Health State Utilities in Children and Adolescents With Osteochondritis Dissecans of the Knee

Joshua Adjei,* MD, Benedict U. Nwachukwu,* MD, MBA, Yi Zhang,* MS, Huong T. Do,* MA, Daniel W. Green,* MD, MS, Emily R. Dodwell,* MD, MPH, and Peter D. Fabricant,*† MD, MPH

Investigation performed at the Hospital for Special Surgery, New York, New York, USA

Background: The impact of osteochondritis dissecans (OCD) lesions of the knee on a child's health-related quality of life has not previously been quantified. Preference-based health utility assessment allows patients to assign quality-of-life valuations (utilities) to different health states and conditions.

Purpose: To determine (1) patient-reported utility scores for health states associated with pediatric OCD lesions of the knee and (2) whether these scores are associated with patient demographics or disease severity.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: Children, adolescents, and young adults being treated for OCD of the knee were interviewed to assess utilities for each of the 6 health states commonly encountered in the treatment of OCD: (1) symptomatic lesion, (2) nonoperative rehabilitation, (3) postoperative rehabilitation, (4) intermediate treatment success, (5) early degenerative knee changes, and (6) successful treatment (asymptomatic). Patients were asked to assign health utilities to each state using a standardized feeling thermometer (scale, 0-100), which were converted to a health state utility (scale, 0-1 [1 = perfect health]). Utilities were reported with descriptive statistics, and comparative analyses were performed to test whether assignments were associated with patient age, sex, or whether the OCD lesion required surgical intervention.

Results: A total of 100 participants treated or undergoing treatment for OCD were prospectively enrolled; 74% were male (n = 74). The median age at the time of survey was 15 years (interquartile range, 13-16.5 years). Utility scores were as follows: symptomatic OCD lesion, 0.15; nonoperative rehabilitation, 0.30; postoperative rehabilitation, 0.30; early degenerative changes, 0.58; intermediate treatment success, 0.65; and successful treatment, 1.0. Utility scores were not associated with age, sex, or whether the participant underwent surgical treatment for the OCD lesion.

Conclusion: The current study quantified patient-reported utilities for 6 OCD lesion health states, which may be used for future health-related quality of life, decision analysis, and quality/safety/value studies. These utility scores were stable and not affected by patient age, sex, or treatment strategy.

Keywords: OCD; cost-effectiveness; sports; arthroscopy; pediatrics; lesions

The impact of osteochondritis dissecans (OCD) of the knee on a patient's physical function and quality of life has not previously been quantified. Measurements of health-related quality of life (HRQoL) seek to capture the impact of a health condition and its treatment on a patient's physical, emotional, and social well-being.[16] Although not well documented in the orthopaedic literature, HRQoL assessments provide greater comparability across different diseases, are a source of useful data for value-based health care initiatives, and are required for the completion of decision analysis studies.[27] Utilities are the underpinnings of cost-effectiveness analysis and have been a valuable source of clinical and economic guidance in sports medicine.[28-30]

HRQoL is presented as a health state utility, with a scaled score between 0 and 1, where 0 is death (or the worst possible outcome) and 1 is perfect health.[6,9,19,30,38,43] HRQoL can be measured with health preference instruments, which incorporate patient personal preferences among health states and have the ability to capture additional quality-of-life dimensions not captured by standard patient-reported outcome measures (PROMs). Direct health preference calculation strategies include time trade-off,[34] standard gamble,[34] and feeling thermometer/visual analog rating scale.[31] These strategies can be used to directly calculate utilities for any given health state. To date, utility scores for patients with OCD of the knee are unknown.

The Orthopaedic Journal of Sports Medicine, 7(12), 2325967119886591
DOI: 10.1177/2325967119886591

The primary aim of the current study was to determine the utilities associated with 6 health states encountered during the spectrum of OCD treatment. The secondary aim was to determine whether utility scores differed with patient age, sex, or whether surgical treatment was required.

METHODS

Institutional review board approval was obtained before the study's initiation. Included patients were 10 to 20 years old at the time of interview. This age range was chosen to best encompass patients who are labeled as pediatric (younger than 20 years according to the American Academy of Pediatrics[1]) and who are most frequently diagnosed with OCD rather than a normal developmental ossification radiographic variant, which is frequently seen in children younger than 10 years of age.[46] Patients underwent OCD treatment between 2010 and 2018. Patients presenting between June 2017 and March 2018 were identified prospectively by the treating surgeon at the time of diagnosis, and patients previously treated for OCD from January 2010 to May 2016 were identified by review of electronic billing records with the International Classification of Diseases 9th (732.7) and 10th (M93.261, M93.262) revision codes. Patients were excluded if they had an ipsilateral knee diagnosis concurrent with the OCD lesion (eg, fracture or patellar subluxation). Noncommunicative patients and those with neurologic, neuromuscular, or genetic syndromes (eg, Rubinstein-Taybi, cerebral palsy, nail-patella syndrome, arthrogryposis, hypophosphatemic rickets, autism, Down syndrome, and Charcot-Marie-Tooth) were excluded.

