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SYMPOSIUM: VALUE BASED HEALTHCARE

Value-based Care in the Management of Spinal Disorders: A Systematic Review of Cost-utility Analysis

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Abstract

Background Spinal disorders are a major cause of disability and compromise in health-related quality of life. The direct and indirect costs of treating spinal disorders are estimated at more than $100 billion per year. With limited resources, the cost-utility of interventions is important for allocating resources.

Questions/purposes We therefore performed a systematic review of the literature on cost-utility for nonoperative and operative interventions for treating spinal disorders.

Methods We searched four databases for cost-utility analysis studies on low back pain management and identified 1004 items. The titles and abstracts of 752 were screened before selecting 27 studies for inclusion; full texts of these 27 studies were individually evaluated by five individuals.

Results Studies of nonoperative treatments demonstrated greater value for graded activity over physical therapy and pain management; spinal manipulation over exercise; behavioral therapy and physiotherapy over advice; and acupuncture and exercise over usual general practitioner care. Circumferential fusion and femoral ring allograft had greater value than posterolateral fusion and titanium cage, respectively. The relative cost-utility of operative versus nonoperative interventions was variable with the most consistent evidence indicating superior value of operative care for treating spinal disorders involving nerve compression and instability.

Conclusion The literature on cost-utility for treating spinal disorders is limited. Studies addressing cost-utility of nonoperative and operative management of low back pain encompass a broad spectrum of diagnoses and direct comparison of treatments based on cost-utility thresholds for comparative effectiveness is limited by diversity among disorders and methods to assess cost-utility. Future research will benefit from uniform methods and comparison of treatments in cohorts with well-defined pathology.

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Introduction

Spinal disorders are a common and important cause of pain, disability, and compromise of health-related quality of life. The 2008 National Health Interview Survey reported the age-adjusted prevalence of low back pain (LBP) in the US adult population to be 27.2% (SE = 0.41%) [40]. Back pain is the second most expensive musculoskeletal condition at an estimated $193.9 billion (in 2002–2004) [39] and is the leading physical complaint prompting physician visits. The incidence of LBP is highest among the workforce demographic: 39% and 35%

in individuals between the ages of 45–64 years and 18–44 years, respectively [39]. Consequently, LBP leads to major economic losses and healthcare expenditure, estimated to exceed $100 billion per year [15]. Given the high prevalence of LBP as well as its substantial socioeconomic impact, evidence regarding the cost-utility of treatment options is important.

Spinal disorders encompass a broad spectrum of pathologies and diagnoses, many of which share the common symptom of LBP. The clinically heterogeneous symptomatic LBP patient demographic encompasses a broad range of underlying pathologies, including spinal structural instability or deformity, neural compression, musculoligamentous injury, and extraspinal disease. Specific pathologies differ importantly in the demographic that is affected, natural history, clinical presentation, and responsiveness to treatment. The most accurate assessment of the utility of interventions for the management of spinal disorders would be based on a cohort with a specific spinal pathology. However, much of the literature of cost-utility in spinal disorders encompasses nonspecific pathology and LBP without a diagnosis.

The management of spinal disorders is characterized by substantial variability [26]. Patients as well as their healthcare providers are frequently faced with the challenging task of deciding between interventions from a broad spectrum of available options. In a healthcare economy with limited resources, providers and consumers of healthcare services need to be accountable for the effectiveness of care and the cost of care. Accountability for the cost-effectiveness of care includes consideration of the direct cost of care and the incremental utility of care compared with alternatives.

In a value-based healthcare economy, the cost-utility of interventions for spinal disorders may be used to determine an appropriate distribution of resources toward interventions with greater value. The value proposition in health care is an analysis of the utility and benefits of care relative to the direct cost and risk of providing the care [28]. Measuring benefits and costs is challenging, and a consensus on the measures that encompass the relevant components of the value component for spinal disorders has not been reached. Traditional outcome measures in orthopaedics, including survival, radiographic outcomes, and disease-specific outcome tools, do not adequately reflect the patient's healthcare experience or the impact of an intervention on health-related quality of life. Similarly, measuring the cost of care is complex and may encompass both direct costs of treatment as well as indirect costs including time away from work or family role, loss of productivity, and cost of caretakers [21]. Estimating costs is challenging because there is poor correlation between charges or reimbursement for care, which are easily measurable, and actual costs, which are not readily estimated. Transparency of costs is important in accurate cost-utility calculations, and the lack of transparency may lead to variability in the accuracy of cost-utility estimates.

Cost-utility analysis is an important determinant of the value of interventions in a value-based healthcare economy. The purpose of this article is to systematically review the literature on cost-utility analysis for the management of symptomatic LBP. The article specifically addresses the issues of: (1) Which nonoperative treatment(s) for LBP have the most favorable incremental cost-utility ratio and the greatest potential to provide the most value? (2) What is the relative cost-utility and value of surgical care over nonsurgical care for patients with LBP? (3) Which surgical procedure(s) used to manage LBP are associated with the most value?

Search Strategies and Criteria

We performed a comprehensive literature search of the MEDLINE, EMBASE, Cochrane Library, and CINAHL databases using their respective medical subject headings. A three-step search strategy was used to identify all potential articles of interest. First, all articles related to LBP or lumbar degenerative diseases were retrieved. Next, the subset of articles that were indexed under the subject headings of cost and cost analysis was identified. Finally, these articles were further filtered to only retain those studies that included quality-of-care data in addition to cost analysis. The search strategy included articles with medical subject headings of articles that included lumbar vertebra and low back pain and/or spinal disease with consideration of costs and utility including keywords of cost and cost analysis, quality of healthcare, quality of life, and quality-adjusted life years (Table 1). Potentially relevant articles lacking online access were ordered from the National Library of Medicine.

A total of 1004 articles (including duplicates) were retrieved on June 24, 2010, with the EMBASE database contributing 55%, MEDLINE contributing 26%, and Cochrane Library contributing 19% of the retrieved articles (Table 1). All three articles retrieved from CINAHL were duplicates. The MEDLINE, Cochrane Library, and CINAHL medical subject headings used for identifying the studies were identical. The EMTREE medical subject headings corresponding to cost and quality search criteria were broader in scope compared with other databases, possibly contributing to the retrieval of the highest number of search results through this database.

