Health-Related Quality of Life and Cost-Effectiveness Analysis in Radiology

Ania Zofia Kielar, MD, FRCPC, Robert H. El-Maraghi, MD, FRCPC, Ruth C. Carlos, MD

The number of radiological studies performed annually, including ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI), has been increasing dramatically. This trend is influenced by several factors, including an aging population with multiple comorbidities and a higher number of overall studies obtained per patient and/or per time period (1). More than ever before, radiology is playing an integral role during both initial investigations and follow-up of patients with acute and chronic illnesses. For example, Beinfeld and Gazelle (2) determined that medical technology has accounted for 19% of the growth in hospital costs between 1998 and 2000 and that imaging costs at one major tertiary care center increased by 50% between 1996 and 2002.

In this challenging practice environment, evidence-based medicine has been recognized as an essential tool for deciding on appropriate diagnostic, medical, and interventional care for patients. Additionally, greater emphasis is being placed on cost-effectiveness analysis (CEA) and health-related quality of life (HRQOL) outcomes to guide utilization of high-tech, often high-cost, diagnostic and therapeutic radiological resources. Equally important (perhaps more so in certain situations), these often less tangible values are increasingly being measured in addition to the physical outcomes. Much of the early development of HRQOL assessments focused specifically on patients with cancer (3–5) and those with chronic renal failure on hemodialysis (6). In these two groups of patients, newly introduced therapies were sometimes associated with modest improvements in survival but simultaneously with potentially significant morbidity. In the field of radiology, CEA and HRQOL measurements can be applied to most patient-related scenarios, including screening tests that use imaging, as well as diagnostic radiology studies and interventional procedures.

UNDERSTANDING HEALTH-RELATED QUALITY OF LIFE

Quality of life (QOL) is a concept with many meanings and encompassing many themes. HRQOL may be defined as the value assigned to the duration of life, as it is modified by impairments of functional health states, caused by disease, injury, attempted treatment, or a policy (7). It can be used to evaluate radiology-related studies in the same way in which it is used in other medical and surgical fields. There are several core domains of HRQOL that are typically included in a global assessment. These include health perceptions, social functions (such as usual social roles, sexual roles, and communication), psychological function (including mood and emotional components), physical abilities (such as mobility, physical activity, and ability for self-care), and impairments (which take into account sensory functions and symptoms) (7).

HRQOL assessment may be combined with survival data in order to merge morbidity and mortality impacts into a single measure. In many industrialized countries, length of life has been steadily increasing over the past century. This is in part due to improvements in hygiene and nutrition as well as preventative medicine and more effective disease-specific medical intervention. Therefore, similar to other medical domains, when assessing a new
diagnostic radiology modality, simply determining “years of life gained” may be insufficient as the sole outcome measure. Rather, it is often the improvement in QOL specifically caused by the healthcare intervention that is a better gauge of its effectiveness. Thus, when deciding which outcomes are appropriate to measure, investigators should determine the potential differences between patient groups with respect to the effects of the study or intervention, the potential side effects or unintended consequences, as well as the outcomes of interest to consumers, patients, and society at large.

**ISSUES IN HEALTH-RELATED QUALITY OF LIFE RELATED TO RADIOLOGY PRACTICE**

With all of these screening, diagnostic, and minimally invasive radiological studies being performed, there is potential for significant impact on an individual’s QOL. One of the issues of CEA and HRQOL in radiology is the remoteness of the radiology test from the ultimate clinical outcome. This clinical outcome often relies on the clinician who is managing the patient’s care and the effectiveness of available, nonradiological, therapies. Nevertheless, radiology does contribute toward certain aspects of HRQOL. For instance, a patient may experience anxiety related to undergoing a new or perhaps unfamiliar type of radiological study. In addition, a patient might be subjected to significant discomfort related either directly or indirectly to the study, as a result of claustrophobia or back pain from lying for a prolonged period in an MRI machine, or perhaps from localized pain and systemic fevers related to an interventional procedure, such as uterine artery embolization. Additionally, financial and social impacts due to time away from work (opportunity costs) or from family activities may also affect patients’ HRQOL.

In situations where a patient may undergo one of several available types of diagnostic tests, the choice of which to perform has traditionally been decided by the ordering physician. However, with greater emphasis now being placed on patient autonomy, compounded with the increasing use of radiology, HRQOL factors and patient preference for attributes of a test (such as avoidance of pain, invasiveness, or inconvenience), unrelated to scientifically determined sensitivity and specificity of the test, are more commonly entertained. This is particularly relevant when a patient is presented with many different investigative imaging modalities to choose from, all of which may have a similar diagnostic accuracy. From a patient’s point of view, it may be worth waiting a period of time for a newer, less readily available and perhaps pain-free test that can give similar information, compared to a more readily available but invasive or uncomfortable standard method. These are issues that can be better evaluated by using HRQOL models and can be combined with CEA.

