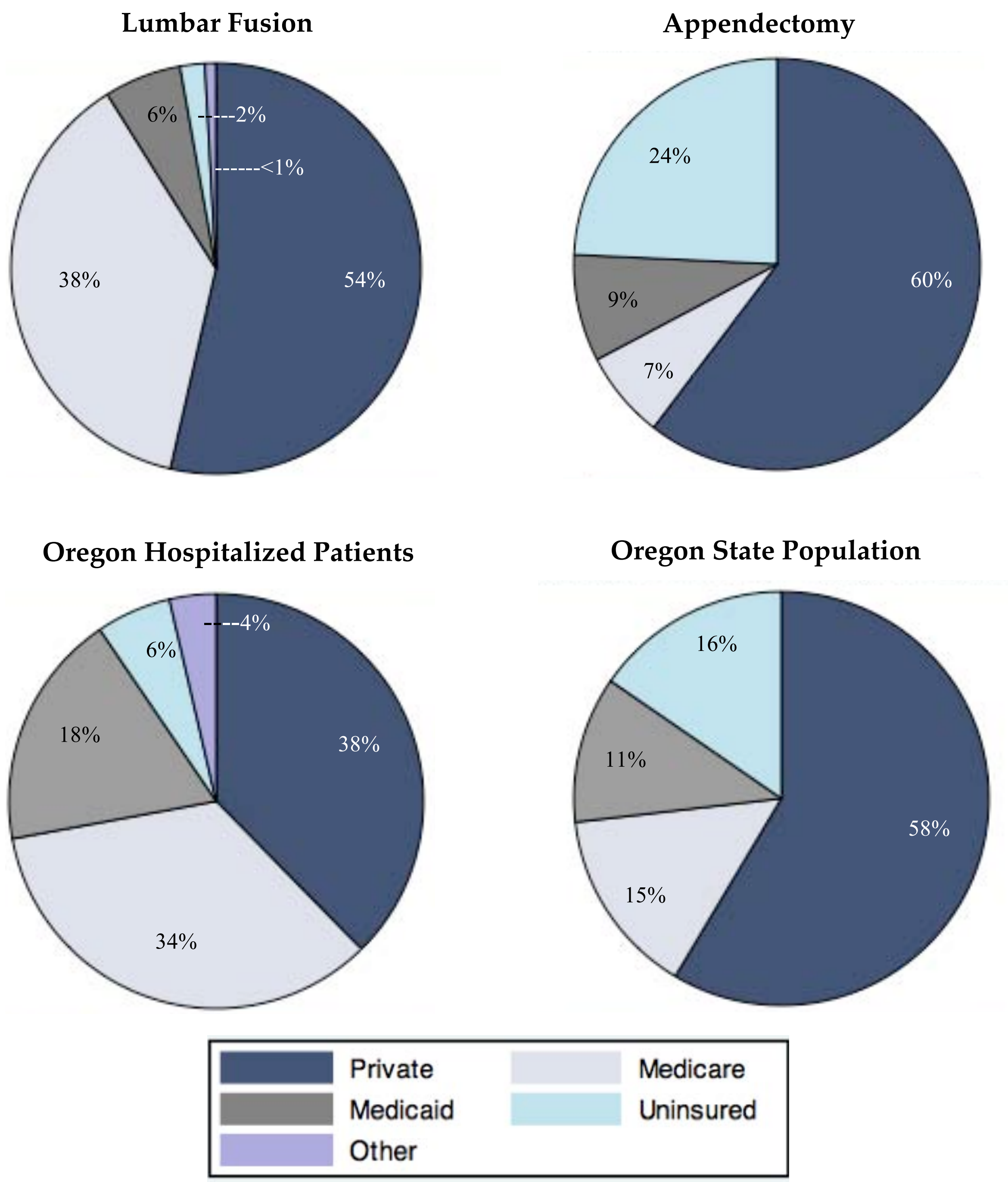


Table 2.

Odds Ratios for Lumbar Fusion Patients Having Private vs. Public Insurance Compared to Oregon Hospitalized Patients

	Age Group*	# Patients	OR	CI
Crude OR	All	339,202	1.73	1.43 - 2.09
Stratified ORs				
Small Group Stratification	18-44/16-45	81,596	3.61	2.02 - 6.94
	45-64/46-65	75,515	1.29	0.95 - 1.77
	65-84/66-85	92,087	1.39	0.81 - 2.28
	85+/86+	28,022	3.36	0.07 -33.99
Stratified at 65	<65/≤65	157,111	1.76	1.35 - 2.32
	≥65/>65	120,109	1.56	0.91 - 2.51
Age-adjusted OR†			**1.63**	1.31 – 2.06

*Hospitalized patient age group (years)/Lumbar fusion patient age group (years)
†Adjusted OR calculated from smallest strata using Mantel-Haenszel method. X^2 test of homogeneity (3 d.f.) = 10.67, p = 0.01. M-H X^2 = 18.36, p < 0.0001.

Table 3.

Odds Ratios for Lumbar Fusion Patients Having Private vs. Public Insurance Compared to Appendectomy Patients				
	Age Group	**# Patients**	**OR**	**CI**
Crude OR	All	663	0.31	0.20 - 0.49
Stratified ORs				
Small Group Decade Stratification	16-25	88	2.00	0.37 - 20.26
	26-35	92	1.07	0.14 - 12.82
	36-45	76	0.39	0.04 - 2.14
	46-55	115	0.16	0.004 - 1.17
	56-65	122	1.03	0.09 - 7.54
	66-75	109	*	*
	76-85	34	*	*
	85+	27	*	*
Three Group Stratification	16-45	256	0.91	0.40 - 2.12
	46-65	237	0.35	0.06 - 1.25
	66+	170	1.91	0.25 - 86.74
Stratified at 65	≤65	493	0.47	0.26 - 0.82
	>65**	170	1.93	0.25 - 86.74
Age-adjusted OR†			**0.85**	0.45 - 1.62

*One or more cells contain value ≤2.
** Stratified result from three-group stratification.
†Adjusted OR calculated from decade strata using Mantel-Haenszel method. X^2 test of homogeneity (7 d.f.) = 9.95, p = 0.19. M-H X^2 = 0.22, p = 0.64.

Table 4.

Odds Ratios for Lumbar Fusion Patients Having Any Insurance (vs. Being Uninsured) Compared to Oregon Hospitalized Patients

	Age Group*	# Patients	OR	CI
Crude OR	All	361,122	3.37	1.77 - 7.39
Stratified ORs				
Small Group Stratification	18-44/16-45	96,759	3.63	1.23 - 17.73
	45-64/46-65	90,077	4.94	2.11 - 15.29
	65+/66+ **	122,048	0.24	0.04 - 9.58
Stratified at 65	<65/≤65	186,836	4.20	2.10 - 9.81
	≥65/>65	122,048	0.23	0.04 - 9.49
Age-adjusted OR†			**3.97**	2.10 - 7.64

*Hospitalized patient age group (years)/Lumbar fusion patient age group (years)
**Because there were no uninsured fusion patients over 85, this age stratum was combined with the next younger group.
†Adjusted OR calculated from small group strata using Mantel-Haenszel method. X^2 test of homogeneity (2 d.f.) = 8.05, p = 0.02. M-H X^2 = 19.86, p < 0.0001.

