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Predictors of the Incidence and Charges for Lumbar Spinal Fusion Surgery in Florida Hospitals During 2010

Anna Ialynychev
University of South Florida, annai@mail.usf.edu

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by

Anna Ialynychev

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Major Professor: Alan M. Sear, Ph.D.
Barbara L. Orban, Ph.D.
Arthur R. Williams, Ph.D.
Nanhua Zhang, Ph.D.

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DEDICATION

I would like to thank my parents for their endless support throughout my academic career. The hard work and determination which they have exemplified in their own lives has been an inspiration to me. They have been role models not just through their words but more importantly, through their actions. Their boundless understanding and encouragement has always helped to carry me forward and their advice has helped me to find my path. I am grateful beyond words for all they have sacrificed and for all of the countless ways that they have helped me to achieve my goals.

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ABSTRACT

Over the past several decades rates of spine surgeries in the U.S. have increased dramatically. Spinal fusion surgery rates, in particular, have grown exponentially despite being one of the most costly, invasive, and controversial methods for treating patients suffering from back conditions. Furthermore, lumbar fusion surgeries continue to be performed at increasing rates despite a lack of scientific evidence and consensus that they are cost-effective and produce better clinical outcomes than less radical treatment of lower back pain. As a result, large amounts of healthcare dollars continue to be invested in these costly procedures which are potentially dangerous and have questionable efficacy in terms of improving patient outcomes.

Importantly, there is a lack of population studies in the literature on spinal fusion surgeries from a health services research perspective. Therefore, the present research is a population based study using an administrative database and includes patients of all ages and payer types. The data used in the present study come from the Florida Agency for Health Care Administration (AHCA) and include all hospitalizations in Florida in 2010.

The objective of the study is to analyze the incidence of spinal fusion surgeries in Florida hospitals for patients of all ages and payer types by demographic variables to understand who gets these surgeries and for which conditions. The first null hypothesis is that there are no statistically significant predictors of the incidence of lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgeries in Florida hospitals. Logistic regression was used to analyze the incidence of fusion surgeries. The binary dependent variable was coded as a “1” for all patients

who were a case (i.e. they received one of the five procedure codes being studied in the present research) and a "0" for all patients who were controls (meaning they did not receive any of the five fusion procedure codes). Logistic regression was used to predict the probability of an observation being a "1" given the independent variables included in the model.

Additionally, hospital charges were analyzed to understand the associated hospital charges with these surgeries. The second null hypothesis is that there are no statistically significant predictors of the charges of lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgeries in Florida Hospitals. A mixed effects model was used to test this hypothesis and the fixed effects which were included in the model were gender, age, race, principal payer, and principal procedure. A mixed effects model was chosen due to the fact that cases who had surgeries performed at the same hospital are not independent and therefore the data were clustered on hospitals. A random intercept term was used to address this fact. SAS software was used to complete all of the analyses.

In 2010, there were 16,236 lumbar/lumbosacral, dorsal/dorsolumbar fusion surgery cases in Florida hospitals that were included in the case population and 21,856 individuals included in the control population for a total of 38,092 included in the study population. An understanding of who is most likely to receive a fusion surgery, at what age, and for which diagnoses, as has been done here, is extremely important. This knowledge can help researchers, policy makers, and physicians alike. Comprehensive physician practice guidelines for performing fusion surgeries still do not exist in the year 2013; therefore, in order to have the greatest impact, the efforts for creating the guidelines should be focused on those individuals who are most likely to receive fusions as shown for the first time by the data analyzed here. Given the high incidence of these surgeries in Florida alone, the need for practice guidelines cannot be overstated.

The total hospital charges in Florida hospitals for the 16,236 cases were $2,095,413,584. Despite having the same principal diagnoses and a similar number of additional diagnoses, patients who received a fusion surgery resulted in approximately three times the charges as those incurred by the controls.

Overall, the high incidence and charges for fusion surgeries shown in this study emphasize the importance of having a better understanding of when these surgeries are justified and for which patients. Without comprehensive practice guidelines established through evidence-based research this is difficult, if not impossible, to accomplish. The diagnoses which are most prevalent and show the most inconsistencies between cases may be a good starting point for such guidelines.

CHAPTER 1: INTRODUCTION

Over the past several decades rates of spine surgeries in the U.S. have increased dramatically. Spinal fusion surgery rates, in particular, have grown exponentially despite being one of the most costly, invasive, and controversial methods for treating patients suffering from back conditions. Furthermore, lumbar fusion surgeries continue to be performed at increasing rates despite a lack of scientific evidence and consensus that they are cost-effective and produce better clinical outcomes than less radical treatment of lower back pain. As a result, large amounts of healthcare dollars continue to be invested in these costly procedures which are potentially dangerous and have questionable efficacy in terms of improving patient outcomes.

Importantly, there is a lack of population studies in the literature on spinal fusion surgeries from a health services research perspective. Therefore, the present research is a population based study using an administrative database and includes patients of all ages and payer types.

During a fusion surgery two or more vertebrae are fused together using bone graft as a space filler in addition to inserting screws, rods or plates to hold the vertebrae in place (Mayo Clinic, 2012). The goal of spinal fusion is to decrease the motion of the back and to stabilize the spine with the intent of stopping the pain associated with such movement (Taher et al. 2012). According to the Healthcare Cost and Utilization Project (HCUP) data, the number of spinal fusion procedures increased from 202,000 in 1997 to 448,000 in 2009 (Russo, 2007).

Furthermore, from 2000 through 2004 hospital stays involving spinal fusions had the greatest increase in total hospital costs with a 93.6% increase.

Besides the increasing rates of this procedure, another reason for the high costs of fusion surgery is the cost of spinal implants and hardware placed inside the patient during the surgery. Tens of thousands of dollars of hardware can be used in a single spinal fusion surgery.

In addition to the growing rates of fusion surgeries and high costs to patients, both monetary and otherwise, a troubling trend of geographic variation continues to exist for the procedure. In 2006, Weinstein et al. reported that fusion surgeries were among the most variable treatments performed by geographic region. The authors suggest that a lack of scientific evidence concerning the procedure, financial incentives for surgeons to perform the procedure, and differences in clinical training among physicians may be responsible for the regional variation.

The increase in rates of spinal fusion also brought about an increase in reoperation and other treatment complications (Deyo, 2009). According to Deyo et al., as fusion surgeries increased and additional technologies such as fusion cages became available after FDA approval in 1996, reoperation rates also increased. Moreover, the use of surgical implants in a spinal fusion was found to increase the risk of nerve injury, blood loss, overall complications, operative time, and repeat surgery (Deyo, 2009).

However, Deyo has primarily used Medicare data to analyze trends of back surgeries in the U.S. The data used in the present study, on the other hand, come from the Florida Agency for Health Care Administration (AHCA) and include all hospitalizations in Florida in 2010. Therefore, this research will be able to undertake a more comprehensive examination of fusion surgeries due to its ability to analyze back patients of all ages, instead of being limited only to those who are ages 65 and over and those with certain disabilities as is the case with Medicare data.

The Florida Hospital Discharge Data has five ICD-9-CM procedure codes for lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgeries. Together, these procedures amount to tens of millions of dollars per year in Florida alone. It is important to know the incidence and hospital charges for these procedures, especially for those procedures which account for the highest total charges. Additionally, the characteristics of the patients upon whom these procedures were performed are also unknown and should be examined.

Although ICD-10-CM diagnosis and procedure codes were available in the year 2010, Florida hospitals were not yet using them and therefore the present analysis used ICD-9-CM codes. ICD-10-CM code sets have fundamental changes which make them more detailed and more specific than their previous version (AMA, 2012). Whereas there are approximately 13,000 diagnosis codes available in the ICD-9-CM code set, there are approximately 68,000 diagnosis codes available in ICD-10-CM. The difference between procedure codes in the two versions is even greater with 3,000 available in ICD-9 and 87,000 available in ICD-10. Some of the benefits of the ICD-10 code sets include the greater detail and specificity for descriptions of body parts involved in the diagnosis or procedure. Similarly, ICD-10 procedure codes provide information about the methodology and approach employed along with any medical devices used. Thus, an analysis using these codes would have allowed for more specificity.

The objective of the study is to analyze the incidence of spinal fusion surgeries in Florida hospitals for patients of all ages and payer types by demographic variables to understand who gets these surgeries and for which conditions. The first null hypothesis is that there are no statistically significant predictors of the incidence of lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgeries in Florida hospitals. Logistic regression was used to analyze the incidence of fusion surgeries. The binary dependent variable was coded as a "1" for all patients who were a case (i.e. they received one of the five procedure codes being studied in the present research) and a "0" for all patients who were controls (meaning they did not receive any of the five fusion procedure codes). Logistic regression was used to predict the probability of an observation being a "1" given the independent variables included in the model.

Additionally, hospital charges were analyzed to understand the associated hospital charges with these surgeries. The second null hypothesis is that there are no statistically significant predictors of the charges of lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgeries in Florida Hospitals. A mixed effects model was used to test this hypothesis and the fixed effects which were included in the model were gender, age, race, principal payer, and principal procedure. A mixed effects model was chosen due to the fact that cases who had surgeries performed at the same hospital are not independent and therefore the data were clustered on hospitals. A random intercept term was used to address this fact. SAS software was used to complete all of the analyses.

CHAPTER 2: REVIEW OF THE LITERATURE

Despite the high rates of back surgeries performed, they are among the most variable treatments performed by geographic location in the U.S. and fusion surgeries, in particular, were more variable than spine surgeries in general (Weinstein, 2006). According to an analysis of Medicare data, the variation in the rates of lumbar discectomy and laminectomy across geographic areas in the years 2002 and 2003 were nearly eightfold. The rates of lumbar fusion, however, varied by a factor of twenty. Moreover, in their comparison of lumbar fusion with other orthopedic procedures such as hip fractures and hip replacement during those years, the authors found that the magnitude of variability was far greater for fusion surgeries. The authors suggest that a lack of scientific evidence (valid practice guidelines indicating the need for surgery), financial incentives for surgeons to perform the procedures, and differences in clinical training among physicians are among the factors which may be responsible for this variation. They point out that from 1992 through 2003 there were many new technologies approved by the FDA that were intended to help alleviate lower back pain. However, these technologies were approved based on meeting FDA safety requirements and not based on their efficacy. On the contrary, most technologies became available in the market in the absence of randomized clinical trials testing their effectiveness in improving patient outcomes.

Geographic Variation

The increase in fusion, discectomy and laminectomy cannot be attributed to an increase in back pain prevalence in the U.S population (Deyo, 2002). Using data from the 2002 NHIS study on the prevalence of back pain, along with the 2002 NAMCS data about physician visit rates, Deyo and colleagues determined that the proportion of all physician visits attributed to back pain remained relatively constant between 1990 and 2002.

In accordance with these findings, Lurie et al. (2003) also concluded that the rates of back surgeries performed could not be attributed to patient characteristics alone. The authors analyzed rates of spinal imaging (specifically MRI and CT) and spine surgery using Medicare claims data for the years 1996 and 1997. Based on their analysis, they found that the rates of spine surgeries varied six-fold across different geographic regions in the U.S. Moreover, they concluded that differences in patient populations and health care resources availability explain only 10% of the variance in the rates of spine surgery. Instead, they found that 22% of the variance could be explained by differences in the rates of use of advanced spinal imaging.

In their paper 'Trends and Geographic variations in Major Surgery for Degenerative Diseases of the Hip, Knee, and Spine,' Weinstein et al. studied the differences among regions for these diseases and examined how these differences changed over time (Weinstein et al. 2004). Musculoskeletal disease is a significant issue in the U.S. In 1995, musculoskeletal disease alone was the cause of $215 billion in health care services spending and lost economic productivity. The authors chose to focus on diseases of the hip, knee, and spine because these three sites are the most common and most costly for all musculoskeletal diseases. Additionally, the past two decades have brought about many new technologies and treatment options for these diseases.

Since clinical trials and long-term cohort studies are rarely performed for these conditions, decisions regarding the choice of treatment for the patient may be done in the absence of a solid foundation of clinical evidence or practice guidelines. Researchers who have examined geographic patterns for treatments of conditions which are characteristic of this nature have discovered an association between the degree of scientific uncertainty and the degree of variation in the incidence of surgery among regions. This phenomenon has been called the 'professional-uncertainty hypothesis.'

This phenomenon has also led to the concept of a "surgical signature" of a region (Weinstein et al. 2004). The belief is that in the absence of consistent agreement in the scientific community regarding the best treatment option for a given condition, physicians will tend to base their treatment choice on their own idiosyncratic clinical experiences, how they were educated, or on the local beliefs of the hospital or area in which they practice. Since physicians will continue to follow this pattern of treatment over time, this will lead to the surgical signature for that area.

In order to examine if these beliefs were accurate for hip, knee, and spine degenerative diseases, Weinstein et al analyzed each of the 306 hospital referral regions (HRRs) in the United States using Medicare claims data for procedures performed on patients with these diagnoses (2004). As a comparison group, patients hospitalized for hip fractures were used since it is known to be a relatively stable hospitalization rate. The authors measured the degree of variability for each of the four procedures from 1992 through 2001. This allowed for an examination of the trends in utilization rates over a ten-year period. In order to examine whether surgical signatures remained constant over time, the authors compared 1992-1993 rates with the 2000-2001 rates. They wished to test how much these rates correlated with one another by evaluating how much the former could "explain" the latter in a statistical analysis. Additionally, the authors examined the trends and patterns of use for two treatment options for degenerative diseases of the spine which were either spine surgery with a fusion or spine surgery without fusion. Finally, the effects of income, population density, and supply of surgeons on the rates of utilization were evaluated.

According to their findings, hip fracture hospitalizations revealed relatively little variation as expected. Knee replacement, however, was approximately four times more variable than hip fracture hospitalizations. This meant that regions with the greatest rates of knee replacement operations were about four times greater than the regions with the lowest rates. Hip replacement rates were five times more variable than hip hospitalization rates. The procedure with the greatest variability in these data, however, was that of back surgery which was found to be seven times more variable.

The regions showed a relatively stable surgical signature over the ten-year period examined for the hip and spine procedures when expressed as a ratio to the U.S. average in the corresponding time period. The knee replacement procedure showed a slight decline in rates.

When examining back surgery with and without fusion, the authors found a 137 percent increase of spine surgery with fusion between 1992 and 2001. Spine surgery without fusion, however, rose only 32 percent over those years. The rate of spine surgery with fusion was thirteen times more variable than the rate for hip fracture hospitalizations.

Given these high rates of unexplained variation, the authors suggest several ways to improve care. Instead of delegating responsibility for choosing the treatment to the doctor, they suggest that the patient must be actively involved in the decision making process (Weinstein et al. 2004). This concept is known as shared decision making and allows the patient to choose the best treatment by aligning the risks and benefits of the available treatments with their preferences and values (Eddy 1984).

Variation in treatments provided to patients has been a serious problem in the past and continues to affect health care delivery. One of the most influential studies on the variation of surgical procedures, in general, was Wennberg's study published in 1973. Wennberg et al., showed that rates of tonsillectomies being performed were greatly influenced by the region in which the patient sought care. In his book Tracking Medicine, Wennberg (2010) explained the distinction between warranted and unwarranted variation. He explained that of the three categories of care - preference-sensitive care, supply-sensitive care, and effective care - preference-sensitive care can have both warranted and unwarranted variation. Preference-sensitive care accounts for approximately 25% of Medicare spending and refers to care where different treatment options exist. Often, among the options is the most conservative choice of no treatment or "watchful waiting." Warranted variation is variation which is due to differences in patient's preferences and values in determining the treatments chosen. These differences may cause one patient with the same condition and symptoms to choose a different treatment option than another patient. Unwarranted variation, however, occurs when there is a lack of consensus concerning the standard of care for a certain condition. Unwarranted variation may also occur when clinicians disagree on the diagnosis of a condition. One example which Wennberg provides is that of tonsillectomy. Tonsillectomies were a very commonly performed procedure in the 1980s. However, Wennberg found that the best predictor of whether a child would receive a tonsillectomy was his place of residence. In the words of the author "geography is destiny." While, tonsillectomies were greatly dependent on local medical opinion, the diagnosis of tonsillitis itself was quite variable from one physician to the next. For instance, some physicians believed that having just one of the three common symptoms associated with tonsillitis – infection of the tonsil, reddened anterior pillars, or palpable cervical lymph nodes - was sufficient to make a diagnosis; others thought that at least two or even all three of the symptoms would be required.

Supply-sensitive care could also be a source of improper clinic care. This type of care accounts for approximately 60% of Medicare spending and is subject to the supply of resources available. According to Wennberg's research, he found that the likelihood of a patient having a certain treatment was proportional to the number of physicians available in the area who performed the treatment. In other words, it was supply rather than demand which determined healthcare utilization. According to Wennberg, supply-sensitive care was influenced primarily by primary care physicians and medical specialists, as opposed to surgeons. This is because supply-sensitive care covers a different range of treatments than does preference-sensitive care. Examples of the types of services which fall under this category include physician visits, referrals to specialists, imaging tests, and hospitalizations. One important distinction between these types of medical services and those included in preference-sensitive care are that they are almost never governed by practice guidelines or medical theory. This lack of standard puts this type of care at risk to be heavily influenced by the specific physician who the patient sees.

Wennberg believed that any treatment given to a patient who would not have wanted that treatment had they been fully informed about all the tradeoffs for that treatment and all available alternatives should be considered a serious form of medical error. One means by which this type of medical error could be avoided is through the use of decision tools and Shared Decision Making (SDM). SDM in medical practice may be described as an interaction between the patient and provider which allows the patient to play an active role in making decisions about tests, medications, procedures, referrals or behaviors (Makoul & Clayman, 2006).

Shared Decision Making in Practice

Decision tools have become more readily available for patients. According to the Agency for Healthcare Research and Quality (AHRQ) there are several noteworthy sources of interactive decision aid tools (AHRQ, 2011). These sources include the Foundation for Informed Medical Decision Making (FIMDM), Health Dialog's Collaborative Care Program, Blue Cross Blue Shield Technology Evaluation Center, and The Cochrane Collaboration. Each of these resources has their own decision tools available to be accessed by the public.

On the FIMDM website one can find decision aid tools for some of the most common conditions including coronary artery disease, prostate cancer, breast cancer and back pain. The decision aids provide patients with evidence-based information concerning different treatment options. Additionally, the FIMDM organization provides interviews with patients who have undergone the treatment options and have had both good and bad outcomes (FIMDM, 2012).

The FIMDM organization also provides tools for physicians and supports research projects on SDM across the country. Their website has a link titled 'SDM in Practice' where one can find Demonstration Sites of organizations and healthcare facilities who are involved in decision aid tools. An example of an organization listed is the Dartmouth-Hitchcock Medical Center (DHMC) and their Center for Shared Decision Making (CSDM). Opening in 1999 CSDM was the first center in the U.S. to be dedicated exclusively to SDM efforts and now serves as a model for other organizations.

