Does patient selection account for the perceived cost savings in outpatient spine surgery? A meta-analysis of current evidence and analysis from an administrative database

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OBJECTIVE From 1994 to 2006 outpatient spinal surgery increased 5-fold. The perceived cost savings with outcomes comparable to or better than those achieved with inpatient admission for the same procedures are desirable in an era where health expenditures are scrutinized. The increase in outpatient spine surgery is also driven by the proliferation of ambulatory surgery centers. In this study, the authors hypothesized that the total savings in outpatient spine surgery is largely driven by patient selection and biases toward healthier patients.

METHODS A meta-analysis assessed patient selection factors and outcomes associated with outpatient spine procedures. Pooled odds ratios and mean differences were calculated using a Bayesian random-effects model. The authors extended this analysis in a novel way by using the results of the meta-analysis to examine cost data from an administrative database of academically affiliated hospitals. A Bayesian approach with priors informed by the meta-analysis was used to compare costs for inpatient and outpatient performance of anterior cervical discectomy and fusion (ACDF) and lumbar laminectomy.

RESULTS Sixteen studies with a total of 370,195 patients met the inclusion criteria. Outpatient procedures were associated with younger patient age (mean difference [MD] −2.34, 95% credible interval [CrI] −4.39 to −0.34) and no diabetes diagnosis (odds ratio [OR] 0.78, 95% CrI 0.54–0.97). Outpatient procedures were associated with a lower likelihood of reoperation (OR 0.42, 95% CrI 0.16–0.80), 30-day readmission (OR 0.39, 95% CrI 0.16–0.74), and complications (OR 0.29, 95% CrI 0.15–0.50) and with lower overall costs (MD −\$121,392.72, 95% CrI −\$216,824.81 to −\$23,632.92). Additional analysis of the national administrative data revealed more modest cost savings than those found in the meta-analysis for outpatient spine surgeries relative to inpatient spine surgeries. Estimated cost savings for both younger patients (\$555 for those age 30–35 years [95% CrI −\$733 to −\$374]) and older patients (\$7290 for those age 65–70 years [95% CrI −\$7380 to −\$7190]) were less than the overall cost savings found in the meta-analysis.

CONCLUSIONS Compared to inpatient spine surgery, outpatient spine surgery was associated with better short-term outcomes and an initial reduction in direct costs. A selection bias for outpatient procedures toward younger, healthier patients may confound these results. The additional analysis of the national database suggests that cost savings in the outpatient setting may be less than previously reported and a result of outpatient procedures being offered more frequently to younger and healthier individuals.

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KEYWORDS spine surgery; inpatient; outpatient; ambulatory surgery; cost analysis; patient selection

ABBREVIATIONS ACDF = anterior cervical discectomy and fusion; BMI = body mass index; CCI = Charlson Comorbidity Index; CDB/RM = (Vizient) Clinical Data Base/Resource Manager; CrI = credible interval; DM = diabetes mellitus; LOS = length of stay; MD = mean difference; OR = odds ratio.

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OVER the past 2 decades, spine surgical procedures have been increasingly performed in the outpatient setting. From 1994 to 2006 the utilization of outpatient fusions, laminectomies, and discectomies increased over 5-fold.⁷ This is partly due to the perception that outpatient spine surgeries are less costly than similar inpatient procedures.^{2,7} With the increasing scrutiny of health expenditures, the perceived cost savings and comparable outcomes to inpatient procedures have made outpatient spine procedures desirable for payers and surgeons.³

Several studies have looked at patient selection and selected outcomes for specific spine surgical procedures, yet no review exists that examines the common patient selection factors and outcomes across the portfolio of outpatient spinal procedures.^{3,13,16,22} All of these studies report improved outcomes for outpatient surgeries and reduced costs. In this paper the authors hypothesize that patient selection—outpatient spine surgery candidates tend to be younger and healthier—is responsible for the claimed cost savings from outpatient spine surgery. As the demands to conserve healthcare resources increase, it is important for clinicians to understand the array of spine surgical procedures that can be efficiently performed in the outpatient setting. Using available observational studies reporting both inpatient and outpatient outcomes for spine surgery, we performed a meta-analysis to characterize the patient selection factors and outcomes associated with the portfolio of outpatient spine surgery. We extended this analysis in a novel way by using the results of the meta-analysis to examine cost data from a national database of academically affiliated hospitals using a Bayesian modeling approach.