Table 5.

Odds Ratios for Lumbar Fusion Patients Having Any Insurance (vs. Being Uninsured) Compared to Appendectomy Patients

	Age Group	# Patients	OR	CI
Crude OR	All	663	15.94	7.49 - 37.62
Stratified ORs				
Small Group Decade Stratification	16-25	88	*	*
	26-35	92	*	*
	36-45	76	3.73	0.64 - 25.77
	46-55	115	5.56	0.92 - 32.49
	56-65	122	18.83	0.21 - 1490.01
	66-75	109	*	*
	76-85	34	*	*
	85+	27	*	*
Four Group Stratification	16-45	256	10.55	3.19 - 54.43
	46-65	237	11.02	2.52 - 48.75
	66-85	143	7.50	0.11 - 152.69
	85+	27	2.00	0.02 - 182.75
Stratified at 65	≤65	493	12.38	5.59 - 30.92
	>65	170	7.27	0.11 - 146.48
Age-adjusted OR†			**10.37**	3.92 - 27.37

*One or more cells contain value ≤2.
†Adjusted OR calculated from decade strata using Mantel-Haenszel method. X^2 test of homogeneity (7 d.f.) = 32.67, $p < 0.0001$. M-H X^2 = 25.95, $p < 0.0001$.

Table 6.

Annual Incidence of Lumbar Fusion and Distribution of Demographic and Diagnosis Data* Among the Different Payer Groups in Lumbar Fusion Patients

***Diagnosis Percentage of Payer Total (Column %)**

		Payer					Total Number
		Private	Medicare	Medicaid	Uninsured	Other	
Demographics							
Age (Years) Mean ± σ		50.18 ±0.89	67.62 ±0.74	47.57 ±2.59	47.38 ±2.20	55 ±8.15	
Gender	Female	124 (50.20)	95 (54.91)	14 (50.00)	5 (62.50)	3 (60.00)	
	Male	123 (49.80)	78 (45.09)	14 (50.00)	3 (37.50)	2 (40.00)	
Oregon Population Number		2,189,000	547,000	428,000	576,000		
Lumbar Fusion Incidence (per 100,000)		**11.28**	**31.63**	**6.54**	**1.38**		
Diagnosis							
Emergent	Trauma	19 (7.69)	1 (0.58)	2 (7.14)	2 (25.00)	0	24 (5.21)
	Tumor	7 (2.83)	11 (6.36)	2 (7.14)	0	1 (20.00)	21 (4.56)
	Infection	2 (0.81)	1 (0.58)	1 (3.57)	0	0	4 (0.87)
Degen-erative	Disc	19 (7.69)	8 (4.62)	2 (7.14)	1 (12.50)	0	30 (6.51)
	Spinal Stenosis	44 (17.81)	48 (27.75)	4 (14.29)	1 (12.50)	2 (40.00)	99 (21.48)
	Spondy-lolisthesis	52 (21.05)	35 (20.23)	5 (17.86)	0	2 (40.00)	94 (20.39)
	Back Pain	33 (13.36)	15 (8.67)	0	1 (12.50)	0	49 (10.63)
	Spondy-losis	21 (8.50)	16 (9.25)	0	0	0	37 (8.03)
Other		50 (20.24)	38 (21.97)	12 (42.86)	3 (37.50)	0	103 (22.34)
Total Number		247 (100)	173 (100)	28 (100)	8 (100)	5 (100)	461 (100)

Table 7.

Proportion of Each Diagnosis Among Lumbar Fusion Patients Contributed by Each Payer Group*

***Payer Percentage of Diagnosis Total (Row %)**

		Payer					Total Number
		Private	Medicare	Medicaid	Uninsured	Other	
Diagnosis							
Emergent	Trauma	19 (79.17)	1 (4.17)	2 (8.33)	2 (8.33)	0	24 (100)
	Tumor	7 (33.33)	11 (52.38)	2 (9.52)	0	1 (4.76)	21 (100)
	Infection	2 (50.00)	1 (25.00)	1 (25.00)	0	0	4 (100)
Degen-erative	Disc	19 (63.33)	8 (26.67)	2 (6.67)	1 (3.33)	0	30 (100)
	Spinal Stenosis	44 (44.44)	48 (48.48)	4 (4.04)	1 (1.01)	2 (2.02)	99 (100)
	Spondy-lolisthesis	52 (55.32)	35 (37.23)	5 (5.32)	0	2 (2.13)	94 (100)
	Back Pain	33 (67.35)	15 (30.61)	0	1 (2.04)	0	49 (100)
	Spondy-losis	21 (56.76)	16 (43.24)	0	0	0	37 (100)
Other		50 (48.54)	38 (36.89)	12 (11.65)	3 (2.91)	0	103 (100)
Total Number		247	173	28	8	5	461 (100)

Figure 3.