Three pediatric PROM scores were recorded prospectively in a subset of patients (Figure 1) prior to treatment initiation to better understand the study cohort; however, these scores were not collected for the purpose of statistical comparison with the health state utilities, which measure a different construct. In younger patients (13 years and younger), parents were allowed to assist with PROM administration, but patients were required to give their own responses. No parental assistance was given for the health utility interviews, as these were administered verbally. For patients enrolled in person at our institution, paper consent was obtained directly from the patient if 18 years or older or from the parent with patient assent if younger than 18 years. Patients identified retrospectively were contacted and consented/assented via phone. Eligible patients were interviewed at a clinical appointment or over the phone, either after surgery or after the initiation of a nonoperative treatment plan. The patient inclusion/exclusion flowchart is displayed in Figure 1.

Patient Utility Interviews

Vignettes for the 6 health states were presented (Figure 2): symptomatic OCD lesion, nonoperative rehabilitation, postoperative rehabilitation, early degenerative changes, intermediate treatment success, and successful treatment. Health states were constructed per the joint consensus of 3 pediatric orthopaedic surgeons (E.R.D., D.W.G., and P.D.F.) who treat patients with OCD. Health utility vignettes were developed with guideline methodology from prior studies reporting on utilities in pediatric patients.[36] All patient interviews were conducted verbally by a single interviewer (J.A.) to ensure consistency and standardization of health state descriptions.

Health utility scores for the 6 OCD health states were acquired with the feeling thermometer method,[37] owing to its demonstrated reliability for direct assessment of HRQoL in children and adolescents.[15,37,42] Participating patients were provided a description of each health state, presented in the same order, and were then asked to numerically rank their preference for each state from a scale of 0 to 100, with 100 being perfect health and 0 being equivalent to the worst health imaginable. Utilities obtained from the feeling thermometer (0-100) were converted to a score from 0 to 1 by dividing by 100 to convert utilities into the standardized format presented in previous studies.[9,18,29,38] Vignettes were presented in simple, pediatric patient–friendly language. For example,

> Imagine that you had a painful knee, were having a hard time walking or running, felt there was occasional clicking or locking of the knee, and that you felt it got worse when you were being more active and limited your activity. You could not put weight on your knee, could not play any sports, and had to take pain medications such as Tylenol or daily ibuprofen. How would you rate this situation on a scale of 0 to 100, where 0 is the worst possible state imaginable and 100 is feeling perfect?

It was emphasized that the situations presented were hypothetical and that the score that patients were

†Address correspondence to Peter D. Fabricant, MD, MPH, Pediatric Orthopaedic Surgery Service, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, USA (email: fabricantp@hss.edu).

*Hospital for Special Surgery, New York, New York, USA.

One or more of the authors has declared the following potential conflict of interest or source of funding: B.U.N. has received educational support from Smith & Nephew and hospitality payments from Stryker, Wright Medical, and Zimmer Biomet. D.W.G. has received royalties from Arthrex, *Current Opinion in Pediatrics*, Page Medical, and Wolters Kluwer Health; consulting fees from Arthrex; and speaking fees from Synthes. E.R.D. has received speaking fees from Synthes. P.D.F. has received educational support from Smith & Nephew and Medical Device Business Systems. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from the Hospital for Special Surgery (No. 2014-404).

