INVESTIGATING RESOURCE UTILIZATION IN ELECTIVE SPINE PATIENTS WITH AFFECTIVE DISORDERS: A RETROSPECTIVE ANALYSIS OF A COHORT OF 1199 ELECTIVE SPINE PATIENTS

by

ZACHARY CHRISTIAN

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ABSTRACT

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ZACHARY CHRISTIAN
The University of Texas Southwestern Medical Center, 2021
Supervising Professor: Carlos A. Bagley, M.D., M.B.A

Background: In elective spine surgery patients, affective disorders (ADs) are associated with increased preoperative opioid use to control pain, longer length of hospital stays, and increased postoperative readmission rates. When assessing healthcare resource utilization, how ADs influence perioperative electronic patient portal (EPP) communication with care providers has not been explored. It is also unclear how ADs influence in-patient and postoperative opioid consumption.

Objective: To investigate the resource utilization of patients with ADs in our population by analyzing the relationship between AD and both perioperative EPP communication, opioid use, and surgical outcomes.

Methods: The records of 1199 consecutive adult patients who underwent elective spinal surgery between January 2010 and August 2017 at a single institution were retrospectively reviewed for analysis. Primary outcomes included the number of perioperative EPP messages sent, perioperative narcotic use, rates of peri-operative complications, hospital length of stays, Emergency Department visits within 6 weeks, and readmissions within 30 after surgery. In the subanalysis, patients with patient-reported outcome measures for pain, anxiety, and depression within 30 days prior to surgery were used to assess whether preoperative narcotic use correlated with reported preoperative pain levels.

Results: Patients with an AD were more likely to take narcotics before surgery and to have active EPP accounts compared to controls. They were also more likely to send postoperative messages, and tended to send more messages. The AD group had higher rates of postoperative complications, ED visits, and readmissions postoperatively. The AD group also requirement more opioid in the inpatient setting and were more likely to refill prescriptions for opioid medications 3- and 12-months after surgery. In the subanalysis, the average rating of pain intensity was notably higher in the AD group; however, there was no statistically significant difference in rates of narcotic use between low- and high-pain cohorts. This was not the case for the control group.

Conclusion: AD patients have increased EPP communication, perioperative opioid use, and postoperative complications. Addressing these concerns early and advocating for resources for this population may prevent more serious morbidity, reduce costs, address the opioid crisis, and improve patient care.

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PRIOR PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

1. Christian ZK, Aoun SG, Afuwape O, Adeyemo E, Barrie U, Badejo O, Dosselman LJ, Pernik MN, Hall K, Reyes VP, El Ahmadieh TY, Al Tamimi M, Bagley CA. Electronic Communication Patterns Could Reflect Preoperative Anxiety and Serve as an Early Complication Warning in Elective Spine Surgery Patients with Affective Disorders: A Retrospective Analysis of a Cohort of 1199 Elective Spine Patients. World Neurosurg. 2020 Sep;141:e888-e893. doi: 10.1016/j.wneu.2020.06.082. Epub 2020 Jun 17. PMID: 32561492.
2. Christian Z, Afuwape O, Johnson ZD, Adeyemo E, Barrie U, Dosselman LJ, Pernik MN, Hall K, Aoun SG, Bagley CA. Evaluating the Impact of Psychiatric Disorders on Preoperative Pain Ratings, Narcotics Use, and the PROMIS-29 Quality Domains in Spine Surgery Candidates. Cureus. 2021 Jan 18;13(1):e12768. doi: 10.7759/cureus.12768. PMID: 33614357; PMCID: PMC7888361.

PRESENTATIONS

1. Afuwape O., & Christian Z.K., & Aoun S.G., & Hall K., & Bagley C.A. (October, 2019). The Relationship Between the Number of MyChart Encounters and Affective Disorders in the Spine Population: A Retrospective Review. Poster presented at: 2019 Congress of Neurological Surgeons Annual Meeting; San Francisco, CA, USA.
2. Christian, Z.K., & Johnson, Z.D., & Aoun, S.G., & Bagley, C.A. (October, 2020). Perioperative Factors That Predict Long-term Opioid Requirements After Spine Surgery. Oral Presentation presented at: UT Southwestern End-of-Rotation Sub-I Presentations; Dallas, TX, USA.

LIST OF ABBREVIATIONS

- AD – Affective Disorder
- ED – Emergency Department
- EPP – Electronic Patient Portal
- IV – Intravenous
- LOS – Length of Stay
- MME – Morphine Milligram Equivalents
- PCA – Patient Controlled analgesia
- PO – Per Os
- PROMIS-29 – Patient Reported Outcomes Measures Information System – 29

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CHAPTER ONE: INTRODUCTION

Affective disorders (ADs), specifically depression, have been shown to negatively affect surgical recovery and prognosis across multiple specialties.[1-5] This impact is amplified in processes with a significant subjective and cognitive component such as degenerative joint or spine disease, as affect can heavily influence the way we perceive pain.[4,6] In the specific setting of spine disease and chronic axial and radicular pain, ADs have been shown to influence patient reported outcome measures before and after surgery and result in decreased perceived gain from surgery.[7-10] This translates into lower patient satisfaction rates and postoperative quality of life, as well as decreased willingness to work with physical therapy after surgery and to regain a measure of independence that would allow resuming of gainful employment.[2,4,11] Affective disorders have the potential effect of adding direct costs to spinal surgery procedures by increasing the incidence of postoperative complications, length of stay, and unplanned readmission rates.[4,9,10] They have also been shown to increase indirect costs by raising postoperative disability rates.[12-14]

This pain perception also contributes to the need for opioid medication to control pain, another cost to the healthcare system. Spinal surgery candidates with chronic back pain have an increased prevalence for preoperative opioid medication compared to the general population.[15] This association is most notable in patients with depression, which is also an independent risk factor for opioid abuse.[16,17] Furthermore, patients with affective disorders (AD) have revealed an association between pain severity and affect, especially when considering the positive correlation between preoperative ratings of depression and anxiety and postoperative perceptions of pain.[2,18-20]

A hidden indirect cost is the strain that these disorders can create on perioperative medical communication with care providers, by increasing patient need for repeated reassurance both before and after surgical procedures. While Electronic Patient Portals (EPPs) have allowed for earlier intervention in patient care and improvement in patient satisfaction scores[21,22], overutilization can stress the physician-patient relationship, and ultimately result in suboptimal care. The objective of this study was to investigate the resource utilization of patients with AD in our population both by analyzing the relationship between AD and both EPP communication and perioperative opioid use, in a retrospective cohort of patients undergoing elective spine surgery at a single institution, and to attempt to understand how these relationships influence surgical outcomes. As a secondary goal, we also wanted to investigate the relationship between preoperative ratings of pain and opioid use amongst AD patients. The conditions that were studied included depression as well as the other entities of the AD spectrum. We also assessed the influence of AD on preoperative narcotic use, surgical outcome, and readmission rates in this patient population, to rule out any aberrant behavior that would justify patterns of communication through the electronic portal. We hypothesized that affective disorder would affect patient communication, increase opioid requirements before and after surgery, and lead to negative surgical outcomes.

CHAPTER TWO: EXPERIMENTAL PROCEDURES

Protocol

The study protocol was approved by our institutional review board (STU 102017-011). This was a retrospective single-center, multiple-surgeon study that included all consecutive patients who underwent elective spine surgery between January 2010 and August 2017. Patient data were prospectively collected in our spine database and retrospectively reviewed using our electronic medical record system for this analysis. Patient consent was not required for retrospective data pooling as patient data were deidentified once collected, as is standard at our institution.