Distribution of Diagnoses for Lumbar Fusion For Each Payer

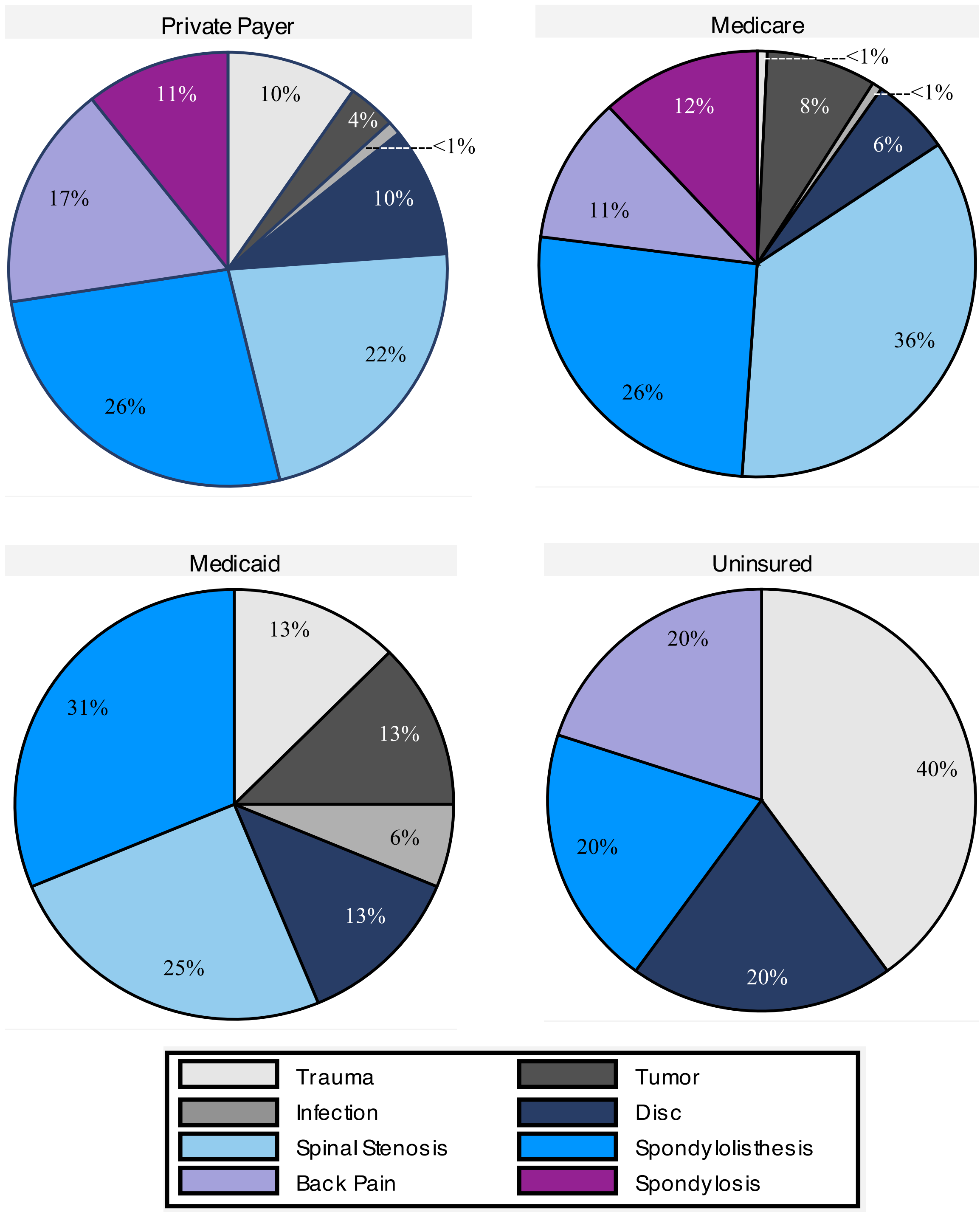


Table 8.

Age Distribution of Each Lumbar Fusion Diagnosis According to Payer

	Trauma				Tumor			
	Private	Medicare	Medicaid	Uninsured	Private	Medicare	Medicaid	Uninsured
16-25	4	-	1	-	-	-	-	-
26-35	3	-	-	-	-	-	-	-
36-45	4	-	1	1	-	-	-	-
46-55	2	-	-	1	4	-	1	-
56-65	2	-	-	-	1	3	1	-
66-75	3	-	-	-	1	6	-	-
76-85	-	1	-	-	-	2	-	-
86+	1	-	-	-	-	-	-	-
Total	19	1	2	2	6	11	2	0

	Infection				Disc			
	Private	Medicare	Medicaid	Uninsured	Private	Medicare	Medicaid	Uninsured
16-25	-	-	-	-	1	-	-	-
26-35	-	-	-	-	3	-	1	-
36-45	-	-	-	-	5	2	-	-
46-55	-	-	1	-	5	1	-	1
56-65	1	1	-	-	5	-	1	-
66-75	1	-	-	-	-	5	-	-
76-85	-	-	-	-	-	-	-	-
86+	-	-	-	-	-	-	-	-
Total	2	1	1	0	19	8	2	1

	Spinal Stenosis				Spondylolisthesis			
	Private	Medicare	Medicaid	Uninsured	Private	Medicare	Medicaid	Uninsured
16-25	2	-	-	-	1	-	-	-
26-35	2	-	1	-	6	-	-	-
36-45	2	-	-	-	5	1	2	-
46-55	12	5	1	-	6	4	3	-
56-65	22	10	2	1	27	5	-	-
66-75	4	19	-	-	6	18	-	-
76-85	-	12	-	-	1	5	-	-
86+	-	2	-	-	-	2	-	-
Total	44	48	4	1	52	35	5	0

	Back Pain				Spondylosis			
	Private	Medicare	Medicaid	Uninsured	Private	Medicare	Medicaid	Uninsured
16-25	-	-	-	-	1	-	-	-
26-35	2	-	-	-	2	-	-	-
36-45	3	-	-	-	8	1	-	-
46-55	19	2	-	1	5	2	-	-
56-65	8	4	-	-	5	3	-	-
66-75	1	8	-	-	-	8	-	-
76-85	-	1	-	-	-	2	-	-
86+	-	-	-	-	-	-	-	-
Total	33	15	0	1	21	16	0	0

Table 9.

Demographic and Insurance Coverage Distributions Among Instrumented and Uninstrumented Lumbar Fusion Patients							
		Instrumented			**Uninstrumented**		
		Overall	**<65**	**>65**	**Overall**	**<65**	**>65**
Demographics							
	Age (Years) Mean ± σ	56.7 ±0.89			57.2 ±1.17		
Gender	Female	146 (57.48%)	105 (57.38%)	41 (57.75%)	95 (45.89%)	53 (44.92%)	42 (47.19%)
	Male	108 (42.52%)	78 (42.62%)	30 (42.25%)	112 (54.11%)	65 (55.08%)	47 (52.81%)
Insurance Coverage							
	Private	137 (53.94%)	130 (71.04%)	7 (9.86%)	110 (53.14%)	82 (69.49%)	28 (31.46%)
Public	Medicare	98 (38.58%)	35 (19.13%)	63 (88.73%)	75 (36.23%)	19 (16.10%)	56 (62.92%)
	Medicaid	12 (4.72%)	12 (6.56%)	0	16 (7.73%)	11 (9.32%)	5 (5.62%)
	Uninsured	3 (1.18%)	3 (1.64%)	0	5 (2.42%)	5 (4.24%)	0
	Other	4 (1.57%)	3 (1.64%)	1 (1.41%)	1 (0.48%)	1 (0.85%)	0
	Total	254	183	71	207	118	89

Table 10.

**Odds Ratios of Instrumented Patients Having Private Insurance†
Compared to Uninstrumented Patients**

	Age Group	# Patients	OR	CI
Crude OR	All	441	1.06	0.71-1.59
Stratified ORs				
Small Group Decade Stratification	16-25	17	*	*
	26-35	24	<0.01	<0.01 - 4.29
	36-45	50	1.00	0.17 - 5.14
	46-55	95	1.60	0.56 - 4.46
	56-65	115	0.80	0.31 - 1.98
	66-75	105	0.33	0.08 - 1.10
	76-85	30	*	*
	85+	5	*	*
Four Group Stratification	16-45	91	0.84	0.22 - 3.13
	46-65	210	1.08	0.55 - 2.09
	66-85	135	0.41	0.12 - 1.26
	85+	5	1.00	0.01 - 104.37
Stratified at 65	≤65	301	0.96	0.54 - 1.70
	>65	140	0.27	0.09 - 0.71
Age-adjusted OR**			**0.83**	0.51 - 1.36

†Odds of having private insurance as opposed to public insurance
*Cells with value ≤2
**Adjusted OR calculated from decade strata using Mantel-Haenszel method. X^2 Test of homogeneity (7 d.f.=7.25) p=0.40. M-H X^2 = 0.53, p=0.47.

Figure 4.

