

Measuring Value in Elective Spine Surgery

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Abstract:

Objective: To summarize the main findings from research on measuring the value in spine surgery.

Summary of Background Data: Determining the value of surgical interventions, which is defined by the quality and efficacy of care received divided by the cost to deliver healthcare, is inherently complex. The two most fundamental components of value-quality and total cost-are multifactorial and difficult to quantify.

Methods: A narrative review of all the relevant papers known to the author was conducted.

Results: It is straightforward to calculate the aggregate hospital cost following a surgical procedure, but it is not simple to estimate the total cost of a procedure-including the direct and indirect costs. These individual metrics can help providers make more educated decisions with regards to improving patient quality of life and minimizing unnecessary costs. A consensus of the appropriate cost-per-quality-adjusted life-year threshold of different spine surgeries needs to be established. As these metrics become more commonplace in spine surgery, the potential for personalized health care will continue to be developed.

Conclusions: As the healthcare system shifts toward value-based care, there is a substantial need for research assessing the value as defined by the quality and efficacy of care received divided by the cost to deliver healthcare of specific spine surgery procedures. Studies on different predictors-both patient-specific and surgical-that may influence outcomes, cost, and value are required.

Keywords:

Value, Spine Surgery, Quality, Cost, Performance Indicators

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Introduction

Spine surgery is a highly utilized and costly procedure in the United States healthcare system¹⁻³. The usage of spine surgery for degenerative lumbar pathology has increased 220% over the last two decades with nearly 80 lumbar fusion procedures performed per 100,000 US adults in 2015². It has been estimated that roughly 7% of the aggregate costs for hospitalization after surgical procedures can be attributed to spinal fusion procedures, with an average hospital stay cost of \$27,600 per patient¹. The combination of increasing utilization and the high costs of various spine procedures have generated interest in optimizing value as defined by the quality and efficacy of care received divided by the cost to deliver healthcare.

As healthcare costs climb, there has been increasing pressure on spine surgeons to demonstrate the clinical utility and cost-effectiveness of treatment interventions. The Patient

Protection and Affordable Care Act and the Centers for Medicare and Medicaid Services have considered several different reimbursement policies-including pay-for-performance payment models-to curb the growing healthcare costs in the United States⁴. Despite much discussion among the spine community and those involved with enacting healthcare policy, there is currently no agreed-upon standard for measuring the overall quality or cost-effectiveness of spine care.

It has been historically difficult to quantify and define value and its encompassing costs of orthopedic surgical procedures. Costs can be divided into the following three major groups: direct, indirect, and intangible. Direct costs are those associated with treatment, indirect costs result from lost wages from the inability to work and intangible costs relate to changes in quality of life that cannot be directly measured in monetary form. Although the direct costs of a procedure are straightforward to calculate, the direct costs associ-

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$$\text{Value} = \frac{\text{Quality} \text{ (checklist icon)}}{\text{Cost} \text{ (stack of coins icon)}}$$

Figure 1. Basic value equation.

ated with healthcare utilization in the postoperative period as well as the indirect costs of surgical care are not as simple to measure⁵. Examples of operative costs include the cost of resources used for treatment, procedural reimbursement based on Current Procedural Terminology codes, hospitalization costs based on Diagnosis Related Group codes, and the costs of discharge to a home or non-home destination. Post-operative costs can include utilization of healthcare resources after surgery (i.e., emergency department and urgent care visits, readmission, reoperation), imaging studies, medications, physical therapy, and rehabilitation costs. Examples of indirect costs include lost income, disability payments, and absenteeism from work. Intangible costs, which can be considered a measure of the patient's general quality of life, are perhaps the most frequently overlooked and challenging costs to define. This cost is infrequently measured in research and in practice, which can make it difficult to quantify. Given that these costs are paramount to patient well-being, it is important to account for them in some capacity⁶. Attempts to quantify indirect costs have been done through the implementation of the quality-adjusted life-year (QALY) metric. However, this metric is not all encompassing and has inherent weaknesses that will be discussed later.

Although most spinal pathologies can be managed non-operatively, there are specific conditions where surgery is indicated. Should pay-for-performance reimbursement structures become a mainstay, developing a fundamental methodology for quantifying quality of care in a reproducible, equitable, and efficient manner will be absolutely essential. Without it, cost will be the default driver of decision-making. Regardless of individual financial incentives, establishing standard metrics of quality and cost-effectiveness in spine care is important for population health research, maximizing healthcare value, and supporting patient-centered decision-making. In this review, we identify the key components of value in a surgical intervention and define the complexities in measuring value in spine surgery, we summarize current methods for defining value, describe the common types of value-based analyses, and we discuss the use of QALYs as a tool for evaluating cost-effectiveness.

