Contingent Valuation Studies in Orthopaedic Surgery: A Health Economic Review

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Abstract *Background:* A greater emphasis on providing high-value orthopaedic interventions has resulted in increased health economic reporting. The contingent-valuation method (CVM) is used to determine consumer valuation of the benefits provided by healthcare interventions. CVM is an important value-based health economic tool that is underutilized in orthopaedic surgery. *Questions/Purposes:* The purpose of this study was to (1) identify previously published CVM studies in the orthopaedic literature, (2) assess the methodologies used for CVM research, and (3) understand how CVM has been used in the orthopaedic cost-benefit analysis framework. *Methods:* A systematic review of the literature using the MEDLINE database was performed to compile CVM studies. Search terms incorporated the phrase *willingness to pay* (WTP) or *willingness to accept* (WTA) in combination with orthopaedic clinical key terms. Study methodology was appraised using previously defined empirical and conceptual criteria for CVM studies. *Results:* Of the 160 studies retrieved, 22 (13.8%) met our inclusion criteria. The economics of joint arthroplasty ($n = 6$, 27.3%) and non-operative osteoarthritis care ($n = 4$, 18.2%) were the most common topics. Most

studies used CVM for pricing and/or demand forecasting ($n = 16$, 72.7%); very few studies used CVM for program evaluation ($n = 6$). WTP was used in all included studies, and one study used both WTP and WTA. Otherwise, there was little consistency among included studies in terms of CVM methodology. Open-ended questioning was used by only ten studies (45.5%), a significant number of studies did not perform a sensitivity analysis ($n = 9$, 40.9%), and none of the studies accounted for the risk preference of subjects. Only two of the included studies applied CVM within a cost-benefit analysis framework. *Conclusion:* CVM is not commonly reported in orthopaedic surgery and is seldom used in the context of cost-benefit analysis. There is wide variability in the methods used to perform CVM. We propose that CVM is an appropriate and underappreciated method for understanding the value of orthopaedic interventions. Increased attention should be paid to consumer valuations for orthopaedic interventions.

Keywords contingent valuation method · cost-benefit analysis · cost-effectiveness analysis · willingness to pay

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Introduction

Understanding the value of healthcare interventions has become increasingly important. Value in healthcare can be defined as the unit of health outcome obtained per dollar spent [26, 32]. The science of health economics consists of formal cost-effectiveness analyses in the form of cost-utility analysis, cost-benefit analysis (CBA), and cost-minimization analysis. Cost-utility analysis is the most commonly recognized form of health economic analysis, and these types of studies rely on dollar per quality adjusted life year (QALY) as the primary unit of analysis. In cost-utility analysis, the cost of the intervention is compared with the expected utility gain (measured in QALY). CBA differs

from cost-utility analysis in that the expected utility gain is expressed in monetary terms, and thus both the numerator and denominator are in monetary units. To define the expected monetary utility gain (or loss), willingness to pay (WTP) for an intervention or willingness to accept (WTA) payment to forgo an intervention are typically ascertained from the healthcare consumer. Advocates of CBA note the ease of comparability across procedures due to the use of strictly monetary units in the calculation [11]. Additionally, CBA acknowledges the role of the patient as a consumer of healthcare and may more easily provide health economists with a tool to evaluate new technologies and programs based on consumer valuations. While there are various stakeholders in healthcare (e.g., hospital systems, providers, payors, and government agencies), the patient is the fundamental consumer of healthcare. Health economists argue that a patient-focused value-based framework benefits all stakeholders [32]. As such, WTP and WTA incorporate patient preferences while the perspective of other stakeholders in the healthcare system is captured through their incurred costs for providing a healthcare intervention. Thus, in a CBA model, patient preferences are compared to the costs incurred by society, the payor, or a healthcare system.

A drawback to CBA is the technical difficulty in accurately measuring WTP or WTA. The contingent valuation method (CVM) was initially introduced and applied to valuation strategies in transport and environmental economics [21, 29]. CVM has since been adapted and applied to healthcare economics [11]. As part of healthcare CVM, the healthcare consumer considers a market that could exist for the benefits achieved with a healthcare intervention. Thus, the consumer elaborates on WTP or WTA based on the *contingency* that this hypothetical market exists. CVM has been reported in various aspects of healthcare [7, 20, 49], and prior reviews have described the role of CVM in analyzing diabetes care [22, 46], reproductive health [28], immunization strategies [10, 50], and geriatric medicine [23]. There have been prior reviews of health economics in orthopaedic surgery [31, 33–35, 42], but to our knowledge no prior review has described the application of CVM or CBA for musculoskeletal care.