The titles and the abstracts of 752 unique articles were initially screened by one of the authors (SI) to identify the subset of studies to be evaluated more closely. The criteria

Table 1. MEDLINE, EMBASE, Cochrane Library, and CINAHL database search strategy details and results (including duplicates)

ID	MEDLINE		Cochrane		EMBASE		CINAHL	
	Limits = English, Human		Limits = English, Human		Limits = English, Human		Limits = English, Human	
	MeSH Headings	Number of hits	MeSH headings	Number of hits	EMTREE headings	Number of hits	CINAHL headings	Number of hits
1	Lumbar Vertebrae	21,892	Lumbar Vertebrae	1537	Lumbar Vertebrae	12,481	Lumbar Vertebrae	2640
2	Spinal Disease	8902	Spinal Disease	1489	Spine Disease	24,449	Spinal Disease	724
3	Low Back Pain	48,712	Low Back Pain	1808	Low Back Pain	113,949	Low Back Pain	3724
4	Cost and Cost Analysis	102,160	Cost and Cost Analysis	30,206	Health Economics	466,415	Cost and Cost Analysis	3416
5	Quality of Health Care	2,795,798	Quality of Health Care	291,906	Economic Evaluation	155,496	Quality of Health Care	6704
6	Quality of Life	68,978	Quality of Life	10,897	Health Care Quality	1,339,158	Quality of Life	19,607
7	Quality-adjusted life years	3979	Quality-adjusted Life-years	2606	Quality of Life	151,471	Quality-adjusted Life-years	140
	Combination		Combination		Combination		Combination	
Results	((1 AND 2) OR 3) AND (4) AND (5 OR 6 OR 7)	257	((1 AND 2) OR 3) AND (4) AND (5 OR 6 OR 7)	191	((1 AND 2) OR 3) AND (4 OR 5) AND (6 OR 7)	553	((1 AND 2) OR 3) AND (4) AND (5 OR 6 OR 7)	3

used for this preliminary screening included relevance of the article's subject matter to the current review on the value of various LBP interventions as well as the availability of cost and utility data in the study.

Full-length texts of this initial subset of studies were evaluated by one of the authors (SI) based on the following inclusion and exclusion criteria to further identify studies eligible for inclusion in this review. Inclusion criteria were (1) English language; (2) adults, 18 years of age and older; (3) at least 15 patients per intervention group at the start of the study; (4) minimum 1-year followup (considered as long-term followup for nonoperative interventions by the Cochrane Back Review Group [6]); (5) cost of intervention data reported; and (6) utility values (SF-6D or EQ-5D) or incremental quality-adjusted life-years (QALYs) gained or incremental cost-utility ratio (ICUR) reported. Exclusion criteria were (1) case reports; (2) meta-analyses or review articles; (3) PhD theses or conference abstracts; (4) modeling studies based on cost-effectiveness analyses; and (5) database search results with unavailable abstracts.

References of all previously published systematic reviews on cost-utility analysis (CUA) of LBP interventions as well as the studies selected for inclusion in this study were also reviewed to identify any additional studies not retrieved earlier or missed in the initial screening. Review of references led to identification of no additional articles for review or inclusion in the study.

Screening the title and abstract based on the relevance of the study in question to the topic of this review yielded 32 studies of interest. Four of the 32 articles [19, 27, 32, 47] were excluded as a result of a followup shorter than 1 year. The study by Ijzelenberg et al. [12] was excluded because it investigated the cost-utility of a LBP prevention program, not an intervention to manage LBP. As a result, a total of 27 studies were selected for inclusion in the systematic review. The earliest study included was published in 1995 [18] and the two latest studies were published in 2010 [8, 17]. The references of articles selected for this review and the previously published systematic review by Dagenais et al. [5] did not yield identification of additional studies. Of the 27 studies, 16 studies included here present the comparative cost-utility of two or more nonoperative interventions in managing symptomatic LBP, four studies evaluate the cost-utility of two operative interventions against each other in managing LBP, and seven studies compare the cost-utility of a nonoperative intervention with an operative intervention. All 27 studies identified for inclusion in this review were examined independently by all the reviewers (SSI, SHB [treating surgeon], MHW, SKT, SSH) on three different aspects to ascertain their study quality: (1) source of risk of bias: each study was assigned a low or high risk of bias based on the 12 question criteria proposed in Cochrane Back Review Group's

(CBRG) 2009 guidelines [7]; (2) strength of recommendation was determined as strong or weak based on the American Thoracic Surgeons (ATS) Guidelines and Recommendations [31]; and (3) quality of evidence was rated as high, moderate, or low based on the ATS Guidelines and Recommendations [31].

The composite quality score was the score for each dimension of quality (risk of bias, strength of recommendation, and quality of evidence). The composite quality score for each study was calculated based on the score it received from the majority of the reviewers on each dimension of quality mentioned. For example, a study receiving a high risk of bias from two reviewers but a low risk of bias from the remaining three was assigned an overall low risk of bias for the purposes of this systematic review. The same study receiving a scoring of strong recommendations from three reviewers and weak recommendations from two reviewers was determined to have made strong recommendations overall for the purposes of this review. A majority opinion on each dimension of the quality score (risk of bias, strength of recommendations, quality of evidence) emerged for each examined study, eliminating the need to reevaluate or resolve any inconclusive overall scores through consensus. There was moderate variability in interobserver grading of articles. Bias (graded as high or low) consisted of five of five authors agreeing 26% of the time (seven of 27 studies), four of five authors agreeing 44% of the time (12 of 27 studies), and three of five authors agreeing 30% of the time (eight of 27 studies). Strength of recommendations (graded as strong or weak) consisted of five of five authors agreeing 30% of the time (eight of 27 studies), four of five authors agreeing 37% of the time (10 of 27 studies), and three of five authors agreeing 33% of the time.

Quality of evidence (graded as high, moderate, low) consisted of five of five authors agreeing 15% of the time, four of five agreeing 33% of the time (nine of 27 studies), and three of five authors agreeing 52% of the time (14 of 27 studies).

Nine studies (six in Table 2, three in Table 3, and zero in Table 4) were determined to have a high risk of bias [7]. The majority of the studies were scored to have weak recommendations (17 of 27) and moderate evidence quality (18 of 27).

The following data were extracted from each selected article: (1) study design; (2) source for utility cost data; (3) study length; (4) compared interventions; (5) number of patients recruited; (6) patients' mean age; (7) percentage lost to followup; (8) baseline patient characteristics; (9) diagnosis or indication; (10) utility values; (11) QALYs gained; (12) total cost: direct charges or reimbursement and estimated indirect costs; and (13) CUA findings.

Many studies estimated an indirect cost, or a societal cost, based on considerations of time from work and lost productivity. All cost data were converted to US dollars (if necessary) using end-of-year currency exchange rates (available at http://www.oanda.com/currency/converter). The inflation-adjusted 2010 US dollar cost of an intervention was calculated using the consumer price index inflation calculator (available at http://data.bls.gov/cgi-bin/cpicalc.pl). For cost data collected over several years, the final year was used as the index year for currency conversion and inflation adjustment. If the year of cost data collection was not specified, the year of publication was used as the index year.