Population Selection Criteria

All adult patients (18+) who had undergone a spinal procedure at our institution were retrospectively reviewed and included in the analysis. Spinal procedures included posterior cervical, anterior cervical, thoracic or lumbar short (≤4 segments), and thoracic or lumbar long (≥5 segments) decompression and/or fusion procedures. The patients were divided into 2 groups. Patients who had received a psychiatric diagnosis of depression, anxiety, bipolar disorder, panic disorder, obsessive-compulsive disorder, and/or posttraumatic stress disorder and were medically treated for their condition were labeled as part of the AD group. The remainder of the patients served as a control group. All patients with an AD were followed and treated by a certified psychiatrist and were cleared by their psychiatrist to undergo their spine surgery. We decided not to subdivide patients according to their psychiatric diagnosis in our analysis, as individuals often carried more than one in the AD spectrum.

For the subset analysis investigating the relationship between preoperative ratings of pain and opioid use amongst AD patients, we included the inclusion criteria of having who underwent elective spine surgery with available patient reported Patient-Reported Outcomes Measurement

Information System- 29 (PROMIS-29) scores within 30 days prior to surgery. PROMIS-29 measures were used to assess levels of anxiety, depression, pain intensity, and pain interference prior to surgery (Appendix A).

Outcome Measures

Electronic Patient Portal Utilization

The EPP studied was MyChart (EPIC Systems Corporation, Madison, Wisconsin, USA). Patients who had an active EPP account were analyzed, and those who had sent at least 1 electronic message preoperatively were labeled as EPP Users. Outcome measures for this study included the number of EPP messages that were sent by the patient to the physician within 30 days before the procedure, within 6 weeks after the procedure, and between 6 and 12 weeks after the procedure, as documented in the electronic medical record. During this period, spine surgeons were included on all messaging sent by the patient. These messages included communication addressed to the spine surgeon, nurse practitioner, and office nursing staff. The follow-up of all patients was with our spine center for the first 90 days after surgery, and no patient was referred to an outside office during that period.

Perioperative measures and prognosis

Demographic and clinical variables were collected to assess potential differences between the AD and control groups. Demographic variables included age, gender, and race. Perioperative outcome measures included alcohol and tobacco use, opioid use preoperatively, in-hospital, and 3- and 12-months postoperatively, pain, depression, and anxiety ratings collected within 30 days prior to the spinal procedure using the PROMIS-29 Pain Intensity, Pain Interference, Depression, and Anxiety domains, intraoperative and postoperative complications, hospital length of stay, emergency department (ED) visits 6 weeks after surgery; and hospital readmissions within 30 days. Narcotic users were defined as patients who were prescribed any narcotic medication within 30 days before the spinal procedure. Opioid medications included buprenorphine, codeine, fentanyl, hydrocodone, hydromorphone, meperidine, methadone, morphine, oxycodone, pentazocine, tapentadol, and tramadol.

Total opioid use while inpatient was collected from oral (PO), intravenous (IV), and pain controlled analgesia (PCA) routes, and then converted into morphine milligram equivalents (MME) to standardize the opioid consumption in accordance with the CDC guidelines for opioid prescription practices and as previously reported in the literature.[23,24] The total MME Opioid intake pre-operatively, intra-operatively, or while the patient was in the post-anesthesia care unit was not included. The total MME was then divided by length of stay (LOS) to calculate an average opioid consumption per hospital day.

Statistical Analysis

Descriptive statistics included mean and standard deviation. For continuous variables, significance was assessed using a simple 1-tailed t-test. The Fisher exact test was used to compare dichotomous variables between groups and assess differences in incidence. Statistical significance was set at $\alpha = 0.05$. The software used for the statistical analysis was SPSS version 25 (IBM Corporation, Armonk, New York, USA).

CHAPTER THREE: RESULTS

Patient Demographics

A total of 1199 patients were identified to be included in the study. The AD group consisted of 621 patients, and the control group had 578 patients (Table 1). Most patients in the AD group were female (55.72%), while the control group consisted mostly of males (64.71%). The majority of patients in both groups were white.

Clinical Characteristics of the Affective Disorders group

In the AD group, 47.18% of patients were diagnosed with depression, 35.10% with anxiety disorder, 1.93% with bipolar disorder, 1.29% with posttraumatic stress disorder, 0.81% with obsessive-compulsive disorder, and 0.64% with panic disorder (Supplemental Table 1). There were 241 patients in the AD group (38.81%) with an unspecified mood disorder, with 68% on antidepressants, 31.5% on anxiolytics, and 0.5% on a mood stabilizer (Supplemental Table 2).

Patient Social History

There was no difference in the history of alcohol or tobacco consumption between the AD and the control group (Table 1). However, the AD group had higher rate of narcotic use in the preoperative period (51.69% vs. 41%, $P < 0.001$).

Procedural Characteristics

Most spinal procedures performed were short lumbar surgical procedures in both groups. However, the incidence of patients undergoing short lumbar procedures was higher in the control group compared with the AD group (69.55% vs. 63.77%, $P = 0.017$). There was no difference between the groups regarding the other types of procedures (Table 1).

Electronic Patient Portal Utilization

More patients in the AD groups had an active EPP account compared with the controls

(75.36% vs. 69.75%, P = 0.014). There was no difference in the percentage of patients who declined opening an EPP account or allowed it to expire between the groups (Table 1).

When considering all patients with an active EPP account at the time of surgery (n=871) (Table 2), there was no difference in the percentage of patients in both groups who sent at least 1 preoperative electronic message (EPP Users, P = 0.345). However, more patients with ADs sent postoperative messages within 6 weeks of the procedure when compared with controls (38.89% vs. 32.75%, P = 0.030), and a comparable number of messages were sent by both groups. There was no difference in the percentage of patients who sent messages between 6 and 12 weeks between the AD group and the controls, however, more messages were sent by patients with an AD compared with controls (0.67 vs. 0.48, P = 0.034).

To account for individuals with active EPP accounts who chose not to use their account, we defined a subcategory of patients who sent at least 1 preoperative message as “EPP Users” (n = 326). There was a similar number of EPP Users in both groups (P = 0.345) (Table 3). While there was a comparable number of EPP Users actively using their account after surgery at 6 weeks and between 6 and 12 weeks, patients with AD were sending more messages per patient compared with the control group during the 6- to 12-week interval (1.3 vs. 0.86, P = 0.048).

There was no difference in the percentage of patients who made preoperative and postoperative phones calls to the clinic providers between the AD and the control groups (Table 3).

Intraoperative and Postoperative Outcomes

Major surgical outcomes are summarized in Table 4 and Table 5. The incidence of intraoperative complications and the average length of hospital stay were not significantly different between the AD and control groups (P = 0.1). However, the rate of postoperative complications was notably higher in the AD group compared with the control group (8.21% vs. 3.98%, P = 0.001). The most common complications were wound infections and wound dehiscence (Supplemental Tables 3 and 4). In addition, patients in the AD group had a higher rate of ED visits within 6 weeks of the spinal procedure (4.99% vs. 2.43%, P = 0.009), with some patients having as many as 3 visits, which did not warrant readmission (Supplemental Table 5). The incidence of patients with at least 1 readmission 30 days postoperatively was higher in the AD group (2.49% vs. 1.38%, P = 0.049) (Table 5).

There was no difference in the percentage of patients in the AD and control groups who required opioid medications to control pain (Table 4). However, AD patients required significantly more total MME to control pain (159.17 vs. 86.61, p=0.05). In fact, the average MME intake per day was significantly higher in the AD group vs the control group (27.45 vs 18.57, p<0.001). In addition, AD patients were more likely to refill prescriptions for opioid medications 3 months (33.55% vs. 23.05%, p<0.001) and 12 months (12.30% vs. 7.97%, p=0.006) after surgery (Table 5).