The purpose of this study was to (1) identify previously published CVM studies in the orthopaedic literature, (2) assess the methodologies used for CVM research, and (3) understand how CVM has been used in the orthopaedic CBA framework. We hypothesize that there is a paucity of evidence on CVM in orthopaedic surgery and that CVM has been rarely applied within the CBA framework. Additionally, we hypothesize that there will be significant heterogeneity in study methodologies.

Materials and Methods

Overview and Eligibility Criteria for Review

A systematic review of the MEDLINE database using the PubMed interface was performed in April 2017. The search was performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and checklist [30]. Contingent valuation studies within

orthopaedic surgery were identified using search terminologies that combined the following economic terms—*willingness to accept*, *willingness to pay*, and *contingent valuation* with the phrase *orthopaedic*, as well as the following anatomic terms: *wrist*, *elbow*, *ankle*, *spine*, *shoulder*, *hip*, and *knee*.

The initial search yielded 160 articles. Each article was reviewed for the inclusion criteria, which were English language and use of contingent valuation methodology (Fig. 1). To further ensure that all appropriate studies were identified, the reference list of each identified study was also reviewed, and no further articles met the inclusion criteria.

Classification of CVM Studies Retrieved

Classification and methodology assessment of retrieved CVM studies was performed in a similar fashion to a prior review by Diener et al. on CVM studies in healthcare [11]. Studies were classified using descriptive methods based on region of origin, journal type of publication, subspecialty area, primary intervention under investigation, method used to elicit responses (in-person, mail, or phone), and whether WTP or WTA was the primary measure.

The methodology of the identified CVM studies was appraised based on considerations that have been previously reported by Diener et al. [11] as being important methodological characteristics to consider in CVM studies. The goal of many of these defined methodological characteristics is to identify study features that may predispose the findings to bias or that may influence the results. Methodological characteristics of interest included (1) whether the status of the program under evaluation was stated (e.g., evaluating existing program vs. introducing new program), (2) provision for gain or loss of utility with health intervention, (3) whether method for valuation (WTP or WTA) was clearly stated, (4) whether patient risk preference is accounted for in monetary valuation, (5) acknowledgment of any possibility for bias, (6) use of sensitivity analysis, (7) disease status of population under study (e.g., currently diseased, undergoing treatment or at risk), (8) timing for valuation question (e.g., ex-ante [before treatment] vs. ex-post), (9) methodology for eliciting valuation (e.g., open-ended questions, bidding game, or payment card), and (10) statement on valuation method and money measurement (i.e., compensating variation vs. equivalent variation). Among these characteristics, we deemed numbers 4, 5, 6, 7, 8, and 9 as the most important methodological characteristics for minimizing bias. Understanding individual patient characteristics and how they may interact with valuation strategies is critical for evaluating bias and contextualizing results. Patient risk preference (no. 4) for accepting monetary loss and motivation for treatment (nos. 7, 8) similarly may impact how a patient assigns monetary value to an intervention. Additionally, certain methodologies may provide the patient with a price point anchor, thereby biasing responses—ideally, open-ended questioning (or a combination that includes these questions)—may elicit valuations without a biased response (no. 9). Finally, as with most economic analyses, the

Fig. 1. The inclusion criteria ensured all appropriate studies were identified; the reference list of each identified study was also reviewed, and no further articles met the inclusion criteria.

possibility for bias should be explicitly stated (no. 5), and sensitivity analyses performed around the derived value (no. 6).

Statistical analyses were primarily descriptive and qualitative in nature. The authors received no external source of funding in conducting this review.

Results

Demographic Characteristics of Included Studies

Our search algorithm retrieved 160 studies from the MEDLINE database (Fig. 1). Of the 160 retrieved studies, 22 studies (13.8%) met our inclusion criteria [2, 5, 6, 8, 9, 12–16, 18, 19, 24, 25, 27, 38–41, 45, 47, 48]. Studies were most commonly from North America ($n = 9$, 40.9%) and were published in clinical journals ($n = 13$, 59.1%). The economics of joint arthroplasty ($n = 6$, 27.3%) and non-operative osteoarthritis care ($n = 4$, 18.2%) were the most common topics.