Other organizations on the FIMDM site focus their SDM efforts on a specific disease or disorder. The University of California San Francisco (UCSF) Breast Cancer Center (BCC) for instance has put together a SDM process for patients diagnosed with breast cancer. The center has a team of pre-medical interns who are in charge of keeping in contact with breast cancer patients and assisting them in SDM. This includes assisting patients with creating a list of questions and concerns prior to their healthcare appointments and providing them with decision aids. Members of the team may even sit in on appointments with the patients and providers in order to take notes and audio recordings and to provide helpful insights to the patients.

Health Dialog's Collaborative Care Program can be used by both physicians and patients to help assist in providing and obtaining the right medical treatments and services (HD, 2012). The website also offers a plethora of information for the following seven surgeries and tests: cardiac catheterization, gall bladder surgery, knee replacement, surgical breast biopsy, colonoscopy, hip replacement, and needle breast biopsy. Health Dialog has a unique vision for their organization which includes the goal of helping individuals by empowering them through teaching them skills, thereby increasing their confidence in their ability to make better healthcare decisions. They also follow the "Whole Person Health" philosophy in which they focus on individuals rather than on their diseases.

The Technology Evaluation Center (TEC) of the Blue Cross and Blue Shield Association is a program which assess the clinical effectiveness and appropriateness of specific medical technologies for specific health conditions based on scientific evidence (B.C.B.S., 2012). The evaluations are carried out by physicians and doctoral-level scientists. Additionally, they are guided by a Medical Advisory Panel (MAP) composed of physician experts. The TEC produces between 20 and 25 reports each year which informs subscribers of the assessments performed and their findings. The TEC has covered a wide range of topics in the past including behavioral health, cardiovascular medicine, and orthopedics. The TEC is committed to evidence-based research which they hope will be utilized by both physicians and patients for improving medical decisions.

The Cochrane Collaboration is an international network which encompasses over 100 countries working together to produce Cochrane Reviews (Cochrane-Collaboration, 2012). Each Cochrane Review addresses a clear and specific healthcare issue. An example of a topic which was evaluated in a Cochrane Review was that of “Pedicle screw fixation methods for traumatic fractures of the thoracic and lumbar spine.” A separate report analyzed “Fusion techniques for degenerative disc disease.” The organization evaluates all evidence-based findings on the topic and primary research which meets certain requirements. Thus far, the Cochrane Collaboration has made available more than 5,000 such reports, including five related to treatments for the lumbar spine. The organization is recognized internationally as the benchmark for high quality research for the effectiveness of medical interventions.

Clinical Practice Guidelines for Lumbar Fusion Surgery

A thorough review of the literature did not reveal any comprehensive, empirically-derived physician practice guidelines for the performance of lumbar fusion surgeries. Due to the fact that no comprehensive clinical practice guidelines exist a number of organizations in the United States have developed guidelines to aid physician decision making in the diagnosis and treatment of back pain. All available guidelines have been reviewed and are summarized below.

Appendix A provides recommendations for the diagnosis and non-surgical treatment of low back pain. The "Diagnosis and Treatment of Low Back Pain Guidelines" were created by the joint efforts of the American College of Physicians and the American Pain Society (Chou, et al, 2007). From their analysis of the available literature on treatments for low back pain they proposed a total of seven recommendations. These recommendations address different aspects of care including the initial assessment of a patient, provision of information to the patient, and care options available for the patient. Their first recommendation states that physicians should attempt to group patients into 1 of 3 broad categories: 1. nonspecific low back pain, 2. back pain potentially associated with radiculopathy or spinal stenosis, or 3.back pain potentially associated with another specific spinal problem. They recommend that this be accomplished through conducting a thorough physical examination in conjunction with a focused history assessment. They suggest that this evaluation should also take into consideration psychosocial risk factors which may serve as predictors for chronic disabling back pain. The organization's seventh recommendation clearly encourages physicians to consider more conservative care options for the patient prior to considering surgery. This recommendation is stated as follows: "For patients who do not improve with self-care options, clinicians should consider the addition of nonpharmacologic therapy with proven benefits- for acute low back pain, spinal manipulation; for chronic or subacute low back pain, intensive interdisciplinary rehabilitation, exercise therapy, acupuncture, massage therapy, spinal manipulation, yoga, cognitive-behavioral therapy, or progressive relaxation."

Another set of practice guidelines titled "The Comprehensive Evidence-Based Guidelines for Spinal Interventional Techniques in the Management of Chronic Spinal Pain" was produced by the American Society of Interventional Pain Physicians (ASIPP) (Manchikanti, 2009). The most recent edition of this document was published in 2009. These guidelines are based on a systematic literature review of the assessment, treatment and outcomes of patients diagnosed with certain neck and back conditions. The Agency acknowledges that a limitation of their work is "a continued paucity of the literature [and] lack of updates." Nevertheless, each recommendation is accompanied by a rating which conveys the strength of the evidence for which that recommendation was based upon. Due to the fact that these guidelines are intended for physicians involved in ongoing pain management, the treatments considered are limited to treatments such as injections and do not address more invasive procedures such as surgery. These guidelines emphasize the importance of correctly diagnosing the patient in order to properly and effectively treat them. For example, they recommend that Facet Joint Interventions be performed only on patients who do not have disc herniation (ICD-9-CM code 722.10) or radiculitis (ICD-9-CM code 724.40).

The U.S. Agency for Health Care Policy and Research (AHCPR) has also published guidelines for the assessment and treatment of lower back pain in adults (1994). In hopes of improving patient outcomes, the AHCPR encourages physicians to approach patient care with the goal of increasing patient tolerance of physical activity, as opposed to focusing solely on pain management. Moreover, they encourage conservative care because they claim that in the absence of dangerous underlying conditions, such as tumors or infections, 90% of patients will recover within four weeks without medical intervention. Some of their recommendations are based on the effectiveness of certain surgical treatments and other invasive procedures. These recommendations are summarized in **Appendix B**.

Organizations which have provided recommendations for surgery of the lumbar spine have been compiled in the present research to create a table of recommendations and matched with the corresponding ICD-9-CM Diagnosis Code which most closely matches the description of the diagnosis. **Appendix C** includes the sources reviewed for surgical recommendations and the corresponding ICD-9-CM Diagnosis Code.

Among these organizations is the Washington State Department of Labor and Industries. In the absence of physician practice guidelines, the Washington State Department of Labor and Industries has promulgated standards of lumbar fusion for degenerative spinal conditions which justify fusion (2009). The Labor and Industries Department recommends first trying conservative care which includes the patient being seen on at least two occasions by the surgeon and that the patient have at least three months of conservative therapy (primarily entailing physical reconditioning) prior to requesting a fusion. These conservative care recommendations are not applicable, however, to those with progressive neurological disease.

Additionally, the Mayo Clinic has written recommendations for back surgery in general and for Spinal Fusion in particular. Both of these recommendations have also been summarized and included in **Appendix C**.

All recommendations included in **Appendix C** were then organized by their respective ICD-9-CM Diagnosis Codes and condensed into **Appendix D**.

Spine Surgery Rates

Research such as that conducted by Richard A. Deyo et al. (2009) reveals that the volume of back surgery in the United States is rapidly increasing. Lumbar fusion surgery rates increased by 100% from 1980 through 1989 (Deyo, 2005). This rate continued to accelerate as the rate of fusion surgeries in the U.S. increased 220% from 1990 through 2001. The increase in rates was greatest following FDA approval of fusion cages in 1996. Rates for these surgeries had the greatest increase among patients who were 60 years of age or older and who were diagnosed as having a degenerative lumbar spine disorder or a herniated disk (Deyo, 2005).

Lumbar discectomy and lumbar laminectomy are two other surgical procedures which are also frequently used to treat lower back pain (Weinstein, 2006). A discectomy is a procedure which removes the portion of a disk which has become herniated and is pressing on a nearby nerve (Mayo Clinic, 2011). Individuals with herniated lumbar disks may experience leg pain, numbness or weakness. A laminectomy, on the other hand, removes a portion of the lamina on the vertebra which is pressing on a nerve. These surgeries are often referred to as decompression procedures because they are typically performed in order to alleviate compression of the nerve roots in the lumbar region of the spine caused by stenosis (narrowing) of the spinal canal (Martin, 2007). Patients with lumbar compression may also suffer from symptoms such as leg pain, numbness, or weakness. However, discectomy and laminectomy surgeries include many potential risks such as causing further spinal degeneration, excessive or abnormal motion, or deformity.

Between 1992 and 2003, lumbar discectomy and laminectomy surgeries in the U.S. rose and then fell slightly (Weinstein, 2006). Through their analysis of Medicare claims and enrollment data, Weinstein and colleagues found that in 1992 the average rate of discectomy and laminectomy was 1.7 per 1,000 Medicare enrollees. The rate for these two procedures peaked in 2001 at 2.2 procedures per 1,000 Medicare enrollees. The rate then had decreased to 2.1 per 1,000 in 2003.

More recently, the rate of complex fusion procedures for spinal stenosis in the U.S. from 2002 through 2007 increased from 1.3 to 19.9 per 100,000 Medicare recipients (Deyo, 2010). As is the case with other diagnoses for lower back conditions, spinal stenosis can also be treated by other, less invasive procedures. The authors of this study compared the outcomes of patients being treated by three different procedures by increasing invasiveness: decompression alone, simple fusion, or complex fusion. Their results also indicated that life-threatening complications increased with increasing invasiveness as did rehospitalizations within 30 days of the original procedure. Moreover, the mean hospital charges for decompression alone were $23,724 while the mean charges for complex fusions were $80,888.

Moreover, this great increase in surgical rates has not led to a coincident improvement in population-level patient outcomes. In fact, studies have shown that areas with higher rates of surgery on the spine have been associated with worse outcomes (Deyo, 2009). Additionally, Social Security Disability Insurance statistics reveal that disability from conditions related to low back pain has actually increased by nearly 5% from 1996 to 2005.

During the 1990s there was an increase in Fusion Surgery for degenerative conditions as well as the approval of new technologies for treating such conditions. Due to the fact that lumbar surgery is purported to stabilize the spine and relieve pain in this area, the need for reoperation should decrease among patients. Martin et al. examined the effect of the increase of fusions on reoperation rates (2007). The authors examined two cohorts: the first was followed from the years 1990 to 1993 whereas the second cohort was examined during the years 1997 to 2000. The authors found that reoperation rates were higher for the cohort examined during the years of 1997 to 2000. Thus, as fusion surgeries increased and additional technologies such as fusion cages became available, reoperation rates also increased.

Some organizations believe that the improper or unnecessary use of lower back imaging may increase the numbers of unnecessary surgeries. Deyo et al. found that MRI rates increased by 307% from 1994 through 2005 in the Medicare population (2009). The authors believe that many factors are likely responsible for this increase and list patient demand, the compelling nature of visual evidence, healthcare practitioner's fear of lawsuits and financial incentives as some of the possibilities. Despite this increase, however, the authors found that imaging was not associated with improvement of subsequent pain, quality of life, or overall improvement.

Rao et al. examined the effects of providing the U.S. Agency for Health Care Research and Policy (AHCPR) guidelines on acute low back pain directly to primary care physicians (2002). The AHCPR guidelines state that imaging of the lumbar spine should only be considered when a patient experiences consistent symptoms lasting for at least one month. The authors distributed pamphlets and held formal seminars about the guidelines for the physicians in a university-affiliated Veterans Affairs Medical Center (2002). The authors then compared the number of MRI orders in the years before and after the educational efforts were undertaken and found that there was no statistically significant reduction in the numbers of MRI exams ordered for patients complaining of lower back pain.

The lack of adherence to guidelines for ordering MRI tests is problematic. While MRI technology continues to be the most sensitive tool for finding abnormalities in the lumbar spine this may not necessarily be beneficial for patients (Rao, 2002). Currently, there is no evidence of a direct association between spinal abnormalities and symptoms. In fact, many individuals who have abnormal MRIs are asymptomatic while other patients who have normal imaging results complain of symptoms (Rao, 2002).

CHAPTER 3: RESEARCH METHODS

Data Sources

The data for the present research came from the publicly available Florida Agency for Health Care Administration (AHCA) Hospital Discharge data sets for the year 2010. The present research will focus on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes for the lumbar/lumbosacral, dorsal/dorsolumbar regions contained in the AHCA datasets.

All ICD-9-CM principal diagnosis codes for any of the five procedure codes for lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgeries were analyzed (refer to **Table 1**) for Florida non-federal hospitals in 2010. Logistic regression analysis was used to evaluate the effects of age, gender, race and the principal payer on the incidence of lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion in these hospitals. Total hospital charges for fusion procedures on the lumbar/lumbosacral, dorsal/dorsolumbar spine were analyzed using ICD-9-CM codes. A mixed effects model was used to analyze the hospital charges.

Methods for Obtaining the Cases

Table 1 provides the fusion surgeries of the lumbar/lumbosacral, dorsal/dorsolumbar spine contained in the ICD-9 CM Procedure Codes 81.08, 81.07, 81.06, 81.05 and 81.04. The use of “dorsal” is synonymous with “thoracic” and “dorsolumbar” is synonymous with “thoracolumbar”.

Table 1: **Fusion Procedure Codes and Descriptions**

ICD-9-CM Procedure Code	Description
81.08	Lumbar and lumbosacral fusion of the anterior column, posterior technique
81.07	Lumbar and lumbosacral fusion of the posterior column, posterior technique
81.06	Lumbar and lumbosacral fusion of the anterior column, anterior technique
81.05	Dorsal and dorsolumbar fusion of the posterior column, posterior technique
81.04	Dorsal and dorsolumbar fusion of the anterior column, anterior technique

All records with an ICD-9-CM Principal Procedure code of 81.08, 81.07, 81.06, 81.05 or 81.04 were obtained from the Florida Hospital Discharge Data for 2010. This produced 16,897 observations. However, due to the fact that the ICD-9-CM procedure codes were defined in a way that other segments of the spine could have been included in this population, the diagnosis codes were used to eliminate those patients who had received a fusion on an area of the spine which did not include the lumbar spine by eliminating those cases which were purely cervical, thoracic, or sacral. This method decreased the population size to 16,368 observations and all diagnoses which were eliminated are identified in **Appendix E**. **Appendix F** provides the list of the 155 principal diagnoses for the 16,368 cases remaining after all of the diagnoses in **Appendix E** were removed from the case population.

Next, the 155 remaining diagnoses for the 16,368 cases were examined. The frequency distribution of the remaining diagnoses revealed that more than 98% of the fusion cases were included in the top 31 principal diagnoses. These 31 diagnoses were used to represent the top principal diagnoses for the cases.

Finally, all of the cases who had a principal diagnoses which was beyond the top 31 diagnoses were analyzed (i.e. those diagnoses which were ranked from 32 to 155 by the frequency of observations for each diagnosis). If any of these patients had a secondary diagnosis in their record of one of the top 31 diagnoses then they were recoded under that diagnosis. In other words, if a case had a principal diagnosis which was ranked 32 or lower by the frequency distribution, but had a secondary diagnosis of one of the top 31 diagnoses, then that case was treated as if this secondary diagnosis was their principal diagnosis and they were added to the other cases who had this same principal diagnosis. For example, the principal diagnosis of intraspinal abscess which had 6 cases and was ranked as the 41st most frequently occurring diagnosis for the case population. These 6 cases were then examined for secondary codes of one of the top 31 most frequently occurring diagnoses. For instance, if one of these cases had a secondary diagnosis of spondylolisthesis, then they were removed from the intraspinal abscess group (reducing the frequency of this diagnosis to 5) and added to the spondylolisthesis group (increasing the frequency of this group by 1). Using this method, 153 patients were recoded for a total population of 16,236 cases. Refer to **Table 2** for the top 31 principal diagnoses for the lumbar/lumbosacral and dorsal/dorsolumbar spinal fusion surgeries for the case population.

A list of all Florida hospitals which performed a lumbar/lumbosacral, dorsal/dorsolumbar fusion surgery in 2010 is provided in **Appendix G** (N=16,236). The hospital bed size and frequency of procedures performed is also included. The hospitals are ranked based on their rate of lumbar fusions per 100 beds.

Table 2: Diagnoses for Lumbar/Lumbosacral, Dorsal/Dorsolumbar Spinal Fusion Surgeries in Florida Hospitals, 2010 (N= 16,236)
(ICD-9-CM Procedure Codes 81.08, 81.07, 81.06, 81.05, 81.04)

Prin Diag	Description	Freq	%
722.52	Degeneration of lumbar or lumbosacral intervertebral disc	3,550	21.86
724.02	Spinal stenosis, lumbar region, without neurogenic claudication	2,767	17.04
722.10	Displacement of lumbar intervertebral disc without myelopathy	2,634	16.22
721.3	Lumbosacral spondylosis without myelopathy	2,141	13.19
738.4	Acquired spondylolisthesis	1,499	9.23
737.30	Scoliosis [and kyphoscoliosis], idiopathic	789	4.86
756.12	Spondylolisthesis	664	4.09
722.83	Postlaminectomy syndrome, lumbar region	360	2.22
805.4	Closed fracture of lumbar vertebra without mention of spinal cord injury	228	1.40
996.49	Other mechanical complication of other internal orthopedic device, implant, and graft	197	1.21
737.39	Other kyphoscoliosis and scoliosis	168	1.03
733.13	Pathologic fracture of vertebrae	150	0.92
722.73	Intervertebral disc disorder with myelopathy, lumbar region	126	0.78
722.93	Other and unspecified disc disorder, lumbar region	118	0.73
724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified	113	0.70
198.5	Secondary malignant neoplasm of bone and bone marrow	103	0.63
721.42	Spondylosis with myelopathy, lumbar region	101	0.62
724.03	Spinal stenosis, lumbar region, with neurogenic claudication	85	0.52
996.78	Other complications due to other internal orthopedic device, implant, and graft	54	0.33
730.28	Unspecified osteomyelitis, other specified sites	50	0.31
724.2	Lumbago	42	0.26
737.10	Kyphosis (acquired) (postural)	42	0.26
737.32	Progressive infantile idiopathic scoliosis	37	0.23
806.4	Closed fracture of lumbar spine with spinal cord injury	35	0.22
754.2	Congenital musculoskeletal deformities of spine	34	0.21
839.20	Closed dislocation, lumbar vertebra	33	0.20
727.40	Synovial cyst, unspecified	30	0.18
756.11	Spondylolysis, lumbosacral region	26	0.16
722.51	Degeneration of thoracic or thoracolumbar intervertebral disc	23	0.14
737.19	Other kyphosis (acquired)	20	0.12
732.0	Juvenile osteochondrosis of spine	17	0.10
Total		**16,236**	**100.00**

Methods for Obtaining the Controls

In order to obtain a control group, all patients who had the same principal diagnosis as those undergoing lumbar fusion but who did not have lumbar fusion were extracted from the 2010 Florida Hospital Discharge Data. However, unlike the cases who were picked based on the fact that they had one of the five spinal fusion procedure codes, controls were picked based on having the same principal diagnosis as the top 31 principal diagnoses of the cases. Therefore, further analysis needed to be performed to distinguish those cases which had a diagnosis related specifically to the spine and those which did not. This was done by separating the top 31 diagnoses into two categories: 1. Those which were definitively lumbar, and 2. Those which were unspecified.