Methods

Search Strategy

To qualify the patient selection factors and outcomes for all types of outpatient spinal surgery, a systematic review of the literature available through July 17, 2016, was performed. “Outpatient surgery” was defined as surgery with discharge from the hospital or surgical care setting on the same day of surgery, while “inpatient” surgery was used to describe all surgeries for which the postoperative admission resulted in a dismissal no earlier than the next calendar day. Searches were performed in PubMed, MEDLINE, and Embase for studies comparing selection factors and outcomes for outpatient and inpatient spine surgeries. We used the following Boolean search string (shown in MEDLINE/Embase format): [(outpatient or ambulatory) and (spine or spinal or lumbar or cervical or thoracic or discectomy or laminectomy) and (surgery or operation or procedure or fusion)].ti,ab. The initial search yielded 5817 unique studies. Two independent reviewers (B.F.M. and P.K.) examined the results. Studies not reporting selection factors and outcomes consistently across both cohorts were excluded.

Selection Criteria

Only studies, including conference presentations and abstracts, reporting both outpatient and inpatient spine

surgery patient criteria and outcomes were included in the meta-analysis. Any study reporting at least 1 patient selection factor (e.g., age or sex) and 1 outcome (e.g., cost or 30-day readmission rate) was included. Measures reported for 1 group of patients needed to be reported for the corresponding comparison group to be included in our analysis. Studies reporting outcomes for only inpatient or outpatient spine surgery procedures were excluded, encompassing case series and case reports. Due to the unique nature of the US healthcare system when it comes to the cost of care, only studies looking at surgeries performed in the US were included.

Two reviewers (B.F.M. and P.K.) independently reviewed the search results to determine study inclusion and subsequently abstracted the data. Any disagreements were resolved via consensus between the 2 reviewers. All authors agreed on the final set of studies included and subsequent analysis and conclusions.

Data Extraction

The data extracted by the 2 aforementioned reviewers included study design, surgery type, number of inpatient and outpatient procedures covered, demographics (to include patient age and sex), measures of comorbidities (both individual and indices—i.e., Charlson Comorbidity Index [CCI]), functional outcomes, readmission rates, reoperation rates, complication rates (including mortality), and reported costs. When mean values and standard deviations were not reported, estimations were made if possible based on available graphs and published methodologies.¹¹ Primary data extraction was completed by one reviewer with accuracy of data entry confirmed by the second reviewer. Publication bias was assessed using funnel plots. We observed a variable amount of evidence for publication balance in studies reporting cost differences. For example, cost data appeared to be subject to publication bias, but the number of studies was also small, making this bias difficult to assess using funnel plots.

Cost Data

Direct cost data on anterior cervical discectomy and fusion (ACDF; ICD-9 code 81.02 and CPT code 22551) and lumbar laminectomy (ICD-9 code 03.09 and CPT codes 63005 and 63047) for patients age 30–35 years and 65–70 years were extracted from a national database of academically affiliated hospitals, the Vizient Clinical Data Base/Resource Manager (CDB/RM). The Vizient cost data are standardized cost data created using each facility’s Medicare cost report cost-to-charge ratio that allows for comparing costs across facilities. All inpatient and outpatient ACDF procedures and lumbar laminectomies performed between October 2012 and September 2016 were included. The data were stratified by age in order to explore the differences in costs for younger and older patients, as younger patients, on average, tend to have fewer comorbidities and are perceived to be healthier. Therefore, younger patients should be less susceptible to patient selection criteria when determining surgical setting, leading to little difference in cost between the inpatient and outpatient settings for this group.

FIG. 1. Study selection flowchart.

Statistical Analysis

Following data abstraction from the selected articles, a meta-analysis of selection factors and outcomes associated with outpatient procedures was performed. Odds ratios or mean differences were reported for parameters of interest where appropriate.