Distribution of Payers
Among Instrumented and Uninstrumented
Lumbar Fusion Patients

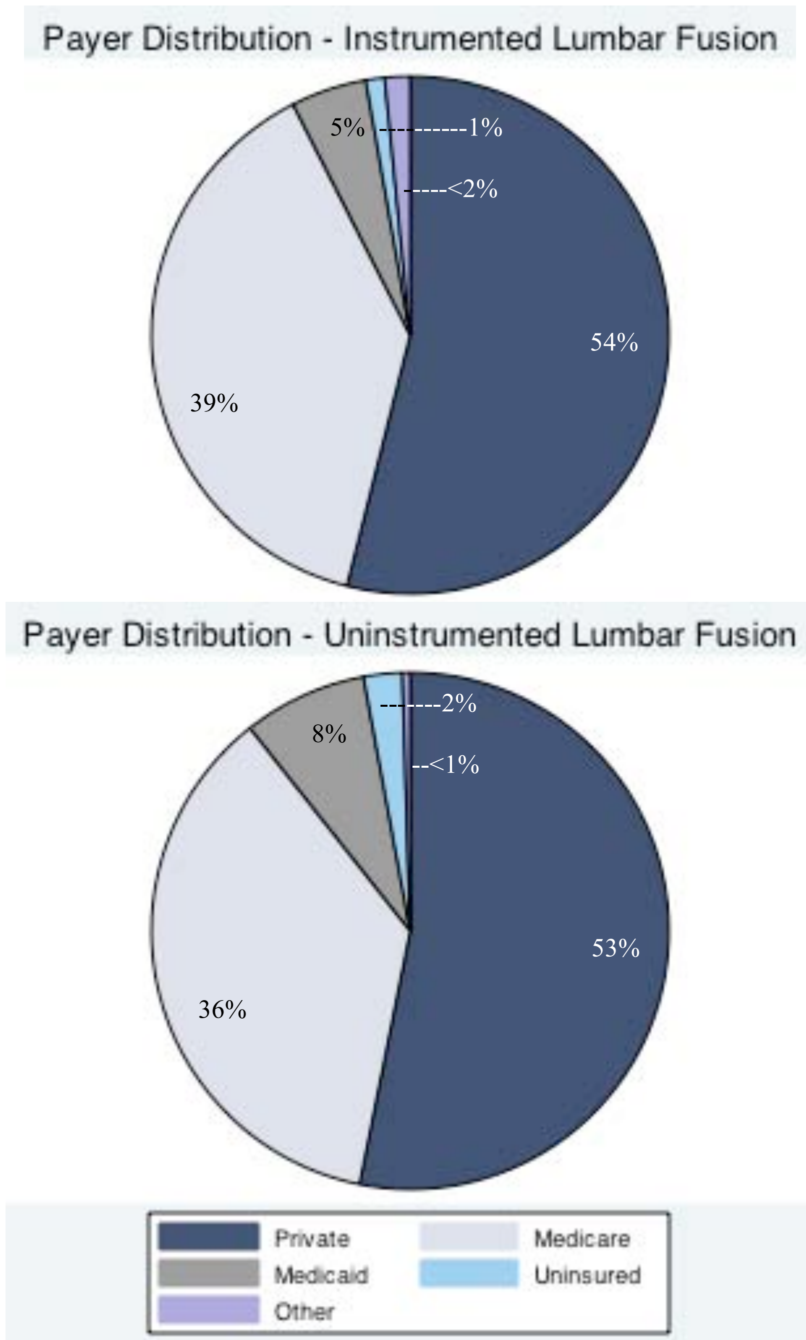


Table 11.

Odds Ratios of Associations Between Diagnosis and Instrumentation Status				
Diagnosis	**# Patients**	**OR**	**95% CI**	
Trauma	24	1.00 (reference)		
Tumor	21	8.25	1.53	44.52
Infection	4	3.67	0.25	53.83
Disc	30	55.00	9.68	312.43
Spinal Stenosis	99	19.25	4.28	86.65
Spondylolisthesis	94	14.22	3.16	63.97
Back Pain	49	22.69	4.74	108.60
Spondylosis	37	34.22	6.70	174.80

Table 12.

Lumbar Fusion Procedure Types According to Payer Group*

Procedure	Payer: Private	Payer: Medicare	Payer: Medicaid	Payer: Uninsured	Payer: Other	Total
Anterior Dorso-Lumbar	**1** (33.33) (0.40)	**2** (67.67) (1.16)	**0**	**0**	**0**	**3** (100) (0.65)
Posterior Dorso-Lumbar	**53** (50.96) (21.46)	**35** (33.65) (20.23)	**13** (12.50) (46.43)	**3** (2.88) (37.50)	**0**	**104** (100) (22.56)
Anterior Lumbo-Sacral	**11** (52.38) (4.45)	**9** (42.86) (5.20)	**1** (4.76) (3.57)	**0**	**0**	**21** (100) (4.56)
Posterior Lumbo-Sacral	**4** (80.00) (1.62)	**1** (20.00) (0.58)	**0**	**0**	**0**	**5** (100) (1.08)
Ant/Post Lumbo-Sacral	**132** (58.15) (53.44)	**81** (35.68) (46.82)	**7** (3.08) (25.00)	**4** (1.76) (50.00)	**3** (1.33) (60.00)	**226** (100) (49.24)
Combi-nation	**46** (45.54) (18.62)	**45** (44.55) (26.01)	**7** (6.93) (25.00)	**1** (0.99) (12.50)	**2** (1.96) (40.00)	**102** (100) (21.91)
Total	247	173	28	8	5	461 (100) (100)

*Actual counts are in boldface type. The percentages of each procedure done in the different payer groups (row percentages) are shaded blue. The distributions of procedures within each payer group (column percentages) are shaded grey.

IV. DISCUSSION

INTERPRETATION OF FINDINGS.

Direction of study findings.

Restatement of study question. The research question for this study was, originally, "do patients with back pain and a public payer receive different surgical treatment than those with back pain and a private payer?" However, the goal of the study is to explore the relationship between payer status and practice variation in lumbar spine surgery. In light of the study findings, a better question would be, "do candidates for lumbar fusion who have different payers receive different surgical treatment?"

When compared to the state population and to appendectomy patients, lumbar fusion patients have lower odds of having private insurance as opposed to public insurance – but higher odds of having private insurance as opposed to any other status. The prior main hypothesis was: among patients undergoing lumbar fusion surgery, the ratio of private to public payers is higher than in the population. Because most lumbar fusion surgery is elective, it is theoretically likely that patients undergoing such procedures would have a preponderance of private insurance. The result, however, is a statistically significant difference in the opposite direction - the odds of having private as opposed to public insurance are about half (0.54; 0.44 - 0.65) compared to a state resident. The situation is similar with regard to the first of the prior secondary hypotheses (among patients undergoing lumbar fusion surgery, the ratio of private to public payers is higher than in a control group of patients undergoing appendectomy.) In this case, it is possible to control for age by calculating stratified results. The age-adjusted odds ratio of having private as opposed to public insurance is 0.85 (0.45 – 1.62). However, there is an interaction with age, so the stratum-specific odds ratios provide a better description of findings. For patients ≤65, the odds that a fusion patient has private as opposed to public insurance are about half, compared to an appendectomy patient (OR = 0.47; 0.26 - 0.82). But for patients over 65, there is no significant difference between the groups (OR = 1.93; 0.25 – 86.74).