Of these 31 diagnoses, 23 were specifically related to the lumbar spine. The following eight diagnoses, on the other hand, may have pertained to a segment of the spine other than the lumbar spine:

1. Other mechanical complication of other internal orthopedic device, implant, and graft.
2. Pathologic fracture of vertebrae.
3. Secondary malignant neoplasm of bone and bone marrow.
4. Other complications due to other internal orthopedic device, implant, and graft.
5. Unspecified osteomyelitis, other specified sites.
6. Congenital musculoskeletal deformities of spine.
7. Synovial cyst, unspecified.
8. Juvenile osteochondrosis of spine.

Those with a Principal Diagnosis of one of the top 23 definitively lumbar diagnoses were included in the control population. Next, all those who had one of the eight remaining unspecified codes were analyzed for a definitive secondary code or a code indicative of the lumbar spine. For example, the first unspecified diagnosis is a mechanical complication of an internal orthopedic device, implant, or graft. Since the cases had a fusion on the spine, it was clear that this orthopedic device was used for the spine. The controls, on the other hand, could have had an issue with an orthopedic device which was for the hip or knee. Therefore, an additional step needed to be taken to analyze these codes for a secondary code which was indicative of the lumbar spine.

The final control population included 21,856 patients. Refer to **Table 3** for the frequencies and percentages of the individuals who did not undergo fusion surgery but had the same principal diagnoses as those who did undergo lumbar/lumbosacral, dorsal/dorsolumbar spinal fusion surgery in Florida hospitals in 2010.

Statistical Methods

Logistic regression was used to analyze the incidence of fusion surgeries. The binary dependent variable was coded as a "1" for all patients who were a case (i.e. they received one of the five procedure codes being studied in the present research) and a "0" for all patients who were controls (i.e. they did not receive any of the five fusion procedure codes). Logistic regression was used to predict the probability of an observation being a "1" given the independent variables included in the model. The independent variables included in the logistic regression model were: gender, age, race, and principal payer. These variables were selected because they are important demographic variables which can answer the research question of interest by providing information of who received fusion surgeries in Florida in 2010.

Table 3: Patients Who Had the Same Diagnoses as those Undergoing Lumbar Fusion but Who Did Not Have Lumbar Fusion in Florida Hospitals, 2010 (N=21,856)

Prin Diag	Description	Freq	%
722.52	Degeneration of lumbar or lumbosacral intervertebral disc	1,393	28.08
724.02	Spinal stenosis, lumbar region, without neurogenic claudication	3,522	55.98
722.10	Displacement of lumbar intervertebral disc without myelopathy	6,594	71.22
721.3	Lumbosacral spondylosis without myelopathy	1,463	40.29
738.4	Acquired spondylolisthesis	193	11.41
737.30	Scoliosis [and kyphoscoliosis], idiopathic	76	8.87
756.12	Spondylolisthesis	112	14.58
722.83	Postlaminectomy syndrome, lumbar region	327	46.51
805.4	Closed fracture of lumbar vertebra without mention of spinal cord injury	3,242	93.00
996.49	Other mechanical complication of other internal orthopedic device, implant, and graft	366	65.47
737.39	Other kyphoscoliosis and scoliosis	18	9.94
733.13	Pathologic fracture of vertebrae	645	89.34
722.73	Intervertebral disc disorder with myelopathy, lumbar region	271	68.26
722.93	Other and unspecified disc disorder, lumbar region	426	80.08
724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified	714	87.39
198.5	Secondary malignant neoplasm of bone and bone marrow	213	93.83
721.42	Spondylosis with myelopathy, lumbar region	75	42.37
724.03	Spinal stenosis, lumbar region, with neurogenic claudication	116	57.71
996.78	Other complications due to other internal orthopedic device, implant, and graft	180	80.36
730.28	Unspecified osteomyelitis, other specified sites	172	85.57
724.2	Lumbago	1,412	97.38
737.10	Kyphosis (acquired) (postural)	21	34.43
737.32	Progressive infantile idiopathic scoliosis	1	2.63
806.4	Closed fracture of lumbar spine with spinal cord injury	23	31.94
754.2	Congenital musculoskeletal deformities of spine	0	0
839.20	Closed dislocation, lumbar vertebra	117	78.00
727.40	Synovial cyst, unspecified	105	80.15
756.11	Spondylolysis, lumbosacral region	11	31.43
722.51	Degeneration of thoracic or thoracolumbar intervertebral disc	40	63.49
737.19	Other kyphosis (acquired)	8	30.77
732.0	Juvenile osteochondrosis of spine	0	0

Note: Percent is based on all patients who had the diagnosis of interest but did not receive a fusion surgery (ICD-9-CM Procedure Codes 81.08, 81.07, 81.06, 81.04, 81.04) divided by all patients who had the diagnosis of interest.

Additionally, unlike the Medicare data often used to study fusion surgeries, AHCA data sets allow for a more comprehensive examination of fusion surgeries due to its ability to analyze back patients of all ages and payer types.

The logistic regression model used to test the null hypothesis of no statistically significant predictors of the incidence of lumbar/lumbosacral, dosral/dorsolumbar spinal fusion surgeries in Florida hospitals is: Logit $P(Y=1) = B_o + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + B_{11}X_{11} + B_{12}X_{12} + B_{13}X_{13}.$

Model fit statistics, the chi-square likelihood ratio, and the type III analysis effects were obtained for the logistic regression model. Additionally, odds ratio estimates and their corresponding Wald confidence intervals were obtained for all of the predictor variables for the case population.

A mixed effects model was used to analyze the total hospital charges for fusion surgeries. A mixed effects model was chosen due to the fact that cases who had surgeries performed at the same hospital are not independent and therefore the data were clustered on hospitals. A random intercept term was used to address this fact. The dependent variable was the total hospital charges for the case population, in dollars. The fixed effects in the model were gender, age, race, payer type, principal procedure, and the sum of the other diagnoses. These variables were selected because they are important demographic variables which can answer the research question of interest by providing information on the total hospital charges for fusion surgeries in Florida in 2010. Principal procedure was analyzed to understand whether there are significant differences in the fusion procedures based on the method of fusion performed on the patient. Additionally, number of additional diagnoses was used as a proxy for severity of illness to analyze whether there is a statistically significant association between the number of additional diagnoses and the total hospital charges.

The mixed effects model used to test the null hypothesis of no statistically significant predictors of charges for lumbar/lumbosacral, dosral/dorsolumbar spinal fusion surgeries in Florida hospitals is: Yij = B0 + B1X1ij + B2X2ij + B3X3ij + B4X4ij + B5X5ij + B6X6ij +B7X7ij + B8X8ij + B9X9ij + B10X10ij + B11X11ij + B12X12ij + B13X13ij + B14X14ij + B15X15ij + B16X16ij + B17X17ij + B18X18ij + u j + eij.

A Type III analysis and solutions for the parameter estimates were obtained for the fixed effects. Additionally, the intracluster correlation coefficient and corresponding design effect was analyzed.

SAS Software version 9.3 was used to complete all of the analyses.

Hypothesis I (Null) - Incidence

There are no statistically significant predictors of the incidence of lumbar/lumbosacral, dosral/dorsolumbar spinal fusion surgeries in Florida hospitals (ICD-9-CM procedure codes 81.08, 81.07, 81.06, 81.05, 81.04).

Logit P (Y=1) = $B_o + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + B_{11}X_{11} + B_{12}X_{12} + B_{13}X_{13}$

Y = (ICD-9-CM procedure codes 81.08, 81.07, 81.06, 81.05, 81.04)

X_1 = Gender (1 if Female, 0 if Male)

X_2 = Age (1 if < 20, 0 if not)

X_3 = Age (1 if 20-39, 0 if not)

X_4 = Age (1 if 40-49, 0 if not)

X_5 = Age (1 if 50-64, 0 if not)

X_6 = Age (1 if 65-74, 0 if not)

(reference level ≥ 75)

X_7 = Race (1 if Black or African American, 0 if not)

X_8 = Race (1 if Other/Unknown, 0 if not)

(reference level = White)

X_9 = Principal Payer (1 if Federal [Tricare, etc.], 0 if not)

X_{10} = Principal Payer (1 if Other/Non-Payment, 0 if not)

X_{11} = Principal Payer (Worker's Compensation, 0 if not)

X_{12}= Principal Payer (1 if Commercial Health Insurance, 0 if not)

X_{13} = Principal Payer (1 if Medicaid/Medicaid Managed Care, 0 if not)

(reference level = Medicare/Medicare Managed Care)

Hypothesis II (Null) – Charges

There are no statistically significant predictors of the charges for lumbar/lumbosacral, dosral/dorsolumbar spinal fusion surgeries in Florida hospitals (ICD-9-CM procedure codes 81.08, 81.07, 81.06, 81.05, 81.04).

$$Y_{ij} = B_0 + B_1X_{1ij} + B_2X_{2ij} + B_3X_{3ij} + B_4X_{4ij} + B_5X_{5ij} + B_6X_{6ij} + B_7X_{7ij} + B_8X_{8ij} + B_9X_{9ij} + B_{10}X_{10ij} + B_{11}X_{11ij} + B_{12}X_{12ij} + B_{13}X_{13ij} + B_{14}X_{14ij} + B_{15}X_{15ij} + B_{16}X_{16ij} + B_{17}X_{17ij} + B_{18}X_{18ij} + u_j + e_{ij}$$

Where ij = to the i^{th} hospital and the j^{th} subject and the distribution of uj ~ $N(0, \sigma^2_u)$ and the distribution of e_{ij} ~ $N(0, \sigma^2_e)$.

Y = Total charges for spinal fusion lumbar surgery (ICD-9-CM procedure codes 81.08, 81.07, 81.06, 81.05, 81.04)

X_1 = Gender (1 if Female, 0 if Male)

X_2 = Age (1 if < 20, 0 if not)

X_3 = Age (1 if 20-39, 0 if not)

X_4 = Age (1 if 40-49, 0 if not)

X_5 = Age (1 if 50-64, 0 if not)

X_6 = Age (1 if 65-74, 0 if not)

(reference level ≥ 75)

X_7 = Race (1 if Black or African American, 0 if not)

X_8 = Race (1 if Other/Unknown, 0 if not)

(reference level = White)

X_9 = Principal Payer (1 if Federal (Tricare, etc.), 0 if not)

X_{10} = Principal Payer (1 if Other/Non-Payment, 0 if not)

X_{11} = Principal Payer (Worker's Compensation, 0 if not)

X_{12} = Principal Payer (1 if Commercial Health Insurance, 0 if not)

X_{13} = Principal Payer (1 if Medicaid/Medicaid Managed Care, 0 if not)

(reference level = Medicare/Medicare Managed Care)

X_{14} = Principal Procedure (1 if ICD-9-CM procedure codes 81.04, 0 if not)

X_{15} = Principal Procedure (1 if ICD-9-CM procedure codes 81.05, 0 if not)

X_{16} = Principal Procedure (1 if ICD-9-CM procedure codes 81.06, 0 if not)

X_{17} = Principal Procedure (1 if ICD-9-CM procedure codes 81.07, 0 if not)

(reference level = ICD-9-CM procedure codes 81.08)

X_{18} = Number of Additional Diagnoses (0-30)

CHAPTER 4: RESULTS

Descriptive Statistics – Incidence

In 2010, there were 16,236 lumbar/lumbosacral, dorsal/dorsolumbar fusion surgery cases in Florida hospitals that were included in the case population and 21,856 individuals included in the control population for a total of 38,092 included in the study population. In 2010, females made up a greater percentage of the cases (54.86%).

The modal age category for the cases was the 50-64 age group (30.21%). The age category for the case population with the least number of cases was the youngest age category of less than twenty years of age (4.18%).

The highest percentage of cases were white (87.96%), followed by black/African American (6.17%) and other/unknown (5.88%). Additionally, the cases had the greatest percentage of individuals with Medicare Insurance (48.23%). The second most frequent insurance type for the cases was Commercial (36.80%). The third most frequent insurance was Medicaid (4.08%). This was followed by Workers' Compensation (3.90%), Federal (Tricare, etc.) (3.53%), and other/non-payment (3.46%).

In the case population, the lumbar fusion surgery which was most prevalent in Florida hospitals in 2010 was principal procedure ICD-9-CM code 81.08, lumbar and lumbosacral fusion of the anterior column, posterior technique which accounted for 10,020 (62%) of the 16,236 total surgeries performed. **Table 4** provides the descriptive statistics for the cases, controls and the total population.

While the age distribution for cases in Table 4 is valid, a clearer relationship between age and those who received spinal fusion surgery in this population can be seen when the continuous distribution is plotted. This also has implications for understanding the drivers of the principal payers for this surgery, which will be addressed in the Discussion and Conclusions.

Figure 1, which shows the individual ages of the patients who received spinal fusion surgery, reveals a continuous distribution of surgery cases from age 1 to 95 years of age, with a small peak at age 14, a "stair-step" distribution of an increasing number of cases from 20-64 years of age, and the major peak at age 67. Then there is the major peak at age 67, a plateau from that point to approximately 75 years of age, and then a rapid decline thereafter.

A diagram of the Age Distributions for the Control Population is available in **Appendix I** and a diagram of the Age Distributions for the entire Study Population is available in **Appendix J.**

Incidence – Model Fit Statistics

The model fit statistics (**Table 5**) describe and test the overall fit of the model. The three statistics below will be useful for comparing nested models if any additional models will be tested.

Table 4: Descriptive Statistics for Lumbar/Lumbosacral, Dorsal/Dorsolumbar Fusion Surgery Cases and their Controls in Florida Hospitals, 2010 (ICD-9-CM Procedure Codes 81.08, 81.07, 81.06, 81.05, 81.04)

	Cases		Controls		Total	
Variable	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Gender						
Female	8,907	54.86	11,659	53.34	20,566	53.99
Male	7,329	45.14	10,197	46.66	17,526	46.01
Age						
<20	679	4.18	228	1.04	907	2.38
20-39	1,409	8.68	2,294	10.50	3,703	9.72
40-49	2,225	13.70	2,625	12.01	4,850	12.73
50-64	4,905	30.21	5,146	23.55	10,051	26.39
65-74	4,402	27.11	4,553	20.83	8,955	23.51
≥75	2,616	16.11	7,010	32.07	9,626	25.27
Race						
White	14,281	87.96	19,034	87.09	33,315	87.46
Black/African American	1,001	6.17	1,542	7.06	2,543	6.68
Other/Unknown	954	5.88	1,280	5.86	2,234	5.86
Principal Payer						
Federal (Tricare, etc.)	573	3.53	448	2.05	1,021	2.68
Medicare	7,830	48.23	12,359	56.55	20,189	53.00
Workers' Comp	633	3.90	690	3.16	1,323	3.47
Commercial	5,975	36.80	5,886	26.93	11,861	31.14
Medicaid	663	4.08	1,196	5.47	1,859	4.88
Other/ Non-Payment	562	3.46	1,277	5.84	1,839	4.83
Principal Procedure						
81.08	10,020	61.71				
81.07	3,033	18.68				
81.06	2,019	12.14				
81.05	1,059	6.52				
81.04	105	0.65				
Total	**16,236**	**100.00**	**21,856**	**100.00**	**38,092**	**100.00**

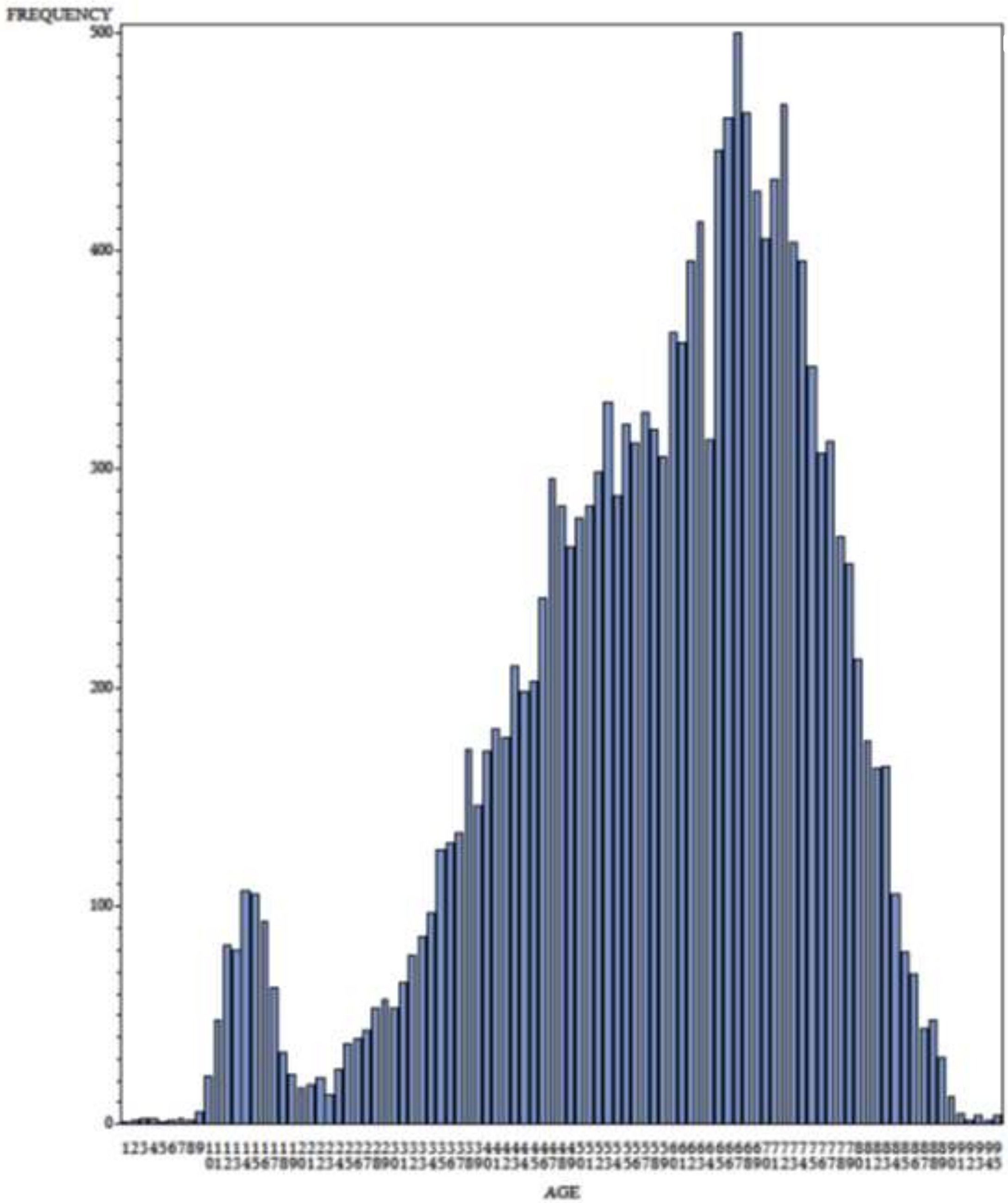

Figure 1: Frequency of Admitted Patients in the Case Population, by Age (N=16,236)

Table 5: Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	51,976.53	49,783.48
SC	51,985.08	49,903.15
-2 Log L	51,974.53	49,755.48

The statistics in **Table 6** test whether the logistic model used fits better than an empty model (i.e. one without any predictor variables). The significant p-value of all three statistics indicates that the model was statistically significant.