Results

Cost-utility of Nonoperative Care

Sixteen studies included in the review compared the cost and utility of nonoperative interventions for LBP (Table 2). Nonoperative studies had substantial deficiencies in defining the pathology treated and the consistency of nonoperative protocols. The baseline characteristics of the various intervention groups were similar in 11 of the 16 studies. The remaining five studies demonstrated considerable bias in baseline cohort selection: the study by van der Roer et al. [42] did not provide any information on the baseline characteristics, the study by Rivero-Arias et al. [30] reported a greater proportion of men and smokers in the control group versus the experimental group, and the difference between the intervention groups in the other three studies [16, 22, 35] related to higher morbidity and disability scores in the experimental intervention group compared with the control group. The length of followup in the nonoperative studies was 1 year or less in the majority of studies.

Five studies [1, 9, 11, 22, 24] reported the cost and utility of specific care but did not perform CUA. Nonsignificant differences in costs and utilities were detected in two of the studies [11, 22] because CUA was not performed. Hoeijenbos et al. [11] postulated that active implementation of the physiotherapy guidelines might lead to worse cost-utility as a result of increased expenditure without generation of additional utility in patients with nonspecific LBP. Bastiaenen et al. [1] did not mention the intention of performing CUA as part of their study, although cost and utility data were collected. At 95% confidence level, the unpaired t-test statistic yields nonsignificant differences in utility ($T = 1.267$, $df = 103$, two-tailed confidence level = 79.2%) but differences in cost ($T = 2.115$, $df = 103$, two-tailed confidence level = 96.31%). Thus, a trend toward better cost-utility of the experimental intervention, consisting of self-management and fear avoidance, relative to usual care can be inferred

Table 2. Design details of studies reporting the comparative CUA of two or more nonoperative interventions

Reference	Year	Diagnosis	Intervention 1	Intervention 2	Intervention 3	Intervention 4	Study design	Number of enrolled patients	Risk of bias	Strength of recommendations and quality of evidence
33	2009	> 3 months of nonspecific low back pain causing disability	Active Physical Treatment (APT)	Graded Activity with Problem Solving Training (GAP)	Combination therapy of APT and GAP	N/A	Economic analysis alongside RCT	172	High	1B
46	2007	< 12 weeks of nonspecific low back pain	Brief Pain Management Program (BPM)	Physical therapy (PT) (including spinal mobilization techniques)	N/A	N/A	RCT	402	Low	1B
1	2008	Lower back and pelvic girdle pain 3 weeks after delivery with onset during or immediately after pregnancy	Usual care (UC): choice among physiotherapist, general practitioner, no action	Experimental intervention (EI): referral to self-management and fear-avoidance program	N/A	N/A	RCT nested within cohort study	126	High	2B
11	2005	Nonspecific low back pain	Standard dissemination of physiotherapy guideline for low back pain in mail with 4 implementation forms	Two small group physiotherapist training sessions 4 weeks apart in addition to standard dissemination of guidelines in mail	N/A	N/A	Observational cohort study	483	Low	2B
9	1998	> 6 months low back pain, discrepancy between objective clinical findings and pain complaints with observable pain behavior	OPCON: Operant program with cognitive program and relaxation	OPDIM: Operant treatment with a group discussion treatment	USUAL: Individualized operant treatment without cognitive training, group discussions upon completion of 10-week waiting period	N/A	Economic evaluation alongside RCT	148	High	2B
24	2005	Chronic low back pain with or without sciatica, ODI at least 16%	Physician consultation with 5-month revisit: physician counseling for posture and spinal mobility exercises, education booklets	Combined manipulation, stabilizing exercises and instruction on exercise inclusion in daily activity sessions once a week for 4 weeks	N/A	N/A	RCT	204	Low	2B
17	2010	> 6 weeks subacute or chronic low back pain	15-minute active management advice and providing of *The Back Book*	Participation in the Back Skills Training program (BeST) with 15 minutes of advice and provision of *The Back Book*	N/A	N/A	RCT with parallel cost-effectiveness analysis	701	Low	1B
42	2008	> 12 weeks nonspecific low back pain	Guideline physiotherapy based on Low Back Pain Guidelines of the Royal Dutch College for Physiotherapy	Intensive group training protocol with exercise therapy, back school and behavioral principles	N/A	N/A	Economic evaluation alongside RCT	114	Low	2B
13	2007	< 12 weeks of subacute, nonspecific low back pain or exacerbation of mild symptoms	Usual Care (UC) by GP based on LBP guidelines from the Dutch College of General Practitioners	Minimal intervention strategy (MIS): 20-minute consultation with the GP to explore the psycho-social prognostic factors	N/A	N/A	Economic evaluation alongside cluster-RCT	314	Low	2B

Table 2. continued

Reference	Year	Diagnosis	Intervention 1	Intervention 2	Intervention 3	Intervention 4	Study design	Number of enrolled patients	Risk of bias	Strength of recommendations and quality of evidence
14	2007	> 3 months of persistent disabling low back pain	Control: Booklet and audio cassette education pack with standard GP care	16 hours of community-based treatment program in addition to the educational booklet and standard GP care	N/A	N/A	RCT	234	High	2C
4	2007	> 12 weeks of low back pain with/without leg symptoms or neurologic signs	6 hours of Individual physiotherapy protocol	12 hours of spinal stabilization physiotherapy	12 hours of pain management program using cognitive behavioral approach	N/A	Randomized, assessor blinded clinical trial with economic analysis	212	High	2B
30	2006	> 6 weeks low back pain with/without leg pain and neurological symptoms	1-hour physiotherapist advice/counseling session with provision of *The Back Book*	2.5 additional hours of physiotherapy treatment with 1 hour of advice/counseling and provision of *The Back Book*	N/A	N/A	Economic evaluation alongside RCT	286[87]	Low	2B
35	2005	4- to 52-week duration of persistent nonspecific low back pain	Usual GP care	Up to 10 total acupuncture treatment sessions in addition to usual GP care	N/A	N/A	RCT	241	Low	1B
38	2004	> 4 weeks low back pain	Best care in general practice	12-week long community exercise program in addition to best care	12-week long spinal manipulation package in addition to best care	6 weeks of manipulation followed by six weeks of exercise in addition to best care	Cost-utility analysis alongside RCT with factorial design	1334	High	2B
22	1999	> 4 weeks but < 6 months of mechanical low back pain	Usual GP care with occasional referrals to physiotherapy	8 hours of cognitive behavioral approach-based exercise program	N/A	N/A	RCT	187	Low	2B
16	2002	> 14 days of nonspecific low back pain with/without referred pain	Standard care protocol	Referral to neuroreflexotherapy in addition to standard care protocol	N/A	N/A	RCT	104	Low	2B

Quality of evidence scale: high = A, moderate = B, low = C; Strength of recommendations scale: strong = 1, weak = 2; N/A = not applicable; RCT = randomized controlled trial.

