The Quality of Cost-Utility Analyses in Orthopedic Trauma

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As health care in the United States transitions toward a value-based model, there is increasing interest in applying cost-effectiveness analysis within orthopedic surgery. Orthopedic trauma care has traditionally underemphasized economic analysis. The goals of this review were to identify US-based cost-utility analysis in orthopedic trauma, to assess the quality of the available evidence, and to identify cost-effective strategies within orthopedic trauma. Based on a review of 971 abstracts, 8 US-based cost-utility analyses evaluating operative strategies in orthopedic trauma were identified. Study findings were recorded, and the Quality of Health Economic Studies (QHES) instrument was used to grade the overall quality. Of the 8 studies included in this review, 4 studies evaluated hip and femur fractures, 3 studies analyzed upper extremity fractures, and 1 study assessed open tibial fracture management. Cost-effective interventions identified in this review include total hip arthroplasty (over hemiarthroplasty) for femoral neck fractures in the active elderly, open reduction and internal fixation (over nonoperative management) for distal radius and scaphoid fractures, limb salvage (over amputation) for complex open tibial fractures, and systems-based interventions to prevent delay in hip fracture surgery. The mean QHES score of the studies was 79.25 (range, 67-89). Overall, there is a paucity of cost-utility analyses in orthopedic trauma; however, the available evidence suggests that certain operative interventions can be cost-effective. The quality of these studies, however, is fair, based on QHES grading. More attention should be paid to evaluating the cost-effectiveness of operative intervention in orthopedic trauma. [Orthopedics. 2015; 38(8):e673-e680.]
The US health care system is transitioning toward value-based health care delivery. Therefore, economic analysis is increasingly being reported as practitioners are called on to demonstrate the value of their interventions. Established treatments, innovative technologies, and alternate care pathways are being appraised with a critical economic lens. Because orthopedic surgery accounts for a significant portion of US health care expenditures, particular attention has been paid to understanding the value of orthopedic intervention. Health care policy leaders in various fields within orthopedic surgery have called on surgeons and subspecialty leaders to focus on understanding the value of orthopedic surgery.

Cost-effectiveness analysis is the most widely accepted tool for assessing the value of an intervention or choosing among similar interventions. In particular, cost-utility analysis, a form of cost-effectiveness analysis that is most widely used in surgical fields, evaluates the economics of health care interventions in extending the quantity and quality of life (see Materials and Methods). To conduct a cost-utility analysis, investigators ascertain a utility for an intervention that is then translated into a quality-adjusted life year (QALY). Cost-utility analysis provides a standardized way to compare the value of an intervention both within and across specialties and is the preferred modality for reporting medical economic decision analysis.

Recent publications showed the cost-effectiveness of joint arthroplasty, sports medicine, and spine surgery. Compared with other fields in orthopedic surgery, little attention has been paid to economic analysis in orthopedic trauma. This lack of attention may be caused by the immediate and restorative nature of interventions in orthopedic trauma. Because of the current economic environment in health care, orthopedic traumatologists must pay attention to the value of interventions.

This systematic review evaluated US-based cost-utility analyses in the orthopedic trauma literature. This study summarized the cost-utility analysis literature and evaluated the quality of the identified studies. The authors hypothesized that there is a paucity of available literature and that the quality of the published literature is poor.

Materials and Methods

Explanation of Terms

In general, 4 methods of cost analysis are often grouped under the term “cost-effectiveness analysis.” These are cost-effectiveness analysis, cost-utility analysis, cost identification (minimization) analysis, and cost-benefit analysis. Several thorough reviews have addressed value measurement and cost analysis within orthopedics. This discussion provides only a brief primer for navigation of this review.

Cost-effectiveness analysis is the principal mode of assessing the cost per health unit gain. As part of the analysis, the cost of an intervention is measured against an objective health outcome, such as infection or mortality. The incremental cost-effectiveness ratio is then calculated by measuring the incremental costs required to achieve an incremental health benefit. Different options can then be compared according to the following formula: (cost of intervention−cost of alternative)/(benefit of intervention−benefit of alternative). Cost-effectiveness analysis is very useful but is limited by lack of patient-centric health determination. Cost-utility analysis is closely related to cost-effectiveness analysis. However, unlike cost-effectiveness analysis, cost-utility analysis provides a patient-centric, subjective utility measure of health, most commonly QALY. An incremental cost-utility ratio can be calculated with cost-utility analysis. Cost-effectiveness analysis and cost-utility analysis are similar and are often conflated under the umbrella term “cost-effectiveness.” However, they are distinct forms of analysis.