Subset Analysis

Patient Demographics

A total of 117 patients were identified to be included in the subset analysis. The AD group consisted of 61 patients and the control group of 56 patients (Table 6). Most patients in the affective disorder group were female (60.66%), while the control group consisted mostly of males (66.07%). The majority of patients in both groups were White.

Clinical Characteristics of the AD group

In the AD group, 49.18% of patients were diagnosed with depression, 36.07% with anxiety disorder, 1.64% with bipolar disorder, and 1.64% with post-traumatic stress disorder (Supplemental Table 6). There were 24 patients in the AD group (39.34%) with an unspecified mood disorder, with 75% on antidepressants, 37.5% on anxiolytics, and 4.17% on a mood stabilizer (Supplemental Table 7).

Procedural Characteristics

Most spinal procedures performed were short lumbar surgical procedures in both groups. Both groups also had a comparable percentage of patients who underwent each procedural subtype (Table 6).

Social History

There was no difference in the history of alcohol or tobacco consumption between the AD and the control group. There was also no difference in the number of patients with a spine surgery history (Table 6).

Overall Pain scores amongst AD and controls

The average rating of Pain Intensity was notably higher in the affective disorder group compared to the control group (7.05 vs 5.91, p=0.004) (Table 6).

Perioperative Outcomes between Low-Pain Cohort (≤6) and High-Pain Cohort (>6)

Patient Demographics

Table 7 demonstrates the mean difference in perioperative outcomes between control and affective disorder groups when the two groups are further subdivided by preoperative pain intensity score, “Low-Pain” ((≤6 Pain score) and “High-Pain” (>6 Pain Score) cohorts. The AD group had significantly more patients in the high-pain cohort compared to controls (68.85% vs 41.07%, p=0.001). For both the AD and control groups, the majority of black patients were in the high-pain cohort (AD: 11.90% vs 0%, p=0.012; control: 30.43% vs 3.03%, p=0.006). Amongst controls, Hispanics fell into the low-pain cohort (2.18% vs 0%, p=0.022). In addition, the average age of controls in the high-pain cohort was greater than the low-pain cohort (64.57 vs 56.67, p=0.029). This was not the case for AD patients.

PROMIS-29 Ratings

Amongst both controls and AD patients, high Pain Intensity ratings correlated with high Pain Interference levels (AD: 17.94 vs 10.73, p<0.001; control: 15.52 vs 11.73, p=0.004); however, for the AD group, it was also associated with higher levels of preoperative depression (9.18 vs 5.67, p<0.001) and anxiety (9.70 vs 6.67, p=0.005).

Patient Medical History

There was no difference in surgical history between patients with affective disorders and control. In addition, amongst AD patients, there was no difference in psychiatric medication use prior to surgery between low-pain and high-pain cohorts as well (Table 7).

Patient Social History

There was no difference in the history of alcohol or tobacco use between low-pain and high-pain cohorts amongst AD and control groups. However, controls in the high-pain cohort had higher rates of preoperative narcotic use compared to the low-pain cohort (65.22% versus 39.39%, p=0.029). Amongst AD patients, there was no statistically significant difference in rates of narcotic use between low- and high-pain cohorts. (Table 7).

Procedural Characteristics

In both AD and control groups, the majority of patients who underwent lumbar short surgeries reported higher levels of preoperative pain (AD: 73.81% vs 47.37%, p=0.023; control: 86.96% vs 57.58%, p=0.006). In addition, the majority of patients who had anterior cervical surgeries reported lower levels of preoperative pain (AD: 16.67% vs 42.11%, p=0.030; control: 4.35% vs 24.24%, p=0.014). Pain levels were not notable for lumbar long and posterior cervical surgeries (Table 7).

Perioperative Outcomes

The incidence of intraoperative complications, average length of hospital stay, postoperative complications, Emergency Department visits within 6 week, and readmission 30 days postoperatively were not significantly different between the low-pain and high-pain cohorts (Table 7).

CHAPTER FOUR: DISCUSSION

The main objective of this study was to investigate the relationship between a preoperative diagnosis of AD and narcotic use, surgical outcomes, resource utilization, and complications after a wide array of spinal procedures. As a secondary, we also wanted to determine the impact of AD on preoperative pain ratings, pain interference using the PROMIS-29 questionnaire, and preoperative narcotic use. We attempted to account for patient demographic data, medical and psychiatric history, and medications.

Patients with a history of an affective disorder have been shown to have worse postoperative outcomes across medical and surgical specialties.2,3 This also appears to be true for those who undergo elective spine procedures[25]. Better quantifying the resource utilization of spine surgical candidates with ADs in terms of preoperative narcotic use, prevalence of intraoperative and postoperative complications, postoperative ED visits, and post-surgery readmissions will provide a better understanding of how these patients influence health care costs. Resource utilization also includes patient-physician communication through phone lines or EPP. Understanding the dynamic of these requirements in the presence of an AD can help surgeons customize patient contact and interaction in a way that would meet their needs preemptively to decrease the number of ED visits and unnecessary readmissions, while identifying potentially serious complications early, thus minimizing resource drain on the health care system.

Patient Characteristics

In our series, patients with an AD were more likely to be white females, while men appeared to form the majority of the control group. These trends are consistent with published data in the literature.[26-30]

The incidence of preoperative narcotic use was notably higher among patients with an AD compared with controls. Alcohol, current tobacco, and former tobacco use were similar between both groups. That finding was not surprising given previous publications showing that spinal surgery candidacy irrespective of mental status is a risk factor for preoperative opioid use and that depression is frequently associated with an increased rate of substance abuse.[15,16] In addition, preoperative narcotic use has been identified as an independent predictor of narcotic consumption after surgery,[31,32] and preoperative pain levels have been shown to influence pain after surgery.[33,34]

These data are also interesting because both groups had undergone a similar distribution of spinal procedures for comparable spinal pathology, but despite similar spinal conditions, patients with ADs demonstrated a greater need for narcotics to control their pain. Additional research assessing the perioperative ratings of pain in our patient population using validated clinical tools will help us better understand the level of pain experienced by these patients and the need for perioperative narcotics for pain control.

Pre-operative opioid use is one of the most consistent predictors of post-operative opioid use listed in the literature, in addition to overall complications, readmissions, and persistent postoperative pain[35-40] and as our data shows, patients are more likely to renew scripts for opioid medication after spine surgery. The management of post-operative pain is a primary focus of both the surgeon and the patient following surgical intervention. Poorly controlled post-operative pain has been shown to be associated with increased length of stay, delayed postoperative mobilization, higher rates of perioperative complications such as postoperative delirium and thromboembolic events, and decreased overall patient satisfaction.[41,42] On the other hand, over-treatment with analgesics may in itself lead to complications including but not limited to delirium, ileus, urinary retention, respiratory depression, and drug dependence.[43] Traditionally, opioids have been the powerhouse for the treatment of postoperative pain. However, a better understanding of the complications associated with opioids in light of the current opioid epidemic has led to a shift towards a focus on multi-modal analgesia.[41,44] Despite this shift, opioids remain a mainstay in the treatment of post-operative pain, particularly in the United States and in surgical fields associated with painful procedures.[45]

The opioid epidemic has been one of the worst health calamities in recent history. The Center for Disease Control states that opioid overdoses alone accounted for nearly 50,000 deaths in 2018, with prescription opioids accounting for one-third of such deaths.[46] Given the utility of opioids in managing acute perioperative pain associated with surgeries, surgeons must find ways to mitigate opioid abuse.