Optimal health, which is considered to be the upper boundary of the continuum of HRQOL, is an abstract notion—it has been interpreted in various ways over time to mean either normal health, or a health state that is free of all disease (7). Therefore, the notion of optimal health may be interpreted either as the absolute upper limit or closer to average health for a particular age group.

There are many factors to consider when assessing HRQOL outcomes in a comparison of two radiology tests for diagnosing a specific pathology. These include determining the target population and its average life expectancy, choosing an appropriate design for testing HRQOL, determining the frequency of imaging test repeats, assessing associated patient discomfort, quantifying the direct impact on patient time or expense, and monitoring the impact of the results (both positive or negative) on health care decisions. The perspectives from which outcomes are measured can be variable and may also have significant value. In terms of perspectives for HRQOL, options include the patient’s personal point of view, the point of view of a society, or, in certain situations, the point of view of an insurance company or a government.

**MEASURING HEALTH-RELATED QUALITY OF LIFE**

HRQOL is commonly measured in one of two ways. The first method uses one of a number of Profile Instruments, which are standardized and validated questionnaires such as FACT, MOS SF-36, and EQ-5D (7). The second method uses Preferences Measurements that ask subjects to make “judgments” regarding the value they place on a particular health state. These judgments are then used to produce an outcome score. Often these rating scores are comprised of questions that are answered using a Likert response scale that grades responses on a scale from 1 to 6 (where 1 = all the time, 6 = none of the time, and all other outcomes are spaced between these two extremes) (7). Typically, profile instruments focus on functional status, whereas preference measurements are...
generally geared to assess preferences of an individual or a group of people related to specific health states. Both of these measures are important for a complete HRQOL determination and are valid when applied to radiology studies as well.

Visual analog scales (VAS) are measurement instruments that assess a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured in an integeric fashion (8). These scales have been used quite commonly in radiology literature to assess HRQOL outcomes of minimally invasive interventions such vertebroplasty (9, 10), stenting of carotid artery stenosis (11), and ultrasound guided transrectal biopsies (12). To date, however, little has been written on screening and diagnostic imaging with respect to overall HRQOL. As an example, claustrophobia and back problems can make an MRI session psychologically distressing and physically uncomfortable for patients, but there are little objective data regarding the direct impacts on HRQOL (13).

DETERMINING PATIENT UTILITIES

Decision analysis is often used to assess available options in conditions of uncertainty. This involves constructing a decision tree that consists of alternative choices, potential consequences of these choices, the probabilities of the outcomes of each choice, and the value assigned to each outcome (14, 15). These methods of determining patient preferences, known as utilities, are used when there is uncertainty about outcomes and there are non-trivial choices with meaningful tradeoffs to be made. Utility-based techniques for deducing patient preferences regarding various possible tests or interventions include using a decision analysis tree, performing a Standard Gamble (SG) assessment, or calculating the time trade-off (TTO) (14).

The SG is a paired comparison in which there are two alternatives with two possible outcomes: a good outcome with the probability $p$ and a bad outcome with the probability of $1 - p$. The probability of outcomes is varied until the respondent is indifferent to the two alternatives (16). An example of an SG begins with a description of a particular health state. The options available are to continue living in the state of health described in the scenario or to take a gamble on an intervention with two possible outcomes (e.g., perfect health versus death). The probabilities of perfect health or death after the intervention in the gamble are systematically altered until the respondent can no longer choose a preference between the certainty of continued life in the described health state and the gamble (16).

On the other hand, the TTO technique measures how much time a subject is willing to trade-off to avoid a specific health outcome. An TTO begins with a specific health state under evaluation. The patient is confronted with a choice and the available options of continuing living in the state of health described for a defined period or to choose perfect health for a variable, but shorter, time period after undergoing the intervention. This time period is varied until the patient is indifferent to the choice between the two alternatives. The indifference point, known as TTO utility, is the length of remaining life in perfect health divided by the length of remaining life with the evaluated health state (16). The results of SG and TTO are often similar, but SG utilities are usually somewhat higher.

QUALITY-ADJUSTED LIFE-YEAR AND ITS COSTS

Outcomes from treatments and other health-influencing activities have two main components: quantity and QOL. Incorporating these two factors is the basis of determining a quality-adjusted life-year (QALY). Development of the concept of QALY has made it possible to encompass the diverse effects of a single investigation or intervention and to compare it with various outcomes, leading to a broadening of the potential uses of CEA in order to efficiently allocate finite monetary resources (17). The advantage of the QALY as a measure of health output is that it can integrate gains from reduced morbidity (quality gain) and reduced mortality (quantity gain) and combine them into a single measure (7).