Most studies used CVM for pricing and/or demand forecasting ($n = 16$, 72.7%); very few studies used CVM for program evaluation ($n = 6$). In-person subject interviews

($n = 11$, 50.0%) were the most commonly used methodology for obtaining responses (Table 1).

Methodological Characteristics of Included Studies

WTP was used in all included studies, and one study used both WTP and WTA. No study used WTA alone. None of the included studies clarified their valuation method by stating whether compensating variation or equivalent variation was used. Ten (45.5%) of the included studies evaluated an existing program, while eight studies (36.4%) evaluated a new program.

Among the methodological characteristics deemed important by authors, there was little consistency among included studies. The majority of studies elicited ex ante responses ($n = 17$, 77.3%) from patients who were afflicted with the condition under investigation (“currently diseased”: $n = 14$, 63.6%). Open-ended questioning was used by ten studies (45.5%), and a significant number of studies did not perform a sensitivity analysis ($n = 9$, 40.9%) or acknowledge the possibility for bias ($n = 8$, 36.4%). Additionally, none of the studies accounted for the risk preference of subjects (Table 2).

Table 1 Demographic characteristics of included studies

	<i>N</i> (22)	%
Region of origin		
North America	9	40.9
Europe	7	31.8
Australia	4	18.2
Asia	2	9.1
Journal classification		
Clinical	13	59.1
Healthcare policy	4	18.2
Healthcare economics	5	22.7
Subspecialty area		
Arthroplasty	6	27.3
Non-operative osteoarthritis care	4	18.2
Sports medicine	3	13.6
Trauma	3	13.6
Spine	2	9.1
Foot and ankle	1	4.5
Other	3	13.6
Pricing objective		
Pricing and/or demand forecast	16	72.7
Program evaluation	6	27.3
Methodology for eliciting responses		
In-person	11	50.0
Online	2	9.1
Telephone	2	9.1
Mail	1	4.5
Combination	5	22.7
Not stated	1	4.5

Table 2 Methodological characteristics of included studies

	<i>N</i> (22)	%
Status of program under evaluation		
Existing program	10	45.5
New program	8	36.4
Not described	4	18.2
Does the study allow for the program under investigation to provide gain or loss of utility?		
No	12	54.5
Yes	10	45.5
Primary valuation method		
Willingness to pay	21	95.5
Willingness to accept	0	0
Willingness to accept and willingness to pay	1	4.5
Statement on valuation method and money measurement (i.e., compensating variation vs. equivalent variation)		
No explicit statement	22	100
Relationship between study population and disease under investigation		
Currently diseased	14	63.6
At future risk	2	9.1
Neither	6	27.3
When is valuation obtained?		
Ex ante	17	77.3
Ex-post	3	13.6
Not applicable	2	9.1
Is risk preference accounted for in money valuation?		
No	22	100
How is valuation elicited?		
Open-ended	10	45.5
Bidding game	5	22.7
Multiple choice	5	22.7
Binary (“Take it or leave it”)	4	18.2
Is the possibility for bias explicitly acknowledged?		
Yes	14	63.6
No	8	36.4
Was sensitivity analysis performed?		
Yes	13	59.1
No	9	40.9

Cost–benefit Analysis

Only two of the included studies used CVM to perform cost–benefit analysis [2, 14]. Alolabi et al. [2] performed a cost–benefit analysis for hemiarthroplasty vs. internal fixation in the treatment of displaced femoral neck fractures in the elderly. The rationale for the study was to explore patient preferences for fixation vs. hemiarthroplasty and whether the associated procedure cost and attendant future procedure costs impacted the value-based choice. The authors used a third-party-payor perspective based on the costs incurred by the Ontario healthcare system. Study participants were Ontario residents, and they were polled on the amount of additional monthly tax they would be willing to pay to have each treatment intervention. As such, in keeping with a payor perspective, the benefit component of the cost–benefit analysis was calculated as the tax income accrued to the payor. The authors used a validated decision board to guide patients through the expected outcomes and complications for both procedures. The authors reported that the majority of participants (56.5%) selected internal fixation, and overall, all participants were willing to pay on average \$22.80 in additional annual tax to ensure provision of internal fixation for displaced femoral neck fractures. Using the total Ontario population (12,687,000), the authors calculated an incremental benefit of \$289,263,600 ($12,687,000 \times \22.80) for internal fixation. Based on comparative procedure costs of \$18,100 and \$15,843 for internal fixation and hemiarthroplasty, respectively, the authors calculated the projected cost of performing internal fixation for these fractures as \$64,714,103 (based on a population incidence of four femoral neck fractures per 1000 and 56.5% of people preferring fixation over hemiarthroplasty). The net benefit was thus calculated to be \$224,549,497 ($\$289,263,600 - \$64,714,103$). Based on these findings, the authors concluded that internal fixation for displaced femoral neck fractures in the elderly potentially provides a net benefit and should be available if patients select it.