Electronic Patient Portal Utilization

Patients in the AD group were more likely to have an active EPP account, possibly suggesting that patients with ADs are more willing to communicate directly with their providers. Interestingly, the number of preoperative messages sent, which is a reflection of EPP utilization before surgery, was similar to the control group. This finding could reflect an increased need for patients without AD to communicate with their surgeon before surgery rather than a conservative use of the portal by patients in the AD group. Patients with no AD who may not have been exposed to chronic states of stress may require additional reassurance before their surgery, which could account for similar rates of preoperative electronic messaging between the groups. It is well documented that patients facing surgery experience heightened levels of stress and anxiety[47], regardless of the extent of the planned surgical procedure.[47,48] Additional research assessing the preoperative and postoperative ratings of depression and anxiety in our patient population using validated clinical tools will better elucidate the effect of these patients and their stress response before and after surgery. In addition, identifying unique themes within the preoperative messages sent by patients with AD might provide a better way to comfort this patient population in preparation for surgery, by developing customized algorithms for patient engagement and reassurance.

On the other hand, patients with ADs tended to send more messages postoperatively compared with controls, by a greater number of individuals using the portal in the 6-week period after surgery or by sending an increased number of messages per patient compared with controls (absolute increase of 51%, P = 0.048). Griffin et al.[49] analyzed the usage of a patient portal system implemented by the UNC Health Care System by patients discharged with acute myocardial infarction, congestive heart failure, or pneumonia. He reported that the odds of being readmitted within 30 days were 66% greater in patients who were active users of the patient portal system when compared with nonusers (P < 0.05). These data suggest that those who elect to use the patient portal system might have more medical concerns that warrant the attention of their providers. In addition, prior studies have shown that patients with ADs have increased postoperative complications and higher ratings of pain after surgery.[2,4,8,12] Therefore, it is possible that patients with affective disorders send more post-operative messages to their providers because they may have legitimate post-operative concerns that need to be addressed early to avoid serious complications and the medical expenses they can create.

There was no difference in phone call communication with our clinic which would otherwise explain the disparity in EPP use between the two groups.

Intraoperative and Postoperative Outcomes

The incidence of intraoperative complications and length of hospital stay were not significantly different between the AD and control groups. However, although surgery and hospital factors did not vary between the 2 groups, the incidence of postoperative complications in the AD group was more than double that of the control group (8.21% vs. 3.98%, P = 0.001). The most common complications were wound infection and wound dehiscence, which all seem to point toward patient-related factors. In addition, patients in the AD group had a higher rate of ED visits within 6 weeks of the spinal procedure (4.99% vs. 2.43%, P = 0.009) and higher rates of readmission within 30 days after surgery (2.49% vs. 1.38%, P = 0.049). Adogwa et al. has previously shown that psychologic disorders, such as depression and anxiety, are likely to be independently associated with higher readmission rates after elective spine surgery.2,3 Our research adds to this body of knowledge by confirming that patients with ADs have not only higher readmission rates but also higher rates of ED visits postoperatively. Our institution has modified its postoperative wound care counseling and its response to electronic patient messaging with more rigorous postoperative care guidelines in an effort to reduce the rate of postoperative infection. We also consider postoperative patient messaging as a risk factor for wound infection, especially in patients with AD, and are meticulous in our questioning regarding proper healing. We also have a lower threshold to see patients earlier in our clinic for wound concerns. Health care spending in the United States is expected to grow from $3.5 trillion in 2017 to $6 trillion by 2027, according to the Centers for Medicare & Medicaid Services.[50] Identifying factors that influence increasing healthcare costs will reveal areas where savings are achievable. This is specifically applicable to spinal surgery candidates with affective disorders prior to surgery, where we may have the opportunity to prevent postoperative complications, ED visits, and readmissions.

Subset Analysis

AD patients reported higher levels of preoperative pain intensity as compared to controls (7.05 vs 5.91, p=0.004). This finding is interesting and could reflect the impact of a psychiatric disease on a patient's perception of pain, specifically with spinal pathology. When further subdividing the AD and control cohorts into the "low-pain" and "high-pain" groups, ethnicity appeared to play a role in the perception of pain intensity. Black patients were more likely to report higher levels of pain intensity in both the AD and control groups, which agrees with reports by Campbell and Edwards who noted that amongst individuals with chronic pain, Black patients were more likely to report higher average pain intensity than other ethnic groups.[51] Hispanic patients in the control cohort all belonged to the "low-pain" category.

When examining the PROMIS-29 questionnaire domains, patients with higher pain scores appeared to have a higher incidence of pain interference in both the control and AD groups. However, it was only in the AD group that higher pain ratings were also associated with a higher incidence of depression and anxiety. It is important to note that the low and high-pain categories in both the AD and control groups were comparable in the incidence of risk factors that have been previously associated with depression and the worsened perception of pain such as smoking[52] and ethanol use.[53] Patients with AD in the low-pain and high-pain groups were also comparably medicated, and all subcategories had similar rates of prior spine surgery. both AD and control groups underwent a similar distribution of spinal surgeries for comparable spinal pathology. Both low- and high-pain cohorts also had similar percentages of patients with a history of spine surgeries, eliminating surgical history as a source of differing pain perceptions. Furthermore, we did not find significant differences in the average dose of opioid medications taken by both controls and AD patients. Therefore, despite similar spinal conditions, surgical and social history, psychiatric medication use, and opioid dosages, patients with affective disorders demonstrated a greater need for narcotics to control lower levels of pain. These findings reinforce the concept of a close relationship between pain, anxiety, and depression, not only in the postoperative setting but also before surgery.

Prior research has shown an increase in preoperative opioid use among spine surgery candidates, especially in patients with depression.[15,54] Our data add to this body of knowledge by clarifying that on average, patients with AD have a higher preoperative rating of pain, as well as a higher level of interference with activities of daily living. However, increased pain levels do not independently account for increased narcotic use given a similar overall prevalence between the control and the AD groups. Interestingly, the incidence of preoperative narcotic use in controls seems to increase with higher levels of pain, but that is not the case in the psychiatric disorder group, which may reflect an intrinsic effect of the psychiatric disorder.[55] AD patients may also have a history of opioid use to control pain, making opioid cessation for lower levels of pain challenging. Goesling et al. proposed that depressed patients may be more likely to struggle with therapeutic opioid dependence or opioid-induced hyperalgesia, making it difficult to discontinue opioids even after improvement in joint pain.[56] Sullivan also noted that depressed patients seem to continue opioid use at lower pain intensity levels and higher levels of physical function than nondepressed patients.[57] This data is unsettling in the context of the opioid crisis plaguing the United States and leading to over 33,000 deaths every year.

Despite variable patterns of preoperative pain intensity, pain interference, and opioid consumption, the incidence of intraoperative complications, average length of hospital stays, postoperative complications, emergency department visits within six weeks, and readmissions 30 days postoperatively were not significantly different between the low-pain and high-pain cohorts in the AD and control groups but that may be an effect of small sample size. As expected, patients with lumbar disease who were scheduled to undergo lumbar procedures complained of higher pain than patients with anterior cervical disease. Future studies of patient satisfaction at their postoperative follow-up will help us better define the impact of preoperative pain in individuals with AD undergoing spine surgery.