Table 6: Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	2,219.05	13	<.0001
Score	2,149.29	13	<.0001
Wald	2,013.20	13	<.0001

The type 3 analysis of effects (**Table 7**) tests the significance of each of the predictor variables individually in improving the model fit. The chi-square test statistics and associated p-values indicate that each of the four variables in the model significantly improve the model fit. Due to the fact that all of our variables are categorical in nature, the type 3 analysis tests the overall effect of each of the variables.

Table 7: Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
Gender	1	24.88	<.0001
Race	2	34.67	<.0001
Payer	5	381.69	<.0001
Age Group	6	1,430.51	<.0001

Incidence - Logistic Regression

Table 8 provides the regression coefficients for each predictor variable. The coefficients (labeled estimate in **Table 8**) give the change in the log odds of the outcome for a one unit increase in the predictor variable. However, since the variables gender, race, payer, and age group are all categorical, the log odds are comparing each one of the levels of the variable to their respective reference (i.e. base) levels.

As can be seen in **Table 8**, females were more likely to receive fusion surgery than males. The maximum likelihood estimates for age show that the youngest age category was more likely to receive a fusion surgery when compared with the ≥75 age group, whereas the age groups of 20-39 and 40-49 were less likely to receive fusion surgery when compared with the ≥ 75 age group. As for race, the maximum likelihood estimates show that there is a negative association with fusion surgery and being black/African American when compared with the white group.

Incidence – Odds Ratio Estimates

The odds ratio estimates in **Table 9** below are the exponentiated coefficients for the predictor variables. The odds ratios can be interpreted as the multiplicative change in the odds for a one unit change in the predictor variable. Refer to Appendix H for a matrix of phi coefficients for the independent variables.

Table 8: Maximum Likelihood Estimates

	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Gender				
Female	0.05 ***	0.01	24.88	<.0001
Male	1 [Reference]	[Reference]	[Reference]	[Reference]
Age				
<20	1.39***	0.07	394.37	<.0001
20-39	-0.34***	0.03	155.12	<.0001
40-49	-0.07*	0.03	30.23	0.0165
50-64	-0.02	0.03	1.22	0.4600
65-74	0.00	0.03		0.9078
≥75	1 [Reference]	[Reference]	[Reference]	[Reference]
Race				
Other/Unknown	0.01	0.03	0.19	0.6649
Black/African American	-0.13***	0.03	16.62	0.0001
White	1 [Reference]	[Reference]	[Reference]	[Reference]
Principal Payer				
Federal (Tricare, etc.)	0.50 ***	0.06	81.38	<.0001
Other/ Non- Payment	-0.55***	0.05	139.17	<.0001
Workers' Comp	0.24***	0.05	22.79	<.0001
Commercial	0.22***	0.02	80.92	<.0001
Medicaid	-0.52***	0.05	124.24	<.0001
Mediare	1 [Reference]	[Reference]	[Reference]	[Reference]

*P < .05; **P<.01; *** P<.001

From **Table 9** it is clear that females are significantly more likely to have spinal fusion surgeries than are males (OR: 1.11, CI: 1.07-1.16). Although the odds ratio estimates show significance for all of the age categories relative to the greater than 75 age category, the more detailed age distribution shown in **Figure 1** shows a clearer picture of the ages of the surgical cases, with modes at 14 years of age and 67 years of age. For the race variable, the odds ratios show a significant negative relationship between being black/African American or being

Table 9: Odds Ratio Estimates for Predicting Fusion Procedures Performed in Florida Hospitals in 2010 Using Logistic Regression (N=16,236)

	No. (%)	OR (95% CI)
Gender		
Female	8,907 (54.86)	1.11 (1.07-1.16)**
Male	7,329 (45.14)	1 [Reference]
Age		
<20	679 (4.18)	10.43 (8.74-9.12.45)**
20-39	1,409 (8.68)	1.85 (1.67-2.05)**
40-49	2,225 (13.70)	2.42 (2.21-2.66)**
50-64	4,905 (30.21)	2.56 (2.36-2.77)**
65-74	4,402 (27.11)	2.61 (2.46-2.78)**
≥75	2,616 (16.11)	1 [Reference]
Race		
Other/Unknown	954 (5.88)	0.90 (0.83-0.99)*
Black/African American	1,001 (6.17)	0.78 (0.72-0.85)*
White	14,281 (87.96)	1 [Reference]
Principal Payer		
Federal (Tricare, etc.)	573 (3.53)	1.48 (1.29-1.70)**
Other/ Non- Payment	562 (3.46)	0.52 (0.46-0.58)**
Workers' Comp	633 (3.90)	1.13 (1.00-1.29)
Commercial	5,975 (36.80)	1.12 (1.04-1.20)**
Medicaid	663 (4.08)	0.53 (0.47-0.60)*
Medicare	7,830 (48.23)	1 [Reference]

* Significant OR < 1.0 indicative of a negative relationship with the dependent variable relative to the reference category.
** Significant OR > 1.0 indicative of a positive relationship with the dependent variable relative to the reference category.

in the other/unknown group and the odds of having lumbar fusion surgery relative to the white group. In terms of principal payer, Federal and Commercial were significantly positively associated with fusion surgery when compared with Medicare, whereas Medicaid and other/non-payment were negatively associated with fusion surgery when compared with Medicare. The odds of individuals with Federal insurance receiving a fusion surgery were 1.48 times greater when compared to the Medicare group.

Descriptive Statistics – Charges

In the present study, total hospital charges were analyzed for lumbar/lumbosacral, dorsal/dorsolumbar fusion surgery cases and their controls in Florida hospitals in 2010. The total hospital charges in Florida hospitals for the 16,236 cases were $2,095,413,584. Refer to **Table 10** for the descriptive statistics of the charges for the cases and controls.

For gender, the analysis of the case population (n=16,236) shows that the highest mean charges of $130,116 were incurred by females. The mean charges for males were only slightly lower at $127,776.

A very complex relationship exists between age and charges. Those younger than twenty years of age had the highest mean charges of $202,703. This was more than $71,000 greater than the next highest mean charges of $131,382 for the 50-64 age category. There are two separate and distinct drivers of high charges in this surgical population. First, there are the costly complex procedures performed on young individuals who had congenital malformations or scoliosis. The second principal driver of high charges in this surgical population was the older individuals with less complex surgeries, but with numerous secondary diagnoses. Multivariate analytical methods tend to obscure this fact and thus, a separate analysis of this is shown in **Table 11**. This Table shows that while the mean number of additional diagnoses for the younger than twenty age group was only 2.80, the percent of those individuals with ICD-9-CM Procedure Codes 81.04 or 81.05 (the two most expensive surgeries in the present research) was 88.37%.

cases in the 65-74 age group had a mean of 6.69 additional diagnoses but only 3.61% of these surgeries were Procedure Codes 81.04 or 81.05.

By race, those in the other/unknown race category, which included American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, other, and unknown, had the highest mean charge of $148,672. White and Black/African American race categories had similar mean charges of $127,713 and $129,587, respectively.

In the payer categories, Medicaid had the highest mean charges of $162,877. Many of the individuals in the youngest age group (i.e. less than 20 years of age) who received fusion surgery were those with congenital malformations or scoliosis. These types of surgeries are complex and are more likely to require one of the more costly procedure types to be used (i.e. ICD-9-CM Procedure Codes 81.04 or 81.05).

As can be seen in **Table 10,** ICD-9-CM Procedure Code 81.04, dorsal and dorsolumbar fusion of the anterior column, anterior technique had the highest mean charges of $261,639. The next highest mean charges of $210,652 were for ICD-9-CM Procedure Code 81.05, dorsal and dorsolumbar fusion of the posterior column, posterior technique. These two categories had the highest mean charges because they are the most complex of the lumbar fusion ICD codes used in the present study.

The three remaining procedure codes analyzed in the present research all had mean charges under $200,000: $117,693 for ICD-9-CM Procedure Code 81.08, $118,085 ICD-9-CM Procedure Code 81.07, and $152,266 for ICD-9-CM Procedure Code 81.06.

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Table 10: Hospital Charges for Lumbar/Lumbosacral, Dorsal/Dorsolumbar Fusion Surgery Cases (n=16,236) and their Controls (n=21,856) in Florida Hospitals, 2010 (ICD-9-CM Procedure Codes 81.08, 81.07, 81.06, 81.05, 81.04)

	Hospital Charges (Dollars)							
	Cases				Controls			
Variable	**Freq**	**Mean**	**SD**	**Range**	**Freq**	**Mean**	**SD**	**Range**
Gender								
Female	8,907	130,116	75,649	3,245 – 1,819,470	11,659	42,329	38,412	821-1,102,262
Male	7,329	127,776	68,912	6,457 -918,147	10,197	43,333	40,361	1,051 - 1,245,505
Age								
<20	679	202,703	97,737	53,759 -664,963	228	49,872	51,015	1,316 – 398,244
20-39	1,409	120,153	54,842	17,694 – 491,361	2,294	39,848	32,043	2,036 - 371,869
40-49	2,225	120,560	56,412	18,494-840,709	2,625	42,527	42,917	1,051-1,245,505
50-64	4,905	131,382	71,875	6,457-872,468	5,146	43,919	40,950	1,051-1,102,262
65-74	4,402	127,756	75,256	3,245-1,819,470	4,553	45,378	44,593	1,142-1,045,776
≥75	2,616	119,810	71,924	18,299-918,147	7,010	41,134	34,351	821-655,586
Race								
White	14,281	127,713	71,491	3,245 – 1,819,470	19,034	42,670	39,770	821 - 1,245,505
Black/African American	1,001	129,587	69,832	6,457 – 664,963	1,542	42,346	37,899	3,268 - 505,156
Other/Unknown	954	148,672	88,910	20,215 – 848,121	1,280	45,231	34,140	1,269 - 345,381
Principal Payer								
Federal (Tricare, etc.)	573	134,233	67,324	21,822 – 509,273	448	52,408	40,543	1,616 -293,047
Medicare	7,830	125,550	73,905	3,245 – 1,819,470	12,359	43,377	38,716	821 - 655,586
Workers' Comp	633	123,166	60,237	20,801 – 872,468	690	40,308	31,010	3,060 - 334,437
Commercial	5,975	129,502	68,897	9,448 – 753,948	5,886	41,269	33,862	1,051 - 472,928
Medicaid	663	162,877	96,223	33,941 – 848,121	1,196	46,317	68,766	2,712 - 1,245,505
Other/ Non-Payment	562	134,733	69,920	29,729 – 488,703	1,277	38,911	33,111	2,028 - 338,229
Principal Procedure								
81.08	10,020	117,693	56,002	3,245 – 848,121				
81.07	3,033	118,085	56,786	18,299 – 629,275				
81.06	2,019	152,266	86,678	26,555 – 1,055,691				
81.05	1,059	210,652	120,612	27,084 – 1,819,470				
81.04	105	261,639	151,725	40,345 – 682,352				
Total	**16,236**	**129,059**	**72,692**	**3,245 – 1,819,470**	**21,856**			

As expected, the mean charges for the controls (n= 21,856) were significantly lower than for the cases. The cases had mean charges which were approximately three to four times greater than the mean charges for the controls. Moreover, the cases and controls had approximately the same mean number of additional diagnoses (6.68 and 6.95, respectively). Thus, despite entering the hospital with the same principal diagnoses and very similar numbers of additional diagnoses, the nonsurgical hospital stays resulted in approximately one third of the charges.

The controls had the highest mean charges for those in the younger than twenty age group ($49,872) and the other/unknown race categories ($45,231). However, slightly higher mean charges were incurred by males ($43,333) than by females ($42,329) in the control group. Additionally, Federal Health Insurance had the highest mean charges of $52,408 followed by Medicaid with mean charges of $46,317.

Table 11: Age, Number of Secondary Diagnoses, ICD Category 81.04 and 81.05, and Mean Charges

Age	Mean Number of Additional Diagnoses	Range	Mean Charges (Dollars)	Median Charges (Dollars)	*Percent in ICD 81.04 or 81.05 (%)
<20	2.80	0-20	202,703	188,859	88.37
65-74	6.68	0-30	127,756	112,883	3.61

* Number of all cases with procedure code 81.04 and 81.05 divided by all of the cases in the respective age category.

Histograms of the total hospital charges have also been included below. Three separate histograms were used to better illustrate the outliers with very high charges. The x-axes for the three graphs were less than $150,000 in **Figure 2**, $150,000-$299,999 in **Figure 3** and greater than or equal to $300,000 in **Figure 4**. Note that the intervals for both axes are different in each of the graphs in order to better illustrate the hospital charges for those cases. As can be seen, the total hospital charges for lumbar/lumbosacral, dorsal/dorsolumbar fusion surgery cases in Florida hospitals in 2010 are positively skewed. This is a typical pattern for hospital charges due to some patients having very costly procedures, long lengths of stay, and/or complicated treatments. As indicated in **Table 10**, the hospital charges for these surgical procedures ranged from $3,245 to $1,819,470 with a mean of $129,059 and standard deviation of $72,692. The median charge for this population was $112,883.

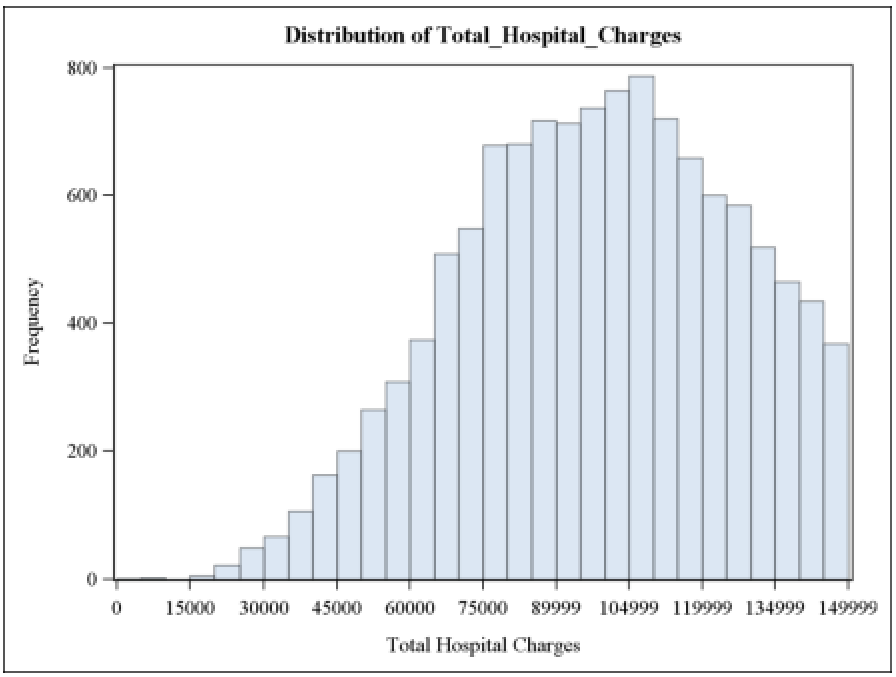

Figure 2: Total Hospital Charges in Dollars (< $150,000), N = 12,049

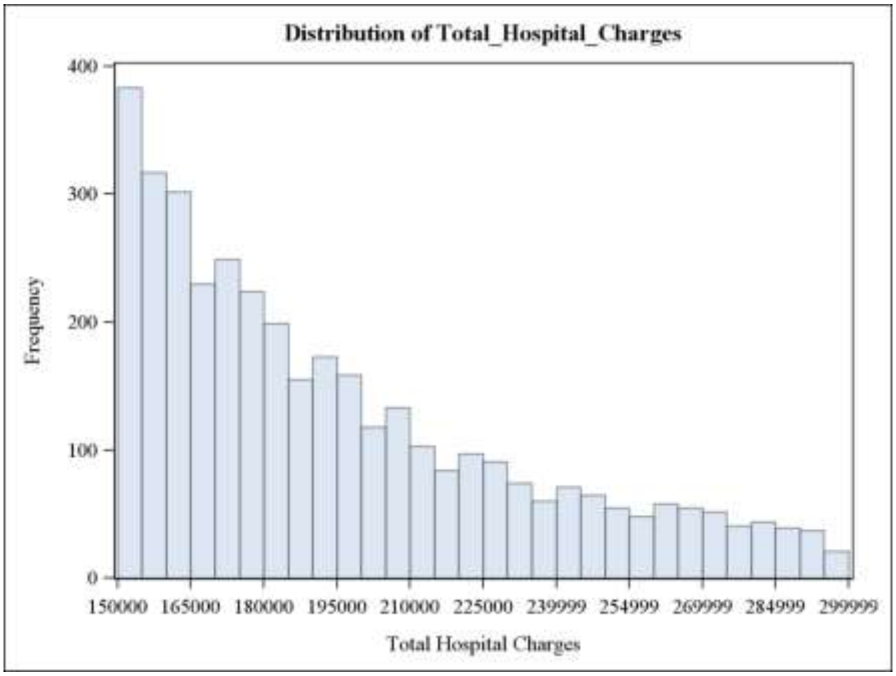

Figure 3: Total Hospital Charges in Dollars ($150,000-$299,999), N = 3,737

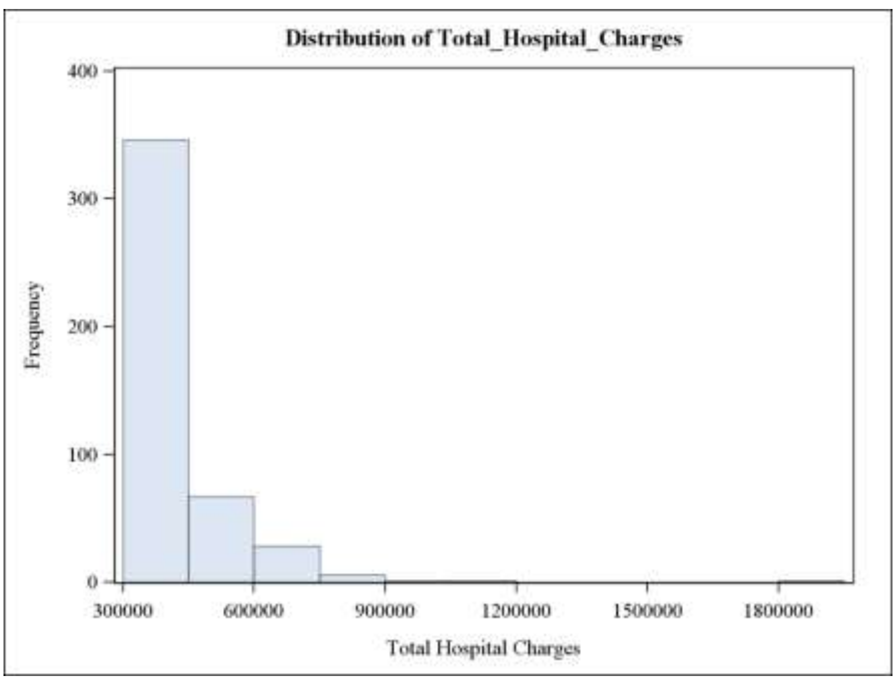

Figure 4: Total Hospital Charges in Dollars (≥ $300,000), N = 450

Charges – Type III Analysis

Type III tests of fixed effects were analyzed (**Table 12**). The type III analysis tests the overall significance of each of the predictor variables individually in improving the fit of the model. The type III F statistics and their associated p-values indicate that gender, age group, payer, principal procedure, and number of additional diagnoses all significantly improved the model fit at alpha = 0.05. Race, on the other hand, was not found to be significant. The larger the F value test statistic is for a given variable, the more significant the associated p-value will be for that variable. The F value statistic for the number of additional diagnoses is notably larger than each of the other fixed effects included in the model (with the exception of the principal procedure). As noted above the number of additional diagnoses is a proxy variable for severity of illness and in **Table 12** it is obvious that charges are very significantly related to the number of medical problems a patient had. While the database did not indicate whether these additional diagnoses were present at the time of admission or developed after admission, a review of the data indicated that many of the secondary diagnoses associated with the highest charges included septicemia or osteomyelitis. While these appear to be hospital acquired infections, a prospective study needs to be done to determine causation. The F value statistic for the principal procedure is also significantly larger than each of the other fixed effects.