Haefeli et al. [14] performed the other identified cost–benefit analysis. The authors used CVM as part of a retrospective patient callback study design to elicit WTP from 105 patients for common lumbar spinal interventions (discectomy for disc herniation, spinal decompression for spinal stenosis, and spinal fusion for degenerative disc disease). Included patients had undergone surgical intervention and were a mean 32 months post-operative from their surgery. Costs were calculated from the hospital cost perspective by using an institutional cost accounting method to tally the costs accrued by 60 representative patients during their care cycle. The monetary unit was the Euro (at the time of the study, 1 Euro equaled approximately 1.3 US dollars). Based on the study population, the mean WTP for spinal fusion, discectomy, and spinal decompression were €11,007, €7170, and €7692, respectively. Based on the lower income demographic of the included patients, the authors adjusted WTP to reflect the national income values. Adjusted WTP values were €21,427, €17,117, and €10,287, respectively. The authors found various predictors for WTP including income, insurance status, and level of pain/disability. In formal cost–benefit analysis, spinal fusion was the only

procedure that demonstrated a lower stated (i.e., non-adjusted) WTP compared to hospital costs (–20% than the actual procedure costs). The WTP for discectomy and decompression were higher than hospital costs by 37 and 10%, respectively.

Discussion

Twenty-two studies were identified that fulfilled our inclusion criteria. CVM is most commonly used to evaluate operative and non-operative arthritis care and is typically applied in the exercise of pricing and/or forecasting. Based on our methodology appraisal, the techniques used to perform CVM are highly variable and potentially subject to bias. Furthermore, only two of the included studies applied CVM in the CBA framework. Therefore, we confirmed our hypotheses. The findings of the present review highlight an opportunity to improve CVM methodologies and to begin to incorporate CVM into the value-based measurement schema. Patient WTP is an important health economic tool that has been evidently ignored in the orthopaedic literature. When WTP is incorporated into CBA, it has significant potential to improve program resource allocation and ensure attention to value-based care.

This study has certain limitations. Like any review that is based on key terms, it is possible that eligible studies were not included in our search retrieval. However, the risk for this was reduced by carefully reviewing the references for each included study to look for potentially eligible studies. Additionally, our study is limited by the lack of a validated quality-assessment tool. Health economic study quality appraisal tools such as the Quality of Health Economic Studies (QHES) [37] are traditionally applied to cost-utility analyses and have scoring domains that do not apply to CVM studies.

There is increasing interest in incorporating cost-effectiveness analyses and value-based measurements in healthcare performance metrics [17, 32]. Prior reviews of cost-effectiveness analyses in sports medicine [33, 42], joint replacement [31], spine surgery [35], and trauma care [34] have advanced our understanding of value-based measurement approaches within orthopaedic surgery. No prior study has looked at CBA or CVM in orthopaedic surgery. With increased incorporation of value-based approaches in the scientific literature during the 1990s, Diener et al. [11] published a review in 1998 reporting on CVM within healthcare. The authors identified 48 studies, and only two of the included studies reported on CVM for surgery. The authors noted that between 1984–1989 and 1990–1996, the published CVM evidence had more than tripled. However, the authors also noted that there was significant heterogeneity in the CVM approaches utilized and that the application of CVM within a CBA framework was often poor. The authors concluded that CVM/CBA holds great promise, although nationally, prescriptive guidelines are lacking. The findings of the present review are in keeping with the findings of Diener et al. [11]. We found that a number of methodological approaches were applied by included authors, with no clear consensus or consistency on preferred

approaches. Furthermore, only two of the identified studies applied CVM in the CBA framework, and both studies had vastly different approaches for managing costs and comparing costs with benefits. For example, Alolabi et al. [2] applied a governmental-payor perspective and used incremental taxation to evaluate the cost–benefit of instituting a new surgical program. In contrast, Haefeli et al. [14] applied a healthcare system cost perspective (hospital costs) and compared these costs to maximum patient WTP to provide comparative cost–benefit for different spine surgery interventions. While both studies have their merits, the study by Haefeli et al. provides a reproducible and reliable framework for future CBA studies in orthopaedic surgery.