Study Limitations

Our study has several limitations. First, the retrospective nature of this study grants limited control over patient selection. One notable disparity within this study is the gender disparity between control and study groups. Whereas the AD group consisted mostly of Caucasian females, our control group was dominated by Caucasian males. This is consistent with current data that reveal women are more likely than men to have a mental health disorder[26-30]. The perception of pain may also be influenced by gender, and this may have affected the pain rating comparison between the AD and control groups. This disparity is also associated with an increased likelihood of women using mental health resources, potentially confounding any significant findings in this report as women may be more inclined to seek help over men. This bias can be controlled for in future studies that account for gender differences with patient selection. Second, although we have accounted for the extent of surgery in terms of number of levels, we have not dichotomized patients into fusion and nonfusion groups. Spinal fusion procedures can be associated with more pain and longer operative times and may impact patient pain, narcotic intake, and messaging. Third, numerous reports have demonstrated that EPP, although useful, have many barriers to their use. One can assume that barriers to access are not equally distributed between groups and that this may be a contributory confounder to our data analysis. Also, this report did not account for physician response time to an EPP inquiry, in a patient population with multiple surgeons. The amount of time it takes a physician to respond to an inquiry can both potentially inflate and deflate the number of patient messages. Delays in response can encourage multiple messages to be sent or none as patients might be too discouraged by long delays in response. Any future studies investigating EPP utilization should be cognizant of this potential effect. Finally, some electronic messages were requests for additional narcotic medication refills. We did not individually review messages or categorize them by content, and the diagnosis of AD, high preoperative pain ratings, and a history of preoperative narcotic medication intake may have influenced the purpose behind postoperative patient messaging.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

Affective Disorders can be a predictor for worse postoperative outcome in spinal surgery candidates. AD patients appear to communicate less than expected before surgery and more after surgery compared with controls. It is still unclear if this pattern of behavior reflects higher resilience to presurgical anxiety compared with the rest of the population. It is also unclear if their increased need for communication after surgery may represent legitimate concerns given their higher risk of postoperative wound infections and complications. Several of these findings are unsurprising and may appear intuitive to practicing surgeons. Addressing these concerns early may prevent more serious morbidity and avoid unnecessary ED visits and readmissions, thus reducing costs and improving patient care. Additional studies of provider response time and of the content of patient electronic communication are warranted to reveal how this information can be used to benefit both our patients and our hospital care system.

In addition, spine surgery candidates with psychiatric disorders are more likely to have opioid use perioperatively. They also have higher preoperative pain rating. The incidence of narcotic medication intake is greater in patients with increased pain scores, although that does not appear to be the case in individuals with psychiatric disorders. It appears that psychiatric disorders may impact the degree of preoperative pain interference and the intake of narcotic medication independently from pain intensity ratings. These findings highlight the importance of detecting and treating depression and anxiety in patients suffering from spine disorders, regardless of surgical intervention planning.

LIST OF TABLES

Table 1: Descriptive characteristics including demographic, social history, Electronic Patient Portal account use, and procedure type for the study population.

		Control Group, n=578	Affective Disorder Group, n=621	p value
Demographics, n (%)				
Age		60.42 (SD =14.71)	59.99 (SD = 13.73)	0.303
Gender	Male	n=374 (64.71)	n=275 (44.28)	<0.001
	Female	n=204 (35.29)	n=346 (55.72)	<0.001
Race	White	473 (81.83)	536 (86.31)	0.017
	Black	56 (9.69)	36 (5.80)	0.006
	Hispanic	25 (4.32)	27 (4.34)	0.98
	Other	24 (4.15)	22 (3.54)	0.58
Social Hx, n (%)				
EtOH		312 (54.00)	322 (51.85)	0.550
Current Tobacco		48 (8.30)	50 (8.05)	0.437
Former Tobacco		162 (28.03)	193 (31.08)	0.124
PreOp Narcotic Use		237 (41.00)	321 (51.69)	<0.001
EPP Account, n (%)				
Active EPP		403 (69.72%)	468 (75.36%)	0.014
Declined EPP		64 (11.07%)	56 (9.08%)	0.119
EPP Code Expired		94 (16.23%)	83 (13.37%)	0.080
Procedure, n (%)				
Posterior Cervical		55 (9.52)	60 (9.66)	0.466
Anterior Cervical		85 (14.71)	110 (17.71)	0.079
Lumbar Long (≥5 segments)		27 (4.67)	31 (4.99)	0.398
Lumbar Short (≤4 segments)		402 (69.55)	396 (63.77)	0.017

Table 2: Electronic Patient Portal use in patients with an active account.

	Control Group (n)	Affective Disorder Group (n)	p value
Patients with an active EPP account	403	468	0.014
Preoperative Messages			
Patients who sent at least 1 **Preoperative** message (**EPP Users**)	148 (36.72%)	178 (38.03%)	0.345
Average number of messages (avg)	1.10	1.22	0.237
Postoperative messages <6wks			
Patients who sent at least 1 message	132 (32.75%)	182 (38.89%)	0.030
Number of Messages (avg)	1.08	1.31	0.089
Postoperative Messages 6-12wks			
Patients who sent at least 1 message	80 (19.85%)	113 (24.14%)	0.063
Number of Messages (avg)	0.48	0.67	0.034

Table 3: EPP use in patients who sent at least 1 preoperative message (EPP Users)

	Control Group (n)	AD Group (n)	p value
EPP Users	148 (36.72%)	178 (38.03%)	0.345
Postoperative Messages <6 weeks			
Patients who sent messages	87 (58.78%)	118 (66.29%)	0.083
Number of Messages (avg)	2.09	2.56	0.111
Postoperative Messages 6-12 weeks			
Patients who sent messages	49 (33.11%)	67 (37.64%)	0.198
Number of Messages (avg)	0.86	1.30	0.048
Phone calls			
Patients who made Preop Calls	399 (69.03%)	424 (68.23%)	0.389
Patients who made Postop Calls	356 (61.59%)	397 (63.93%)	0.202

Table 4: Summary of intraoperative patient outcomes

	Control Group, n=578 (%)	AD Group, n=621 (%)	p value
Intraoperative Complications	2 (0.35)	0 (0)	0.079
Average LOS	2.37	2.69	0.100
Number of patient requiring opioids	472 (81.80%)	526 (84.98%)	0.07
MEE	86.61	159.17	0.005
MEE average	18.57	27.45	<0.001

Table 5: Summary of postoperative patient outcomes

	Control Group, n=578 (%)	AD Group, n=621 (%)	p value
Postoperative Complications	23 (3.98)	51 (8.21)	0.001
Postoperative ED visits <6 weeks	14 (2.43)	31 (4.99)	0.009
Readmittance within 30 days	8 (1.38)	17 (2.74)	0.049
3 mo f/u	133 (23.05)	206 (33.55)	<0.001
12 mo f.u	46 (7.97)	76 (12.30)	0.006

Table 6: Descriptive characteristics including demographic and PROMIS-29 Pain Intensity Responses for the study population

Value		Control, n=56	AD/AD Meds, n=61	p value
Demographics, n (%)				
Age (SD)		59.91 (15.46)	61.48 (12.58)	
Gender	Male	n=37 (66.07%)	n=24 (39.34%)	0.002
	Female	n=19 (33.93%)	n=37 (60.66%)	0.002
Race	White	40 (71.43)	48 (78.69)	0.261
	Black	8 (14.29)	5 (8.20)	0.190
	Hispanic	4 (7.14)	5 (8.20)	0.366
	Other*	4 (7.14)	3 (4.92)	0.350
Surgery Type				
Lumbar Short		39 (69.64%)	40 (65.57%)	0.64
Lumbar Long		1 (1.79%)	0 (%)	0.44
ACDF		9 (16.07%)	15 (24.6%)	0.25
PCDF		6 (10.71%)	5 (8.2%)	0.64
Misc		1 (1.79%)	1 (1.64%)	0.95
EtOH History		26 (46.43%)	32 (52.46%)	0.52
History of Prior Spine Surgery		17 (30.36%)	25 (41%)	0.23
Pain Intensity		5.91	7.05	0.004