Charges – Solution for Fixed Effects

Table 13 shows the solution estimates for the fixed effects included in the model. According to the solution estimates for gender, the estimated mean hospital charges for females are $2,210 lower than the mean hospital charges for males (p = 0.0095). It is important to note, however, that the descriptive statistic for gender revealed that the mean charges for females were

Table 12: Type III Tests of Fixed Effects

Effect	F Value	Pr > F
Gender	6.73	0.0095
Race	0.69	0.5028
Age Group	15.07	<.0001
Payer	3.20	0.0069
Principal Procedure	319.75	<.0001
Number of Additional Diagnoses	2,576.79	<.0001

actually $2,340 greater than for the males. This may be an indication of potential confounding occurring in the model. Based on the Phi Coefficients provided in Appendix K, along with a separate Stepwise Regression which was run for the model, it appears as though the variables age and payer are correlated.

The analysis of the age categories shows that all age groups were found to increase significantly the total hospital charges when compared to the greater than or equal to 75 age category ($p = <.0001$). The less than 20 years of age category had the greatest estimated mean difference of $28,638 in total hospital charges as compared to the greater than or equal to 75 age category.

Of the payer types, every insurance category, excluding Federal Health Insurance, was found to significantly increase mean hospital charges when compared to Medicare. Medicaid had the greatest estimated mean difference of $7,473 compared to Medicare ($p = 0.0037$).

All of the principal procedure codes, except Code 81.07, were found to significantly increase mean hospital charges when compared to Code 81.08 ($p < 0.0001$). Code 81.04 had the greatest estimated mean difference of $103,960.00 in total hospital charges as compared to Code 81.08. The next largest mean difference was $62,803.00 for Code 81.05, followed by $28,254 for Code 81.06. Procedure Code 81.07 was not statistically different from Code 81.08 because both are fairly routine types of surgery. While Code 81.08 is the default type of fusion surgery with the greatest n, Code 81.07 was the second most frequently performed procedure of the five types of fusion surgeries analyzed here. Moreover, the mean charges of the two procedures differed by less than $400.

Lastly, the analysis of the number of additional diagnoses shows that for every additional diagnosis present in a patient's hospital record, the estimated mean hospital charges increases by $5,193 ($p < 0.0001$).

The estimated mean differences in the total hospital charges between the White race category and the Black/African American and the Other/Unknown race categories were not found to be statistically significant.

Charges – Intracluster Correlation Coefficient

As can be seen in **Table 14**, the intracluster correlation coefficient (ICC) is 0.34. This is quite large and indicates that patients who had surgeries performed within the same hospital are not independent and the data were clustered on hospitals. The effect of a large intracluster correlation coefficient is a reduced effective sample size (ESS) or power. The 16,236 cases from the 112 hospitals in the present study would be equivalent to 424 cases obtained from a random sample, thus reducing the effective sample size to 424. Therefore, the results in this study will

Table 13: Solution for Fixed Effects

Effect	Gender	Race	Age Group	Payer	Principal Procedure	Estimate	Standard Error	t Value	P Value
Intercept						74,483.00	3,571.19	20.86	<.0001
Gender	F					-2,209.71	851.61	-2.59	0.0095
Gender	M					0	.	.	.
Race		Black/African American				-391.42	1,789.86	-0.22	0.8269
Race		Other				2,264.82	2,008.83	1.13	0.2596
Race		White				0	.	.	.
Age Group			<20			28,638.00	4,110.50	6.97	<.0001
Age Group			20-39			10,741.00	2,239.00	4.80	<.0001
Age Group			40-49			8,477.49	1,987.46	4.27	<.0001
Age Group			50-64			10,574.00	1,410.58	6.26	<.0001
Age Group			65-74			8,228.50	1,331.80	6.18	<.0001
Age Group			≥75			0	.	.	.
Payer				Federal		3,171.06	2,604.55	1.22	0.2234
Payer				Other/Non-payment		5,490.31	2,688.93	2.04	0.0412
Payer				Workers' Comp		6,241.15	2,501.99	2.49	0.0126
Payer				Commercial		4,947.66	1,410.00	3.51	0.0005
Payer				Medicaid		7,472.50	2,570.74	2.91	0.0037
Payer				Medicare		0	.	.	.
Principal Procedure					81.04	103,960.00	5,371.31	19.35	<.0001
Principal Procedure					81.05	62,803.00	2,391.08	26.27	<.0001
Principal Procedure					81.06	28,254.00	1,430.32	19.75	<.0001
Principal Procedure					81.07	251.25	1,139.72	0.22	0.8255
Principal Procedure					81.08	0	.	.	.
Num Add Diagnoses						5,192.70	102.29	50.76	<.0001

have less significant effects and decrease the power when compared to a model treating every patient as an independent sample.

Table 14: Intracluster Correlation

ICC	0.34
Design Effect	38.26
Effective Sample Size	424.36

Even though the effective sample size using this statistical methodology was 424, this is still a large sample size and the p-values found in **Table 14** are still statistically significant and valid.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

Discussion - Incidence

There were two separate drivers of high incidence in the surgical population. First, there were young individuals who received fusion surgeries related to congenital malformations or scoliosis. Second, there were older patients in the case population who had fusion surgery because of degenerative conditions or injury. The two separate drivers of high incidence in the surgical population are evident in the bimodal distribution seen in **Figure 1** displaying the frequency of patients in the case population by age.

The major peak is due to the degenerative lumbar spine diseases which are shown in the Principal Diagnoses for lumbar/lumbosacral, dorsal/dorsolumbar Spinal Fusion Surgeries (**Table 2**). The top two diagnoses in this Table (722.52 and 724.02) account for 39% of all surgeries, and these are obviously degenerative diseases of the spine which are age-related. The next three top diagnoses (722.10, 721.3, 738.4) are also likely related to increasing age, and account for another 39% of the surgical cases. Thus, the top five Principal Diagnoses account for 78% of all the surgeries. These latter three diagnoses are not as strongly correlated with age as the top two, and some proportion of these latter cases are also occurring in middle-aged patients, but the majority are probably in patients 60 years of age and older. The sixth most frequently occurring diagnosis (737.30) is for scoliosis and accounts for about five percent of all surgeries. These are likely the 10-19 year old patients mentioned above, which creates the smaller peak in that age range.

Scoliosis [and kyphoscoliosis] (idiopathic) is the sixth most frequently occurring diagnosis and accounts for approximately five percent of the surgeries. Although, while not as frequently occurring as the aforementioned diagnoses, progressive infantile idiopathic scoliosis and juvenile osteochondrosis of the spine were also in the top 31 most frequently occurring principal diagnoses. Cases with these diagnoses are most likely to be in the 0-19 age range at the time of surgery.

As for the relationship between the age distribution, principal diagnoses and principal payers for the cases (**Table 4**), the top three payers, respectively, were Medicare (48%), Commercial (37%) and Medicaid (4%). The peak of the frequency distribution at 67 years of age clearly explains why Medicare is the principal payer (48%) in the surgery population (though a few cases are paid for by Medicare in the middle age range for patients who are on Social Security disability insurance as well). **Although the limited clinical practice guidelines which are available for lumbar fusion surgery do not recommend spinal fusion for the top four principal diagnoses found here, it is evident that when patients are covered by health insurance and payment is available the surgery will likely be done.**

Commercial insurance would be the principal payer for those between 20-64 years of age. Some of these cases are due to age-related disorders and it was with physician choice that surgery was performed. Others with commercial insurance had a principal diagnosis of spondylolisthesis, which, based on practice guidelines, such as they are, would justify fusion surgery. Commercial insurance is also the payer for many of the surgeries performed on young people in which scoliosis was the principal diagnosis. According to the murky clinical practice guidelines for scoliosis, fusion surgery is justified when the degree of curvature is severe enough. Still, this is also an area which is highly dependent on the judgment of the surgeon. Since the degree of curvature can be measured objectively, the clinical guidelines (and reimbursement) for this should be based upon the objective measured degree of curvature.

Finally, while not necessarily high on the list in **Table 3**, several principal diagnoses (737.30, 737.32, 732.0) are more prevalent in the 0-19 age group. This is the group for which Medicaid is the principal payer and would explain why the Medicaid percentage, while small, was still the third highest principal payer category. Additional analysis which was done shows that a high percentage of the Tricare payments were for young women (less than 20 years of age) (Refer to Appendix H), indicating a likely diagnosis of scoliosis (with physician judgment leading to the surgery).

Controls were obtained by identifying all patients in the 2010 Florida Hospital Discharge Data with the same principal diagnosis as the cases but who did not receive lumbar/lumbosacral, dorsal/dorsolumbar fusion surgery. The final control population included 21,856 patients. The analysis of the controls revealed that some diagnoses were more likely to be treated with surgery, while others were not. For example of all of the patients in Florida hospitals who had a principal diagnosis of Lumbago (a very subjective diagnosis) in Florida hospitals in 2010, 97% of them did not receive a fusion surgery. Similarly, of all of the patients in the dataset who had a closed fracture of a lumbar vertebra, without mention of spinal cord injury, 93% of them did not receive a fusion surgery. On the other hand, all of the patients in the dataset who had congenital musculoskeletal deformities of the spine or juvenile osteochondrosis of the spine received a fusion surgery.

Logistic regression was used to find the statistically significant predictors of the incidence of lumbar/lumbosacral, dorsal/dorsolumbar fusion surgeries in Florida hospitals. The results from the logistic regression analysis indicated that gender, race, payer, and age group were all statistically significant predictors of the incidence of fusion surgery ($p < 0.001$). More specifically, females were more likely than males to receive fusion surgery. This may be a result of two separate causes that differentially affect females. First, according to the American Academy of Orthopedic Surgeons, adolescent idiopathic scoliosis is ten times more likely to occur in females than in males (McIntosh & Weiss, 2012). The second health condition which may also be associated with a higher incidence of fusion surgeries in females is osteoporosis. One of the most common places for fractures caused by osteoporosis to occur is in the spine. Although osteoporosis does occur in males, it is most common in females who are beyond menopause (Mayo Clinic, 2013). Thus, both of these health conditions may be responsible in part for the increased rates of females receiving lumbar/lumbosacral, dorsal/dorsolumbar fusion surgeries.

An understanding of who is most likely to receive a fusion surgery, at what age, and for which diagnoses, as has been done here, is extremely important. This knowledge can help researchers, policy makers, and physicians alike. Comprehensive physician practice guidelines for performing fusion surgeries still do not exist in the year 2013; therefore, in order to have the greatest impact, the efforts for creating the guidelines should be focused on those individuals who are most likely to receive fusions as shown for the first time by the data analyzed here. Given the high incidence of these surgeries in Florida alone, the need for practice guidelines cannot be overstated.

Discussion - Charges

The total hospital charges in Florida hospitals for the 16,236 cases were $2,095,413,584. The descriptive results for the charges analysis showed that the highest mean charges were incurred by females, though the multivariate analysis estimated higher charges for the males. The relationship between age and charges was found to be a complex one. Those younger than 20 years of age had the highest mean charges of any age category with a mean charge of $202,703. This can be explained by the types of diagnoses within this age group and the procedures used to treat these diagnoses. Patients under the age of 20 who received a fusion surgery were most likely to have had congenital malformations or scoliosis. These diagnoses are most often treated with one of the two most costly fusion procedure techniques (ICD-9-CM procedure codes 81.04 or 81.05). Thus, although the volume of these types of surgeries was relatively small (the <20 group had the smallest n of 679), they were complex and very costly procedures. Furthermore, the relationship between age and charges for those 20 years and older was not monotonic. The analysis of the charges by age group showed that the 50-64 age group had the highest frequency of cases (n= 4,905) and the highest mean charges ($131,382) for those 20 years of age and greater. A potential explanation for these findings may be that individuals in the 50-64 age group are below retirement age but have more degeneration in their spine than younger age groups. Thus, this may make them more vulnerable to acquiring work-related injuries. The decreased frequency in the oldest age group is likely because the risks of operation increase later in life with elderly individuals who are more frail and likely to have a greater number of comorbidities.

Medicaid had the highest mean charges of all the payer categories. A likely reason for the high mean charges for Medicaid seen in this study may be attributed to the fusions performed on the youngest patients who received complex and costly surgeries for congenital malformations or scoliosis. Medicaid provides insurance coverage for qualifying young individuals. The fusions from age 1 through 9 years of age are likely due to congenital malformations. From 10-19 years of age the majority of these surgeries are likely due to scoliosis. These types of surgeries are complex and are more likely to require one of the more costly procedure types to be used (i.e. ICD-9-CM Procedure Codes 81.04 or 81.05).

Importantly, the type III analysis in the mixed model revealed that the number of additional diagnoses, which was used as a proxy for severity of illness, was the most significant predictor in the model. The larger the F value test statistic is for a given variable, the more significant the associated p-value will be for that variable. The F value for the number of additional diagnoses was greater than each of the other fixed effects included in the model. Moreover, it was shown that the cases and controls had a very similar mean number of additional diagnoses. **Thus, despite having the same principal diagnoses and a similar number of additional diagnoses, patients who received a fusion surgery resulted in approximately three times the charges as those incurred by the controls.** Again, this finding suggests the need for clear, evidence-based physician practice guidelines to define the conditions for which these invasive and potentially dangerous surgeries are justified.

Additionally, the F value statistic for the principal procedure had the second largest value after the mean number of additional diagnoses. The solutions for fixed effects shows that procedure 81.04 had the highest estimate of 103,960 for predicting total hospital charges, followed by procedure 81.05 with an estimate of 62,803. Given that these two procedures are so much more costly than the other three procedure codes, practice guidelines should also specify which procedures are most effective for which diagnoses.

Overall, the high incidence and charges for fusion surgeries shown in this study emphasize the importance of having a better understanding of when these surgeries are justified and for which patients. Without comprehensive practice guidelines established through evidence-based research this is difficult, if not impossible, to accomplish. The diagnoses which are most prevalent and show the most inconsistencies between cases may be a good starting point for such guidelines. Additionally, given the difference in charges between the five fusion procedures, analysis should be conducted on the best and proper use of all of these procedures and included in physician practice guidelines for fusion surgeries.

Limitations and Suggestions for Future Research

The first limitation of the present research was the ICD-9-procedure codes used in the analysis. In the year 2010, during which the data were gathered, the Florida Agency for Health Care Administration (AHCA) Hospital Discharge datasets used ICD-9-CM diagnosis and procedure codes. These codes are not as detailed or specific as the newly available ICD-10-CM codes. Whereas the ICD-9-CM codes have approximately 13,000 diagnosis codes, there are approximately 68,000 diagnosis codes available in ICD-10-CM. Furthermore, the difference between procedure codes in the two versions is even greater with 3,000 available in ICD-9 and 87,000 available in ICD-10. The ICD-10 codes provide additional information about the methodology and approach employed along with any medical devices used. Thus, future research on fusion surgery utilizing ICD-10 codes would benefit from the added detail of the diagnoses and procedures which were not available in the dataset used for this study.

Second, the present research used secondary de-identified data. Thus, there were limitations of what could be analyzed and which study designs could be used. Future research could be conducted using a prospective design to study the effectiveness of fusion surgeries. This type of a study design would allow for more in-depth analysis of long-term outcomes addressing issues such as pain, complications (including reoperations) and overall functioning post-surgery.

Third, a prospective study could answer questions such as what length of time passed between the onset of back pain (or other medical problem) and the time of the surgery. This would be an important study since, in many cases back pain is known to resolve on its own. In fact, spinal fusion during the first three months of symptoms was not recommended by the Agency for Health Care Policy and Research when the diagnosis did not include a fracture, dislocation, tumor or infection (1994).

Fourth, a prospective study could analyze the amount and quality of information provided to patients regarding treatment options (including risks and benefits). Specifically, a study of whether patients are being fully informed about all options and receive accurate information about potential outcomes. Additionally, research could be conducted on how the long-term effectiveness of conservative care (e.g. physical therapy) compares with surgical treatment for different diagnoses. The present research has shown which diagnoses occur most frequently for which individuals and thus, can be used to help tailor patient decision aids to better meet individual needs.

Fifth, a prospective study design could differentiate between diagnoses which were present at the time of admission and those which occurred as a result of the hospital stay or treatments provided. Osteomyelitis was a secondary diagnosis which was present in many of the cases with the highest charges in the data used here. Since fusion surgery or prior spinal surgery could be a cause of osteomyelitis, its onset could be analyzed in a prospective study. In a prospective study, if any of the costly secondary diagnoses identified here are found to be frequently occurring after admission, then the extraordinarily high charges for these procedures could be reduced through better aseptic practices in hospitals.