CVM, and specifically CVM performed within a CBA framework, has unique appeal for value-based decision making. Compared to other health economic analytic methods such as cost-utility analysis, CBA has some distinct advantages: (1) WTP is based on welfare economics; (2) WTP is expressed in monetary units, and thereby enables a more comprehensive and comparable valuation of healthcare interventions than quality adjusted life years; and (3) CBA provides tangible metrics to ensure distributive efficiency across hospital, payor, and governmental stakeholders. The latter advantage allows healthcare systems to resemble a competitive market by allocating resources to the highest value interventions. The validity and applicability of CVM in healthcare have been established [4, 36, 44], but our review demonstrates that CVM is not commonly applied for musculoskeletal health economics. This finding is all the more surprising given that, in the USA, the Office of Management and Budget required that a CBA be performed for all “economically significant” regulations proposed by federal agencies [1]. Adoption of CVM within orthopaedic surgery is potentially limited by a lack of familiarity with the concept as well as inexperience with the technical aspects of CVM and CBA. We propose that more attention should be paid to studying the cost–benefit of different orthopaedic interventions. Within a value-based framework, CBA can be a useful adjunct to cost-utility analysis for eliciting health state preference, providing valuations and ultimately demonstrating the comparative value of different orthopaedic procedures.

CBA is not without its criticisms. Critics of CBA note that WTP can be influenced by the income of study participants and that those with higher income are more likely to have a higher WTP. This criticism can be reduced by applying an income-based WTP adjustment that is pegged to the national income, as was applied by Haefeli et al. [14]. Another criticism of CBA is that inputs are purely financial and do not consider clinical effectiveness; however, the evidence demonstrates that WTP is an appropriate measure of quality of life and that WTP tracks with disease severity and treatment efficacy [14, 44]. An important criticism of CBA and CVM is a lack of standardized best practices. Our study demonstrated that there is significant heterogeneity in the analytic methods applied for CVM. For example, we found that there was no consistency in how valuations were elicited—e.g., open-ended questions were most frequently applied to elicit WTP but were not used in the majority of

studies. In September 2016, the Second Panel on Cost-Effectiveness in Health and Medicine [43] provided recommendations for the conduct, methodology, and reporting of cost-effectiveness analyses; however, stratagems pertaining to CBA were not explicitly incorporated. We believe that governmental agencies and medical professional societies should develop a set of guidelines for CBA research and also work to develop a research agenda for funding and conducting these studies. In 1993, the National Oceanic and Atmospheric Administration (NOAA) published guidelines for environmental contingent valuation studies performed within a CBA framework [3]. Such initiatives can be instructive for beginning to develop widely accepted guidelines for applying CBA within surgery and medicine.

In conclusion, CVM is not commonly reported in orthopaedic surgery and is seldom used in the context of cost–benefit analysis. There is wide variability in the methods used to perform CVM. We propose that CVM is an appropriate and underappreciated method for understanding the value of orthopaedic interventions. Increased attention should be paid to consumer valuations for orthopaedic interventions.

Compliance with Ethical Standards

Conflict of Interest: Benedict U. Nwachukwu, MD, MBA, Claire D. Eliasberg, MD, Kamran S. Hamid, MD, MPH, Michael C. Fu, MD, MHS, Bernard R. Bach, MD, and Answorth A. Allen, MD, declare that they have no conflicts of interest. Todd J. Albert, MD, reports royalties from DePuy Synthes and Facet Link; investment interest in Biomerix, Crosstrees Medical, Gentis, International Orthopaedic Alliance, InVivo Therapeutics, InVuity, Paradigm Spine, Pulse Equity, and Spinicity; stock options in Vital 5; personal fees from Zimmer Biomet and Lineum Cervical System and Polaris Spinal System; and medical advisory board membership at United Healthcare, outside the submitted work.

Human/Animal Rights: N/A

Informed Consent: N/A

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