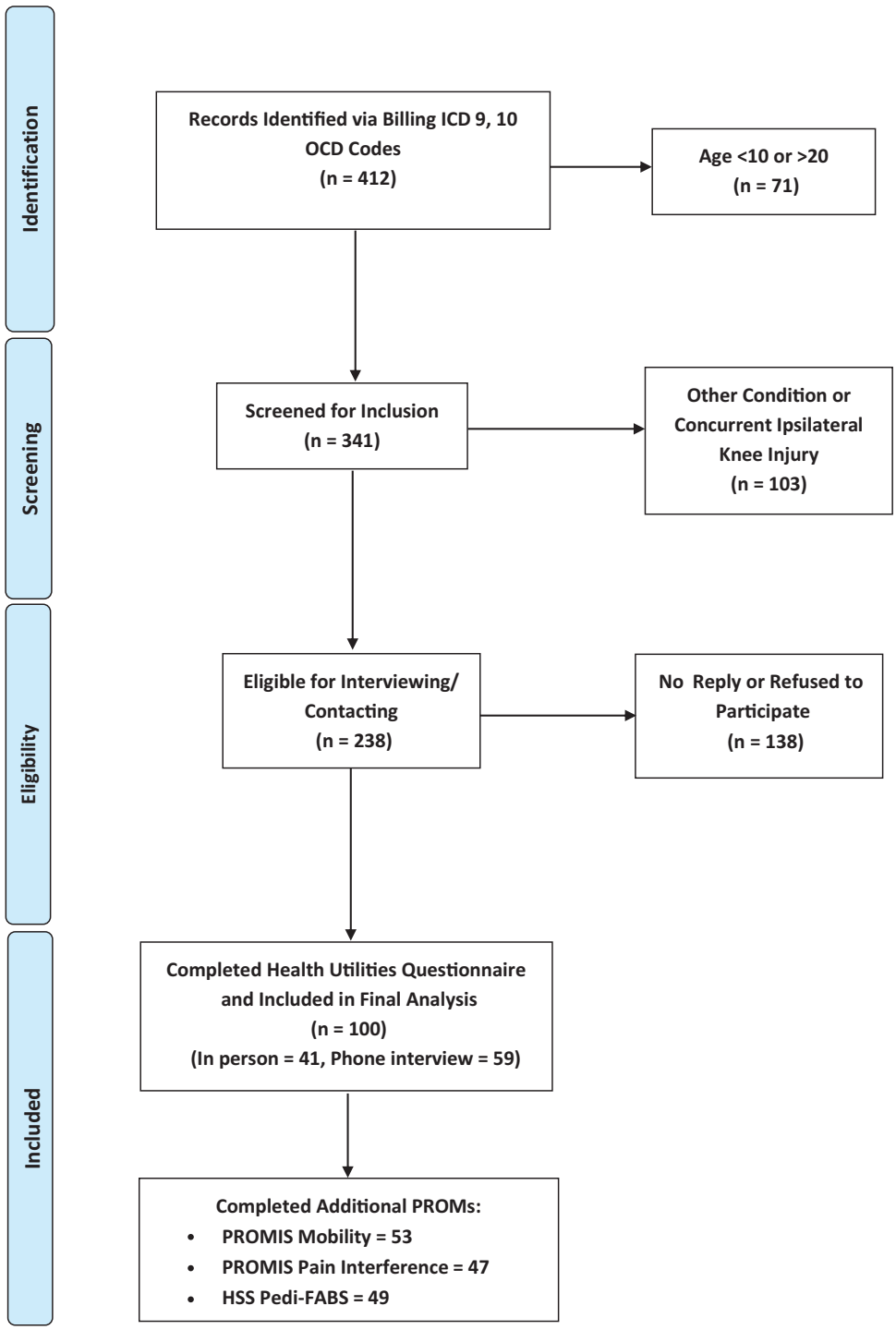

Figure 1. Patient inclusion/exclusion flowchart. HSS Pedi-FABS, Hospital for Special Surgery Pediatric Functional Activity Brief Scale; ICD, International Classification of Diseases; OCD, osteochondritis dissecans; PROMIS, Patient-Reported Outcomes Measurement Information System.

providing was not meant to capture their current state of health. The evaluation scale was reiterated at the end of every health state, and clarification was provided whenever necessary or as requested.

Clinical Data and Patient-Reported Outcomes

For prospectively identified patients, the Patient-Reported Outcomes Measurement Information System (PROMIS)

(1) **Symptomatic osteochondral injury [Injury]**
- Your knee is painful and swollen
- You have a hard time walking or running
- There is occasional painful clicking and locking of the knee
- The pain gets worse with activity and limits activity
- It hurts to put weight on your knee
- You cannot play any sports
- You take pain medications such as ibuprofen or Tylenol, which lessen but do not eliminate pain

(2) **Symptomatic osteochondral injury undergoing early rehabilitation [Nonoperative rehabilitation]**
- You do physical therapy for 45 minutes twice per week
- You do home exercises for 30 minutes on the days that you don't do physical therapy
- You have pain in your knee joint
- Your knee is mildly swollen
- Your knee hurts whenever you are moving a lot and being more active
- You cannot play high-intensity sports

(3) **Immediately postoperatively for osteochondral injury [Operative rehabilitation]**
- You just had surgery for OCD injury
- You are in a brace that keeps your knee straight
- You wear the brace 24 hours per day
- Your knee is mildly swollen
- You take pain medications as needed
- You do physical therapy for 45 minutes twice per week, plus home exercises
- You cannot play high-intensity sports