In conclusion, another type of research on spinal fusion surgery which could be conducted in the future is related to geographic variation. The geographic variation of spinal fusion has been well documented within the United States. The results for incidence and charges found in the present study may be similar for other large states (e.g. CA, TX, NY), but in states with smaller populations and/or rural states, the results could be very different. Therefore, while the results for incidence and charges in Florida may be representative for other large states in the United States, this cannot be known unless the study is replicated.

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APPENDICES

Appendix A: Summary of Recommendations for Diagnosis and Treatment of Low Back Pain by the American College of Physicians and the American Pain Society

Table A1: Summary of Recommendations for Diagnosis and Treatment of Low Back Pain by the American College of Physicians and the American Pain Society

	Recommendation
1.	Clinicians should conduct a focused history and physical examination to help place patients with low back pain into 1 of 3 broad categories: nonspecific low back pain, back pain potentially associated with radiculopathy or spinal stenosis, or back pain potentially associated with another specific spinal cause. The history should include assessment of psychosocial risk factors, which predict risk for chronic disabling back pain (strong recommendation, moderate-quality evidence).
2.	Clinicians should not routinely obtain imaging or other diagnostic tests in patients with nonspecific low back pain (strong recommendation, moderate-quality evidence).
3.	Clinicians should perform diagnostic imaging and testing for patients with low back pain when severe or progressive neurologic deficits are present or when serious underlying conditions are suspected on the basis of history and physical examination (strong recommendation, moderate-quality evidence).
4.	Clinicians should evaluate patients with persistent low back pain and signs or symptoms of radiculopathy or spinal stenosis with magnetic resonance imaging (preferred) or computed tomography only if they are potential candidates for surgery or epidural steroid injection (for suspected radiculopathy) (strong recommendation, moderate-quality evidence).
5.	Clinicians should provide patients with evidence-based information on low back pain with regard to their expected course, advise patients to remain active, and provide information about effective self-care options (strong recommendation, moderate-quality evidence).
6.	For patients with low back pain, clinicians should consider the use of medications with proven benefits in conjunction with back care information and self-care. Clinicians should assess severity of baseline pain and functional deficits, potential benefits, risks, and relative lack of long-term efficacy and safety data before initiating therapy (strong recommendation, moderate-quality evidence). For most patients, first-line medication options are acetaminophen or nonsteroidal anti-inflammatory drugs.
7.	For patients who do not improve with self-care options, clinicians should consider the addition of nonpharmacologic therapy with proven benefits—for acute low back pain, spinal manipulation; for chronic or subacute low back pain, intensive interdisciplinary rehabilitation, exercise therapy, acupuncture, massage therapy, spinal manipulation, yoga, cognitive-behavioral therapy, or progressive relaxation (weak recommendation, moderate-quality evidence).

Source: Diagnosis and treatment of low back pain: A joint clinical practice guideline from the American College of Physicians and the American Pain Society. Chou et al., 2007.

Appendix B: Summary of Surgical Recommendations for the Spine by the US Agency for Health Care Policy and Research

Table A2: Summary of Surgical Recommendations for the Spine by the US Agency for Health Care Policy and Research

Recommend	Recommend Against
Discuss surgical options with patients with persistent and severe sciatica and clinical evidence of never root compromise after 1 month of conservative therapy.	Disc surgery in patients with back pain alone, no red flags, and no nerve root compression.
Standard discectomy and microdiscectomy have similar efficacy in the treatment of a herniated disk.	Percutaneous discectomy less efficacious than chymopapain.
Chymopapain used after ruling out allergic sensitivity, acceptable but less efficacious than discectomy to treat herniated disc.	Surgery for spinal stenosis within the first 3 months of symptoms.
	Spinal fusion during the first 3 months of symptoms in the absence of fracture, dislocation, complications of tumor or infection.

Source:. Acute low back pain problems in adults: Assessment and treatment. AHCPR, 1994.

Appendix C: Spinal Fusion Recommendations with Corresponding ICD-9-CM Diagnosis Codes

Table A3: Spinal Fusion Recommendations by the Mayo Clinic with Corresponding ICD-9-CM Diagnosis Codes, Part I

	Recommendation For Spinal Fusion	**ICD-9-CM Diagnosis Code***	**Description (Visible on X-ray, C-T scan, or MRI scan)**
Mayo Clinic (2012)	A Broken vertebra causes the spinal column to become unstable.	805.4 805.5 806.4 806.5	Closed fracture of lumbar vertebra without mention of spinal cord injury; Open fracture of lumbar vertebra without mention of spinal cord injury; Closed fracture of lumbar spine with spinal cord injury; Open fracture of lumbar spine with spinal cord injury.
	A spinal deformity such as severe** Scoliosis (a sideways curvature of the spine) is present.	737.30 737.32	Scoliosis [and kyphoscoliosis], idiopathic; Progressive infantile idiopathic scoliosis.
	Abnormal or excessive motion between two vertebrae (a common side effect of severe arthritis) causes the spine to become unstable.	721.3 721.42	Lumbosacral spondylosis (age-related wear and tear affecting the spinal discs), without myelopathy; Spondylosis (age-related wear and tear affecting the spinal discs), with myelopathy, lumbar region.
	Spondylolisthesis (one vertebra slips forward and onto the vertebra below it) causes severe back pain or nerve crowding that produces leg pain or numbness.	756.12 738.4 839.20 839.30	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis Closed dislocation, lumbar vertebra Open dislocation, lumbar vertebra
	Following the removal of a damaged (herniated) disc.	722.10	Displacement of lumbar intervertebral disc without myelopathy.

* ICD codes added by A.I.

**Severe was added by A.I even though that wording was not used in the 2012 Mayo Clinic Article, it was used in a Mayo Clinic Article also published in 2012 regarding surgery for treating scoliosis.

Sources: 1. Spinal fusion. Adapted from Mayo Clinic, Mayo Clinic Staff, 2012; 2. Scoliosis. Adapted from Mayo Clinic, Mayo Clinic Staff, 2012.

Appendix C (Continued)

Table A4: Spinal Fusion Recommendations by the Mayo Clinic with Corresponding ICD-9-CM Diagnosis Codes, Part II

Mayo Clinic (2011)	Back surgery may be required if the following conditions are progressive, painful, or causing nerve compression:		
	1. Scoliosis – a curvature of the spine	737.30 737.32	Scoliosis [and kyphoscoliosis], idiopathic; Progressive infantile idiopathic scoliosis
	2. Spondylolisthesis – the forward slippage of a segment of the spine	756.12 738.4	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis
	3. Spinal stenosis – narrowing of the spinal canal typically from arthritis	724.02 724.03	Spinal stenosis, lumbar region, without neurogenic claudication Spinal stenosis, lumbar region, with neurogenic claudication
	4. Radiculopathy – the irritation and inflammation of a nerve caused by a herniated disc	724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified
	5. Degenerative Disc Disease – the development of pain in a disc as a result of its normal wear and tear	722.52	Degeneration of lumbar or lumbosacral intervertebral disc

* ICD codes added by A.I.

**Severe was added by A.I even though that wording was not used in the 2012 Mayo Clinic Article, it was used in a Mayo Clinic Article also published in 2012 regarding surgery for treating scoliosis.

Source: Back surgery: When is it a good idea? Adapted from Mayo Clinic, Mayo Clinic Staff, 2011.

Appendix C (Continued)

Table A5: Spinal Fusion Recommendations by the Washington State Department of Labor and Industries with Corresponding ICD-9-CM Diagnosis Codes, Part I

Washington State Department of Labor & Industries			
I. Surgical criteria for patients with no prior lumbar surgery.	1. Patient has mechanical (non-radicular) low back pain with instability	756.12 738.4 756.11	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis; Spondylolysis, lumbosacral region (One or more bones of the L1-L5 vertebrae AND the S1-S5 vertebrae).
	2. Patient has at least Grade 2 spondylolisthesis with one or more of the following:	756.12 738.4	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis
	A. Objective signs/symptoms of neurogenic claudication	724.03	Spinal stenosis, lumbar region, with neurogenic claudication.
	B. Objective signs/symptoms of unilateral or bilateral radiculopathy, which are corroborated by neurologic examination and by MRI or CT (with or without myelography)	724.4	Thoracic (T1-T12) or lumbosacral neuritis or radiculitis, unspecified.
	C. Instability of the lumbar segment	756.12 738.4 756.11	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis; Spondylolysis, lumbosacral region.

Source: Surgical Guidelines for Lumbar Fusion. Adapted from Washington State Department of Labor & Industries, the Office of the Medical Director, 2009.

Appendix C (Continued)

Table A6: Spinal Fusion Recommendations by the Washington State Department of Labor and Industries with Corresponding ICD-9-CM Diagnosis Codes, Part II

II. Surgical criteria for patients with prior lumbar laminectomy, discectomy, or other decompression at the same level of the spine (L1- L5).	1. Mechanical (non-radicular) low back pain with instability	756.12 738.4 756.11	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis; Spondylolysis, lumbosacral region.
	2. Mechanical (non-radicular) low back pain with pseudospondylolisthesis, rotational deformity or other condition leading to a progressive (measurable) deformity		
	3. Objective signs/symptoms compatible with neurogenic claudication or lumbar radiculopathy that is supported by MRI or CT (with or without myelography)	724.03	Spinal stenosis, lumbar region, with neurogenic claudication.
	4. Evidence from a post-laminectomy structural study of either: A. 100% loss of facet surface area unilaterally B. 50% combined loss of facet surface area bilaterally		

Source: Surgical Guidelines for Lumbar Fusion. Adapted from Washington State Department of Labor & Industries, the Office of the Medical Director, 2009.

Appendix C (Continued)

Table A7: Spinal Fusion Recommendations by the WSJ, DHHS, and AHRQ with Corresponding ICD-9-CM Diagnosis Codes

Wall Street Journal	1. Spinal instability	738.4 756.12 756.11	Acquired (caused by trauma or daily wear-and-tear on the spine) spondylolisthesis; Spondylolisthesis - forward slippage of a segment of the spine; Spondylolysis, lumbosacral region.
	2. Spinal fracture	805.4 805.5 806.4 806.5	Closed fracture of lumbar vertebra without mention of spinal cord injury; Open fracture of lumbar vertebra without mention of spinal cord injury; Closed fracture of lumbar spine with spinal cord injury; Open fracture of lumbar spine with spinal cord injury.
	3. Severe scoliosis	737.30 737.32	Scoliosis [and kyphoscoliosis], idiopathic; Progressive infantile idiopathic scoliosis.
D.H.H.S.	1. Spinal instability coupled with intractable pain as a result of spondylolisthesis	738.4 756.12	Acquired spondylolisthesis; Spondylolisthesis - forward slippage of a segment of the spine.
	2. Spinal instability coupled with intractable pain as a result of spondylolysis	756.12 738.4 756.11	Spondylolisthesis - forward slippage of a segment of the spine; Acquired spondylolisthesis; Spondylolysis, lumbosacral region.
	3. Scoliosis	737.30 737.32	Scoliosis [and kyphoscoliosis], idiopathic; Progressive infantile idiopathic scoliosis.
A.H.R.Q.	1. Symptomatic spinal stenosis	724.03	Spinal stenosis, lumbar region, with neurogenic claudication.
	2. Degenerative spondylolisthesis	756.12	Spondylolisthesis - forward slippage of a segment of the spine.
	3. Isthmic spondylolisthesis	738.4	Acquired (caused by trauma or daily wear-and-tear on the spine) spondylolisthesis.

Sources: 1. Top spine surgeons reap royalties, Medicare bounty. Adapted from the Wall Street Journal, Carreyrou, J. & Mcginty, T. Wall Street Journal, 2010; 2. Diagnosis and treatment of degenerative lumbar spinal stenosis. Adapted from the National Guideline Clearinghouse, AHRQ, 2011; 3. Diagnosis and treatment of degenerative lumbar spinal spondylolisthesis. Adapted from the National Guideline Clearinghouse, AHRQ, 2008; 4. Low back disorders. Adapted from the National Guideline Clearinghouse, AHRQ, 2011

Appendix D: Summary Table of Fusion Recommendations with Corresponding ICD-9-CM Diagnosis Codes

Table A8: Summary Table of Fusion Recommendations with Corresponding ICD-9-CM Diagnosis Codes

ICD-9-CM Diagnosis Code	Description
Lumbar Fractures	
805.4	Closed fracture of lumbar vertebra without mention of spinal cord injury
805.5	Open fracture of lumbar vertebra without mention of spinal cord injury
806.4	Closed fracture of lumbar spine with spinal cord injury
806.5	Open fracture of lumbar spine with spinal cord injury
Herniated Disk	
722.10	Displacement of lumbar intervertebral disc without myelopathy
722.73	Intervertebral disc disorder with myelopathy, lumbar region
Disc Degeneration	
722.52	Degeneration of lumbar or lumbosacral intervertebral disc
Spondylosis	
721.3	Lumbosacral spondylosis without myelopathy
721.42	Spondylosis, with myelopathy, lumbar region
Vertebra Dislocation	
839.20	Closed dislocation, lumbar vertebra
839.30	Open dislocation, lumbar vertebra
Scoliosis	
737.30	Scoliosis [and kyphoscoliosis], idiopathic
737.32	Progressive infantile idiopathic scoliosis
737.33	Scoliosis due to radiation
737.42	Lordosis associated with other conditions
737.43	Scoliosis associated with other conditions
Spondylolisthesis	
738.4	Acquired spondylolisthesis
756.12	Spondylolisthesis
Spinal Stenosis	
724.02	Spinal stenosis, lumbar region, without neurogenic claudication
724.03	Spinal stenosis, lumbar region, with neurogenic claudication
Spondylolysis	
756.11	Spondylolysis, lumbosacral region

Sources: 1. Spinal fusion. Adapted from Mayo Clinic, Mayo Clinic Staff, 2012; 2. Scoliosis. Adapted from Mayo Clinic, Mayo Clinic Staff, 2012; 3. Back surgery: When is it a good idea? Adapted from Mayo Clinic, by Mayo Clinic Staff, 2011. 4. Surgical Guidelines for Lumbar Fusion. Adapted from Washington State Department of Labor & Industries, the Office of the Medical Director, 2009. 5. Top spine surgeons reap royalties, Medicare bounty. Adapted from the Wall Street Journal, by Carreyrou, J. & Mcginty, T. Wall Street Journal, 2010; 6. Diagnosis and treatment of degenerative lumbar spinal stenosis. Adapted from the National Guideline Clearinghouse, by AHRQ, 2011; 7. Diagnosis and treatment of degenerative lumbar spinal spondylolisthesis. Adapted from the National Guideline Clearinghouse, by AHRQ, 2008; 8. Low back disorders. Adapted from the National Guideline Clearinghouse, by AHRQ, 2011.

Appendix E: Eliminated ICD-9-CM Principal Diagnosis Codes

Table A9: Principal Diagnosis Codes which were Eliminated from the Case Population because they Pertained to an Area of the Spine which Did Not Include the Lumbar Spine (N= 529)

PRIN DIAG	DESCRIPTION	FREQ
805.2	Closed fracture of dorsal [thoracic] vertebra without mention of spinal cord injury	124
724.6	Disorders of sacrum	49
722.72	Intervertebral disc disorder with myelopathy, thoracic region	39
722.11	Displacement of thoracic intervertebral disc without myelopathy	32
722.0	Displacement of cervical intervertebral disc without myelopathy	29
806.25	Closed fracture of T7-T12 level with unspecified spinal cord injury	24
737.34	Thoracogenic scoliosis	22
721.0	Cervical spondylosis without myelopathy	20
721.1	Cervical spondylosis with myelopathy	19
724.01	Spinal stenosis, thoracic region	18
721.41	Spondylosis with myelopathy, thoracic region	15
721.2	Thoracic spondylosis without myelopathy	14
723.0	Spinal stenosis in cervical region	12
806.29	Closed fracture of T7-T12 level with other specified spinal cord injury	12
720.2	Sacroiliitis, not elsewhere classified	9
722.71	Intervertebral disc disorder with myelopathy, cervical region	9
722.4	Degeneration of cervical intervertebral disc	8
806.26	Closed fracture of T7-T12 level with complete lesion of cord	8
722.92	Other and unspecified disc disorder, thoracic region	6
805.07	Closed fracture of seventh cervical vertebra	6
839.21	Closed dislocation, thoracic vertebra	5
722.82	Postlaminectomy syndrome, thoracic region	4
806.20	Closed fracture of T1-T6 level with unspecified spinal cord injury	4
805.06	Closed fracture of sixth cervical vertebra	3
723.1	Cervicalgia	2
805.05	Closed fracture of fifth cervical vertebra	2
806.24	Closed fracture of T1-T6 level with other specified spinal cord injury	2
171.6	Malignant neoplasm of connective and other soft tissue of pelvis	1
213.6	Benign neoplasm of pelvic bones, sacrum, and coccyx	1
215.0	Other benign neoplasm of connective and other soft tissue of head, face, and neck	1
427.32	Atrial flutter	1
435.9	Unspecified transient cerebral ischemia	1
491.22	Obstructive chronic bronchitis with acute bronchitis	1
507.0	Pneumonitis due to inhalation of food or vomitus	1

Appendix E (Continued)

518.0	Pulmonary collapse	1
584.9	Acute kidney failure, unspecified	1
590.10	Acute pyelonephritis without lesion of renal medullary necrosis	1
599.0	Urinary tract infection, site not specified	1
682.3	Cellulitis and abscess of upper arm and forearm	1
715.36	Osteoarthrosis, localized, not specified whether primary or secondary, lower leg	1
718.85	Other joint derangement, not elsewhere classified, pelvic region and thigh	1
724.1	Pain in thoracic spine	1
736.79	Other acquired deformities of ankle and foot	1
741.92	Spina bifida without mention of hydrocephalus, dorsal (thoracic) region	1
801.64	Open fracture of base of skull with cerebral laceration and contusion, with prolonged [more than 24 hours] loss of consciousness and return to pre-existing conscious level	1
805.01	Closed fracture of first cervical vertebra	1
805.03	Closed fracture of third cervical vertebra	1
805.6	Closed fracture of sacrum and coccyx without mention of spinal cord injury	1
807.02	Closed fracture of two ribs	1
807.07	Closed fracture of seven ribs	1
808.53	Multiple open pelvic fractures with disruption of pelvic circle	1
824.4	Bimalleolar fracture, closed	1
824.9	Unspecified fracture of ankle, open	1
825.25	Closed fracture of metatarsal bone(s)	1
839.08	Closed dislocation, multiple cervical vertebrae	1
851.46	Cerebellar or brain stem contusion without mention of open intracranial wound, with loss of consciousness of unspecified duration	1
851.80	Other and unspecified cerebral laceration and contusion, without mention of open intracranial wound, unspecified state of consciousness	1
865.04	Injury to spleen without mention of open wound into cavity, massive parenchymal disruption	1
952.15	T7-T12 level with unspecified spinal cord injury	1