Due to the potential heterogeneity of the data based on varying study designs and populations, the meta-analysis utilized a Bayesian hierarchical framework to generate a random-effects model for the total pooled effect of each measure of interest. Bayesian analytical approaches have been increasingly used in medical research as they allow researchers to easily incorporate prior knowledge into the modeling approach; past experiences can be easily incorporated in the parameter estimates. The Bayesian approach to meta-analysis allowed the uncertainty associated with each parameter of interest, in this case the patient selection factor and outcome differences, to be explicitly modeled through assumptions about the statistical distribution of these parameters.²⁶ Using this modeling approach acknowledges the uncertainty inherent in estimating population parameters from a subset of data but offers the analysts the ability to incorporate some prior knowledge of how the parameters may be statistically distributed.

The CDB/RM cost data were analyzed using a Bayesian estimation for mean differences. This methodology allowed us to use the information gained in the meta-analysis, specifically the distribution of cost differences as

determined by the meta-analysis, to inform the estimate of the distribution of cost differences seen in the CDB/RM data. An additional advantage over the classic t-test is the ability to accept a null value, in this case that the cost difference found in the meta-analysis persists in the CDB/RM data.¹² The Bayesian methodology relies on multiple simulations of the distribution, in this case 100,000 simulations, leading to a robust estimate of the distribution of the mean difference in the CDB/RM data. We also ran the model with a naïve prior distribution, a normal distribution with a variance that is 1000 times the standard deviation of the population data, to test the sensitivity of the model to the informed prior distribution. To the best of our knowledge, this is a novel approach for validating reported differences in outcomes from a meta-analysis comparing options for surgical management of a disease.

Data analysis was performed using R (R Foundation for Statistical Computing, <https://cran.r-project.org/doc/manuals/fullrefman.pdf>), the bmeta package (http://statistica.it/gianluca/bmeta/bmeta_manual.pdf), and the BEST package (<https://cran.r-project.org/web/packages/BEST/vignettes/BEST.pdf>). Mean differences and odds ratios were both calculated to include 95% credible intervals.

Results

The initial search resulted in 7570 studies, of which 5817 were found to be unique (Fig. 1). After excluding

TABLE 1. Characteristics of included studies

Authors & Year	Design	Surgery Type	Inpatient	Outpatient
Silvers et al., 1996	RCS	ACDF	53	50
Stieber et al., 2005	RCS	ACDF	Inpatient 1: 30; inpatient 2: 30	30
Best & Sasso, 2007	RCS	Lumbar decompression in patients over 65 yrs	30	233
Liu et al., 2009	RCS	ACDF	64	45
Walid et al., 2010	RCS	ACDF, LMD, & LDF	578	97
Wohns, 2012	RCS	Lumbar fusion	102	85
Pugely et al., 2013	RCS	Lumbar discectomy (single level)	2658	1652
Baird et al., 2014 ⁴	RCS	Cervical spine	170,974	21,533
Bekelis et al., 2014	RCS	Lumbar discectomy	102,592	47,125
Martin et al., 2014	RCS	1-level ACDF	2317	597
Missios et al., 2014	RCS	Spinal cord stimulators	4197	4843
McGirt et al., 2015	RCS	ACDF	6120	1168
Ortega et al., 2015	RCS	IPD for LSS	182	229
Adamson et al., 2016*	RCS	ACDF	Total: 484; 1-level ACDF: 274; 2-level ACDF: 210	Total: 1000; 1-level ACDF: 629; 2-level ACDF: 365
Chin et al., 2016	RCS	LLIF	40	30
Smith et al., 2016	RCS	MIS lumbar fusion	160	873

IPD for LSS = interspinous process decompression for lumbar spinal stenosis; LDF = lumbar decompression and fusion; LLIF = lateral lumbar interbody fusion; LMD = lumbar microdiscectomy; MIS = minimally invasive surgery; RCS = retrospective cohort study.