Defining Value in Healthcare

The value of healthcare can be conceptualized as an improvement in a specific clinical outcome per unit cost. Put simply, value is a ratio of quality and cost (Fig. 1). When considered at the population level, this metric compares the



Figure 2. Categories of Innovation.

overall improvement in a health metric for a specific patient group to the total cost of care. The goals of any healthcare system should include the provision of high value of care while also ensuring economic stability for its survival⁷. This analysis should consider alternative treatments as well as potential future treatments in relation to the planned intervention. In certain scenarios, it may be prudent to invest in more expensive primary interventions to avoid cheaper but ineffective current alternatives or the risk of even more costly secondary treatment interventions in the future.

Unfortunately, measuring value in the modern healthcare system is particularly challenging due to the widely variable costs, lack of consolidated outcome measure reporting, and heterogeneity of different patient populations and healthcare systems⁷. Low-value care can be defined, however, in two holistic ways as follows: i) failing to achieve an adequate outcome or health benefit (e.g., the numerator of the value equation) or ii) achieving an average or modest health benefit for an excessive cost investment (e.g., the denominator of the value equation)^{8,9}.

One way to approach the value of care is through the categories of innovation lens. Category I Innovations, as defined by Chandra and Skinner, are treatments that are very inexpensive yet have widely appreciated benefits (e.g., antibiotics, beta blockers). Patients who receive this type of intervention either benefit from its very low cost or from the avoidance of significantly adverse effects that would have resulted without its implementation. Category II Innovations tend to be very effective as well, but only for a small subset of the population. Angioplasties using a stent are an example of this type of treatment. Finally, Category III Innovations have very small, unclear, or potentially deleterious effects on the patient (e.g., vertebroplasty). While Category III Innovations are undoubtedly cost-ineffective, they are often seen in practice due to a lack of research surrounding their efficacy (or lack thereof). Not all treatment options will be considered Category I Innovations, but it is important to evaluate the clinically proven effectiveness of a new (or existing) intervention before adopting it (Fig. 2)¹⁰.

Despite the abundance of literature, the optimal method for measuring the cost-effectiveness of spine care remains to be established. One major limitation is the inherent complexity in defining and reporting healthcare costs, which makes precise measurements and comparisons of cost-effectiveness data particularly challenging⁷. Another limitation is the wide range of heterogeneity in the methodology of studies that estimate the cost-effectiveness of spine care^{11,12}. Furthermore, there has been a general concern that

cost-effectiveness studies are susceptible to publication bias¹³. A more standardized and structured approach for estimating cost-effectiveness in spine surgery would be beneficial in addressing these challenges.

While standardization of costs would be an important step toward the implementation of cost-effective care, it is also important to note the full scope of potential effects that any cost-adjustments could have on the healthcare system as a whole. In the late 20th Century, William Kissick postulated the “iron triangle,” a model that demonstrates the interconnected nature of healthcare quality, access, and cost. In other words, a given intervention meant to improve one of the pillars will directly affect the other two pillars. For example, a decision to impose a price ceiling on certain surgical procedures at a hospital may increase access by incentivizing surgeons to see more patients, but may also have the unintended consequence of decreased quality of care¹⁴.

Agarwal et al. emphasized the importance of trying to simultaneously better all three outcomes (by improving access and quality while keeping costs low) in the case of orthopedic and neurologic surgery, specifically, by means of “reducing surgical implant costs and the incidence of surgical site infection.” To address this issue, physician awareness interventions and leveraging the Hawthorne effect were suggested, though randomized control trials have not conclusively supported the efficacy of this adjustment. Another option involves the utilization of incentive-based programs, such as bundled payments, to encourage more cost-effective care. Programs like the Bundled Payments for Care Improvement and for Joint Replacement performed by Medicaid supported this notion given they resulted in significant cost savings without sacrificing quality for joint replacement surgeries¹⁴.

Performance Indicators in Spine Surgery

Specific criteria for performance indicators can vary, but they are generally defined as objective metrics of performance that can be used to compare an organization’s performance with established standards or that of other organizations over time. It is important to distinguish a performance indicator from a performance score or metric. A performance indicator-based on the National Quality Forum definition-must meet the following three criteria: i) comparisons with established standards, ii) the use of risk adjustment and/or exclusion criteria, and iii) the use of benchmarking¹⁵. In contrast, a performance score or metric is simply an outcome measurement that does not necessarily have any established standard¹⁶. Performance indicators do not inherently contain information regarding cost. However, these measures could easily be combined with cost data to yield estimates of overall value.