Appendix F: Full List of ICD-9-CM Principal Diagnosis Codes

Table A10: Principal Diagnoses for Lumbar/Lumbosacral, Dorsal/Dorsolumbar Spinal Fusion Surgeries in Florida Hospitals, 2010 (N= 16,368) (ICD-9-CM Procedure Codes 81.04, 81.05, 81.06, 81.07, 81.08)

Prin Diag	Description	Freq	%
722.52	Degeneration of lumbar or lumbosacral intervertebral disc	3,535	21.59
724.02	Spinal stenosis, lumbar region, without neurogenic claudication	2,748	16.78
722.10	Displacement of lumbar intervertebral disc without myelopathy	2,624	16.02
721.3	Lumbosacral spondylosis without myelopathy	2,125	12.98
738.4	Acquired spondylolisthesis	1,489	9.09
737.30	Scoliosis [and kyphoscoliosis], idiopathic	776	4.74
756.12	Spondylolisthesis	656	4.01
722.83	Postlaminectomy syndrome, lumbar region	356	2.17
805.4	Closed fracture of lumbar vertebra without mention of spinal cord injury	224	1.37
996.49	Other mechanical complication of other internal orthopedic device, implant, and graft	197	1.20
737.39	Other kyphoscoliosis and scoliosis	160	0.98
733.13	Pathologic fracture of vertebrae	150	0.92
722.73	Intervertebral disc disorder with myelopathy, lumbar region	123	0.75
722.93	Other and unspecified disc disorder, lumbar region	105	0.64
198.5	Secondary malignant neoplasm of bone and bone marrow	103	0.63
721.42	Spondylosis with myelopathy, lumbar region	101	0.62
724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified	101	0.62
724.03	Spinal stenosis, lumbar region, with neurogenic claudication	84	0.51
996.78	Other complications due to other internal orthopedic device, implant, and graft	54	0.33
730.28	Unspecified osteomyelitis, other specified sites	50	0.31
724.2	Lumbago	37	0.23
737.10	Kyphosis (acquired) (postural)	37	0.23
737.32	Progressive infantile idiopathic scoliosis	37	0.23
754.2	Congenital musculoskeletal deformities of spine	34	0.21
806.4	Closed fracture of lumbar spine with spinal cord injury	34	0.21
839.20	Closed dislocation, lumbar vertebra	33	0.20
727.40	Synovial cyst, unspecified	30	0.18
756.11	Spondylolysis, lumbosacral region	24	0.15
722.51	Degeneration of thoracic or thoracolumbar intervertebral disc	22	0.13
732.0	Juvenile osteochondrosis of spine	17	0.10
737.19	Other kyphosis (acquired)	17	0.10
733.82	Nonunion of fracture	12	0.07
756.19	Other anomalies of spine	12	0.07

Appendix F (Continued)

730.08	Acute osteomyelitis, other specified sites	11	0.07
996.40	Unspecified mechanical complication of internal orthopedic device, implant, and graft	11	0.07
721.7	Traumatic spondylopathy	9	0.05
730.18	Chronic osteomyelitis, other specified sites	9	0.05
738.5	Other acquired deformity of back or spine	9	0.05
358.9	Myoneural disorders, unspecified	7	0.04
170.2	Malignant neoplasm of vertebral column, excluding sacrum and coccyx	6	0.04
324.1	Intraspinal abscess	6	0.04
996.47	Other mechanical complication of prosthetic joint implant	6	0.04
349.2	Disorders of meninges, not elsewhere classified	5	0.03
722.6	Degeneration of intervertebral disc, site unspecified	5	0.03
724.00	Spinal stenosis, unspecified region	5	0.03
203.00	Multiple myeloma, without mention of having achieved remission	4	0.02
237.71	Neurofibromatosis, type 1 [von recklinghausen's disease]	4	0.02
720.0	Ankylosing spondylitis	4	0.02
737.20	Lordosis (acquired) (postural)	4	0.02
996.67	Infection and inflammatory reaction due to other internal orthopedic device, implant, and graft	4	0.02
998.59	Other postoperative infection	4	0.02
038.9	Unspecified septicemia	3	0.02
239.2	Neoplasm of unspecified nature of bone, soft tissue, and skin	3	0.02
344.60	Cauda equina syndrome without mention of neurogenic bladder	3	0.02
359.1	Hereditary progressive muscular dystrophy	3	0.02
723.4	Brachial neuritis or radiculitis NOS	3	0.02
724.3	Sciatica	3	0.02
724.5	Backache, unspecified	3	0.02
733.22	Aneurysmal bone cyst	3	0.02
737.12	Kyphosis, postlaminectomy	3	0.02
756.14	Hemivertebra	3	0.02
998.89	Other specified complications of procedures not elsewhere classified	3	0.02
094.0	Tabes dorsalis	2	0.01
198.3	Secondary malignant neoplasm of brain and spinal cord	2	0.01
198.4	Secondary malignant neoplasm of other parts of nervous system	2	0.01
202.80	Other malignant lymphomas, unspecified site, extranodal and solid organ sites	2	0.01
213.2	Benign neoplasm of vertebral column, excluding sacrum and coccyx	2	0.01

Appendix F (Continued)

215.7	Other benign neoplasm of connective and other soft tissue of trunk, unspecified	2	0.01
228.09	Hemangioma of other sites	2	0.01
343.2	Congenital quadriplegia	2	0.01
343.9	Infantile cerebral palsy, unspecified	2	0.01
721.8	Other allied disorders of spine	2	0.01
721.90	Spondylosis of unspecified site, without mention of myelopathy	2	0.01
722.80	Postlaminectomy syndrome, unspecified region	2	0.01
724.9	Other unspecified back disorders	2	0.01
729.2	Neuralgia, neuritis, and radiculitis, unspecified	2	0.01
733.00	Osteoporosis, unspecified	2	0.01
733.29	Other bone cyst	2	0.01
733.81	Malunion of fracture	2	0.01
996.41	Mechanical loosening of prosthetic joint	2	0.01
996.42	Dislocation of prosthetic joint	2	0.01
996.43	Broken prosthetic joint implant	2	0.01
996.75	Other complications due to nervous system device, implant, and graft	2	0.01
996.77	Other complications due to internal joint prosthesis	2	0.01
015.00	Tuberculosis of vertebral column, unspecified	1	0.01
015.05	Tuberculosis of vertebral column, tubercle bacilli not found by bacteriological examination, but tuberculosis confirmed histologically	1	0.01
015.06	Tuberculosis of vertebral column, tubercle bacilli not found by bacteriological or histological examination, but tuberculosis confirmed by other methods [inoculation of animals]	1	0.01
038.0	Streptococcal septicemia	1	0.01
038.12	Methicillin resistant Staphylococcus aureus septicemia	1	0.01
038.19	Other staphylococcal septicemia	1	0.01
053.19	Herpes zoster with other nervous system complications	1	0.01
192.3	Malignant neoplasm of spinal meninges	1	0.01
201.90	Hodgkin's disease, unspecified type, unspecified site, extranodal and solid organ sites	1	0.01
203.80	Other immunoproliferative neoplasms, without mention of having achieved remission	1	0.01
209.73	Secondary neuroendocrine tumor of bone	1	0.01
225.3	Benign neoplasm of spinal cord	1	0.01
228.01	Hemangioma of skin and subcutaneous tissue	1	0.01
237.9	Neoplasm of uncertain behavior of other and unspecified parts of nervous system	1	0.01
238.0	Neoplasm of uncertain behavior of bone and articular cartilage	1	0.01

Appendix F (Continued)

250.60	Diabetes with neurological manifestations, type II or unspecified type, not stated as uncontrolled	1	0.01
272.0	Pure hypercholesterolemia	1	0.01
324.9	Intracranial and intraspinal abscess of unspecified site	1	0.01
330.8	Other specified cerebral degenerations in childhood	1	0.01
335.0	Werdnig-Hoffmann disease	1	0.01
335.11	Kugelberg-Welander disease	1	0.01
335.21	Progressive muscular atrophy	1	0.01
336.8	Other myelopathy	1	0.01
336.9	Unspecified disease of spinal cord	1	0.01
338.21	Chronic pain due to trauma	1	0.01
343.1	Congenital hemiplegia	1	0.01
343.8	Other specified infantile cerebral palsy	1	0.01
349.0	Reaction to spinal or lumbar puncture	1	0.01
349.1	Nervous system complications from surgically implanted device	1	0.01
349.31	Accidental puncture or laceration of dura during a procedure	1	0.01
349.82	Toxic encephalopathy	1	0.01
359.0	Congenital hereditary muscular dystrophy	1	0.01
359.21	Myotonic muscular dystrophy	1	0.01
648.93	Other current conditions classifiable elsewhere of mother, antepartum condition or complication	1	0.01
674.84	Other complications of puerperium, postpartum condition or complication	1	0.01
715.90	Osteoarthrosis, unspecified whether generalized or localized, site unspecified	1	0.01
716.18	Traumatic arthropathy, other specified sites	1	0.01
716.98	Arthropathy, unspecified, other specified sites	1	0.01
719.88	Other specified disorders of joint, other specified sites	1	0.01
722.2	Displacement of intervertebral disc, site unspecified, without myelopathy	1	0.01
722.70	Intervertebral disc disorder with myelopathy, unspecified region	1	0.01
724.8	Other symptoms referable to back	1	0.01
727.50	Rupture of synovium, unspecified	1	0.01
729.5	Pain in limb	1	0.01
733.19	Pathologic fracture of other specified site	1	0.01
733.90	Disorder of bone and cartilage, unspecified	1	0.01
733.95	Stress fracture of other bone	1	0.01
733.99	Other disorders of bone and cartilage	1	0.01
737.29	Other lordosis (acquired)	1	0.01
738.9	Acquired deformity of unspecified site	1	0.01
756.10	Anomaly of spine, unspecified	1	0.01

Appendix F (Continued)

756.15	Fusion of spine (vertebra), congenital	1	0.01
756.17	Spina bifida occulta	1	0.01
756.83	Ehlers-Danlos syndrome	1	0.01
756.9	Other and unspecified anomalies of musculoskeletal system	1	0.01
759.82	Marfan syndrome	1	0.01
759.89	Other specified congenital anomalies	1	0.01
780.2	Syncope and collapse	1	0.01
780.8	Generalized hyperhidrosis	1	0.01
786.50	Chest pain, unspecified	1	0.01
805.5	Open fracture of lumbar vertebra without mention of spinal cord injury	1	0.01
905.1	Late effect of fracture of spine and trunk without mention of spinal cord lesion	1	0.01
926.11	Crushing injury of back	1	0.01
926.8	Crushing injury of multiple sites of trunk	1	0.01
996.2	Mechanical complication of nervous system device, implant, and graft	1	0.01
996.44	Peri-prosthetic fracture around prosthetic joint	1	0.01
996.59	Mechanical complication due to other implant and internal device, not elsewhere classified	1	0.01
996.63	Infection and inflammatory reaction due to nervous system device, implant, and graft	1	0.01
996.69	Infection and inflammatory reaction due to other internal prosthetic device, implant, and graft	1	0.01
996.73	Other complications due to renal dialysis device, implant, and graft	1	0.01
V54.17	Aftercare for healing traumatic fracture of vertebrae	1	0.01

Appendix G: Lumbar/Lumbosacral, Dorsal/Dorsolumbar Surgery Frequency by Florida Hospital

Table A11: Lumbar/Lumbosacral, Dorsal/Dorsolumbar Surgery Frequency by Florida Hospital, 2010 (N=16,236)

Facility Number	Facility Name	Beds	Freq	%
100019	HOLMES REGIONAL MEDICAL CENTER - MELBOURNE	514	552	3.40
100006	ORLANDO REGIONAL MEDICAL CENTER	808	517	3.18
100204	NORTH FLORIDA REGIONAL MEDICAL CENTER - GAINESVILLE	325	424	2.61
100007	FLORIDA HOSPITAL - ORLANDO	1,067	419	2.58
100022	JACKSON MEMORIAL HOSPITAL - MIAMI	1,498	404	2.49
100088	BAPTIST MEDICAL CENTER – JACKSONVILLE	619	385	2.37
100248	LARGO MEDICAL CENTER	256	357	2.20
100212	OCALA REGIONAL MEDICAL CENTER	200	338	2.08
100023	CITRUS MEMORIAL HOSPITAL - INVERNESS	198	334	2.06
100062	MUNROE REGIONAL MEDICAL CENTER - OCALA	421	333	2.05
100087	SARASOTA MEMORIAL HOSPITAL	806	325	2.00
100040	SAINT VINCENT'S MEDICAL CENTER – JACKSONVILLE	528	314	1.93
100025	SACRED HEART HOSPITAL - PENSACOLA	466	304	1.87
100069	UNIVERSITY COMMUNITY HOSPITAL AT CARROLLWOOD - TAMPA	120	303	1.87
100127	MORTON PLANT HOSPITAL - CLEARWATER	687	296	1.82
100220	GULF COAST MEDICAL CENTER LEE MEMORIAL HEALTH SYSTEM - FORT MYERS	349	271	1.67
100264	OAK HILL HOSPITAL - BROOKSVILLE	214	266	1.64
100128	TAMPA GENERAL HOSPITAL	988	263	1.62
100034	MOUNT SINAI MEDICAL CENTER - MIAMI BEACH	955	254	1.56
100244	CAPE CORAL HOSPITAL	291	244	1.50
23960088	ST LUKE'S HOSPITAL - JACKSONVILLE	313	232	1.43
100213	BLAKE MEDICAL CENTER - BRADENTON	383	214	1.32
100258	DELRAY MEDICAL CENTER - DELRAY BEACH	493	212	1.31
100018	NAPLES COMMUNITY HOSPITAL	420	205	1.26
100009	UNIVERSITY OF MIAMI HOSPITAL	560	193	1.19
100017	HALIFAX HEALTH MEDICAL CENTER - DAYTONA BEACH	654	193	1.19
100075	ST JOSEPHS HOSPITAL - TAMPA	807	191	1.18
100236	FAWCETT MEMORIAL HOSPITAL - PORT CHARLOTTE	238	189	1.16
100166	DOCTORS HOSPITAL OF SARASOTA	168	183	1.13
100239	EDWARD WHITE HOSPITAL - SAINT PETERSBURG	167	178	1.10
23960017	FLORIDA HOSPITAL CELEBRATION HEALTH - CELEBRATION	112	177	1.09
100012	LEE MEMORIAL HOSPITAL - FORT MYERS	415	174	1.07

Appendix G (Continued)

100231	WEST FLORIDA HOSPITAL - PENSACOLA	531	162	1.00
100080	JFK MEDICAL CENTER - ATLANTIS	460	159	0.98
23960025	PHYSICIANS REGIONAL MEDICAL CENTER - PINE RIDGE - NAPLES	101	159	0.98
100243	BRANDON REGIONAL HOSPITAL	407	158	0.97
100113	SHANDS HOSPITAL AT THE UNIVERSITY OF FLORIDA - GAINESVILLE	852	157	0.97
100151	MAYO CLINIC - JACKSONVILLE	214	153	0.94
100093	BAPTIST HOSPITAL INC - PENSACOLA	492	152	0.94
110199	MIAMI CHILDREN'S HOSPITAL	289	145	0.89
100026	BAY MEDICAL CENTER - PANAMA CITY	323	141	0.87
100131	AVENTURA HOSPITAL AND MEDICAL CENTER	407	137	0.84
100161	CENTRAL FLORIDA REGIONAL HOSPITAL - SANFORD	226	135	0.83
100043	MEASE DUNEDIN HOSPITAL - DUNEDIN	143	134	0.83
100073	HOLY CROSS HOSPITAL INC - FORT LAUDERDALE	571	132	0.81
100028	PARRISH MEDICAL CENTER - TITUSVILLE	210	125	0.77
100253	JUPITER MEDICAL CENTER	163	125	0.77
100168	BOCA RATON COMMUNITY HOSPITAL	400	124	0.76
100223	FORT WALTON BEACH MEDICAL CENTER	257	124	0.76
100249	SEVEN RIVERS REGIONAL MEDICAL CENTER - CRYSTAL RIVER	128	124	0.76
100260	SAINT LUCIE MEDICAL CENTER - PORT SAINT LUCIE	229	123	0.76
100254	CAPITAL REGIONAL MEDICAL CENTER - TALLAHASSEE	198	119	0.73
100242	GULF COAST MEDICAL CENTER - PANAMA CITY	176	115	0.71
100250	ALL CHILDREN'S HOSPITAL INC - SAINT PETERSBURG	259	110	0.68
110001	MEASE COUNTRYSIDE HOSPITAL - SAFETY HARBOR	300	106	0.65
100183	CORAL GABLES HOSPITAL	245	105	0.65
100038	MEMORIAL REGIONAL HOSPITAL - HOLLYWOOD	713	104	0.64
100084	LEESBURG REGIONAL MEDICAL CENTER	294	98	0.60
100191	COMMUNITY HOSPITAL - NEW PORT RICHEY	389	95	0.59
110010	WELLINGTON REGIONAL MEDICAL CENTER	158	94	0.58
100030	HEALTH CENTRAL - OCOEE	171	93	0.57
100002	BETHESDA MEMORIAL HOSPITAL - BOYNTON BEACH	401	90	0.55
100008	BAPTIST HOSPITAL OF MIAMI	680	88	0.54
23960052	BAPTIST MEDICAL CENTER SOUTH - JACKSONVILLE	196	88	0.54
100157	LAKELAND REGIONAL MEDICAL CENTER	851	87	0.54
100044	MARTIN MEMORIAL MEDICAL CENTER - STUART	244	86	0.53
110003	GULF BREEZE HOSPITAL - GULF BREEZE	65	85	0.52
100176	PALM BEACH GARDENS MEDICAL CENTER - PALM BEACH GARDENS	199	78	0.48

Appendix G (Continued)