* Because this study reported the results of 1-level and 2-level ACDF separately, it was treated as 2 separate studies in the meta-analysis.

those studies that were not looking at human spine surgeries (5754) and those not comparing inpatient and outpatient cohorts for the same surgery (45), we were left with 18 studies that compared inpatient and outpatient spine surgeries. Two of these were further deemed unsuitable for use in the meta-analysis because they did not report data equally for the inpatient and outpatient groups. Thus, the final group of studies for inclusion were the 16 studies described in Table 1.

The number of patients included in the studies ranged from 70 to 192,507. All of the included 16 studies were retrospective cohort studies and are further described in Table 1. For those studies performing further analysis on matched subgroups, only the unmatched groups and corresponding data were used in the meta-analysis. Adamson et al. reported results separately for 1-level and 2-level ACDF surgeries, and therefore their study was treated as if it were 2 separate studies for the purpose of the meta-analysis.¹ In total, data from 370,195 patients (290,611 inpatients and 79,584 outpatients) were used in the analysis. The characteristics of the patients included in the analysis are summarized in the Supplemental Table.

Patient Selection

Age

Thirteen studies (counting the 1-level and 2-level cohorts described by Adamson et al., which we evaluated independently, as separate studies) reported mean ages of both the inpatient and outpatient cohorts.^{1,6,9,14,15,17–19,24,25,27,28} Eleven of these studies reported greater mean ages for the patients undergoing procedures on an inpatient basis. A total of 119,554 inpatients and 57,763 outpatients were included in the analysis. Patients undergoing an outpatient

procedure were younger than those undergoing an inpatient procedure (mean difference [MD] –2.34, 95% credible interval [CrI] –4.39 to –0.34) (Fig. 2).

Diabetes Mellitus

Six of the studies reported rates of diabetes mellitus (DM) in their patient cohorts; all of these studies reported higher rates of DM for those undergoing inpatient spine surgeries.^{1,14,15,17,24,27} A total of 9723 inpatient and 3774 outpatient procedures were analyzed. In total, 13.8% of inpatient cases involved patients with DM, compared to 12.6% of outpatient cases. Overall, the odds of undergoing an outpatient surgery are about one-third less for those who have DM compared to those who do not (odds ratio [OR] 0.78, 95% CrI 0.54–0.97) (Fig. 3).

Additional patient selection variables were also reported but did not yield overall significant differences in pooled analysis. Thirteen studies reported sex differences among outpatient and inpatient spine surgeries, and 8 of these studies reported that women were less likely to undergo outpatient spine surgery. Nine studies captured body mass index (BMI), either mean values or as a measure of obesity, and 8 of these studies reported that those with higher BMI values were more likely to be treated in the inpatient setting. Ten of the studies used various measures of comorbidities to include rates of chronic obstructive pulmonary disease (COPD), hypertension, coronary artery disease, and the CCI. All 4 studies reporting a CCI found that undergoing inpatient spine surgery was associated with a higher CCI.

Outcomes

In addition to looking at patient selection criteria, all 16

FIG. 2. Forest plot for age as a factor for patient selection between inpatient and outpatient spine surgery.

studies quantified relationships between outcomes, both surgical and financial, and surgical setting. Two studies looked at functional outcomes and found improved outcomes for those undergoing outpatient spine surgeries.^{9,23} Mean length of stay (LOS) was reported by 3 studies, but it was not analyzed due to the fact that outpatient surgeries, based on their definition, should inherently have a shorter LOS.^{10,16,17} All other outcomes measured were found in more than 2 studies and were used in the meta-analysis.

Reoperation Rate

Six of the studies examined the relationship between surgical setting and 30-day reoperation rates, with all reporting lower reoperation rates for outpatient spine surgeries.^{1,15,19,21,23} In the pooled analysis, undergoing an outpatient spine surgery was associated with a reduction of almost 60% in the odds of undergoing a reoperation (OR 0.42, 95% CrI 0.16–0.80) (Fig. 4).