(4) **Continued osteochondral injury symptoms at medium to long-term time frame with functional limitations [Early degenerative change]**
- There is a dull ache present at the knee that gets worse at the end of the day or with prolonged activity
- There is occasional stiffness and limited range of motion of the knee joint
- There is a small amount of swelling in the knee
- You can walk and run but have pain after a while
- You need to take ibuprofen/Tylenol on a regular basis to prevent worsening pain
- You are able to play sports but unable to perform at levels similar to before initial OCD injury

(5) **Surgically or nonoperatively treated chondral defect with diminished symptoms and return to activity but with lower functional state [Intermediate treatment success]**
- You are now several months from surgical or nonoperative treatment and have been cleared by your physician
- You do not have pain at rest but occasional soreness with high-level activity
- Your knee is not typically swollen and there is no clicking or locking
- You occasionally need to take ibuprofen or Tylenol
- On return to higher intensity sporting, your ability is diminished compared with before the injury

(6) **Surgically or nonoperatively treated osteochondral injury with full return to preinjury status [Successful treatment]**
- There is no pain at the knee and you do not have any swelling or clicking
- You no longer need a brace
- You no longer need any medications for pain
- You are able to play sports and perform at levels similar to before the injury

Figure 2. Health states as described to patients. OCD, osteochondritis dissecans.

Pediatric Mobility (v 1.0),[14,33] the Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS),[11] and the PROMIS Pain Interference (Version 1.0)[14,32] were collected at the clinical visit to further characterize the study cohort. Participants completed the questionnaires for their pretreatment functional status, pain, and physical activity level, as is standard of care at our institution. All questionnaires were completed electronically. PROMIS measures were completed with computer adaptive test forms.[12,14]

Statistical Analysis

In total, 100 patients were enrolled as recommended for utilities acquisition studies.[43] The Shapiro-Wilk test was used to test the normality of utility score distribution for each health state. Median and interquartile range (IQR) were reported for each health state utility score. Spearman correlation coefficients were calculated to assess the association of patient age on utility score assignments for each health state. Mann-Whitney *U* tests were used to evaluate

the effect of patient sex or treatment (eg, whether treated with surgery or nonoperatively) on utility score assignments. Bonferroni correction was applied to all analyses to account for multiple comparisons; all analyses were 2-tailed, and significance level was set at $P < .05$. Analyses were performed with SAS (Version 9.4; SAS Institute, Inc).

RESULTS

Study Demographics

Of the 100 patients, 74 were male. The median age at the time of survey was 15 years (IQR, 13-16.5 years). The median follow-up time from diagnosis to health utility collection was 2 years (IQR, 0.6-3.65 years). The most common location of OCD lesions was the medial femoral condyle (n = 51). Lesions of the lateral femoral condyle were the next-most prevalent (n = 20), followed by lesions of the trochlea (n = 16) and patellar defects (n = 13). Of the 100, 11 patients had bilateral OCD lesions, 66 patients underwent operative treatment for OCD, and 34 patients were treated nonoperatively. Surgical management techniques included transarticular OCD drilling, lesion fixation, combined treatment (OCD drilling and fixation), osteochondral autograft transfer, and autologous chondrocyte implantation procedures (Table 1).

Utility Calculations

Utilities for the 6 health states are presented in Table 2. There were no significant associations between any health state utility score and patient age, sex, or treatment (Table 3).

DISCUSSION

The primary aim of the current study was to determine utility scores for 6 health states that a child, adolescent, or young adult may experience throughout the course of treatment of OCD of the knee. Patients with OCD assigned a low utility to the symptomatic health state (0.15). To put this into perspective, numerous studies have similarly shown a low health utility for symptomatic orthopaedic conditions in the pediatric population. Nwachukwu et al[30] demonstrated health state utilities as low as 0.3 in patients with symptomatic recurrent patellar dislocations. Low health state utility scores have also been computed for a number of chronic nonorthopaedic conditions affecting young people, including diabetes-associated end-stage kidney disease (0.51),[20] diabetes-associated stroke (0.23),[20] cerebral palsy (0.39),[4] hearing impairment (0.35),[3] and visual impairment (0.48).[4] While the health utility score does seem low, we do believe that 0.15 is a plausible number, specifically because children and adolescents may add significant negative weight to a symptomatic health state that precludes them from successfully performing activities of daily living and participating in sports/activities alongside their peer group.