Table 3. Details of studies reporting the comparative CUA of a nonoperative intervention relative to an operative intervention

Reference	Year	Diagnosis	Intervention 1	Intervention 2	Study design	Number of enrolled patients	Risk of bias	Strength of recommendations and quality of evidence
44	2008	Intervertebral disc herniation	Surgical care: open or microdiscectomy decompression	Conservative care: active physical therapy, education/counseling with home exercise instructions, nonsteroidal antiinflammatory drug (if tolerated) and other additional interventions (prescribed by the physician or seeked by the patient)	Cost-utility evaluation alongside RCT	RCT: 501 [45] Observational cohort: 743 [44]	Low	1A
10	2007	Matched controls (I1): > 1 month of sick-listing, physician-certified low back problem Cases (I2): Lumbar disc herniation	Conservative treatment	Discectomy	Economic evaluation alongside RCT (CUA: case-control study)	Prospective cohort study: 1822	High	1B
25	2007	Failed Back Surgery Syndrome (FBSS) and radicular pain refractory to conservative treatment	Spinal cord stimulation (SCS): implanted stimulators, temporary stimulators	Reoperation: laminoforaminotomy, laminectomy, fusion, discectomy	Randomized controlled crossover trial	40	High	2B
29	2005	> 12 months of chronic low back pain with/without referred pain	Intensive rehabilitation program including one hydrotherapy session/day	Spinal fusion surgery: posterolateral fusion (41%), 360° fusion (41%) and graft stabilization (18%)	Economic evaluation alongside RCT	349	High	2C
18	1995	2 weeks of bed rest, lumbar disc herniation with radicular pain, sciatica	Conservative treatment with medication, bed rest, and physiotherapy	Surgical treatment including discectomy	Utility data source: RCT cost data: MEDSTAT commercial database	Long-term RCT 126 Short-term RCT 106	Low	2A
36	2008	Symptoms of neurogenic claudication or radicular leg pain with associated neurologic signs for 12 weeks, cross-sectional image-confirmed diagnosis of spinal stenosis with or without associated degenerative spondylolisthesis (DS)	Nonoperative care	Decompressive posterior laminectomy for spinal stenosis and decompressive posterior laminectomy with bilateral single level fusion for spinal stenosis associated with DS	Prospective cohort study	Spinal stenosis group: 634 Degenerative spondylolisthesis group: 601	Low	1A

Table 3. continued

Reference	Year	Diagnosis	Intervention 1	Intervention 2	Study design	Number of enrolled patients	Risk of bias	Strength of recommendations and quality of evidence
41	2008	Lumbosacral radicular syndrome lasting 6–12 weeks with radiographically confirmed disc herniation	Prolonged conservative care up to 6 months	Early surgery within 2 weeks of randomization with decompression, unilateral transflaval approach to remove herniated disc and loose degenerated disc material	Economic evaluation alongside RCT	283	Low	1A

Reference	Utility tool	Δ (Utility) or Δ(QALY)	Cost perspective (indirect costs)	Δ(Cost)	Followup length (years)	Index year	ICUR (inflation-adjusted 2010 US dollars)	Conclusion
37	EQ-5D	I1-I2: 0.21 (95% CI, 0.16–0.25)	Society (yes)	I1-I2: $14,137 (95% CI, $11,737–$16,770)	2	2004	$80,160 ($57,198–$109,723)	Surgery has moderate cost-utility over conservative care at 2-year followup with an ICUR of $80,160/QALY relative to conservative care
10	EQ-5D	I2-I1: 0.327	Not reported (yes)	I1-I2: $1520	2	2007	$4891	Surgery has better cost-utility than conservative care with an ICUR of $4891/QALY
25	Not reported	I1-I2: 0.18 (95% CI, −0.03 to 0.35) $p = 0.09$	Hospital (no)	I1-I2: −$1971 (95% CI, −$14,045 to $10,696) $p = 0.754$	Mean of 3.1	1995	59% probability of SCS domination over reoperation	59% probability of SCS domination over reoperation
29	EQ-5D	I2-I1: 0.068 (95% CI, −0.02 to 0.156) $p = 0.13$	National Health Service and Patient (no)	I2-I1: £3,304 (95% CI, £2317–4291) $p < 0.001$	2	2005	$77,930 (−$537,913 to 715,736)	With an ICUR of $77,930/QALY for surgery over rehabilitation, rehabilitation is preferred as a first-line therapy for chronic LBP
18	Time trade-off instrument	I2-I1: 0.43	Third party payer (no)	$12,550	10	1993	$44, 089	Lumbar discectomy, with an ICUR of $44,089/QALY, has better cost-utility than conservative treatment

Table 3. continued

Reference	Utility tool	Δ (Utility) or Δ(QALY)	Cost perspective (indirect costs)	Δ(Cost)	Followup length (years)	Index year	ICUR (inflation-adjusted 2010 US dollars)	Conclusion
36	EQ-5D	I2 (spinal stenosis without DS) –I1: 0.17 (95% CI, 0.12–0.22) I2 (spinal stenosis with DS) – I1: 0.23 (95% CI, 0.19–0.27)	Individual patient	I2 (spinal stenosis)– I1: $13192 I2 (spinal stenosis with DS) – I1: $$26,588	2	2008	Spinal stenosis without DS: $77,600 (CI, $49,600–$120,000) Spinal stenosis with DS: $115,600 (CI, $90,800–$144,900)	Although more expensive than nonoperative care over 2 years (ICUR of $77,600 and $115,600 for spinal stenosis without and with DS, respectively), surgery demonstrated better health outcomes
41	EQ-5D, SF-6D	I2 – I1: 0.044 (95% CI, 0.005–0.083)	Healthcare, Society	Healthcare: I2- I1: €1819 (€842 to €2790) Society: I2 – I1: € – 12 (€ – 4029 to €4006)	1	2008		

Quality of evidence scale: high = A, moderate = B, low = C; Strength of recommendations scale: strong = 1, weak = 2; RCT = randomized controlled trial; QALY = quality-adjusted life-years; ICUR = incremental cost-utility ratio.

based on the data reported by Bastiaenen et al. [1] in patients with postpartum lower back and pelvic girdle pain with onset during or immediately after pregnancy. With nonsignificant differences in utilities but significant differences in costs, a trend toward better cost-utility of USUAL (with lowest cost) over OPDIM (with moderate cost) and OPCON (with highest cost) may exist [9] in patients with more than 6 months of nonspecific LBP with discrepancy between objective clinical findings and the patients' pain complaints. Combination therapy of exercise and manipulation was more expensive than physician consultation without generating additional utility improvements, indicating better cost-utility of consultation over combination therapy [24] in patients with an Oswestry disability index (ODI) of at least 16% and chronic LBP with or without sciatica.