Beyond cost-effectiveness analysis and cost-utility analysis, cost-benefit analysis uses purely financial variables to compare the expected cost and monetary benefit of a procedure. To perform a cost-benefit analysis, the cost of a particular intervention is compared with consumer willingness to pay to achieve the health state afforded by that intervention. Health care consumers are queried to understand how much they are willing to pay for the intervention or to achieve a certain health state. Cost identification (minimization) analysis is another form of cost-effectiveness analysis in which the costs of particular interventions are compared and the least costly intervention is preferred. However, cost minimization is difficult to perform successfully because valid assessment requires the comparator health states to have equal outcomes (eg, equal rate of union for 2 methods of fracture fixation).

Overview and Eligibility Criteria for Review

Review of the literature was performed with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with a PRISMA checklist. The current study identified US-based cost-effectiveness analyses published during a 15-year period between January 1999 and January 2014. Studies underwent further review if they met the following a priori inclusion criteria: (1) the study was pertinent to fracture management of any kind; (2) the study was conducted in the United States; (3) the study was clinically based; (4) the study included cost-utility analysis; and (5) the study involved operative intervention. Studies were excluded if they were not relevant to fracture care, were nonclinical (ie, review or editorial), were not conducted in the United States, or were nonoperative.

Search Methods for Identification of Studies

The PubMed interface was used to search the MEDLINE database. An a priori search algorithm using PubMed medical subject headings was constructed. The
search function included 2 simple search terms: “fracture” and “cost.” An updated search was completed on January 15, 2014.

The search strategy identified 971 studies. Studies were included or excluded based on a review of study titles and abstracts. Review of these 971 articles identified only 8 studies that were suitable for inclusion. To further ensure that all appropriate studies were identified, the reference list of the 8 identified studies was also reviewed. No further articles met the inclusion criteria.

A recent study on the indexing of primary studies in orthopedic surgery found that, with appropriate search strategies, MEDLINE achieved a recall rate of 90%; MEDLINE and Embase achieved a recall rate of 91%; and MEDLINE, Embase, and Cochrane achieved a recall rate of 97%.16 The authors restricted the search to the MEDLINE database.

Quality Scoring

To assess the quality of economic studies, the Quality of Health Economic Studies (QHES) instrument was used. This instrument is a validated questionnaire that includes 16 questions with weighted binary responses that range from 1 to 9 points.17 Questions were derived by a panel of 8 experts in health economics, and point values were derived with a random-effects general least-squares regression, based on a conjoint analysis of survey results from 120 international health economists.18 Scores for the QHES instrument range from 0 to 100. There is no accepted value that defines high quality. However, since the introduction and application of the QHES instrument, the reported mean and median scores across various fields has been 80 to 90.19-21 Therefore, the authors considered a QHES score of greater than 85 an indicator of high quality.

Data Analysis

Based on previously identified predictors of high-quality evidence in orthopedic surgery,22-25 statistical analysis was performed to determine predictors of scoring 85 or higher on the QHES. Predictors of interest included the use of outcome or health state data from a patient sample, perspective of analysis, time horizon of analysis, mode of economic analysis, conflict of interest statement, perceived conflict of interest, funding source, more than 2 authors with an advanced degree beyond MD, and journal of publication.

Economic findings in the identified studies were reported descriptively. When appropriate, economic findings were presented as an incremental cost-effectiveness ratio ($/QALY gained). Although there is no consensus on the appropriate incremental cost-effectiveness ratio value on which to base decisions about resource allocation,26 the commonly quoted thresholds for cost-effectiveness are $50,000 and $100,000 per QALY gained.27 Some health care economists suggested that the cost-effectiveness threshold should be related to a country’s financial stability and societal willingness to pay.26 Thus, in the US context, interventions costing less than $100,000 per QALY gained would likely be deemed cost-effective.