TABLE 1
Patient Characteristics and Treatment Demographics[a]

Variable	n or Median (IQR)
Patients	100
Female	26
Male	74
Nonoperative	34
Operative	66
Transarticular drilling	24
Internal fixation	20
Combination (drilling and fixation)	15
Osteochondral autograft transfer	5
Autologous chondrocyte implantation	2
Age, y	
At diagnosis	13 (10-14)
At surgery (n = 66)	13 (11.25-15)
At survey	15 (13-16.25)
Time from diagnosis to survey, y	2 (0.6-3.65)
Patients with lesions	
Unilateral	89
Bilateral	11
OCD location	
Medial femoral condyle	51
Lateral femoral condyle	20
Trochlea	16
Patella	13
Patient-reported outcome measures	
PROMIS Pediatric Mobility (n = 53)	38.6 (35.27-55.57)
PROMIS Pain Interference (n = 49)	50 (37.55-55.84)
HSS Pedi-FABS (n = 47)	21 (10.5-27.5)

[a]HSS Pedi-FABS, Hospital for Special Surgery Pediatric Functional Activity Brief Scale; IQR, interquartile range; OCD, osteochondritis dissecans; PROMIS, Patient-Reported Outcomes Measurement Information System.

TABLE 2
OCD Health States and Calculated Utilities[a]

Health State	Utility, Median (IQR)
Symptomatic OCD lesion	0.15 (0.05-0.25)
Nonoperative rehabilitation	0.30 (0.20-0.50)
Postoperative rehabilitation	0.30 (0.10-0.45)
Early degenerative change	0.58 (0.50-0.70)
Intermediate treatment success	0.65 (0.50-0.75)
Successful treatment	1.0 (1.0-1.0)

[a]IQR, interquartile range; OCD, osteochondritis dissecans.

There was a low and equivalent health utility assignment for patients undergoing rehabilitation either postoperatively or as part of a nonoperative treatment strategy. Patients assigned a utility score of 1.0 (perfect health) for achieving successful treatment and a utility score of 0.65 for the intermediate treatment success health state. These health utility scores were not associated with patient age, sex, or treatment (surgery vs nonoperative treatment), which supports the stability of these utility score calculations. To our knowledge, no previous studies have reported health state utilities for OCD of the knee.

TABLE 3
Associations Between Health State Utilities and Age, Sex, and Treatment[a]

	Age		Sex, Median (IQR)			Treatment, Median (IQR)		
Health State	Spearman ρ [95% CI]	*P* Value	Female (n = 26)	Male (n = 74)	*P* Value	Operative (n = 66)	Nonoperative (n = 34)	*P* Value
Symptomatic OCD	–0.051 [–0.245 to 0.147]	.99	0.10 (0-0.80)	15 (0-55)	.99	0.15 (0.05-0.25)	0.15 (0.07-0.25)	.99
Nonoperative rehabilitation	–0.105 [–0.295 to 0.094]	.99	0.40 (0-0.90)	30 (0-80)	.87	0.35 (0.15-0.40)	0.30 (0.20-0.50)	.26
Postoperative rehabilitation	0.084 [–0.114 to 0.276]	.99	0.37 (0-0.70)	30 (0-90)	.99	0.30 (0.10-0.45)	0.30 (0.10-0.40)	.99
Early degenerative change	0.184 [–0.012 to 0.368]	.40	0.60 (0.25-0.85)	55 (0-85)	.99	0.60 (0.50-0.75)	0.55 (0.40-0.65)	.99
Intermediate treatment success	–0.079 [–0.271 to 0.119]	.99	0.70 (0.25-0.85)	60 (0-90)	.51	0.68 (0.50-0.75)	0.55 (0.40-0.70)	.13
Successful treatment	0.052 [–0.146 to 0.246]	.99	1.0 (0.80-1.0)	100 (70-100)	.99	1.00 (1.00-1.00)	1.00 (0.95-1.00)	.99

[a]All *P* values are Bonferroni corrected. There were no associations between health utility assignments for any health state and patient age, sex, or treatment. IQR, interquartile range; OCD, osteochondritis dissecans.

Documentation of utilities for health states related to the treatment of OCDs will be helpful in future decision analysis, HRQoL, and quality/safety/value studies on OCD.

Some recent studies have evaluated subjective and objective outcomes after knee OCD treatment in young patients, including subjective measurements of patient satisfaction.[2,8,17,26] Although these studies report rates of patient satisfaction with treatment, no health utility states were published that could be utilized for future studies. Despite the importance of having valid and clinically relevant health utility values for a given disease to perform decision analysis (eg, cost-effectiveness) research, to date, these values have not been elucidated for OCD. Rather, the only similar health utility publications report values for adults and for health states including end-stage osteoarthritis,[6,18,38] reactive and inflammatory arthritis,[5,35,39] and postarthroplasty surgery in active middle-aged adults.[7] These are neither applicable nor clinically relevant to the study of OCD in children, adolescents, and young adults, further underscoring the importance of the findings in the current study.