30-Day Readmission Rate

Data from a total of 30,782 patients in 5 studies were used to look at the relationship between spine surgery setting and 30-day readmission rates.^{1,6,18,25,27} All 5 studies reported lower readmission rates for patients undergoing outpatient procedures. Similar to the trends found with reoperation rates, undergoing an outpatient procedure was associated with a 60% reduction in the odds of being readmitted to the hospital following the surgery (OR 0.39, 95% CrI 0.16–0.74) (Fig. 5).

Complication Rate

Thirteen of the studies reported the relationship between surgical setting and complication rates.^{4,6,8,9,14,15,17,18,21,23,25,27,28} The granularity with which complications were measured varied between studies, but all separated minor complications from major complications (including mortality). All 13 studies found that outpatient surgeries

FIG. 3. Forest plot for effect of diabetes on spine surgery setting.

FIG. 4. Forest plot for comparison of reoperation rates between inpatient and outpatient spine surgery.

were associated with lower complication rates and mortality rates for those reporting them. In total, undergoing an outpatient surgery was associated with a 70% reduction in the odds of having a complication (OR 0.29, 95% CrI 0.15–0.50). In an attempt to reduce some of the selection differences between the outpatient and inpatient populations, we also performed a meta-regression for complication rates. Unfortunately, only 9 studies had sufficient selection data—i.e., age and results were similar to those found in the aforementioned meta-analysis (OR 0.28, 95% CrI 0.14–0.50) (Fig. 6).

Cost

Four of the studies compared costs for outpatient and inpatient spine surgeries, with all reporting significantly lower costs for outpatient procedures.^{11,15,16,21} Overall, outpatient spine surgeries were less costly than inpatient procedures (MD -\$121,392.72, 95% CrI -\$216,824.81 to -\$23,632.92) (Fig. 7). This is not surprising, as outpatient surgeries inherently require less time in the hospital and therefore fewer services and less testing during the initial hospitalization. In one study, the authors (Ortega et al.) did look at 18-month costs following inpatient and outpatient interspinous process decompression device placement for lumbar stenosis and found that cost differences were negligible.¹⁹ Due to this discrepancy in cost reporting, 2 meta-

analysis models were run: one with initial costs and one including 18-month costs from Ortega et al. The cost difference remained regardless of the cost data used.

The mean difference and distribution of cost data from the above meta-analysis was then used to assess the difference in direct costs between inpatient and outpatient ACDF and lumbar laminectomy surgeries in the CDB/RM dataset. It is important to note that CDB/RM uses the well-accepted cost-to-charge ratio to standardize costs across patients, payers, and hospitals. Because selection on age appeared to be consistent across all studies, cost differences were analyzed for a younger age group (30–35 years) and an older age group (65–70 years). While direct costs were lower for outpatient procedures in both subgroups, they were only lower by \$555 for those age 30–35 years (95% CrI -\$733 to -\$374), while those age 65–70 years had a larger cost difference of \$7290 (95% CrI -\$7380 to -\$7190).

Discussion

To the best of our knowledge, this meta-analysis is the first to perform a comprehensive analysis of the differences in outpatient and inpatient spine surgeries. We also used a novel approach to attempt to validate the meta-analysis results on cost differences using a Bayesian approach to es-

FIG. 5. Forest plot for comparison of 30-day readmission rates between inpatient and outpatient spine surgery.

FIG. 6. Forest plot for comparison of complication rates between inpatient and outpatient spine surgery.

timiate cost differences in a national dataset. Prior reviews have looked specifically at ACDF surgeries and have found that performing this procedure in the outpatient setting on the correct subset of patients is safe and cost-effective.^{13,16} We found that those patients undergoing outpatient surgeries tended to be younger and were less likely to have DM. Qualitatively, the outpatient surgery patients were also more likely to be male and have a lower number of comorbidities. This is similar to selection criteria reported in reviews of ACDF surgeries and, to a lesser extent, outpatient orthopedic surgical procedures.^{10,13,16} Considering the probable selection bias that exists when looking at outpatient spine surgery outcomes, it is difficult to know how to best interpret the improved outcomes that seem to be associated with the outpatient setting. Two of the studies included in this review attempted to reduce this bias by using propensity score matching between inpatients and outpatients and still found that the perceived benefits of outpatient spine surgery persisted.^{15,17} Unfortunately, propensity score matching is not without flaws and even when well executed cannot fully reduce selection bias (see <https://gking.harvard.edu/publications/why-propensity-scores-should-not-be-used-for-matching>).^{5,20}