120001	ARNOLD PALMER MEDICAL CENTER - ORLANDO	443	78	0.48
120009	MARTIN MEMORIAL HOSPITAL SOUTH - STUART	100	78	0.48
100137	HEART OF FLORIDA REGIONAL MEDICAL CENTER - DAVENPORT	194	77	0.47
100070	VENICE REGIONAL MEDICAL CENTER	312	75	0.46
100181	LARKIN COMMUNITY HOSPITAL - SOUTH MIAMI	142	75	0.46
100010	SAINT MARY'S MEDICAL CENTER - WEST PALM BEACH	463	73	0.45
100032	BAYFRONT MEDICAL CENTER INC - SAINT PETERSBURG	480	72	0.44
100225	MEMORIAL REGIONAL HOSPITAL SOUTH - HOLLYWOOD	280	72	0.44
100061	MERCY HOSPITAL - MIAMI	473	68	0.42
100072	FLORIDA HOSPITAL FISH MEMORIAL - ORANGE CITY	139	68	0.42
100135	TALLAHASSEE MEMORIAL HOSPITAL	770	68	0.42
100047	CHARLOTTE REGIONAL MEDICAL CENTER - PUNTA GORDA	208	67	0.41
100219	FLAGLER HOSPITAL - SAINT AUGUSTINE	316	66	0.41
100173	UNIVERSITY COMMUNITY HOSPITAL - TAMPA	475	64	0.39
100035	MANATEE MEMORIAL HOSPITAL - BRADENTON	319	63	0.39
100077	PEACE RIVER REGIONAL MEDICAL CENTER - PORT CHARLOTTE	219	62	0.38
100105	INDIAN RIVER MEDICAL CENTER - VERO BEACH	335	62	0.38
100256	REGIONAL MEDICAL CENTER BAYONET POINT - HUDSON	290	62	0.38
110009	H LEE MOFFITT CANCER CTR & RESEARCH INSTITUTE HOSPITAL – TAMPA	206	62	0.38
100224	UNIVERSITY HOSPITAL AND MEDICAL CENTER - TAMARAC	317	61	0.38
100179	MEMORIAL HOSPITAL JACKSONVILLE	425	60	0.37
100109	FLORIDA HOSPITAL HEARTLAND MEDICAL CENTER - SEBRING	159	59	0.36
100054	TWIN CITIES HOSPITAL - NICEVILLE	65	57	0.35
100154	SOUTH MIAMI HOSPITAL, INC	467	54	0.33
23960041	SACRED HEART HOSPITAL ON THE EMERALD COAST - MIRAMAR BEACH	58	53	0.33
100052	WINTER HAVEN HOSPITAL	466	50	0.31
100055	HELEN ELLIS MEMORIAL HOSPITAL - TARPON SPRINGS	168	50	0.31
120002	DR P PHILLIPS HOSPITAL - ORLANDO	237	45	0.28
100169	FLORIDA HOSPITAL MEMORIAL MEDICAL CENTER - DAYTONA BEACH	277	44	0.27
100039	BROWARD GENERAL MEDICAL CENTER - FORT LAUDERDALE	716	42	0.26
23960034	WUESTHOFF MEDICAL CENTER – MELBOURNE	115	42	0.26
100234	COLUMBIA HOSPITAL - WEST PALM BEACH	250	39	0.24

Appendix G (Continued)

110006	PALMS WEST HOSPITAL - LOXAHATCHEE	175	39	0.24
100110	OSCEOLA REGIONAL MEDICAL CENTER - KISSIMMEE	235	35	0.22
100228	WESTSIDE REGIONAL MEDICAL CENTER - PLANTATION	224	35	0.22
110403	GOOD SAMARITAN MEDICAL CENTER - WEST PALM BEACH	333	35	0.22
100020	DOCTORS HOSPITAL INC - CORAL GABLES	281	34	0.21
100180	ST PETERSBURG GENERAL HOSPITAL	219	34	0.21
100238	NORTHSIDE HOSPITAL - SAINT PETERSBURG	288	29	0.18
100246	LAWNWOOD REGIONAL MEDICAL CENTER & HEART INSTITUTE - FORT PIERCE	341	29	0.18
100086	NORTH BROWARD MEDICAL CENTER - POMPANO BEACH	409	27	0.17
100162	WINTER PARK MEMORIAL HOSPITAL	331	27	0.17
120005	HEALTHPARK MEDICAL CENTER - FORT MYERS	368	24	0.15
100051	SOUTH LAKE HOSPITAL - CLERMONT	104	23	0.14
100092	WUESTHOFF MEDICAL CENTER-ROCKLEDGE - ROCKLEDGE	291	23	0.14
100122	NORTH OKALOOSA MEDICAL CENTER - CRESTVIEW	110	23	0.14
100217	SEBASTIAN RIVER MEDICAL CENTER - SEBASTIAN	129	23	0.14
100126	PALMS OF PASADENA HOSPITAL - SAINT PETERSBURG	307	21	0.13
100200	IMPERIAL POINT MEDICAL CENTER - FORT LAUDERDALE	204	20	0.12
100177	CAPE CANAVERAL HOSPITAL - COCOA BEACH	150	17	0.10
100001	SHANDS JACKSONVILLE MEDICAL CENTER - JACKSONVILLE	695	16	0.10
111527	MEMORIAL HOSPITAL WEST - PEMBROKE PINES	304	16	0.10
100209	KENDALL REGIONAL MEDICAL CENTER - MIAMI	412	15	0.09
100226	ORANGE PARK MEDICAL CENTER - ORANGE PARK	255	15	0.09
23960046	LAKEWOOD RANCH MEDICAL CENTER - BRADENTON	120	15	0.09
120004	FLORIDA HOSPITAL ALTAMONTE - ALTAMONTE SPRINGS	341	14	0.09
100189	NORTHWEST MEDICAL CENTER - MARGATE	215	13	0.08
100210	NORTH SHORE MEDICAL CENTER - FMC CAMPUS - LAUDERDALE LAKES	459	11	0.07
100057	FLORIDA HOSPITAL WATERMAN - TAVARES	204	10	0.06
110008	WEST BOCA MEDICAL CENTER - BOCA RATON	195	10	0.06
100014	BERT FISH MEDICAL CENTER - NEW SMYRNA BEACH	112	9	0.06
100029	NORTH SHORE MEDICAL CENTER - MIAMI	357	9	0.06
100056	CLEVELAND CLINIC HOSPITAL - WESTON	155	8	0.05
100071	BROOKSVILLE REGIONAL HOSPITAL	120	8	0.05

Appendix G (Continued)

120006	NCH HEALTHCARE SYSTEM NORTH NAPLES HOSPITAL CAMPUS - NAPLES	261	7	0.04
100187	PALMETTO GENERAL HOSPITAL - HIALEAH	360	6	0.04
100114	JACKSON NORTH MEDICAL CENTER - NORTH MIAMI BEACH	382	5	0.03
100255	TOWN & COUNTRY HOSPITAL - TAMPA	201	5	0.03
23960032	VILLAGES REGIONAL HOSPITAL, THE - THE VILLAGES	198	5	0.03
100121	BARTOW REGIONAL MEDICAL CENTER	72	4	0.02
110012	SHRINERS HOSPITALS FOR CHILDREN-TAMPA	60	4	0.02
100053	HIALEAH HOSPITAL	378	3	0.02
100067	ST ANTHONY'S HOSPITAL - SAINT PETERSBURG	395	3	0.02
100063	MORTON PLANT NORTH BAY HOSPITAL - NEW PORT RICHEY	154	2	0.01
100015	LARGO MEDICAL CENTER - INDIAN ROCKS	166	1	0.01
100230	MEMORIAL HOSPITAL PEMBROKE - PEMBROKE PINES	301	1	0.01
100259	SOUTH BAY HOSPITAL - SUN CITY CENTER	112	1	0.01

Appendix H: Patient and Demographic Details of Federal Insurance Payment for ICD-9-CM Procedure Code 81.05

Table A12: Patient and Demographic Details of Federal Insurance Payment for ICD-9-CM Procedure Code 81.05 (n=36)

Obs	Gender	Age	Payer	Principal Diagnosis	Facility Number	Facility Name
1	F	9	TRICARE	737.30	100075	ST JOSEPHS HOSPITAL
2	M	10	TRICARE	737.30	100025	SACRED HEART HOSPITAL
3	F	11	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
4	M	11	TRICARE	754.2	120001	ARNOLD PALMER MEDICAL CENTER
5	M	12	TRICARE	737.39	100088	BAPTIST MEDICAL CENTER
6	F	12	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
7	M	12	TRICARE	737.30	100025	SACRED HEART HOSPITAL
8	F	13	TRICARE	737.30	100075	ST JOSEPHS HOSPITAL
9	F	13	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
10	F	13	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
11	F	13	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
12	F	14	TRICARE	330.8	100025	SACRED HEART HOSPITAL
13	F	14	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
14	F	15	TRICARE	737.30	110199	MIAMI CHILDREN'S HOSPITAL
15	F	15	TRICARE	737.30	100173	UNIVERSITY COMMUNITY HOSPITAL
16	F	16	TRICARE	737.30	100069	UNIVERSITY COMMUNITY HOSPITAL AT CARROLLWOOD
17	F	16	TRICARE	737.39	120001	ARNOLD PALMER MEDICAL CENTER

Appendix H (Continued)

18	M	16	TRICARE	737.30	100025	SACRED HEART HOSPITAL
19	M	17	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
20	F	17	TRICARE	737.30	100173	UNIVERSITY COMMUNITY HOSPITAL
21	M	17	TRICARE	737.30	100088	BAPTIST MEDICAL CENTER
22	F	38	TRICARE	996.43	100244	CAPE CORAL HOSPITAL
23	F	45	TRICARE	733.13	100157	LAKELAND REGIONAL MEDICAL CENTER
24	M	48	TRICARE	732.0	100040	SAINT VINCENT'S MEDICAL CENTER
25	F	53	TRICARE	737.12	100019	HOLMES REGIONAL MEDICAL CENTER
26	M	53	TRICARE	733.13	100019	HOLMES REGIONAL MEDICAL CENTER
27	F	54	TRICARE	737.30	100113	SHANDS HOSPITAL AT THE UNIVERSITY OF FLORIDA
28	M	55	VA	722.11	100019	HOLMES REGIONAL MEDICAL CENTER
29	M	55	VA	198.5	100128	TAMPA GENERAL HOSPITAL
30	M	61	TRICARE	721.41	100006	ORLANDO REGIONAL MEDICAL CENTER
31	M	61	VA	806.29	100157	LAKELAND REGIONAL MEDICAL CENTER
32	M	62	TRICARE	996.49	100054	TWIN CITIES HOSPITAL
33	F	62	TRICARE	724.02	100231	WEST FLORIDA HOSPITAL
34	M	63	TRICARE	722.11	100179	MEMORIAL HOSPITAL JACKSONVILLE
35	F	68	VA	733.13	100023	CITRUS MEMORIAL HOSPITAL
36	M	77	VA	198.5	100248	LARGO MEDICAL CENTER

Appendix I: Graph of Age Distribution of the Control Population

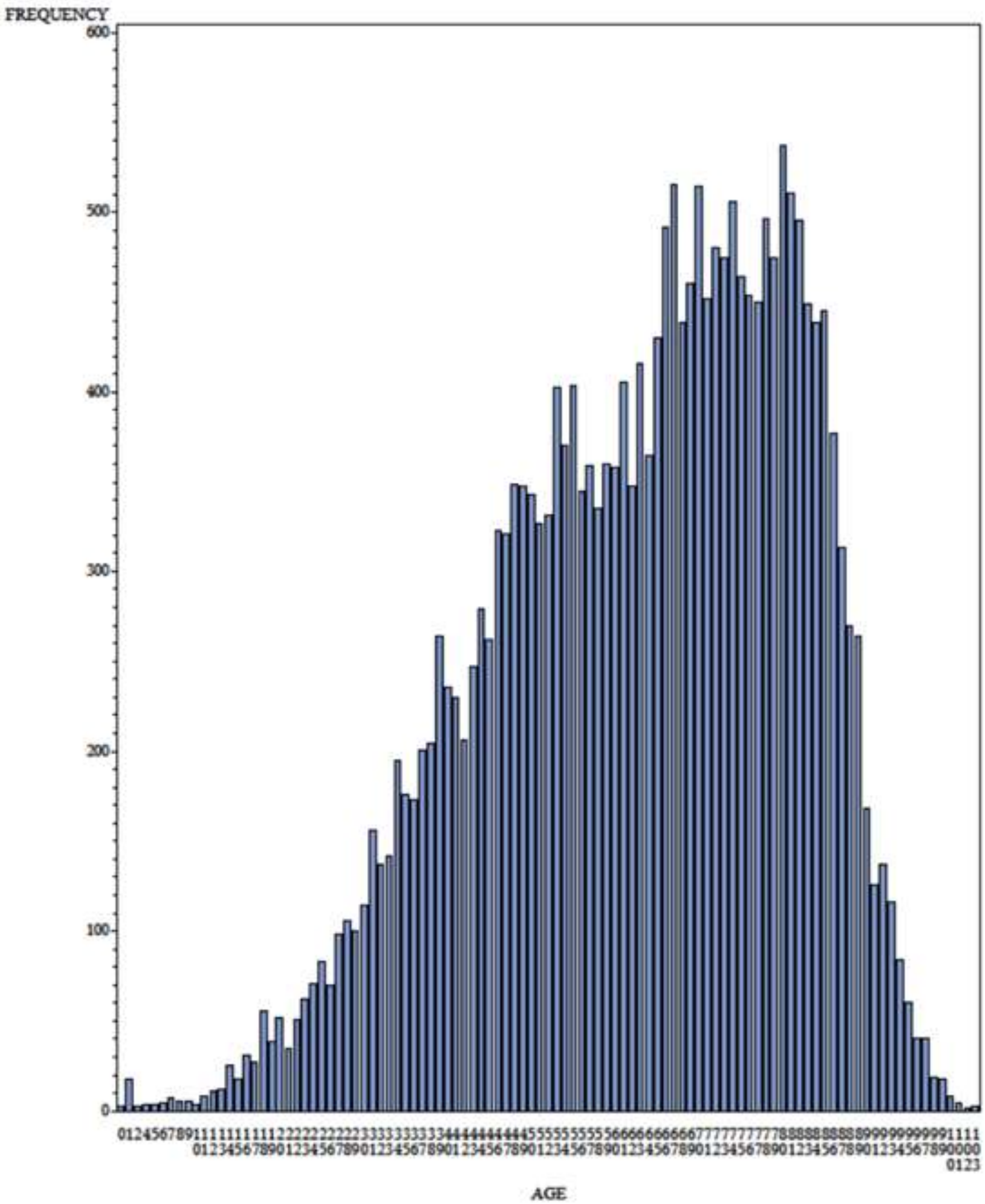

Figure A1: Frequency of Admitted Patients in the Control Population, by Age (N=21,856)

Appendix J: Graph of Age Distribution of the Study Population

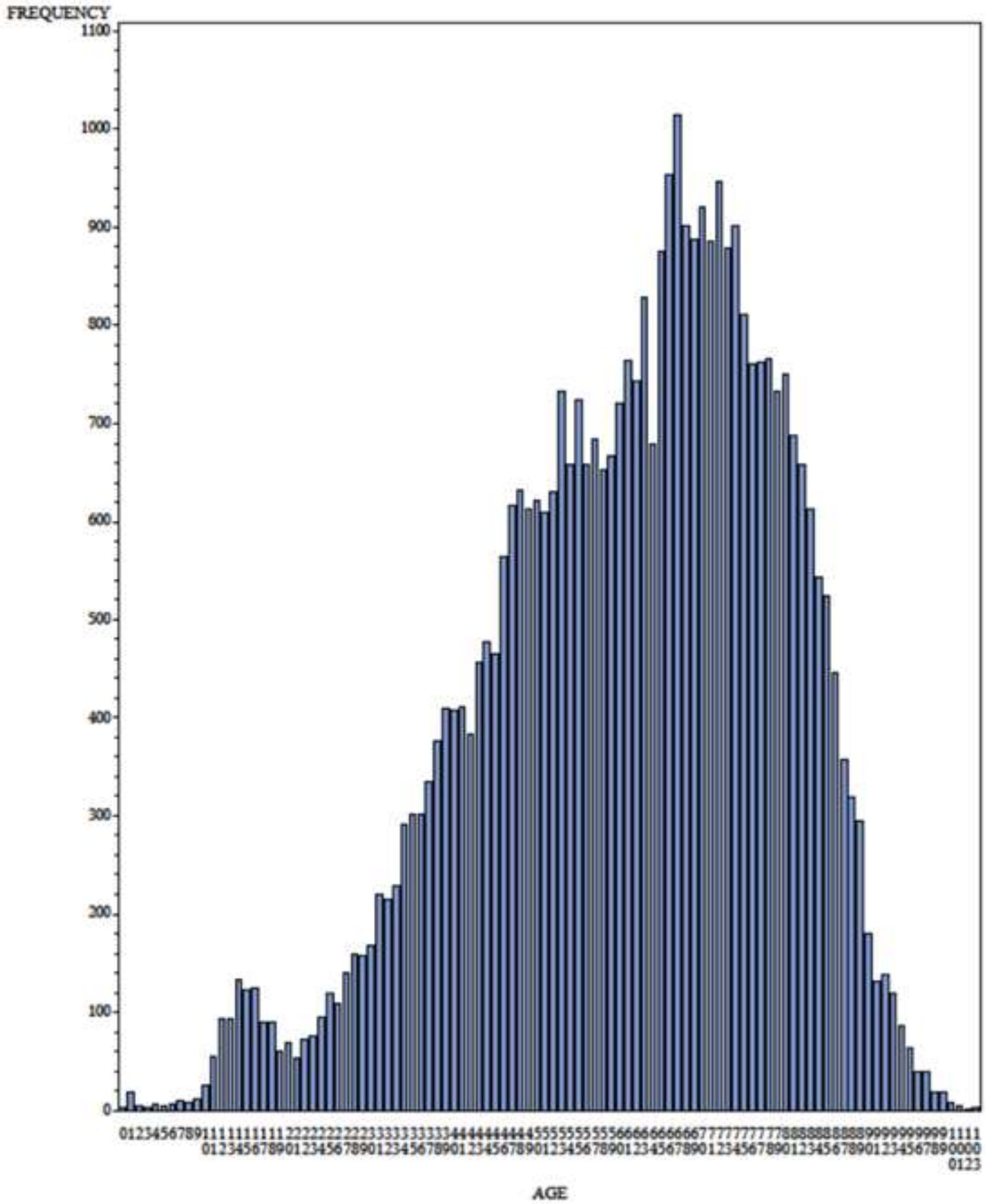

Figure A2: Frequency of Admitted Patients in the Study Population by Age (N=38,092)

Appendix K: Phi Coefficients for the Independent Variables

Table A13: Total Population Phi Coefficients

	GENDER	AGE	RACE	PAYER
GENDER	1.00	0.10	0.02	0.14
AGE	0.09	1.00	0.17	0.78
RACE	0.02	0.17	1.00	0.15
PAYER	0.14	0.78	0.15	1.00

Table A14: Case Population Phi Coefficients

	GENDER	AGE	RACE	PAYER
GENDER	1.00	0.09	0.02	0.11
AGE	0.09	1.00	0.20	0.77
RACE	0.02	0.20	1.00	0.16
PAYER	0.11	0.77	0.16	1.00

Table A15: Control Population Phi Coefficients

	GENDER	AGE	RACE	PAYER
GENDER	1.00	0.12	0.03	0.17
AGE	0.12	1.00	0.16	0.79
RACE	0.03	0.16	1.00	0.16
PAYER	0.17	0.79	0.16	1.00