Interpreting the results from the study hypotheses alone signifies that lumbar fusion patients are less likely to have private insurance, compared to public insurance, both when compared against the state population and the appendectomy population. But this finding deserves further evaluation and explanation, given that it is contrary to the *a priori* hypothesis.

The original study question and the prior hypotheses stipulate a comparison between private and public payers but do not include other payer categories. Most significant in this respect is the exclusion of uninsured patients. Therefore, the revised research question includes all payer categories. When compared to all other possibilities – other insurance or being uninsured - the age-adjusted odds that a lumbar fusion patient has private insurance are 2.04 (95% CI

1.22 – 3.41), compared to an appendectomy patient. (Crude odds are nonsignificant; only crude odds can be calculated in comparison to the state population, and the result is nonsignificant.)

Therefore, compared to the state population and appendectomy patients, lumbar fusion patients do have lower odds of having private insurance *compared to public*, but fusion patients still have overall higher odds of just having private insurance, as opposed to any other insurance or being uninsured. Lumbar fusion patients have lower odds of having private compared to public insurance, compared to Oregon residents and appendectomy patients, because the latter groups are much more often uninsured – but when they have insurance, it is more likely to be private insurance rather than public.

When compared to the state population and to appendectomy patients, lumbar fusion patients have higher odds of having insurance of any kind as opposed to being uninsured. A more general way to include all payer categories is to simply compare the odds of being insured as opposed to having no insurance. The fusion patient's odds of having insurance of any kind are 9.06 times the odds of a state resident. Compared with the appendectomy group, the age-adjusted odds that a fusion patient is insured are 10.37 (95% CI 3.92 – 27.37).

When compared to all other hospitalized patients in Oregon, lumbar fusion patients have higher odds of both having private vs. public insurance and of being insured vs. being uninsured. There is another reason that the results of the hypothesis testing differ from the *a priori* expectations. This reason relates to the relative ages of the tested populations, and it can be approached by the inclusion of an additional control group. Because of the age requirements of Medicare, the potential confounding effect of age varies according to the age (confounding and interaction between age and other variables is specifically discussed below.) As a given population gets older, it develops an increasing number of Medicare patients, so the ratio of public to private payers would be expected to increase (excluding secondary payers). In this study the chosen control populations – Oregon state residents and appendectomy patients – are both younger than the fusion population (mean ages 37.10 ± 0.01, 33.19 ± 1.04, and 56.88 ± 0.71, respectively). In the analyses, age adjustment techniques were used to offset this problem. But to further strengthen the results, comparison to the entire Oregon hospitalized population was added. At a mean age of 46.93 ± 0.04, the Oregon hospitalized population is still younger than the fusion group. Therefore, the fusion group would be both more likely to have insurance, and more likely to have a greater ratio of public to private payer patients. But, compared to other hospitalized patients, the age-adjusted odds that a fusion patient is insured are 3.97 (2.10 – 7.64). The age-adjusted odds that the insurance is private rather than public are 1.63 (1.31 – 2.06).

The results of testing the study hypotheses show that fusion patients have lower odds of private insurance, compared to public insurance and in reference to the state and appendectomy populations. But fusion patients have higher odds of having private insurance as opposed to any other payer status. Fusion patients also have greater odds of having private as opposed to public insurance when compared to all other Oregon hospitalized patients. Therefore, overall, fusion patients have greater odds of having private insurance than would be expected if the null hypotheses were true in the first two parts of the study.

Interaction and confounding.

Age confounding. Analyses within the lumbar fusion group provide an opportunity to explore potential confounders. Perhaps the most significant confounder in this study is age, as discussed above. It is logical that payer group would be associated with age, and the study findings are consistent with that correlation. Also, clinical experience predicts that there would be an association between age and diagnosis, and this relationship is confirmed as well. Therefore, the observed relationship between payer group and diagnosis could be explained by confounding. However, there are also theoretical grounds for an independent association between those two variables. The private payer group includes different kinds of commercial payers. Automobile insurance as a payer, for example, would likely be associated with trauma diagnoses. Worker's compensation would likely be associated with conditions such as back pain or disc herniation. Also, as this study demonstrates, the more emergent diagnoses are more likely to be associated with uninsured status or with Medicaid. (In this situation, unlike the last two, the association is not likely representative of an increase in the incidence of emergent diagnoses in that payer group. Rather, the incidence is likely similar, but the absence of significant numbers of elective cases causes elevation of the proportion of urgent diagnoses within the payer group.)

On the other hand, an association between Medicare and spinal stenosis, for example, is likely to be the result of confounding by age.

Age interaction. Furthermore, the effect of age is not uniform across the age groups; it varies depending on the age level. In many instances in this study, age stratified testing produces substantially different results in the strata. Also, the age requirements for Medicare provide a theoretical basis for a differential influence of age between patients older or younger than 65. These two factors suggest that there is most likely an interaction between age and payer. However, a formal test of interaction did not reach a statistically significant level ($p = 0.36$). Perhaps there was insufficient power to detect an interaction. Despite the results of the formal interaction test, both the age-adjusted and the stratified results are reported, given the differences between strata.

It is likely that the confounding effects of age are blurred due to the age categories used in the study. Logic suggests that the age interaction is most pronounced at the point of Medicare enrolment at 65. However, it is not possible to separate 65-year olds in this study, and they are included with the younger group. Of course, there may be other ages at which a shift in insurance coverage occurs and contributes to the differential effect that denotes interaction. The point at which young adults are no longer eligible for coverage under a parental policy is one example. But the universal application of Medicare suggests that qualification for Medicare at age 65 is the predominant driver of the interaction.

The age categorization used in this study would be expected to bias the results towards the null hypothesis.

Diagnosis confounding. The study provides reason to suspect confounding by diagnosis, as well. As described above, diagnosis is associated with payer – partly through confounding by age, but possibly independently associated as well. And again as described above, diagnosis is associated with age. Finally, diagnosis is clearly associated with instrumentation status (a reassuring finding). Therefore, the observed association between payer and instrumentation status may represent confounding by diagnosis. It is interesting that the probability value for this association reached statistical significance only in the older age group. The association cannot be explained by age alone, because age and instrumentation status appear independent of each other. There may be an interaction between age and payer, further complicated by the confounding association between age and diagnosis. Although this suggested model is complex, each relationship is supported by the findings in the study. As a whole, the proposed associations offer a potential explanation for the stratified results that describe the correlation between payer and instrumentation status.

Additional confounders. Procedure type may be confounding the results as well. This variable is associated with instrumentation status, a finding that correlates well with clinical practice. Likewise, procedure is associated with diagnosis – a logical and expected result. Procedure is associated with age, also, although this observation could be explained by confounding with diagnosis. Finally, procedure is associated with payer status in the same pattern as described for diagnosis – the association is statistically significant only for the older age stratum. Therefore, although procedure type may be an additional confounder, the observations may also be explained by diagnosis and age alone.

There are two additional theoretically confounding variables worthy of mention: smoking status and, likely to a lesser degree, co-morbidity. The current study does not provide means to evaluate these two factors, but both have relationships to key study variables. Both smoking and co-morbidity can relate to age and therefore to payer. And both (especially smoking) are major determinants of surgical decision making for lumbar fusion. This includes the determination to proceed with surgery as well as the choice of procedure and use of instrumentation. In other words, smoking and co-morbidity have a significant relationship between and both the predictor and outcome variables of this study, which creates the potential for confounding or interaction.