We also found that outpatient spine procedures generally appear to result in fewer complications, fewer reoperations, and decreased initial costs. These findings are not unique to the spine surgery arena; others have noted similar findings associated with orthopedic surgery outpatient procedures.¹⁰ Our additional analysis using the results of the meta-analysis and Bayesian techniques suggests that the cost reductions that come from outpatient procedures may be overstated or at least not uniform across age groups. Younger patients, as a group, tend to have fewer comorbidities than older patients and therefore are less susceptible to patient selection criteria when determining which spine surgical setting is most appropriate for the patient. It appears that patient selection is less of a factor among younger individuals in our additional analysis due to the reduced outpatient cost savings within this group compared to the more heterogeneous older group of patients.

Only one study looked at long-term outcomes and found that the benefits of outpatient surgery in the setting of interspinous process device placement were negligible.¹⁹ Given the likelihood of selection bias for outpatient spine procedures, there is a high probability that the benefits of outpatient spine surgery in our analysis and past reviews

FIG. 7. Forest plot for comparison of costs between inpatient and outpatient spine surgery.

stem from healthier, younger, and lower-risk patients being offered an outpatient procedure.

Study Limitations

Our study, while comprehensive in its review, is not without limitations. First, all of the included studies were retrospective studies, which can lead to selection bias in the reported outcomes. This bias is evident in some of the differences seen in patient selection criteria for those chosen to undergo outpatient versus inpatient spine surgeries. Ideally, randomized controlled trials would exist in this arena and would provide an additional perspective on the effects of patient selection on reported outcomes. Second, there was quite a bit of variability in both patient selection variables and outcomes across the studies. This made it difficult to include the maximum number of studies in each analysis. Third, a few of the studies that consistently reported patient selection and outcome data were several orders of magnitude larger than many of the other studies, thereby having a large influence on the pooled effects. Fourth, the reporting of functional outcomes, such as the Oswestry Disability Index, Neck Disability Index, or pain scale scores, varied widely between the included studies; therefore, these measures could not be analyzed in the meta-analysis. Finally, publication bias likely drove many of our results, as those with positive findings—i.e., outpatient is superior to inpatient surgery—are more likely to be published.

Conclusions

Across the portfolio of spine surgeries, those performed in the outpatient setting, compared to those in the inpatient setting, were associated with more favorable short-term outcomes and an initial reduction in direct costs. Yet there tends to be a selection bias for outpatient procedures toward younger, healthier patients, which may confound these outcomes. The additional analysis of the national database suggests that cost savings in the outpatient setting may be a result of outpatient procedures being offered more frequently to younger and healthier individuals. To the best of our knowledge, this is a novel approach for validating reported differences in outcomes from a meta-analysis that compares options for surgical management of a disease. Future studies should focus on quantifying outcomes and cost reductions beyond 90 days and reducing or correcting for the selection bias that likely has a significant role in the favorable outcomes associated with outpatient spine surgery in our study.

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Disclosures

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Author Contributions

Acquisition of data: Mundell, Kerezoudis. Analysis and interpretation of data: Mundell, Kerezoudis. Drafting the article: Bydon, Mundell, Gates, Alvi. Critically revising the article: Bydon, Gates, Kerezoudis, Alvi, Freedman, Nassr, Hohmann. Reviewed submitted version of manuscript: Bydon, Alvi, Freedman, Nassr, Hohmann. Approved the final version of the manuscript on behalf of all authors: Bydon. Statistical analysis: Mundell, Kerezoudis. Study supervision: Bydon.

Supplemental Information

Online-Only Content

Supplemental material is available with the online version of the article.

Supplemental Table. <https://thejns.org/doi/suppl/10.3171/2018.4.SPINE1864>.

Previous Presentations

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