Table 7: Baseline Preoperative Variables and Patient Outcomes by Preoperative Pain Scores: Low-Pain (≤6 Pain score) and High Pain (>6 Pain Score) Cohorts

	Control (n=56)			AD (n=61)		
	Low-Pain Cohort (≤6 Pain score)	High-Pain Cohort (>6 Pain score)	P value	Low-Pain Cohort (≤6 Pain score)	High-Pain Cohort (>6 Pain score)	P value
	33 (58.93%)	23 (41.07%)		19 (31.15%)	42 (68.85%)	0.001
Demographic						
Male	21 (63.64%)	16 (69.57%)	0.325	8 (42.11%)	16 (62.00%)	0.336
Female	12 (36.36%)	7 (30.43%)	0.325	11 (57.89%)	26 (38.00%)	0.336
White	24 (72.72)	16 (69.57)	0.155	16 (84.21)	32 (76.19%)	0.138
Black	1 (3.03%)	7 (30.43)	0.006	0 (0%)	5 (11.90%)	0.012
Hispanic	4 (12.12)	0	0.022	3 (15.79)	2 (4.76)	0.122
Misc	4 (12.12)	0	0.022	0	3 (7.14)	0.042
Age	56.67	64.57	0.029	58.37	62.88	0.112
PROMIS-29 Scores						
Pain Interference	11.73	15.52	0.004	10.73	17.94	<0.001
Anxiety	7	8.19	0.156	6.67	9.70	0.005
Depression	5.59	7.38	0.061	5.67	9.18	<0.001
Social Hx						
Hx back surg	9 (27.27)	8 (34.78)	0.281	18 (36.84)	7 (42.86)	0.354
Antipsych med	NA	NA		17 (89.47)	37 (88.10)	0.449
Narco	13 (39.39)	15 (65.22)	0.029	7 (36.84)	24 (57.14)	0.086
Smoker	9 (27.27)	8 (34.78)	0.281	5 (26.32)	17 (40.48)	0.212
EtOH	16 (48.48)	10 (43.48)	0.359	11 (57.89)	21 (50)	0.311
Surgery Type						
Lumbar Short	19 (57.58)	20 (86.96)	0.006	9 (47.37%)	31 (73.81)	0.023
Lumbar Long	0	1 (4.35%)	0.164	0	0	
ACDF	8 (24.24)	1 (4.35%)	0.014	8 (42.11)	7 (16.67)	0.030
PCDF	5 (15.15)	1 (4.35)	0.083	2 (10.53)	3 (7.14)	0.343
Misc	1 (3.03)	0	0.162	0	1 (2.38)	0.162
Intraoperative outcomes						
complication	0	0		0	0	
LOS	1.35	2.39	0.143	1.86	1.89	0.285
Postop outcomes						
Readmission	0	0		0	1 (2.38)	0.162
Complication	2 (6.06)	0	0.080	2 (10.53)	2 (4.76)	0.285
ER	1 (3.03	1 (4.35)	0.402	2 (10.53)	2 (4.76)	0.285

Supplemental Table 1: Distribution of ADs in spinal surgical candidates in the AD group

Diagnosis (n=621)	Count	%
Anxiety (n=218, 35.10%)		
Anxiety	75	12.08
Anxiety, bipolar disorder	1	0.16
Anxiety, bipolar disorder, and depression	4	0.64
Anxiety, bipolar disorder, depression, and PTSD	1	0.16
Anxiety and depression	125	20.13
Anxiety, depression, and OCD	2	0.32
Anxiety, depression, and panic	2	0.32
Anxiety, depression, and PTSD	2	0.32
Anxiety and OCD	2	0.32
Anxiety and panic	2	0.32
Anxiety and PTSD	2	0.32
Bipolar disorder (n=12, 1.93%)		
Bipolar disorder	1	0.16
Bipolar Disorder and anxiety	1	0.16
Bipolar disorder, anxiety, and depression	4	0.64
Bipolar disorder, anxiety, depression, and PTSD	1	0.16
Bipolar Disorder and depression	4	0.64
Bipolar disorder and PTSD	1	0.16
Depression (n=293, 47.18%)		
Depression	152	24.48
Depression and anxiety	125	20.13
Depression, anxiety, and bipolar disorder	4	0.64
Depression, anxiety, bipolar disorder, and PTSD	1	0.16
Depression, anxiety, OCD	2	0.32
Depression, anxiety, panic	2	0.32
Depression, anxiety, PTSD	2	0.32
Depression and bipolar disorder	4	0.64
Depression and PTSD	1	0.16
Mood disorder (n=1, 0.16%)		
OCD (n=5, 0.81%)		
OCD	1	0.16
OCD and anxiety	2	0.32
OCD, anxiety, and depression	2	0.32
Panic (n=4, 0.64%)		
Panic and anxiety	2	0.32
Panic, anxiety, and depression	2	0.32
PTSD (n=8, 1.29%)		
PTSD	1	0.16
PTSD and anxiety	2	0.32
PTSD, anxiety, and depression	2	0.32
PTSD, anxiety, depression, bipolar disorder	1	0.16
PTSD and bipolar disorder	1	0.16
PTSD and depression	1	0.16
No diagnosis (n=241, 38.81%)		

Supplemental Table 2: Antidepressant, anxiolytic, and mood stabilizer medication use by spine surgery candidates in the affective disorder group

Medication use (n=241)	Count	%
Antidepressant (n=164, 68.05%)		
Antidepressant	135	56.02
Antidepressant and anxiolytic	29	12.03
Anxiolytic (n=105, 43.57%)		
Anxiolytic	76	31.54
Anxiolytic and antidepressant	29	12.03
Mood stabilizer (n=1, 0.41%)		

Supplemental Table 3: Distribution of IntraOperative Complications

Complication	**Control (n)**	**AD (n)**
durotomy (incidental)	1	0
dural tear	1	0

Supplemental Table 4: Distribution of PostOperative Complications

Complication	**Control (n)**	**AD (n)**
wound infection	5	11
injury (MVA or fall)	0	8
wound dehiscence	5	6
dysphagia	0	4
seroma	2	1
disc herniation	2	1
osteomyelitis	1	1
atelectasis	1	1
DVT, PE	2	0
retrolithesis	1	0
Other infection	1	0
fecal impaction	1	0
synovial cyst	1	0
Ogilvie syndrome	1	0
dural defect	1	0
CSF leak	0	1
seizure	0	1
cellulitis	0	1
hypertensive emergency	0	1
contact dermatitis	0	1
hyponatremia	0	1
pneumonia, bronchitis	0	1
empyema	0	1

Neuritis	0	1

Supplementary Table 5: Distribution of ER Visits in Control and Affective Disorder Groups within 6 weeks after their spinal procedures

# ER visits	Control	AD
0	562	590
1	14	27
2	0	3
3	0	1
average # of ER visits (at least 1 ER visit)	0.02 (1)	0.06 (1.16)
p value	0.004 (0.029)	

Supplemental Table 6 : Distribution of Affective Disorders in spinal surgical candidates in the AD group

Diagnosis (n=37)	Count	%
Anxiety (n=22, 36.07%)		
Anxiety	7	11.48
Anxiety, bipolar disorder, and depression	1	1.64
Anxiety and depression	13	21.31
Anxiety, depression, and PTSD	1	1.64
Bipolar disorder (n=1, 1.64%)		
Bipolar disorder, anxiety, and depression	1	1.64
Depression (n=30, 49.18%)		
Depression	15	24.59
Depression and anxiety	13	21.31
Depression, anxiety, and bipolar disorder	1	1.64
Depression, anxiety, PTSD	1	1.64
PTSD (n=1, 1.64%)		
PTSD, anxiety, and depression	1	1.64
No diagnosis (n=24, 39.34%)		