<u>Interpretation</u>

Examined as a group, lumbar fusion patients actually have a smaller ratio of private to public payer patients than both the Oregon population and appendectomy patients. But that is because the fusion group is older and therefore has a much higher proportion of Medicare patients. The fusion group actually does have a higher proportion of private-payer patients than would be expected, given the group's age. The larger proportion of private-payer patients does not signify a reduced proportion of public pay patients; rather, the proportion difference stems from a much smaller number of uninsured patients.

Findings in the Medicare group and the private-payer group are comparable in many regards. It seems most likely that there is no significant difference between the surgical management of the two groups. Of course, it is known that the private insurers typically follow Medicare in creating their policies. Such knowledge provides a theoretical basis for the interpretation that the private payers and Medicare may be very similar.

On the other hand, the findings in the Medicaid group bear a greater resemblance to the observations of the uninsured group. There are very few fusion patients in both of these two groups. Also, the ratio of urgent to elective diagnoses is higher. Together, these observations suggest that Medicaid and uninsured patients do receive different surgical care, compared to the private-payer (and Medicare) patients. For the most part, Medicaid or uninsured patients do not receive elective fusion procedures; lumbar fusions in these patients appear mainly limited to more emergent situations.

But once a decision has been made in favor of surgery, it seems that the choice of procedure and instrumentation is made regardless of insurance status. The main determinant of instrumentation use and procedure type appears to be diagnosis. Although it could not be evaluated in this study, on clinical grounds it is likely that smoking is a significant contributor to this decision as well, and confounding by this and other variables likely explains the observed association between payer and instrumentation.

STUDY LIMITATIONS

Some of the limitations of this study are alluded to or described above. The inclusion of several other variables would have been helpful: secondary payer, smoking status, and co-morbidity data. Also, individual age (or different age group categories) would facilitate analysis. Besides providing more information, this would solve the two problems caused by the age brackets used in the study dataset (described in more detail in the "Methods" section). The first problem is the lack of perfect correlation between the age groups of the fusion patients and the Oregon hospitalized patients. The other is the inclusion of 65 year olds, i.e. Medicare patients, with the younger group (61-65) rather than with the rest of the Medicare patients over 65. Both of these problems would be expected to bias the study results towards the null hypothesis.

Another issue, also related to age, is the selection of the operative patient control group. As described earlier, appendectomy was chosen because it has fairly standard indications, and is therefore likely to exhibit less geographic variation, although this procedure has not been studied in the Dartmouth Atlas. Also, appendectomy is simply coded, and so less subject to coding error. And finally, like most lumbar fusion patients, appendectomy patients are often otherwise healthy individuals. Therefore, co-morbidities would be less likely to confound the findings. However, the appendectomy patients proved much younger than the fusion patients, and the number of appendectomy cases over 65 was quite small. Methods of age adjustment have been described above. However, perhaps the choice of a different surgical procedure would produce a population bearing more resemblance to fusion patients. Appendix E lists the procedures that have been studied as part of the Dartmouth Atlas of Health Care, along with the respective ranges of state-specific rates across the U.S. The factor difference between the lowest- and highest-rate states is included also. Chole-cystectomy has the lowest geographical variability among the procedures studied, varying 2.2-fold between 2.5 cases per 1,000 Medicare enrollees in 2007 (several states) and 5.5 (Alabama; also per 1,000 Medicare enrollees in 2007). (Dartmouth Institute, 2011) Per HCUP-net, the mean age for cholecystectomy patients in Oregon in 2009 was 52.53 years. (AHRQ, 2011) Thus, cholecystectomy patients are closer than appendectomy patients to the age of lumbar fusion patients. Furthermore, this is also a procedure often performed on otherwise healthy individuals. Perhaps this procedure would provide a better control group for the study.

There are some other limitations inherent to the study design. Although the HCUP databases are a valuable resource, the information is limited. Using the entire OHDDS would have provided more detailed information. However, this database has its limitations as well. First, this database does not capture outpatient procedures, and an increasing number of spine surgeries are done on an outpatient basis. Since the payer might influence the decision whether to use an outpatient or inpatient setting, this limitation could result in a failure to capture specific subgroups, leading to biased results. However, the effect on this study should be minimal, as lumbar fusion is not (yet) commonly performed on an outpatient basis.

Also, because rates of spine surgery vary so profoundly from one region to another, extrapolating the result is problematic. It would be interesting to look at this issue in an area with a low rate of spinal surgery, in comparison to Oregon. Findings from the national level would be noteworthy.

The most important limitation is expected from the study design – the lack of outcomes information. It appears that there is a difference in fusion rates between those who have private insurance or Medicare and those who have Medicaid or are uninsured. However, without outcomes information, we cannot know whether the uninsured are underserved, or the private patients are undergoing excessive surgeries – which has been referred to as the "moral hazard" of having health insurance. Perhaps the ideal rate is somewhere in between.

SIGNIFICANCE OF FINDINGS

The relationship between payer status and lumbar fusion suggests that payer is a factor in practice variation. This finding has implications in the creation of public policy regarding public health insurance. In this study, the association between fusion and public payer appears to depend on the type of public insurance. To the extent that the study allows fusion care to be compared between the payer groups, it seems that private-pay patients and Medicare patients are relatively similar. But with the other public payer, Medicaid, fusion care more closely resembles the pattern of the uninsured. As described above, one cannot say whether the Medicare patients are over-treated, or the Medicaid patients under-treated. But the treatment is clearly different, suggesting that the payer influences the level of care, at least to some degree. Whether desired or not, in either in devising the details of public health coverage, or in considering the privatization of care, there are opportunities to manipulate the level of care.

The findings of this study are also significant to all individuals as patients. Admittedly, too many people do not have any choice regarding their insurance status. But for those who do have options, it is important to realize that the choice may influence the type of care that is offered. For example, going without health insurance is likely a matter of unfortunate necessity for most of the uninsured. But some people may weigh the purchase of health insurance against other competing financial considerations. It is common knowledge that emergency care can be obtained regardless of insurance status or the ability to pay, and some people may place a lesser priority on routine preventive care. But there is a substantial grey-zone of intermediate-level care in between the two extremes, and patient care in that zone is likely most susceptible to influence on the basis of insurance status. The problem relates to the debatable definition of "necessary" care. For example, consider a case of severe back pain caused by mobile spondylolisthesis: a successful lumbar fusion may prevent disability. There is valid reasoning behind the claim that such a surgery is "necessary," but it is not urgent. Therefore, under the current system, it would be difficult to obtain the procedure without health care coverage or – as suggested by this study – even with Medicaid. On the other hand, perhaps individuals with private insurance are receiving lumbar fusions in the opposite situation – when the procedures are unlikely to help, or when smaller surgical procedures or even non-surgical care would suffice. This study only looked at broad payer categories: private, Medicare, Medicaid, uninsured. But the private category, at least, is a heterogeneous group. It is possible that there are demonstrable differences in care between different categories of private insurance. Certainly, overall cost, out-of-pocket costs, and convenience are all factors when individuals or employers choose health care policies. But the different types of coverage may be associated with differing levels of care, in ways that are currently not apparent to consumers.