Graded activity with problem-solving demonstrated better cost-utility over active physical therapy and combination therapy [33] (Table 5) in patients with more than 3 months of nonspecific LBP severe enough to lead to disability. Physical therapy had an ICUR of $4594/QALY relative to brief pain management with a greater than 83% probability of being cost-effective at a willingness-to-pay threshold of £10,000 ($15,930)/QALY [46] in patients with less than 12 weeks of nonspecific LBP. A back skills training program generated a 90% probability of being more cost-effective than advice alone [17] in patients with more than 6 weeks of LBP. Although a minimal intervention strategy with 20-minute consultations emerged more cost-effective compared with usual care in the sensitivity analysis, the results of the primary analysis reporting inconclusive comparative cost-utility was endorsed by the authors of the study [13] in patients with less than 12 weeks nonspecific LBP or symptom exacerbation. The addition of a community-based active exercise component to education had an ICUR of $8650/QALY over education alone [14] in managing persistent LBP lasting > 3 months. Pain management was more cost-effective compared with individual physiotherapy and spinal stabilization physiotherapy [4] in a population with > 12 weeks of LBP. Individual physiotherapy had a favorable ICUR of $2216/QALY over spinal stabilization physiotherapy [4]. Physiotherapy was more cost-effective than advice alone at an ICUR of $6379/QALY [30] for patients with > 6 weeks of LBP. Acupuncture had an ICUR of $4241/QALY over usual care [35] in a population with persistent LBP lasting anywhere from 4 to 52 weeks. Spinal manipulation appeared the most cost-effective intervention followed by manipulation and community exercise, community exercise, and best care (in that order) [38] for patients with > 4 weeks of LBP. Referral to neuroreflexotherapy in addition to standard care with a cost utility of $88/QALY was more cost-effective than standard

Table 4. Details of studies reporting the comparative CUA of two operative interventions

Reference	Year	Diagnosis	Intervention 1	Intervention 2	Study design	Number of enrolled patients	Risk of bias	Strength of recommendations and quality of evidence
34	2007	Isthmic spondylolisthesis (30%), primary disc degeneration (35%), secondary disc degeneration (35%)	Posterolateral fusion: posterior fusion with no intervertebral support	Circumferential fusion: posterolateral fusion plus intervertebral support	Cost-utility evaluation alongside RCT	146	Low	1A
6	2007	> 6 months pain/functional deficit resulting from degenerative disc disease between L3-S1 (based on radiographic evidence) with failed nonoperative care [40]	One-level and two-level circumferential lumbar fusion with titanium cage	One-level and two-level circumferential lumbar fusion with femoral ring allograft	Economic evaluation alongside RCT	83	Low	1A
3	2009	Not reported	Decompression and posterolateral fusion with iliac crest bone graft (ICBG)	Decompression and posterolateral fusion with rhBMP-2/ACS	RCT	106	Low	2A
8	2010	Mechanical low back pain (31.25%), stenosis requiring facet resurrection (31.25%), spondylolisthesis (21.25%), postdiscectomy instability (16.25%)	Single-level decompression and posterolateral fusion with autogenous iliac crest bone graft (ICBG)	Single-level decompression and posterolateral fusion with rhBMP-2/matrix	FDA Investigational Device Exemption trial	96	Low	2B

Reference	Utility tool	Δ (Utility) or Δ(QALY)	Cost perspective (indirect costs)	Δ(Cost)	Followup length	Index year	ICUR (inflation-adjusted 2010 US dollars)	Conclusion
34	EQ-5D	Δ U: I1: 0.13 (95% CI, 0.07–0.18) Δ U: I2: 0.24 (95% CI, 0.19–0.29)	Society (yes)	I2 – I1: −$ 12,943 (95% CI, −$21,442 to $5428) $p = 0.012$	4–8 years	2004	$56,948 (95% CI, $31,396–$3,159,725)	Circumferential fusion dominates posterolateral fusion with a probability greater than 85% with an incremental saving of $49,306/QALY
6	SF-6D Standard Gamble	Δ U: I1-I2: −0.1392 (95% CI, −0.2349 to −0.0436)	National Health Service (yes)	I1-I2: £1950 (95% CI, £849–£3145) $p < 0.001$	2 years	2006	Femoral ring allograft dominates over titanium cage for use in circumferential lumbar fusion	Femoral ring allograft dominates over titanium cage for use in circumferential lumbar fusion
3	SF-6D Standard Gamble	Δ U: I1: 0.10 ± 0.10 Δ U: I2: 0.11 ± 0.12 $p = 0.757$	Healthcare system (no)	I1 – I2: $2319	2 years	2009	rhBMP-2/matrix has a more favorable (lower) cost-utility value than iliac crest bone graft	rhBMP-2/matrix has better cost-utility than iliac crest bone graft

Table 4. continued

Reference	Utility tool	Δ (Utility) or Δ(QALY)	Cost perspective (indirect costs)	Δ(Cost)	Followup length	Index year	ICUR (inflation-adjusted 2010 US dollars)	Conclusion
8	SF-6D Standard Gamble	Δ U: 0.153	Third party payer (yes)	$37,085 ± $12,788	5 years	2010	Actual Reimbursement: $53,914 Medicare Reimbursement: $50,949	ICUR for posterolateral fusion over a 5-year period is: actual reimbursements: $53,914/QALY Medicare reimbursements: $50,949

Quality of evidence scale: high = A, moderate = B, low = C; Strength of recommendations scale: strong = 1, weak = 2; RCT = randomized controlled trial; QALY = quality-adjusted life-years; ICUR = incremental cost-utility ratio.

care alone at $538/QALY [16] in managing > 14 days of nonspecific LBP.

Overall, cost-utility studies comparing two nonoperative interventions against each other evaluated a heterogeneous group of interventions applied toward the management of nonspecific LBP of varying durations and with variable, uniquely defined protocols. As a result, direct comparison of CUA data across different studies is not feasible, and other than potential trends toward greater value, no definitive conclusions can be drawn regarding the superiority of one nonoperative intervention over another. Notable trends include greater cost-effectiveness of graded activity over physical therapy and pain management in patients with LBP lasting > 3 months; cognitive behavioral therapy (BeST program) and physiotherapy over advice for LBP lasting > 6 weeks; acupuncture, exercise, and neuroreflexotherapy over usual care; individual physiotherapy over spinal stabilization physiotherapy in patients with > 12 weeks of LBP; and spinal manipulation over exercise for > 4 weeks of LBP. However, these findings are only supported by strong single-study evidence and need further substantiation before application to patient care or healthcare policy.