Supplemental Table 7 : Antidepressant, anxiolytic, and mood stabilizer medication use by spine surgery candidates in the affective disorder group

Medication use (n=24)	Count	%
Antidepressant (n=18, 75%)		
Antidepressant	14	58.33
Antidepressant and anxiolytic	4	16.67
Anxiolytic (n=9, 37.5%)		
Anxiolytic	5	20.83
Anxiolytic and antidepressant	4	16.67
Mood stabilizer (n=1, 4.17%)		

APPENDIX A

Snapshots of Patient Reported Outcomes Measures Information System – 29 (PROMIS-29) Pain Intensity, Pain Interference, Anxiety, and Depression Measures

Pain Intensity
In the past 7 days…

How would you rate your pain on average?..	☐ 0 No pain	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10 Worst imaginable pain

Pain Interference

In the past 7 days…	**Not at all**	**A little bit**	**Somewhat**	**Quite a bit**	**Very much**
How much did pain interfere with your day to day activities?.....................	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
How much did pain interfere with work around the home?.......................................	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
How much did pain interfere with your ability to participate in social activities?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
How much did pain interfere with your household chores?..................................	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Anxiety

In the past 7 days…	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
I felt fearful...	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I found it hard to focus on anything other than my anxiety..	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
My worries overwhelmed me.....................	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I felt uneasy...	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Depression

In the past 7 days...	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
I felt worthless..	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I felt helpless	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I felt depressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I felt hopeless	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

REFERENCES

1. Ghoneim MM, O'Hara MW. Depression and postoperative complications: an overview. *BMC Surg.* 2016;16:5.
2. Adogwa O, Elsamadicy AA, Mehta AI, et al. Association Between Baseline Affective Disorders and 30-Day Readmission Rates in Patients Undergoing Elective Spine Surgery. *World Neurosurg.* 2016;94:432-436.
3. Elsamadicy AA, Adogwa O, Lydon E, et al. Depression as an independent predictor of postoperative delirium in spine deformity patients undergoing elective spine surgery. *J Neurosurg Spine.* 2017;27(2):209-214.
4. Nayar G, Elsamadicy AA, Zakare-Fagbamila R, Farquhar J, Gottfried ON. Impact of Affective Disorders on Recovery of Baseline Function in Patients Undergoing Spinal Surgery: A Single Institution Study of 275 Patients. *World Neurosurg.* 2017;100:69-73.
5. Rawal S, Kwan JL, Razak F, et al. Association of the Trauma of Hospitalization With 30-Day Readmission or Emergency Department Visit. *JAMA Intern Med.* 2019;179(1):38-45.
6. Campos WK, Linhares MN, Sarda J, et al. Predictors of Pain Recurrence After Lumbar Facet Joint Injections. *Front Neurosci.* 2019;13:958.
7. Bakhsheshian J, Scheer JK, Gum JL, et al. Impact of poor mental health in adult spinal deformity patients with poor physical function: a retrospective analysis with a 2-year follow-up. *J Neurosurg Spine.* 2017;26(1):116-124.
8. Alvin MD, Miller JA, Lubelski D, et al. The Impact of Preoperative Depression and Health State on Quality-of-Life Outcomes after Anterior Cervical Diskectomy and Fusion. *Global Spine J.* 2016;6(4):306-313.
9. Trief PM, Grant W, Fredrickson B. A prospective study of psychological predictors of lumbar surgery outcome. *Spine (Phila Pa 1976).* 2000;25(20):2616-2621.
10. Alentado VJ, Caldwell S, Gould HP, Steinmetz MP, Benzel EC, Mroz TE. Independent predictors of a clinically significant improvement after lumbar fusion surgery. *Spine J.* 2017;17(2):236-243.
11. Austevoll IM, Gjestad R, Grotle M, et al. Follow-up score, change score or percentage change score for determining clinical important outcome following surgery? An observational study from the Norwegian registry for Spine surgery evaluating patient reported outcome measures in lumbar spinal stenosis and lumbar degenerative spondylolisthesis. *BMC Musculoskelet Disord.* 2019;20(1):31.
12. Strom J, Bjerrum MB, Nielsen CV, et al. Anxiety and depression in spine surgery-a systematic integrative review. *Spine J.* 2018;18(7):1272-1285.
13. McGirt MJ, Bydon M, Archer KR, et al. An analysis from the Quality Outcomes Database, Part 1. Disability, quality of life, and pain outcomes following lumbar spine surgery: predicting likely individual patient outcomes for shared decision-making. *J Neurosurg Spine.* 2017;27(4):357-369.
14. Schiavolin S, Broggi M, Visintini S, Schiariti M, Leonardi M, Ferroli P. Change in quality of life, disability, and well-being after decompressive surgery: results from a longitudinal study. *Int J Rehabil Res.* 2015;38(4):357-363.
15. Walid MS, Zaytseva NV. Prevalence of mood-altering and opioid medication use among spine surgery candidates and relationship with hospital cost. *J Clin Neurosci.* 2010;17(5):597-600.

16. CDC. Anxiety and depression. *Centers for Disease Control and Prevention.* 2009.
17. Linton SJ, Bergbom S. Understanding the link between depression and pain. *Scand J Pain.* 2011;2(2):47-54.
18. Chapman CR, Cox GB. Anxiety, pain, and depression surrounding elective surgery: a multivariate comparison of abdominal surgery patients with kidney donors and recipients. *J Psychosom Res.* 1977;21(1):7-15.
19. Elsamadicy AA, Adogwa O, Cheng J, Bagley C. Pretreatment of Depression Before Cervical Spine Surgery Improves Patients' Perception of Postoperative Health Status: A Retrospective, Single Institutional Experience. *World Neurosurg.* 2016;87:214-219.
20. Adogwa O, Elsamadicy AA, Cheng J, Bagley C. Pretreatment of Anxiety Before Cervical Spine Surgery Improves Clinical Outcomes: A Prospective, Single-Institution Experience. *World Neurosurg.* 2016;88:625-630.
21. Winstanley EL, Burtchin M, Zhang Y, et al. Inpatient Experiences with MyChart Bedside. *Telemed J E Health.* 2017;23(8):691-693.
22. Kummerow Broman K, Oyefule OO, Phillips SE, et al. Postoperative Care Using a Secure Online Patient Portal: Changing the (Inter)Face of General Surgery. *J Am Coll Surg.* 2015;221(6):1057-1066.
23. Adeyemo EA, Aoun SG, Barrie U, et al. Comparison of the Effect of Epidural versus Intravenous Patient Controlled Analgesia on Inpatient and Outpatient Functional Outcomes After Adult Degenerative Scoliosis Surgery: A Comparative Study. *Spine J.* 2020.
24. Adeyemo EA, Aoun SG, Barrie U, et al. Enhanced Recovery After Surgery Reduces Postoperative Opioid Use and 90-Day Readmission Rates After Open Thoracolumbar Fusion for Adult Degenerative Deformity. *Neurosurgery.* 2020.
25. Kim EJ, Chotai S, Stonko DP, et al. Patient-reported outcomes after lumbar epidural steroid injection for degenerative spine disease in depressed versus non-depressed patients. *Spine J.* 2017;17(4):511-517.
26. Bebbington PE. The origins of sex differences in depressive disorder: bridging the gap. *Int Rev Psychiatry.* 1996;8(4):295-332.
27. Nolen-Hoeksema S, Girgus JS, Seligman ME. Sex differences in depression and explanatory style in children. *J Youth Adolesc.* 1991;20(2):233-245.
28. Marcus SM, Kerber KB, Rush AJ, et al. Sex differences in depression symptoms in treatment-seeking adults: confirmatory analyses from the Sequenced Treatment Alternatives to Relieve Depression study. *Compr Psychiatry.* 2008;49(3):238-246.
29. Labaka A, Goni-Balentziaga O, Lebena A, Perez-Tejada J. Biological Sex Differences in Depression: A Systematic Review. *Biol Res Nurs.* 2018;20(4):383-392.
30. Bandelow B, Michaelis S. Epidemiology of anxiety disorders in the 21st century. *Dialogues Clin Neurosci.* 2015;17(3):327-335.
31. Ahn J, Bohl DD, Tabaraee E, Aboushaala K, Elboghdady IM, Singh K. Preoperative narcotic utilization: accuracy of patient self-reporting and its association with postoperative narcotic consumption. *J Neurosurg Spine.* 2016;24(1):206-214.
32. Rozell JC, Courtney PM, Dattilo JR, Wu CH, Lee GC. Preoperative Opiate Use Independently Predicts Narcotic Consumption and Complications After Total Joint Arthroplasty. *J Arthroplasty.* 2017;32(9):2658-2662.