Study characteristics of interest were abstracted from the identified studies. Factors associated with high-quality evidence (QHES≥85) were determined with 1-sided Fisher’s exact test to obtain a univariate odds ratio. P<.05 was considered significant. Statistical analysis was performed with Stata version 12.1 software (Statacorp, College Station, Texas). Identified studies were graded with the QHES by an author with experience in economic analysis (B.U.N.).

RESULTS

Overview of Eligible Studies

The search algorithm retrieved 971 studies from the MEDLINE database (Figure 1). Of the 971 retrieved studies, 801 (82.5%) were relevant to fracture management. Of these studies, 192 (24.0%) were US-based clinical studies.
and 31 of these used cost-utility analysis. Of these 31 studies, 23 were deemed nonoperative. Nonoperative studies primarily dealt with pharmacologic and screening modalities for osteoporosis management and treatment and fall prevention. Thus, this review included 8 cost-utility analyses that evaluated operative interventions for fracture management (Table).

**Economic Findings in Identified Studies**

Of the 8 identified studies, 4 evaluated the cost-effectiveness of operative interventions in hip and femur fractures.\(^{28-31}\) Faucett et al\(^{30}\) examined the cost-effectiveness of reconstruction nailing over standard intramedullary nailing for all femoral shaft fractures. The authors found in their base case that, when reconstruction nailing is performed instead of standard intramedullary nailing, the incremental cost-effectiveness ratio is $115,323/QALY gained. Based on sensitivity analysis, routine use of reconstruction nails was cost-effective. However, if there was a high rate of missed femoral neck fractures (>38%), if the probability of an ipsilateral femoral neck fracture was greater than 7%, and if the overall complication rate associated with reconstruction nails was low (<0.9%), then reconstruction nailing became cost-effective. Dy et al\(^{30}\) evaluated the cost-effectiveness of 2 systems-based interventions to prevent surgical delay of hip fractures. The first intervention involved employing medical personnel for after-hours preoperative evaluation. This strategy was associated with an incremental cost-effectiveness ratio of $2318/QALY gained. The second strategy also involved an after-hours operating room team. This strategy was associated with an incremental cost-effectiveness ratio of $43,153/QALY gained. In another study, Faucett et al\(^{30}\) analyzed the cost-effectiveness of ipsilateral hip fracture fixation compared with ipsilateral hip fracture fixation and contralateral prophylactic fixation in patients with femoral neck or intertrochanteric hip fractures. In the base case analysis, the use of ipsilateral hip fracture fixation and contralateral prophylactic fixation was associated with an incremental cost-effectiveness ratio of $142,795/QALY. Sensitivity analysis showed that the cost-effectiveness of prophylactic fixation was dependent on the risk of contralateral fracture as well as patient age at initial fracture. Slover et al\(^{31}\) analyzed the cost-effectiveness of total hip arthroplasty (THA) compared with hemiarthroplasty for the management of femoral neck fractures in active elderly patients. When THA was performed instead of hemiarthroplasty, the incremental cost-effectiveness ratio was $1960/QALY gained. The cost-effectiveness of THA vs hemiarthroplasty in this study was driven by the utility and functional benefits associated with the patient’s health state after THA.

Two studies evaluated the management of upper extremity fractures.\(^{32,33}\) Another study assessed management strategies for clavicle fractures.\(^{34}\) Shauver et al\(^{32}\) compared cast immobilization with 3 surgical options for managing distal radius fractures in the elderly. The authors found that cast immobilization was a dominant strategy for both external fixation and wire fixation. (In this case, “dominant” means that casting is both less costly and is assigned a higher utility.) Although open reduction and internal fixation (ORIF) was more costly, it was associated with significantly more utility gain. Thus, the incremental cost-effectiveness ratio for ORIF compared with cast immobilization for radius fracture was $15,330/QALY gained. Similarly, Davis et al\(^{33}\) compared cast immobilization with ORIF for acute non-displaced midwrist scaphoid fractures. The authors used both direct and indirect costing methods. When both direct and indirect (ie, lost productivity) costs were considered, ORIF was dominant across all age groups. When only direct costs were included in the computation, the incremental cost-effectiveness ratio ranged from $5438/QALY gained in 25-year-olds to $29,850/QALY gained in 65-year-olds.