FURTHER DIRECTIONS

Studying practice variation and payer. Following the above reasoning, it would be interesting to repeat this study with a larger population, to permit comparisons between finer insurance categories.

Also, further work must be done to clarify the factors behind the practice variation associated with payer status. As discussed earlier in this paper, the factors can be placed in three general categories – system, physician, and patient – and payer status potentially affects all three. The payer is part of the system, and can influence the level of care directly in many ways. For example, as with the Oregon Health Plan, the payer can set levels of care and deny coverage outside those limits. More subtly, perhaps, the payer can manipulate the reimbursement for individual services, or sometimes even provide incentives or disincentives to organizations, physicians, or patients. In some situations, such as in many Health Maintenance Organizations, practice guidelines are used to define and control the level of care. Whether or not a particular payer is trying to maximize profit, the payer must remain solvent, and so the overall costs of the covered group are a primary concern. But we do not know the extent to which any of these particular interventions is responsible for shaping the level of care, and this topic needs further analysis.

The physician, on the other hand, is likely to attend to the needs of the individual patient rather than group costs. The physician is nonetheless subject to the influences of the system, and there are many possible ways in which the physician may interact with the system in determining the level of care. For example, in many areas, it is not uncommon for spine surgeons to refuse to "accept" new patients with Medicaid. Some refuse Medicare, as well. (Of course, all surgeons still see these patients as inpatient or emergency room consultations, consistent with the findings in this study that the odds of undergoing fusion surgery for an emergent diagnosis are much higher among uninsured and Medicaid patients.) The overhead costs in running a surgical practice are undoubtedly the rationale behind excluding public-payer patients as a group. But could potential reimbursement affect a surgeon's care in an individual case? Or, what about the case in which the surgeon knows that a given payer requires hours of paperwork and phone calls to obtain "authorization"? We do not know the degree to which the physician may be responsible for changes in the level of care based on the patient's payer status, so this is another area needing exploration.

Finally, the patient's role calls for further investigation. Different payers require their enrollees to shoulder distinct financial obligations. Co-payments or degree of coverage of hospital, professional, or ancillary services could sway an individual's decision about proceeding with an elective operation. Some payers either suggest or demand second opinions – another way in which patients might be systematically influenced.

Studying practice variation and lumbar fusion. Outcomes research is needed regarding lumbar fusion and back pain. The large Spine Patient Outcomes Research Trial (SPORT) has addressed spinal stenosis, degenerative spondylolisthesis, and lumbar disc herniation, but additional studies are needed in other areas. The SPORT trials have demonstrated some of the difficulty in large outcome studies of surgical results, and back pain is a significantly more complex issue. (Weinstein JN & al., 2007) (Weinstein JN & al., 2008) (Weinstein JN & al., 2006) Nonetheless, such clinical studies are needed. But the issue of outcomes might also be addressed within the context of a practice variation study. For example, with population disability data, one could test the correlation between spine-related disability and spine surgery rates.

Studying practice variation in general. It will also be valuable to continue studying the factors responsible for practice variation – such work has the potential to guide standardization and raise the overall quality of care. Referring to Appendix E, it is clear that virtually every procedure is subject to some degree of practice variation. And as discussed earlier in this paper, medical care and virtually all aspects of health care are variable as well. So the work done in this study could be applied to myriad other procedures, medical and surgical. Similarly, the factors responsible for practice variation are complex. We are just beginning to appreciate some of the issues, but a multitude of potentially relevant topics are emerging. Studies analogous to this one could be used to examine factors besides payer.

V. SUMMARY AND CONCLUSIONS

The odds that a lumbar fusion patient is insured, compared to the Oregon state population, are 9.06. But the prior primary hypothesis of the study is: among patients undergoing lumbar fusion surgery, the ratio of private to public payers is higher than in the population. The odds ratio resulting from testing the primary hypothesis is 0.54 (0.44 - 0.65).

Compared to other hospitalized patients, the age-adjusted odds that a fusion patient is insured are between 2.10 and 7.64. The age-adjusted odds that the insurance is private rather than public are between 1.31 and 2.06.

In comparison with the appendectomy group, the age-adjusted odds that the fusion patient is insured are 10.37 (3.92 – 27.37). The first prior secondary hypothesis of the study is: among patients undergoing lumbar fusion surgery, the ratio of private to public payers is higher than in a control group of patients undergoing appendectomy. The result depends on age. For patients ≤65, the resultant odds ratio is 0.47 (0.26 - 0.82). For patients over 65, the odds are statistically nonsignificant, and the overall odds do not reach statistical significance.

Therefore, this first part of the study shows that the odds of a lumbar fusion patient having insurance are significantly higher than in the state population, and are also significantly higher than in other hospitalized patients.

The older age of the fusion group and the resultant predominance of Medicare explains why – in answer to the study hypotheses - lumbar fusion patients have a greater ratio of public to private insurance, when compared to the state population or to appendectomy patients. Even though lumbar fusion patients are less likely to have private vs. public insurance (compared to the Oregon state population and to appendectomy patients), the private payer group is substantially over-represented among fusion patients, considering what would be expected from the age of the group. This interpretation is confirmed by comparing the lumbar fusion group to other hospitalized patients - the fusion patient has 1.63 times the age-adjusted odds of having private instead of public insurance compared to all other patients hospitalized in Oregon (95% CI 1.31 – 2.06). Thus, the conclusion is that lumbar fusion patients are both more likely to be insured, and more likely to have private insurance, than would be expected.

Within the lumbar fusion patient group, controlling for age, there is a statistically significant association between payer and diagnosis. For a patient who has Medicaid or is uninsured, in contrast to a patient with private insurance or Medicare, the age-adjusted odds that the fusion procedure is associated with an urgent instead of an elective diagnosis are 4.16 (1.45 – 11.99).

Considering age and diagnosis, payer does not likely have a significant association with either procedure or instrumentation status. The other prior secondary hypothesis is: among patients undergoing instrumented lumbar fusion, the ratio of private to public payers is higher than that among patients undergoing un-instrumented lumbar fusion. The result depends on age; the stratified odds ratios are: ≤65 OR = NS; >65 OR = 0.27 (0.09 - 0.71). The overall age-adjusted odds are 0.83 (0.51 – 1.36).

The stratified results suggest that older patients with private insurance are less likely to obtain instrumentation, compared to older patients with public insurance. But there are statistically significant associations between payer and age, age and diagnosis, and diagnosis and instrumentation. Because the age association is an interaction rather than simple confounding, the observed association between payer and instrumentation in the older stratum likely represents confounding by the associations with the other variables. The main determinant of instrumentation use appears to be diagnosis.

The specific goal of this project was to address the following question: Do patients with back pain and a public payer receive different surgical treatment than those with back pain and a private payer? Patients with a private payer are indeed over-represented among fusion patients. However, patients with a private payer appear to obtain similar surgical care compared to Medicare patients. On the other hand, patients who are uninsured appear much less likely to undergo lumbar fusion. Patients who are uninsured or who have Medicaid are less likely to have a lumbar fusion for elective diagnoses. However, if undergoing fusion surgery, patients appear to obtain similar types of procedures or instrumentation, regardless of payer group.