In future and ongoing investigations, the results of the current study may be combined with existing literature on treatment outcomes, surgical and nonoperative success and failure rates, and treatment cost to perform decision analysis studies for OCD treatment in young patients. Similar studies have recently been performed for anterior cruciate ligament surgery,[23,40,41] meniscal surgery,[13,21,22,44] cartilage repair,[10,24,25] and other sports medicine topics.[28] To encourage the widespread use of utility acquisition for HRQoL studies in orthopaedic surgery, standardized guidelines should be developed for the creation of vignettes for utilities acquisition for variable outcome-based conditions.

Health state utility studies have the ability to change clinical practice. Health state utilities give clinicians quantifiable insight into the aggregated perspectives of a patient cohort beyond the breadth of PROMs by sampling patients' preferences outside the context of their own health state. In context, health utilities can be used as an adjunct to align surgeon as well as patient goals and expectations. To date, however, no health state utility studies have been performed evaluating OCD lesion treatment strategies, owing to a lack of health state utility data.

Limitations of the current study include the potential for response bias with the use of the feeling thermometer instrument, wherein participants may be reluctant to utilize the extreme ends of the scale.[45] However, the feeling thermometer provided a simple, easy-to-comprehend framework for pediatric patients to directly provide health state preferences. The feeling thermometer has been similarly used successfully in previous studies involving children and adolescents.[15,37,42] While we provided detailed descriptions of the 6 health states, we had concerns that patients who did not experience 1 or more of the described health states (such as physical therapy or surgical management) may have had a different understanding of those health states as compared with participants who actually experienced that health state during their treatment. However, treatment strategy was not associated with patients' health utility assignments in this study, arguing in favor of the stability of these health state utility assignments regardless of treatment strategy. This was important because patients were interviewed in various stages of treatment. Also, because these patients were otherwise healthy and did not have any other acute or chronic health conditions, they may have overstated the impact of OCD and rated a lower health utility than that of children who had OCD within a perspective of another chronic health condition. However, children who present with OCD are frequently otherwise healthy; therefore, the effect of OCD on the health utility states of the study cohort is likely representative of the population at large. One noted limitation of our study was the variability in time and location where patients were interviewed, which also varied in

relation to the timing of treatment. However, all patients were interviewed by a single interviewer, and health state scenarios were presented via identical vignette templates. Additionally, it was emphasized that utility vignette scenarios were hypothetical and therefore independent of the actual treatment received by any individual.

The 3 variables included in the analysis of the stability of the health utility ratings (age, sex, and treatment strategy) represent those from the study that have the most clinical relevance to affecting the patient experience. Future studies might consider testing the stability of health state constructs against additional factors. Although PROMs and health utility state assignments measure distinct constructs, future studies may seek to investigate the relationship between appropriate PROMs and health utilities. In the current cohort, PROM scores were primarily collected during routine follow-up patient visits as a means of clinically tracking clinical progression. Future studies should further establish the impact of PROM-quantified disease burden on health utility assignment.

CONCLUSION

The current study provides health utilities for 6 health states encountered in the diagnosis and treatment of OCD of the knee in children, adolescents, and young adults. By providing these scores, future research can be performed to quantify the net benefit of various treatment and outcome modalities relative to baseline symptomatic health states, specifically through decision analysis, HRQoL, and quality/safety/value studies. These studies have the potential to change clinical practice. The utility scores reported in this study were stable in that they were not affected by patient age, sex, or treatment strategy.

ACKNOWLEDGMENT

The authors thank Madison R. Heath for her assistance with manuscript preparation.