Pearson et al\(^{34}\) compared ORIF with nonoperative treatment for displaced midshaft clavicle fractures in adults. The cost-effectiveness of surgical intervention was $65,000/QALY gained. However, the incremental cost-effectiveness ratio was highly dependent on the durability of benefit from surgical intervention. The result was $28,150/QALY for a lifetime benefit associated with surgery and $82,110/QALY for a benefit that lasted for only 1 year.

A study that evaluated the cost-effectiveness of amputation compared with salvage for Gustilo type IIIB and IIIC open tibial fractures found that salvage was both less costly and produced a greater QALY than amputation.\(^{35}\)

**Quality of Identified Studies**

The quality of cost-utility analysis in orthopedic trauma is fair. The mean QHES score for all identified studies was 79.25 (range, 67-89). Consistent with earlier methods for reporting author-derived quality scores of published cost-utility analyses in orthopedics, the authors present the quality of studies in aggregate but not the quality score for each individual study.\(^{36}\) Figure 2 shows how often each QHES criterion was fulfilled.

High-quality evidence was defined as a QHES score of greater than 85. Only 2 studies met this criterion. None of the a priori defined variables showed a statistically significant association with high-quality evidence.

**DISCUSSION**

This systematic review of the trauma literature included evidence from 8 cost-utility analyses in orthopedic trauma that met the eligibility criteria. Few cost-utility analyses have been performed in orthopedic trauma, and the quality of evidence is fair. The hypothesis was partially confirmed by the study.

Most identified studies evaluated hip and femur fractures. Based on the current evidence, systems-based interventions to prevent surgical delay of hip fractures...
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<tr>
<th>Journal</th>
<th>Study Design</th>
<th>Area of Analysis</th>
<th>Perspective</th>
<th>Baseline Population</th>
<th>Time Horizon</th>
<th>Major Findings</th>
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<tr>
<td>J Orthop Trauma</td>
<td>Decision analysis</td>
<td>Femoral shaft fractures</td>
<td>Hospital</td>
<td>Lifetime</td>
<td>$115,323/QALY gained when reconstruction nailing performed vs standard intramedullary nailing for femoral shaft fractures</td>
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<td>J Hand Surg Am</td>
<td>Decision analysis</td>
<td>Distal radius fractures</td>
<td>Societal</td>
<td>Lifetime</td>
<td>≥ 65 years old</td>
<td>$15,330/QALY gained when ORIF performed vs cast immobilization; casting dominant to external fixation and wire fixation</td>
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<tr>
<td>J Bone Joint Surg Am</td>
<td>Decision analysis</td>
<td>Hip fractures</td>
<td>Hospital</td>
<td>1 year</td>
<td>Not specified</td>
<td>$2318/QALY gained when medical personnel available for after-hours preoperative evaluation; $43,153/QALY gained when operating room team available to staff hip fracture surgery after hours</td>
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<tr>
<td>J Orthop Trauma</td>
<td>Decision analysis</td>
<td>Clavicle fractures</td>
<td>Societal</td>
<td>Lifetime</td>
<td>33-year-olds</td>
<td>$65,000/QALY gained when ORIF performed vs nonoperative management of displaced midshaft clavicle fractures</td>
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<tr>
<td>J Orthop Trauma</td>
<td>Markov model</td>
<td>Hip fractures</td>
<td>Various health care systems</td>
<td>Lifetime</td>
<td>79-year-old woman</td>
<td>$142,795/QALY gained when ipsilateral hip fracture fixation and prophylactic contralateral hip fixation performed vs ipsilateral fracture fixation alone</td>
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<tr>
<td>Plast Reconstr Surg</td>
<td>Decision analysis</td>
<td>Open tibia fractures</td>
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<td>Limb salvage for Gustilo IIIB and IIIC open tibia fractures dominant vs amputation</td>
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<tr>
<td>J Arthroplasty</td>
<td>Markov model</td>
<td>Hip fractures</td>
<td>Payer</td>
<td>20 years</td>
<td>Healthy, active 70-year-olds</td>
<td>$1960/QALY gained when total hip arthroplasty chosen over hip hemiarthroplasty for displaced femoral neck fractures</td>
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<tr>
<td>Plast Reconstr Surg</td>
<td>Decision analysis</td>
<td>Scaphoid fractures</td>
<td>Societal</td>
<td>Lifetime</td>
<td>Various age groups</td>
<td>Cost-effectiveness of ORIF compared with casting for acute nondisplaced midwaist scaphoid fractures varies based on age; $5438-29,850/QALY gained in patients 25-65 years old; after incorporation of indirect costs, ORIF dominant across all age groups</td>
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Abbreviations: ORIF, open reduction and internal fixation; QALY, quality-adjusted life year.