Presently, performance indicators are not being widely used to measure quality and effectiveness in spine surgery. In a recent systematic review, St-Pierre et al. summarized how various performance indicators are currently employed

in spine surgery¹⁵. Using the National Quality Forum definition of a performance indicator, the authors found that only 19 of 865 articles screened discussed some type of performance measure, and none of these met the necessary criteria to be considered performance indicators. Nonetheless, there did appear to be some consensus regarding basic performance metrics. Notably, the included studies utilized a few specific metrics-visual analog scale, Neck Disability Index, Oswestry Disability Index (ODI), EuroQol-5, and Short Form-36/Short Form-12 metrics. These commonly used performance metrics could easily be incorporated into any performance indicator scoring systems that may be developed in the future.

More recently, prospective database registries have been developed to store patient-reported outcomes (PROs) across multiple institutions, providing ample data of specific metrics that are relevant to the outcomes of particular procedures¹⁷⁻²⁰. These PROs are another class of performance metrics that could be included in a standardized performance indicator scoring system. A system would need to be developed that not only utilizes these standard metrics, but also allows for adjustment with different patient populations and explicitly defines a benchmark outcome goal.

Value of Care Measurements in Spine Surgery

QALY is one of the most commonly used metrics for quality of care, taking into account both estimates of the length and quality of life²¹. Cost data can be directly combined with QALY data to estimate cost-per-QALY (e.g., dollars per QALY)²². Generally, a medical intervention is considered to be cost effective if the cost-per-QALY is less than a predetermined threshold of willingness to pay²³⁻²⁵. Various willingness-to-pay thresholds have been cited in the literature, each of which is dependent upon the specific context and goal of the intervention (i.e., life extending, lifesaving, or quality of life improvement) and the definition of the “payer” (i.e., an individual patient or society)²⁶⁻²⁸. In the United States, a range of \$50,000-\$100,000 has been often referenced as a target threshold^{29,30}. Given the inherent subjectivity involved in such a decision from a payer’s perspective, no precise threshold for cost-per-QALY has been established. Importantly, a change in QALY from a medical or surgical intervention can signify substantial clinical benefit³¹.

However, while QALYs are a widely appreciated means of quantifying the cost-effectiveness of healthcare, it remains a flawed methodology. Neumann and Cohen note the impracticality of assessing each individual patient’s preferences and priorities, which necessitates the use of generic functions and limits the applicability to a specific patient. Even on a broad population-based scale, QALY values do not always align with public opinion on the right course of action. For example, some conditions are viewed as always requiring treatment, regardless of the cost or likelihood of a positive outcome. Furthermore, even when individual preferences are assessed, the different surveys and methods for de-

Table 1. Common Health Economic Analyses. Cost-benefit, Cost-effectiveness, and Cost-utility Analyses.

Common Economic Analyses Used in Healthcare Research	
Type of Analysis	Description
Cost-benefit analysis	Systematic approach to directly compare the benefit or gain of different interventions in relation to their cost. The metric used is always a monetary value (e.g., dollars). The dollars spent are subtracted from the dollars gained/saved, and the net cost-benefit is determined.
Cost-effectiveness analysis	Systematic approach to compare the costs and health outcomes of different interventions. The metric used is always a monetary value (e.g., the net cost) required to achieve a specific outcome. However, the outcome can vary depending on the study design. Examples of outcomes include lives saved or cases averted.
Cost-utility analysis	Methodology that compares the ratio between the net cost and the number of quality years gained by a specific intervention. The metric used is typically the cost per quality-adjusted life-year (QALY). Cost is measured in monetary value (e.g., dollars). QALY measures both the quantity and quality of years gained. The quantity is the total number of years. The quality is a weighted metric to estimate the overall quality-of-life of a given year lived. This ranges from 0 (equivalent to death) to 1 (a year of perfect health).

termining a patient's preferences can generate inconsistent responses. The issue of age- and ability-based discrimination also arises, given that older and sicker patients have less potential QALYs available. Finally, the quantification of QALYs may weigh a couple of years in great health and many years in poor health equally, which is important to consider as well³².