REFERENCES

1. American Academy of Pediatrics. Age limits of pediatrics. *Pediatrics*. 1988;81(5):736-736.
2. Ananthaharan A, Randsborg PH. Epidemiology and patient-reported outcome after juvenile osteochondritis dissecans in the knee. *Knee*. 2018;25(4):595-601.
3. Barton GR, Stacey PC, Fortnum HM, Summerfield AQ. Hearing-impaired children in the United Kingdom, IV: cost-effectiveness of pediatric cochlear implantation. *Ear Hear*. 2006;27(5):575-588.
4. Bennett JE, Sumner W 2nd, Downs SM, Jaffe DM. Parents' utilities for outcomes of occult bacteremia. *Arch Pediatr Adolesc Med*. 2000;154(1):43-48.
5. Beresniak A, Russell AS, Haraoui B, Bessette L, Bombardier C, Duru G. Advantages and limitations of utility assessment methods in rheumatoid arthritis. *J Rheumatol*. 2007;34(11):2193-2200.
6. Bozic KJ, Chiu VW, Slover JD, Immerman I, Kahn JG. Health state utility in patients with osteoarthritis of the hip and total hip arthroplasty. *J Arthroplasty*. 2011;26(6 suppl):129-132.e121-e122.
7. Chawla H, Nwachukwu BU, van der List JP, Eggman AA, Pearle AD, Ghomrawi HM. Cost effectiveness of patellofemoral versus total knee arthroplasty in younger patients. *Bone Joint J*. 2017;99B(8):1028-1036.
8. Cotter EJ, Frank RM, Wang KC, et al. Clinical outcomes of osteochondral allograft transplantation for secondary treatment of osteochondritis dissecans of the knee in skeletally mature patients. *Arthroscopy*. 2018;34(4):1105-1112.
9. Davis EM, Lynd LD, Grubisic M, et al. Responsiveness of health state utility values in knee osteoarthritis. *J Rheumatol*. 2013;40(12):2075-2082.
10. de Windt TS, Sorel JC, Vonk LA, Kip MMA, Ijzerman MJ, Saris DBF. Early health economic modelling of single-stage cartilage repair: guiding implementation of technologies in regenerative medicine. *J Tissue Eng Regen Med*. 2017;11(10):2950-2959.
11. Fabricant PD, Robles A, Downey-Zayas T, et al. Development and validation of a pediatric sports activity rating scale: the Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS). *Am J Sports Med*. 2013;41(10):2421-2429.
12. Fabricant PD, Suryavanshi JR, Calcei JG, Marx RG, Widmann RF, Green DW. The Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS): normative data. *Am J Sports Med*. 2018;46(5):1228-1234.
13. Feeley BT, Liu S, Garner AM, Zhang AL, Pietzsch JB. The cost-effectiveness of meniscal repair versus partial meniscectomy: a model-based projection for the United States. *Knee*. 2016;23(4):674-680.
14. Irwin DE, Gross HE, Stucky BD, et al. Development of six PROMIS pediatrics proxy-report item banks. *Health Qual Life Outcomes*. 2012;10:22.
15. Juniper EF, Guyatt GH, Feeny DH, Griffith LE, Ferrie PJ. Minimum skills required by children to complete health-related quality of life instruments for asthma: comparison of measurement properties. *Eur Respir J*. 1997;10(10):2285-2294.
16. Khanna D, Tsevat J. Health-related quality of life—an introduction. *Am J Manag Care*. 2007;13(suppl 9):S218-S223.
17. Kramer DE, Yen YM, Simoni MK, et al. Surgical management of osteochondritis dissecans lesions of the patella and trochlea in the pediatric and adolescent population. *Am J Sports Med*. 2015;43(3):654-662.
18. Kunkel ST, Sabatino MJ, Kang R, Jevsevar DS, Moschetti WE. The cost-effectiveness of total hip arthroplasty in patients 80 years of age and older. *J Arthroplasty*. 2018;33(5):1359-1367.
19. Lamsal R, Finlay B, Whitehurst DGT, Zwicker JD. Generic preference-based health-related quality of life in children with neurodevelopmental disorders: a scoping review [published online June 21, 2019]. *Dev Med Child Neurol*. doi:10.1111/dmcn.14301
20. Lee JM, Rhee K, O'Grady MJ, et al. Health utilities for children and adults with type 1 diabetes. *Med Care*. 2011;49(10):924-931.
21. Lester JD, Gorbaty JD, Odum SM, Rogers ME, Fleischli JE. The cost-effectiveness of meniscal repair versus partial meniscectomy in the setting of anterior cruciate ligament reconstruction. *Arthroscopy*. 2018;34(9):2614-2620.
22. Mather RC 3rd, Garrett WE, Cole BJ, et al. Cost-effectiveness analysis of the diagnosis of meniscus tears. *Am J Sports Med*. 2015;43(1):128-137.
23. Mather RC 3rd, Hettrich CM, Dunn WR, et al. Cost-effectiveness analysis of early reconstruction versus rehabilitation and delayed reconstruction for anterior cruciate ligament tears. *Am J Sports Med*. 2014;42(7):1583-1591.
24. Miller DJ, Smith MV, Matava MJ, Wright RW, Brophy RH. Microfracture and osteochondral autograft transplantation are cost-effective treatments for articular cartilage lesions of the distal femur. *Am J Sports Med*. 2015;43(9):2175-2181.
25. Mistry H, Metcalfe A, Smith N, et al. The cost-effectiveness of osteochondral allograft transplantation in the knee. *Knee Surg Sports Traumatol Arthrosc*. 2019;27:1739-1743.
26. Murphy RT, Pennock AT, Bugbee WD. Osteochondral allograft transplantation of the knee in the pediatric and adolescent population. *Am J Sports Med*. 2014;42(3):635-640.