Cost-utility of Nonoperative and Operative Care

Seven studies compared the cost and utility of nonoperative and operative care (Table 3). Five of the seven studies compared the cost-utility of operative intervention for lumbar discectomy compared with nonoperative care. Among the studies comparing the relative cost-utility of operative versus nonoperative studies for lumbar disc herniation, operative care demonstrated a significant incremental benefit and outcome advantage over nonoperative care in all four studies and clear cost-effectiveness compared with nonoperative care in three of four studies. ICUR (in inflation-adjusted 2010 US dollars) of surgery relative to nonoperative care was estimated at $80,160/QALY [37], $4891/QALY [10], and $44,089/QALY [18]. One study evaluated cost savings to society, demonstrating a cost saving of > $4000 for early operative care compared with nonoperative care [41]. Nonoperative care for the management of nonspecific lumbar degenerative disorders (such as failed back surgery syndrome and nonspecific chronic LBP lasting > 12 months) is favored over nonspecific operative strategies. The incremental cost-utility ratio for operative care was $77,930/QALY [29] (with < 20% probability of being cost-effective at £30,000 ($47,835)/QALY). At a willingness-to-pay threshold of $45,000/QALY [23] established by the National Institute for Health and Clinical Excellence (NICE), two of the studies [29, 37] indicate favorable cost-utility of surgery

Table 5. Cost and Utility data of studies reporting comparative CUA of two or more non-operative interventions

Reference	Utility tool	Δ (Utility) or Δ(QALY)	Cost perspective (indirect costs)	Δ(Cost)	Followup length	Index year	ICUR (inflation-adjusted 2010 US dollars)	Conclusion
33	EQ-5D	Δ(QALY): I3-I1: −0.014 (0.094 to 0.066) Δ(QALY): I3-I2: −0.045 (−0.119 to 0.029)	Society (yes)	I3-I1: −€407 (−€6987; €5900) I3-I2: €4787 (−€984; €10,540)	1 year	2009	I1-I3: $56,782 I3-I2: $176,304	I1-I3: $56,782 I3-I2: $176,304
46	EQ-5D	Δ(QALY): −0.020 (−0.06 to 0.02) p = 0.35	Health care (no)	I1-I2: −£61.79 (−£146.76; £23.18) p = 0.15	1 year	2002	$4,594	$4,594
1	EQ-5D	ΔU: I1-I2: 0.04	Society (yes)	I2-I1: −€4,341.1 (−€8,850; €167.7)	1 year	2003	Trend toward better cost-utility of experimental intervention over usual care: nonsignificant differences in utility with experimental intervention costing less than usual care	Trend towards better cost-utility of experimental intervention over usual care: nonsignificant differences in utility with experimental intervention costing less than usual care
11	EQ-5D	Graphical representation: nonsignificant differences	Society (yes)	I2-I1: €892	1 year	2002	Nonsignificant differences in costs and utilities	Nonsignificant differences in costs and utilities
9	Maastricht Utility Measurement Questionnaire	Graphical representation: non-significant differences	Not reported (yes)	I1-I2: $2458.4 I2-I3: $5766.26	1 year	1993	Trend toward best cost-utility of USUAL, followed by OPDIM and then OPCON	Trend toward best cost-utility of USUAL followed by OPDIM and then OPCON
24	15D Quality of Life Instrument	I1: 0.91 (0.082) I2: 0.91 (0.0078) ΔU: p = 0.007	Society (yes)	I2-I1: $1,662 ($907)	2 years	2002	CUA not performed due to high percentage of missing baseline HRQOL data: trend toward better cost-utility of consultation over combination therapy	CUA not performed as a result of high percentage of missing baseline HRQOL data: trend toward better cost-utility of consultation over combination therapy
17	EQ-5D	Δ(QALY): I2-I1: 0.099	Healthcare provider (no)	I2-I1: £196.87	1 year	2008	$2,620	$2,620
42	EQ-5D	Δ(QALY): I2-I1: 0.03 (95% CI, −0.06 to 0.12)	Society (yes)	I2-I1: €233 (−€2185, €2764)	1 year	2008	$7,343	$7,343
13	EQ-5D	Δ(QALY): I1-I2: 0.004 (95% CI, −0.04 to 0.03)	Society (yes)	I2-I1: €490 (−€987; €92)	1 year	2007	$73,331	$73,331
14	EQ-5D	ΔU: 0.04 (−0.01 to 0.09)	Health care (no)	I2-I1: £27 (−£159, £213)	1.25 years (CUA over 1 year)	2007	$9,102	$9,102

Table 5. continued

Reference	Utility tool	Δ (Utility) or Δ(QALY)	Cost perspective (indirect costs)	Δ(Cost)	Followup length	Index year	ICUR (inflation-adjusted 2010 US dollars)	Conclusion
4	EQ-5D	Δ(QALY): I1-I3: −0.01 Δ(QALY): I1-I2: 0.09 Δ(QALY): I2-I3: −0.10	National Health Service (no)	I1-I3: £309 I1-I2: £95 I2-I3: £214	1.5 years	2007	$2,216	$2,216
30	EQ-5D	ΔU: I2-I1: −0.001 (−0.06 to 0.06)	Society (yes, not included in CUA)	I2-I1: £60 (−£5 to £126)	1 year	2006	$6,379	$6,379
35	SF-6D	ΔU: I2-I1: 0.02 (−0.028 to 0.068)	National Health Service (yes, not included in CUA)	I2-I1: £114.50 (−£39.74 to 268.73)	2 years	2002	$8,249	$8,249
38	EQ-5D	ΔU: I3-I4: 0.008 ΔU: I4-I2: 0.016 ΔU: I2-I1: 0.017	Health care (no)	I3-I2: £55 I2-I4: £17 I4-I1: £125	1 year	2002	I3-I4: $15,552 I4-I1: $6793 I3-I1: $8581 I2-I1: $14,836	I3-I4: $15,552 I4-I1: $6793 I3-I1: $8581 I2-I1: $14,836
22	EQ-5D	ΔU: −0.02 (−0.08 to 0.04) p = 0.47	Society (yes)	I1-I2: £148.28 (−£145.92 to £442.48) p = 0.32	1 year	1999	Nonsignificant differences in costs and utilities	Nonsignificant differences in costs and utilities
16	EQ-5D	ΔU: I1: −0.146 ΔU: I2: −0.117	Not reported (yes)	I1: 495,514 (2020−2,235 to 550) pesetas I2: 122,394 (56,442–282,014) pesetas	1 year	2002	Average case cost-utility of I1: $538/QALY Average case cost-utility of I2: $88/QALY	Average case cost-utility of I1: $538/QALY Average case cost-utility of I2: $88/QALY

QALY = quality-adjusted life-years; ICUR = incremental cost-utility ratio.

over nonoperative care, whereas the other two studies [10, 18] support nonoperative care over operative interventions. Maintenance of an incremental benefit of operative care over a longer period of followup would result in conclusive evidence of cost-effectiveness of operative care at the NICE threshold for the management of symptomatic intervertebral disc herniation.