A commonly used justification for a threshold figure for adoption of a new medical intervention has been that $50,000 per QALY gained is approximately the cost-effectiveness ratio equivalent to that calculated for patients with chronic renal failure on hemodialysis. Renal dialysis has been a federal entitlement to all US citizens under Medicare since 1982 (18). As a result, it has been argued that interventions and other therapies demonstrating similar or improved cost-effectiveness to that seen with dialysis should also be made universally available (19).

A wide range of values for the cost of a life-year is used in many research designs and is often far beyond the
current threshold of $50,000. Furthermore, the value of $50,000 per QALY threshold has persisted for over two decades without adjustment for inflation or changes in technology and likely no longer reflects the true cost of the intervention. As stated by Ubel et al., there is increasing societal willingness to pay more for medical interventions and there are more complex interactions between societal desire to control health care costs and the rate of development of new technologies. In their meta-analysis, they discussed the surveys that they conducted relating tradeoffs between money and risk (19). These analyses indicated that in numerous instances in which a therapy became accepted, the cost per QALY gained significantly exceeded the conventional cost-effectiveness threshold of $50,000 to $100,000 per QALY. In their review, for 1997, they determined a value per incremental QALY of $265,000. Thus, it has been argued by some that the value of 1 QALY should be adjusted upward and that society should be willing (and prepared) to spend more money for 1 QALY (15, 19).

Given that there are numerous ways to calculate the value of life, combined with the inhomogeneous populations being assessed, there is currently no consensus regarding the most suitable dollar value per QALY gained in order to most effectively base resource allocation decisions, nor is there a consistent value determined for the willingness to pay to gain an additional QALY.

**COST OF LIFE CALCULATIONS**

Various assessment tools are used to determine the value of life and to calculate its cost, but this is a controversial area of active research. Several criteria have been used in the past but the values are relative and depend not only on the patient population in question and their specific circumstances but also on the country in which the value is being calculated (19). Moreover, several methods can be used to measure cost of life, including human capital (HK), contingent valuation (CV), revealed preference/job risk (RP-JR), and revealed preference/nonoccupational safety (RP-S).

HK assessment values additional healthy life-years lived (due to the intervention) based on fair market wages, and it represents the present value of future earnings. CV is based on willingness and ability of society to pay (18).

The revealed preference (RP-JR and RP-S) approaches confer a value of life based on specific economic decisions, rather than answering hypothetical questions that have no actual resource allocating implication for the respondents, as in CV analysis (18). Hirth et al. (18) use an example of assessing the extent to which riskier jobs command higher wages, in order to indirectly determine how much workers implicitly value their lives. RP-JP proposes that the additional compensation employees are willing to accept to work in hazardous jobs, with a higher risk of fatality, indirectly represents the monetary value of a life-year. For example, Job A incurs one more fatality per 1000 workers than does Job B but pays $5,000 more per year. The implied value of life is $5,000,000. RP-S uses the cost of nonoccupational safety measures for which we are willing to pay as an estimate for value of a life-year. For example, if we are willing to pay an additional $50 for a car safety feature that decreased the risk of death from 10 per 100,000 to 5 per 100,000 (approximately $10 per additional life saved), then the implied value of life is $1,000,000.

Each method of valuation has its unique limitations. HK and CV methods have been criticized, suggesting that they assign more weight to the lives of people who are wealthy. The RP approach often involves populations of self-selected individuals, thereby decreasing the ability to generalize the findings to society at large.

The monetary value placed on human life is considered to be quite high in the United States compared with many other less industrialized countries, due to the country’s relative financial strength. Recent events have led to a more public discourse on the cost of a life. After the terrorist attacks on September 11, 2001, in New York City, the average settlement award for the families of the 2880 victims killed in the event was $2 million, whereas the amount paid for injured victims was almost $400,000. In the final report of the September 11th Victim Compensation Fund of 2001, the methodology also incorporated individual circumstances of each victim. They assessed the financial history of the victim, including assumptions about future earnings, in order to award loss computations to families in a tailored manner. They also took into account the victim’s age, the age and status of members of the household, and the type of employment held by the victim, including benefits and underlying insurance coverage, to determine the expected compensation (20).

Hirth et al.’s (18) review of 42 articles published in the literature regarding estimates on the value of life determined that there was a large variability in the cost of a
life, ranging from $460,511 to $19,322,894 based on 1997 US dollar constants. The various results may have been influenced by the population sampled, the economic situation of the region, and the technique used to calculate the values.

**UNDERSTANDING COST-EFFECTIVENESS**

Cost-effectiveness is gradually playing a more important role in health care decision-making (14). Without cost considerations, finite health care resources would likely be inefficiently allocated, resulting in an overall reduction of health benefits. Economic evaluation of a test may be performed by many different means including cost minimization analysis, cost-benefit analysis (CBA), and, most commonly, CEA. CBA looks at all outcomes in monetary terms, whereas CEA is expressed as the cost per QALY.