27. Nwachukwu BU, Hamid KS, Bozic KJ. Measuring value in orthopaedic surgery. *JBJS Rev*. 2013;1(1).
28. Nwachukwu BU, Schairer WW, Bernstein JL, Dodwell ER, Marx RG, Allen AA. Cost-effectiveness analyses in orthopaedic sports medicine: a systematic review. *Am J Sports Med*. 2015;43(6):1530-1537.
29. Nwachukwu BU, So C, Schairer WW, et al. Economic decision model for first-time traumatic patellar dislocations in adolescents. *Am J Sports Med*. 2017;45(10):2267-2275.
30. Nwachukwu BU, So C, Zhang Y, et al. Adolescent and caregiver-derived utilities for traumatic patella dislocation health states. *J Pediatr Orthop*. 2019;39(10):e755-e760.
31. Parkin D, Devlin N. Is there a case for using visual analogue scale valuations in cost-utility analysis? *Health Econ*. 2006;15(7):653-664.
32. Quinn H, Thissen D, Liu Y, et al. Using item response theory to enrich and expand the PROMIS(®) pediatric self report banks. *Health Qual Life Outcomes*. 2014;12:160.
33. Rodday AM, Graham RJ, Weidner RA, Rothrock NE, Dewalt DA, Parsons SK. Leveraging pediatric PROMIS item banks to assess physical functioning in children at risk for severe functional loss. *J Patient Rep Outcomes*. 2017;1(1):10.
34. Ryder HF, McDonough C, Tosteson AN, Lurie JD. Decision analysis and cost-effectiveness analysis. *Semin Spine Surg*. 2009;21(4):216-222.
35. Schmitt J, Meurer M, Klon M, Frick KD. Assessment of health state utilities of controlled and uncontrolled psoriasis and atopic eczema: a population-based study. *Br J Dermatol*. 2008;158(2):351-359.
36. Schottel PC, O'Connor DP, Brinker MR. Time trade-off as a measure of health-related quality of life: long bone nonunions have a devastating impact. *J Bone Joint Surg Am*. 2015;97(17):1406-1410.
37. Schunemann HJ, Griffith L, Stubbing D, Goldstein R, Guyatt GH. A clinical trial to evaluate the measurement properties of 2 direct preference instruments administered with and without hypothetical marker states. *Med Decis Making*. 2003;23(2):140-149.
38. Souchek J, Byrne MM, Kelly PA, et al. Valuation of arthritis health states across ethnic groups and between patients and community members. *Med Care*. 2005;43(9):921-928.
39. Stephen DM, Barnett AG. Using microsimulation to estimate the future health and economic costs of salmonellosis under climate change in central Queensland, Australia. *Environ Health Perspect*. 2017;125(12):127001.
40. Stewart BA, Momaya AM, Silverstein MD, Lintner D. The cost-effectiveness of anterior cruciate ligament reconstruction in competitive athletes. *Am J Sports Med*. 2017;45(1):23-33.
41. Swart E, Redler L, Fabricant PD, Mandelbaum BR, Ahmad CS, Wang YC. Prevention and screening programs for anterior cruciate ligament injuries in young athletes: a cost-effectiveness analysis. *J Bone Joint Surg Am*. 2014;96(9):705-711.
42. Teitelbaum JE, Rajaraman RR, Jaeger J, Para S, Rakitt T. Correlation of health-related quality of life in children with inflammatory bowel disease, their parents, and physician as measured by a visual analog scale. *J Pediatr Gastroenterol Nutr*. 2013;57(5):594-597.
43. Tolley K. What are health utilities? *Health Economics*. 2009;2.
44. van de Graaf VA, Scholtes VA, Wolterbeek N, et al. Cost-effectiveness of early surgery versus conservative treatment with optional delayed meniscectomy for patients over 45 years with non-obstructive meniscal tears (ESCAPE study): protocol of a randomised controlled trial. *BMJ Open*. 2016;6(12):e014381.
45. Wiener L, Battles H, Zadeh S, Widemann BC, Pao M. Validity, specificity, feasibility and acceptability of a brief pediatric distress thermometer in outpatient clinics. *Psychooncology*. 2017;26(4):461-468.
46. Zbojniewicz AM, Laor T. Imaging of osteochondritis dissecans. *Clin Sports Med*. 2014;33(2):221-250.