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APPENDICES

APPENDIX A

ICD-9 Procedure Codes Used for Patient Selection

Codes used to select lumbar fusion:

81.04 DRSL/DRSLUMB FUS ANT/ANT

81.05 DRSL/DSLMB FUS POST/POST

81.06 LUMB/LMBSAC FUS ANT/ANT

81.07 LUMB/LMBSAC FUS POST/POST

81.08 LUMB/LMBSAC FUS ANT/POST

Codes used to identify instrumentation patients:

84.51 INS SPINAL FUSION DEVICE

84.8 INS/REPL INTERSPINE DEV

84.82 INS/REPL PDCL STABIL DEV

84.52 INSERT RECOMBINANT BMP

Codes used to select appendectomy patients:

47.01 LAP APPENDECTOMY

47.09 OTHER APPENDECTOMY

APPENDIX B

Data Fields Provided in the Study Dataset

Age Category (in 5-year increments, beginning with 16-20)

Gender

Regional Location (first 3 digits only of zip code)

Operative Diagnoses

Co-Morbidity Diagnoses

Procedure Codes

Payer

APPENDIX C

ICD-9 Diagnosis Code Classification Employed in the Study

Trauma:

805.4 FX LUMBAR VERTEBRA-CLOSED

806.4 CLOSED FRACTURE OF LUMBAR SPINE WITH SPINAL CORD INJURY

Tumor:

213.2 BENIGN NEOPLASM OF VERTEBRAL COLUMN, EXCLUDING SACRUM AND COCCYX

225.3 BENIGN NEOPLASM OF SPINAL CORD

225.4 BENIGN NEOPLASM OF SPINAL MENINGES

733.13 PATHOLOGIC FRACTURE OF VERTEBRAE

198.5 SECONDARY MALIGNANT NEOPLASM OF BONE AND BONE MARROW

Infection:

324.1 INTRASPINAL ABSCESS

Disc Displacement:

722.1 DISPLACEMENT OF LUMBAR INTERVERTEBRAL DISC WITHOUT

MYELOPATHY

Lumbar Stenosis:

724.02 SPINAL STENOSIS, LUMBAR REGION, WITHOUT NEUROGENIC CLAUDICATION

Spondylolisthesis:

756.11 CONGENITAL SPONDYLOLYSIS, LUMBOSACRAL REGION

756.12 CONGENITAL SPONDYLOLISTHESIS

738.4 ACQUIRED SPONDYLOLISTHESIS

Back Pain:

724.5 BACKACHE, UNSPECIFIED

724.2 LUMBAGO

722.52 DEGENERATION OF LUMBAR OR LUMBOSACRAL INTERVERTEBRAL DISC

Lumbar Spondylosis:

721.3 LUMBOSACRAL SPONDYLOSIS WITHOUT MYELOPATHY

721.42 SPONDYLOSIS WITH MYELOPATHY, LUMBAR REGION

APPENDIX D

Selected Contingency Tables and Calculation Examples

1. Lumbar fusion compared to Oregon population.

Lumbar Fusion compared to Oregon Population Private vs. Public Payer			
	Private Payer	**Public Payer**	
Fusion	247	201	
Population	2,189,000	975,000	

$$OR = \frac{247 \times 975{,}000}{2{,}189{,}000 \times 201} = 0.54$$

2. Lumbar fusion compared to Oregon hospitalized population.

Lumbar Fusion compared to Oregon Hospitalized Population Private vs. Public Payer				
	Private Payer	**Public Payer**	**Age Stratum**	
Fusion	73	14	18-44/ 16-45	OR=3.61 Number in stratum=81,596
Population	48,131	33,378		
Fusion	139	63	45-64/ 46-65	OR=1.29 Number in stratum=75,515
Population	47,528	27,785		
Fusion	19	115	65-84/ 66-85	OR=1.39 Number in stratum=92,087
Population	9,747	82,206		
Fusion	1	4	85+/ 86+	OR=3.36 Number in stratum=28,022
Population	1,939	26,078		

Age-adjusted OR calculated using Mantel-Haenszel method, a variance weighted average of the stratum specific odds ratios.

3. Lumbar fusion compared to appendectomy patients.

Lumbar Fusion compared to Appendectomy Population Private vs. Public Payer			
	Private Payer	**Public Payer**	**Age Stratum**
Fusion	15	2	16-25
Appendectomy	45	12	

OR=2.00
Number in stratum=74

OR obtained for each stratum, and weighted average calculated as in Example 2, above.

Lumbar Fusion compared to Appendectomy Population Insured vs. Uninsured			
	Insured: Private+Medicare+Medicaid	**Uninsured**	**Age Stratum**
Fusion	17	0	16-25
Appendectomy	49	14	

Weighted average of stratum specific OR calculated as above.

4. Instrumentation status in lumbar fusion patients.

Instrumented compared to Uninstrumented Population Private vs. Public Payer			
	Instrumented	**Uninstrumented**	**Age Stratum**
Private Payer	2	11	16-25
Public Payer	0	2	

OR obtained for each stratum, and weighted average calculated as in Example 2, above.

APPENDIX E

Range of US Inpatient Surgical Procedure Rates Compiled from the Dartmouth Atlas of Healthcare*

Procedure	Lowest Rate State(s)	Highest Rate State	Range**	Range Factor
Abdominal Aortic Aneurysm Repair	Hawaii	Kentucky	**0.3 – 1.3**	**4.3**
Back Surgery	Hawaii	Wyoming	**1.6 – 10.0**	**6.3**
Cardiac Valve Replacement	Hawaii	Delaware	**0.6 – 2.0**	**3.3**
Carotid Endarterectomy	Hawaii	Mississippi	**0.4 – 3.5**	**8.8**
Cholecystectomy	Dist. of Columbia, Hawaii, New Hampshire, Vermont	Alabama	**2.5 – 5.5**	**2.2**
Colectomy	Hawaii	North Dakota	**0.7 – 2.0**	**2.9**
Coronary Angiography	Hawaii	Alabama	**6.3 – 27.4**	**4.3**
Coronary Artery Bypass Grafting	Hawaii	Alabama	**1.7 – 5.4**	**3.2**
Hip Replacement	Hawaii	Minnesota	**1.0 – 5.3**	**5.3**
Knee Replacement	Hawaii	South Dakota	**2.9 – 12.9**	**4.5**
Lower Extremity Bypass	Alaska	Alabama	**0.4 – 1.3**	**3.3**
Mastectomy	Vermont	South Dakota	**0.4 – 1.8**	**4.5**
Percutaneous Coronary Interventions	Hawaii	Arkansas	**3.0 – 14.3**	**4.8**
Radical Prostatectomy	West Virginia	Minnesota	**0.9 – 2.9**	**3.2**
Transurethral Prostatectomy	New Hampshire	North Dakota	**2.0 – 5.3**	**2.7**

*http://www.dartmouthatlas.org/data/topic/all.aspx **Per 1,000 Medicare enrollees in 2007, updated Feb. 2011