33. Sangesland A, Storen C, Vaegter HB. Are preoperative experimental pain assessments correlated with clinical pain outcomes after surgery? A systematic review. *Scand J Pain.* 2017;15:44-52.
34. Petersen KK, Arendt-Nielsen L, Simonsen O, Wilder-Smith O, Laursen MB. Presurgical assessment of temporal summation of pain predicts the development of chronic postoperative pain 12 months after total knee replacement. *Pain.* 2015;156(1):55-61.
35. Armaghani SJ, Lee DS, Bible JE, et al. Preoperative opioid use and its association with perioperative opioid demand and postoperative opioid independence in patients undergoing spine surgery. *Spine (Phila Pa 1976).* 2014;39(25):E1524-1530.
36. Behman R, Cleary S, McHardy P, et al. Predictors of Post-operative Pain and Opioid Consumption in Patients Undergoing Liver Surgery. *World J Surg.* 2019;43(10):2579-2586.
37. Cozowicz C, Olson A, Poeran J, et al. Opioid prescription levels and postoperative outcomes in orthopedic surgery. *Pain.* 2017;158(12):2422-2430.
38. Cryar KA, Hereford T, Edwards PK, Siegel E, Barnes CL, Mears SC. Preoperative Smoking and Narcotic, Benzodiazepine, and Tramadol Use are Risk Factors for Narcotic Use After Hip and Knee Arthroplasty. *J Arthroplasty.* 2018;33(9):2774-2779.
39. Jain N, Phillips FM, Weaver T, Khan SN. Preoperative Chronic Opioid Therapy: A Risk Factor for Complications, Readmission, Continued Opioid Use and Increased Costs After One- and Two-Level Posterior Lumbar Fusion. *Spine (Phila Pa 1976).* 2018;43(19):1331-1338.
40. Yang MMH, Hartley RL, Leung AA, et al. Preoperative predictors of poor acute postoperative pain control: a systematic review and meta-analysis. *BMJ Open.* 2019;9(4):e025091.
41. Kurd MF, Kreitz T, Schroeder G, Vaccaro AR. The Role of Multimodal Analgesia in Spine Surgery. *J Am Acad Orthop Surg.* 2017;25(4):260-268.
42. van Boekel RLM, Warle MC, Nielen RGC, et al. Relationship Between Postoperative Pain and Overall 30-Day Complications in a Broad Surgical Population: An Observational Study. *Ann Surg.* 2019;269(5):856-865.
43. de Boer HD, Detriche O, Forget P. Opioid-related side effects: Postoperative ileus, urinary retention, nausea and vomiting, and shivering. A review of the literature. *Best Pract Res Clin Anaesthesiol.* 2017;31(4):499-504.
44. Stoicea N, Costa A, Periel L, Uribe A, Weaver T, Bergese SD. Current perspectives on the opioid crisis in the US healthcare system: A comprehensive literature review. *Medicine (Baltimore).* 2019;98(20):e15425.
45. Gerbershagen HJ, Pogatzki-Zahn E, Aduckathil S, et al. Procedure-specific risk factor analysis for the development of severe postoperative pain. *Anesthesiology.* 2014;120(5):1237-1245.
46. Control CfD. Overdose Death Maps | Opioid Overdose | CDC Injury Center. 2018
47. Starkweather AR, Witek-Janusek L, Nockels RP, Peterson J, Mathews HL. Immune function, pain, and psychological stress in patients undergoing spinal surgery. *Spine (Phila Pa 1976).* 2006;31(18):E641-647.
48. Jangland E, Gunningberg L, Carlsson M. Patients' and relatives' complaints about encounters and communication in health care: evidence for quality improvement. *Patient Educ Couns.* 2009;75(2):199-204.

49. Griffin A, Skinner A, Thornhill J, Weinberger M. Patient Portals: Who uses them? What features do they use? And do they reduce hospital readmissions? *Appl Clin Inform.* 2016;7(2):489-501.
50. Services CfMM. NHE Fact Sheet. *Centers for Medicare & Medicaid Services.* 2019.
51. Campbell CM, Edwards RR. Ethnic differences in pain and pain management. *Pain Manag.* 2012;2(3):219-230.
52. Kim DH, Park JY, Karm MH, et al. Smoking May Increase Postoperative Opioid Consumption in Patients Who Underwent Distal Gastrectomy With Gastroduodenostomy for Early Stomach Cancer: A Retrospective Analysis. *Clin J Pain.* 2017;33(10):905-911.
53. Kao SC, Tsai HI, Cheng CW, Lin TW, Chen CC, Lin CS. The association between frequent alcohol drinking and opioid consumption after abdominal surgery: A retrospective analysis. *PLoS One.* 2017;12(3):e0171275.
54. Strine TW, Kroenke K, Dhingra S, et al. The associations between depression, health-related quality of life, social support, life satisfaction, and disability in community-dwelling US adults. *J Nerv Ment Dis.* 2009;197(1):61-64.
55. Sun EC, Darnall BD, Baker LC, Mackey S. Incidence of and Risk Factors for Chronic Opioid Use Among Opioid-Naive Patients in the Postoperative Period. *JAMA Intern Med.* 2016;176(9):1286-1293.
56. Goesling J, Moser SE, Zaidi B, et al. Trends and predictors of opioid use after total knee and total hip arthroplasty. *Pain.* 2016;157(6):1259-1265.
57. Sullivan MD. Depression Effects on Long-term Prescription Opioid Use, Abuse, and Addiction. *Clin J Pain.* 2018;34(9):878-884.

VITAE

Zachary Christian (March 16th 1993-present) is a fourth-year medical student at UT Southwestern Medical School who is interested in neurosurgery. He grew up in Dallas, Texas and completed his undergraduate education at Columbia University, where he worked in a neuropsychology lab looking at social dominance hierarchy amongst mouse strains and mouse models for autism and mast-cell deficiency. He graduated with a B.A. in Neuroscience & Behavior in 2015 and spent two years working at the Center for Depression Research and Clinical Care in the Department of Psychiatry at UT Southwestern Medical Center. Beginning medical school in the fall of 2017, Zach served as Co-President of the American Association of Neurological Surgery. Zach will graduate with his M.D. and a distinction in Research in May 2021, and he hopes to pursue a career as an attending physician at an academic medical center.
On his spare time, Zach likes to run Spartan races and Tough Mudders, bouldering, watching Netflix, and spending time with his family and friends

Permanent Address:
3035 Marburg St.
Dallas, TX 75215