A QALY by itself is not the only way to estimate quality of care when assessing cost-effectiveness or cost-utility. There are several other study designs that can be used to quantify and compare cost-effectiveness of interventions^{33,34}. Angevine et al. provided an overview of three economic analyses for evaluating healthcare interventions: i) cost-benefit analysis, ii) cost-effectiveness analysis, and iii) cost-utility analysis (Table 1). Each of these methodologies address the following important question: which intervention will give a patient the most benefit relative to its overall cost? The main difference in these methodologies is the primary outcome measure used. Cost-benefit, cost-effectiveness, and cost-utility analyses designs measure the following outcomes, respectively: monetary value (dollars gained or saved), specific health outcomes, and QALYs³⁴. When undertaking a cost-utility analysis, a cost-effectiveness ratio can be calculated, which is defined as the "total costs (direct + indirect) of an intervention divided by the quality of life gained from, or utility of, the intervention." An incremental cost-effectiveness ratio can also be calculated; the incremental cost-effectiveness ratio is the ratio between the differences in cost and the differences in quality of life or utility gained between separate medical and/or surgical interventions, used to quantify how much more cost effective a given intervention may be³³. These metrics can be used to compare the cost-effectiveness of surgical versus medical management, or perhaps two different surgical options. Each of these methodologies provides a unique perspective to the overall value of a procedure, with specific advantages and disadvantages, particularly for spine surgery³⁴.

Parker et al. identified 1454 patients undergoing elective lumbar surgery for disk herniation, revision disk herniation, stenosis, and spondylolisthesis³⁵. The authors assessed the

ODI, numeric rating scale pain scores for back pain and leg pain, and quality of life with the EuroQol-5D at baseline and 12 months after surgery. In this study, the minimum clinically important difference (MCID) was used to define the clinically significant improvement in disability (e.g., ODI). Specifically, MCID was defined as a threshold to assess the correlation between the change in a PRO measure and an externally validated measure of a patient's actual perception of their clinical improvement following the intervention of interest. Although there was significant improvement in PROs at 1 year postoperatively, nearly 40% of patients failed to achieve the MCID threshold. The average QALY achieved was 0.29 for all diagnoses with a mean total cost of \$28,340; however, nearly 20% of patients reported no gain in QALY at 1 year postoperatively. At 2 years postoperatively, the average QALY achieved was 0.62 for all diagnoses with a mean total cost of \$31,834; 14% of patients reported no gain in QALY at 2 years postoperatively. Importantly, there was substantial variability in the cost-per-QALY gained at the patient level across all diagnoses. For example, in patients with a diagnosis of spondylolisthesis undergoing laminectomy and fusion, there was a range of cost-per-QALY from \$10,728/QALY to \$302,937/QALY³⁵.

Porter et al. introduced in 2004 the concept of defining the value of healthcare in terms of patient "outcomes achieved per dollar spent"⁷⁷. In 2013, Nwachukwu et al. broadened Porter's theory and introduced guidelines pertaining to the field of orthopedic surgery, stressing the use of disease-specific, patient-reported outcome measures and the intricacies of cost variables when calculating the value of care³⁶. Berglund et al. applied this concept to total shoulder arthroplasty and introduced the procedure value index (PVI). PVI is a ratio calculated using patient-reported outcome measures (PROM) in units of MCIDs over the mean cost of care. They used four different PROMs with calculated MCIDs for each and utilized the following three different measurements of cost: total hospitalization cost, total charges, and total reimbursement. The authors stated that the inclusion of these three different aggregate costs would yield a PVI that is pertinent to the payer, patient, and hospital

system³⁷⁾.

This wide variability in effectiveness demonstrates a lack of generalizability and the need for patient-specific treatment modalities. Furthermore, there is a need to identify specific patient- and surgical- risk factors that may place patients at risk for a less than desirable outcome. These individual metrics can help providers make more educated decisions with regards to improving patient quality of life and minimizing unnecessary costs. Additionally, a consensus of the appropriate cost-per-QALY threshold of different spine surgeries needs to be established. As these metrics become more commonplace in spine surgery, the potential for personalized health care will continue to be developed.

Conclusion

As efforts to control increasing healthcare costs in the United States continue, it is essential to quantify the value of different surgical interventions thoroughly and accurately. This particularly applies to elective spine surgical procedures, which are increasingly utilized and have high associated costs. Determining the value of surgical interventions is inherently complex. The two most fundamental components of value-quality and total cost-are both difficult to quantify. Quality, often reported in the form of subjective outcome measures, is a challenge to define and standardize among different patients. Although it is straightforward to calculate the aggregate hospital cost following a surgical procedure, it is not simple to estimate the total cost of a procedure-including direct and indirect costs. As the healthcare system shifts toward value-based care, there is a substantial need for research assessing the value of specific spine surgery procedures. Furthermore, there is a need to investigate different predictors-both patient-specific and surgical-that may influence outcomes, cost, and value.

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