Operative versus nonoperative care studies were limited by high rates of patient crossover and poorly defined nonoperative protocols. Salient differences in the baseline characteristics between the surgical and nonoperative care groups were mentioned in two of the five studies. In the study by Tosteson et al. [37], the patients in the surgical care group were younger, more likely to have L5/S1 herniation, worse utility and pain scores as well as either applied for or were receiving compensation. Rivero-Arias et al. [29] noted a greater proportion of women in the nonoperative care group and a greater proportion of men in the operative care group in addition to certain differences in the occupational characteristics between the groups as well. In general, the number of patients enrolled in these studies was greater than the number enrolled in the studies comparing two operative interventions against each other. Furthermore, only two of the five studies in this set reported a $< 10\%$ loss to followup, including the studies by Tosteson et al. [37] and North et al. [25].

Two studies included consideration of implants including pedicle screws for spondylolisthesis and spinal cord stimulation [25, 36]. Adding fusion to the decompression reduces the cost-effectiveness of decompressive surgery, because patients with spinal stenosis treated with laminectomy had a cost of $77,600/QALY compared with patients with degenerative spondylolisthesis treated with laminectomy and fusion who had a cost of $115,600/QALY [36]. The use of spinal cord stimulation compared with reoperation in the management of LBP refractory to primary surgery concluded that spinal cord stimulation was cost-effective with a probability of 59% and produced greater cost-utility with a probability of 72% at a willingness-to-pay threshold of $40,000/QALY [25] (Table 3). However, this study was limited by its crossover randomized controlled trial study design as well as the small number of 40 patients enrolled. A more rigorous study design with a greater number of patients is thus required to confirm and validate the preliminary results obtained by North et al. [25].

Cost-utility of Operative Care

Four studies addressed comparative CUA of alternative operative interventions (Table 4). All four studies included evaluated the cost-utility of lumbar fusion. Circumferential fusion was cost saving compared with posterolateral fusion with an ICUR of $49,306/QALY by costing less and providing greater utility $> 85\%$ of the time in patients with isthmic spondylolisthesis or primary/secondary disc herniation [34]. Femoral ring allograft was more cost-effective than a titanium cage in circumferential fusion with a close to 100% probability for patients with degenerative disc disease between L3 and S1 leading to functional deficits. The cost-effectiveness acceptability curve indicated only a 0.2% probability for titanium cage to be cost-effective at a high willingness-to-pay (WTP) threshold of £1,000,000 ($1,594,500). Indirect costs were accounted for while computing total costs in both these studies. The remaining two studies [3, 8] in this subset of studies on operative interventions evaluated the comparative cost-utility of bone morphogenetic protein (BMP) to iliac crest bone graft (ICBG) in posterolateral fusion. The BMP and ICBG cost and utility data were pooled and a combined ICUR (in inflation-adjusted 2010 US dollars) of $53,914/QALY was reported by Glassman et al. [8] on observing nonsignificant differences between the BMP and ICBG intervention groups composed of multiple pathologies including mechanical LBP, stenosis requiring facet resurrection, spondylolisthesis, and postdiscectomy instability (Table 4). Recombinant human BMP-2/matrix was proposed to have a better cost-utility than ICBG3 based on a cost-computing Markov model that took into account the higher incidence of complications and revision surgeries associated with ICBG.

Overall, among the operative interventions, strong single-study evidence [14] points to the greater cost-utility of circumferential fusion over posterolateral fusion in a population with back pain secondary to primary or secondary disc degeneration and isthmic spondylolisthesis. For circumferential fusion, Freeman et al. [6] indicate greater value in the use of a femoral ring allograft over a titanium cage in patients with > 6 months of functional deficits resulting from degenerative disease between the L3 and S1 levels. The comparative cost-utility of BMP over ICBG is dependent on cost calculations of ICBG in comparison to recombinant protein with a minimal difference in utility between the interventions. These studies only evaluated the cost-utility of lumbar fusion and provide no information on the cost-utility of fusion compared with other surgical procedures.

Discussion

In a value-based healthcare economy, the preferred goal for healthcare delivery is superior patient value [26]. Using interventions providing the most value to the patients is essential to achieve this high standard of patient care.

The cost-utility of an intervention may be used to identify interventions that provide the most benefit to patients (as measured by patient-centered outcome measures) while incurring the least expenses. The primary goal of this article was to review the cost-utility literature on LBP interventions for the level of evidence supporting the greater value of one intervention over another. Literature on the CUA of interventions for LBP is important in understanding the cost-utility of treatment strategies for spinal disorders relative to other healthcare interventions.