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<tr>
<th>Study</th>
<th>Number</th>
<th>Reference</th>
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<tr>
<td>Faucett et al</td>
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<td>Shauver et al</td>
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Although the utility of preoperative intervention for certain fractures is undeniable (e.g., hip fractures), there are many opportunities within orthopedic trauma to examine the value of operative interventions.

The quality of studies identified in this review was fair. Only 2 studies met the a priori QHES score cutoff for high-quality evidence. Few of the identified studies included a statement of perspective analysis and the use of discounting. The QHES instrument is largely based on recommendations from the Panel on Cost-Effectiveness in Health and Medicine.8,40

For future cost-utility analyses in orthopedic trauma, the authors recommend paying increased attention to the checklist developed by the Panel on Cost-Effectiveness in Health and Medicine.8 The checklist consists of 38 items recommended for inclusion in a journal article reporting the results of cost analysis. High-quality cost analysis and improved reporting of evidence will be more important and may more effectively show the utility of operative intervention.

**Limitations**

This review had certain limitations. As with any review, it is possible that appropriate studies were not identified. The authors used broad search terms and reviewed 971 abstracts. They also performed a reference search based on the identified authors used broad search terms and reviewed 971 abstracts. They also performed a reference search based on the identified studies to attenuate the risk of this particular weakness. Another limitation was the inclusion of only US-based cost-utility analyses. Of all identified studies, 542 (55.6%) were not performed in the United States, which suggests that most research in orthopedic trauma is being performed outside of the United States. Further, because other countries have already been paying attention to economic analysis in health care decision making, a significant number of non-US-based cost-utility analyses may have been excluded. However, the goal of this study was to focus on US-based cost-utility analyses. Utilities and health state preferences may vary based on the study population. Therefore, a European or Canadian patient may not value evidence. Economic analysis and outcome modeling are particularly helpful when the utility of an intervention is unknown. In such scenarios, economic analysis can aid in decision making when choosing a cost-effective option (i.e., an option that maximizes patient outcome and can be performed at a reasonable price point). Orthopedic trauma is the longest-standing subspecialty within orthopedics. As a result, fracture fixation is the norm and the benefits are self-evident. As a result, there may be apathy within the field to show the value of fracture management. Even for procedures with well-established clinical benefit, subspecialty leaders recently sought to demonstrate the value of orthopedic intervention. Ruiz et al6 analyzed the direct and indirect costs associated with TKA vs nonoperative management for the treatment of knee osteoarthritis. The authors found that TKA saved money. They reported an age-weighted mean societal cost savings of $18,930 with a concomitant age-weighted QALY gain of 2.4. With reform of the health care delivery system and budgetary constraints, resource allocation will likely be preferentially allotted to fields that can demonstrate their value.5,6 Although the utility of operative intervention for certain fractures is undeniable (e.g., hip fractures), there are many opportunities within orthopedic trauma to examine the value of operative interventions.
operative intervention in the same way as a US patient. Further, by including only US-based studies, this study highlighted the significant lack of attention devoted to this subject in the United States, where the cost of health care has been escalating. The current study was also limited by the small number of available studies. Interpretation of the incremental cost-effectiveness ratios presented in this review is limited because in most cases these ratios were derived from a single study with a limited set of assumptions. More work is needed to better evaluate the validity of assumptions and the effect of alternate decision tree and modeling scenarios.

Conclusion
This review found few cost-utility analyses in orthopedic trauma. The quality of the available evidence is variable and overall is only fair. More attention should be paid to cost-utility analysis research in orthopedic trauma. Researchers should strive to adhere to the guidelines provided for reporting cost analyses in medicine. The information provided in this review may help researchers to identify areas for further work.

References