There are a number of limitations to this study, some in the literature regarding CUA as well as others specific to our review. First, patient value is measured at the level of specific medical conditions. Therefore, CUA of spinal disorders should focus on specific diagnoses. The lack of specificity regarding the diagnosis that underlies the symptom of LBP is a fundamental limitation of the cost-utility literature on LBP. The articles included in this review had nonspecific LBP as a primary focus rather than a specific lumbar pathology. Therefore, the ability to translate cost-utility conclusions from this review across different spinal conditions and treatments is limited. Because LBP is a symptom associated with a heterogeneous collection of clinical diagnoses and conditions, there is a need for future CUA research identifying the most effective intervention for a specific medical diagnosis instead of generalized symptomatic LBP. A given intervention might vary in its effectiveness when used for different underlying medical conditions causing symptomatic LBP. Consequently, evaluating the cost-utility of an intervention in the treatment of a variety of underlying medical conditions causing LBP may provide erroneous estimates of the intervention's value as a result of inherent weaknesses in study design. Study bias including a heterogeneous cohort and lack of uniform treatment and followup may increase confounding variables and limit the ability of a study to detect differences between alternative treatments. Thus, future translational CUA research may benefit from and provide more definitive data by enrolling a more homogeneous patient population diagnosed with a single underlying medical condition causing the symptom of LBP. Second,interstudy reliability in cost-utility articles on LBP is poor with no studies evaluating identical interventions or confirming each other's findings. The lack of interstudy reliability limits the translational ability of these studies. Regardless of how strong the data from an individual study might be, multiple independent studies confirming each other's conclusions are required to initiate modifications to standard clinical protocols. Currently, no guidelines exist that specify the minimum threshold of evidence that would justify modifying the clinical management of LBP. Reaching such a consensus will be critical to provide an overall framework for interpreting newly generated results as well as ensuring streamlining of future research efforts. Third, meta-analysis could not be performed in this systematic review because of the heterogeneity of diagnoses and treatments within the included studies. In addition to interintervention diversity, a considerable degree of intraintervention variability in the implementation of nonoperative interventions also exists. As a result, direct comparisons of nonoperative CUA data, even between studies examining the same set of interventions, is challenging and requires careful consideration of the implementation methodology. Fourth, studies exploring the cost-utility of combination therapies or experimental interventions are difficult to interpret, especially if the cost-utility of the individual component interventions pooled together is not understood. Fifth, care must be taken while interpreting the ICUR values within the context of the cost perspective used to compute it. Although the societal perspective is preferred from the standpoint of healthcare policy, the physician and the patient perspective might be the most valuable from an individual point of view. This factor must not be overlooked when comparing cost-utility values across studies. Sixth, there is some disagreement on how to handle nonsignificant differences in costs and effects. Three distinct approaches became evident during the course of this systematic review. Some studies [11, 22] decided to forego the intended CUA once nonsignificant differences were realized, reasoning that CUA will be inconclusive. The second approach pooled the different cost and utility data across interventions to obtain a composite cost-utility value [8]. The final approach adopted by Johnson et al. [14] proposes that CUA (with confidence intervals and cost-effectiveness acceptability curves) must be performed to identify the intervention most likely to be cost-effective regardless of whether statistically significant differences exist, because inconclusiveness is not a solution to a situation in which practicality demands that one intervention be chosen over another. However, such an approach would require careful consideration of the sensitivity of cost-effectiveness curves to minute changes in the input cost and utility estimates, affecting the credibility and reliability of drawn recommendations. It is also essential to recognize that statistical significance of costs or utility might not always translate into clinically or economically important differences. Small sample size in computing the variables of cost or utility might lead to a Type II or beta error, in which a difference between the two interventions being compared is detected when none exists (that is, the null hypothesis is erroneously rejected). Thus, care must be taken to extrapolate whether statistical significance translates into clinical or economic importance while interpreting the CUA data of all the studies included in this literature. Seventh, because LBP is a symptom associated with a heterogeneous collection of clinical diagnoses and conditions, future CUA research must be organized around identifying the most valuable intervention for a specific medical diagnosis instead of generalized symptomatic LBP. A given intervention might vary in its effectiveness when used for different underlying medical conditions causing symptomatic LBP. Consequently, evaluating the cost-utility of an intervention in the treatment of a variety of underlying medical conditions causing LBP may provide erroneous estimates of the intervention's value as a result of inherent weaknesses in study design. Thus, future translational CUA research may benefit from and provide more definitive results by enrolling a more homogeneous patient population diagnosed with a single underlying medical condition causing the symptom of LBP.

The cost-utility studies for nonoperative care of LBP demonstrate cost-effectiveness of graded activity over physical therapy and pain management; cognitive behavioral therapy (BeST program) and physiotherapy over advice; acupuncture, exercise, and neuroreflexotherapy over usual care; individual over spinal stabilization physiotherapy; and spinal manipulation over exercise. All these findings are supported by strong single-study evidence only. As a result, the implications of these studies require interstudy confirmation before translation into clinical practice and healthcare policy.

The comparative cost-effectiveness of surgical management relative to nonoperative care is dependent on the specific diagnosis and treatment. Operative care for spinal disorders involving nerve compression and instability demonstrates moderate to strong evidence for cost-effectiveness compared with nonoperative, especially in studies involving longer followup. The role of operative and nonoperative care in degenerative lumbar disorders without well-defined pathology and treatments is difficult to interpret and points to the importance of studies with well-defined diagnoses and treatments. Comparison of operative and nonoperative strategies for spinal disorders is challenging as a result of patient willingness to randomize to care and confounding effects of crossover [2]. Further studies with discrete diagnoses and treatment protocols will be required to address this important comparison, and observational studies based on prospective registries may be useful with appropriate stratification of cases by matching cohorts and propensity scores.

In studies comparing alternative operative strategies, current evidence indicates that circumferential fusion and femoral ring allograft are more cost-effective and thus provide greater value than posterolateral fusion and a titanium cage, respectively, among the operative interventions. Given the gradual increase in the rates of lumbar fusion with this procedure accounting for 47% of the costs associated with back surgery [43], delineating and understanding the cost-utility and the value of this procedure is important. The interaction of BMP with allograft may, however, favor the use of a nonresorbable interbody spacer for anterior spine surgery [20].

We found inconclusive information regarding the relative value of three pairs of interventions: recombinant human BMP versus ICBG, surgical versus nonsurgical care, and physiotherapy versus pain management. Although the studies by Carreon et al. [3] and Glassman et al. [8] both reported nonsignificant differences in utilities, the cost-effectiveness of care is dependent on a definition of the cost of ICBG and this cost has been reported variably. The four studies comparing surgical care with nonoperative management produced mixed findings, and a conclusive assessment of cost-effectiveness in comparing operative and nonoperative care is clearly dependent on the length of followup and a definition of a WTP threshold. Because the decision between opting for nonoperative care versus surgery is an important decision with major consequences for the various stakeholders, further elucidation of these preliminary results is necessary. The cost-utility of physiotherapy relative to pain management is unclear with the study by Whitehurst et al. [46] supporting physiotherapy, whereas the study by Critchley et al. [4] reported dominance of pain management. Additionally, because the study by North et al. [25] was a crossover randomized controlled trial with a small sample size of 40 patients, the comparative value of spinal cord stimulation relative to reoperation for patients with failed back surgery syndrome may benefit from a study with a bigger sample size. Identification of the underlying cause of failure of back surgery is also important, because outcomes of revision surgery are dependent on the pathology addressed by the revision.

CUA is an important study design for the assessment of management strategies for spinal disorders in a value-based healthcare economy. The CUA of alternative interventions may have important implications for healthcare policy and resource allocation. The literature identified in this systematic review is limited by large variability in the pathologies encompassed within and between studies. Future CUA in spinal disorders will benefit from direct comparison of well-defined spinal pathologies and consistent interventions.

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