CBA has the advantage of determining a value for every thing in the same units, thereby permitting direct comparison of treatment costs with health benefits. However, there is difficulty in assigning a monetary value to a health scenario, and this has limited its use in the medical field (21).

On the other hand, CEA is a quantitative method for comparing costs of alternative interventions to achieve the same objectives, and it provides a numerical estimate of the magnitude of final effects of an intervention on health outcomes. Calculating the cost of an illness includes both the direct costs of diagnosis and therapy but also takes indirect costs into account. These include patient out-of-pocket costs, ancillary care, transportation costs, and “opportunity costs,” which represent the lack of ability to generate income related to missed work due to an illness (21). The difference in cost between the two interventions being compared is placed in the numerator, and the difference in effectiveness, typically in life-years, between the same two interventions is placed in the denominator (7). Thus, the results of CEA are usually expressed as additional cost per additional life-year gained. When a diagnostic test is said to be “cost-effective,” the additional health benefits it provides are considered to be a good value for the money spent compared with those of the alternatives (21). Although CEA may be conducted from a variety of perspectives, the societal perspective is favored. When CEA is conducted from the societal perspective, everyone affected by the intervention is considered in the analysis, and all significant health outcomes and resultant costs are included, regardless of who experiences the specific outcome or cost. Therefore, as a society, there is an increasing need to collectively decide how much a year of life is worth in order to determine if an intervention is “cost-effective” (13).

Evaluating HRQOL as a global outcome may be more appropriate for therapeutic interventions, rather than diagnostic or screening studies. Limited exploration of radiology-specific measures of HRQOL has recently been undertaken (13, 22). Furthermore, disease-specific measures of HRQOL are being developed, acknowledging that not all QALYs are equal. For example, if consideration is given to an example of two patients with a similar affliction of arthritis of the hands, the shortcomings of this view become apparent. If the first patient is a piano player and the second is a translator, the effects of arthritis on the first patient will have a much greater impact on their HRQOL than in the second patient. Valuation of time is also an issue. CEA studies frequently do not include the monetary or lost-labor costs associated with time spent by the patient and/or unpaid caregivers among the resource costs of a medical intervention. This is especially true in radiological studies and is becoming a more important factor with increasing use of imaging technology.

In addition to the methodological issues in CEA and HRQOL, there are many controversial issues of equity and distributive justice that become apparent when attempting to provide health care within a society in which provider or patient resources are limited. Distributive justice is a principle of numerous dimensions designed to allocate goods or services that are in limited supply. Variables in distributive justice include the goods or services that are subject to distribution, such as health care, income and other opportunities. It also depends on the subjects of the distribution (individual persons, groups of people, or reference classes). Finally, distributive justice deals with on what basis or how the goods or services should be distributed (equality, according to individual characteristics or free market transactions, or perhaps by some other measure) (23, 24).

However, societal values are not homogeneous, nor are they always completely understood or accounted for; thus, this is an important area of active epidemiological research. Additionally, imperfect as it is, radiologists must practice within the existing framework of cost-effective care and so, within this context, we need to understand how radiology contributes to HRQOL.
HRQOL, QALYs, and CEA have been explored in radiology in a wide variety of clinical conditions and tests, including screening studies for cervical cancer, lung cancer (25), mammography (26), and colon cancer (27). In addition, this type of analysis has been performed for diagnostic studies involving MRA versus conventional angiography in renal artery stenosis (13), and it has been applied to interventional procedures such as comparison of uterine artery embolization versus hysterectomy for uterine fibroid treatment (28). Uterine artery embolization is a minimally invasive procedure for treating fibroids that has previously been determined to be a cost-effective alternative to hysterectomy across a wide range of assumptions about the costs and effectiveness of the two procedures. Interestingly, the study results were also sensitive to changes in QOL values (28). For example, in one study comparing the HRQOL of uterine artery embolization to hysterectomy for the treatment of uterine fibroids, after accounting for hospital, physician, and patient costs, as well as morbidity and mortality costs, the temporary reduction in HRQOL during the recovery period between embolization and hysterectomy influenced the relative cost-effectiveness of the newer procedure over the standard alternative. As another example in radiology, it has been shown that vertebroplasty is an interventional radiology procedure that is both safe and efficacious for treating compression fractures, with a corresponding improvement in patients’ pain and QOL (9).

In contrast, for lung cancer screening, it was concluded that given the current knowledge and practice, even reductions in lung cancer mortality of up to 20% were unlikely to be cost effective, using a value of $50,000 per life-year saved as the threshold to define a cost-effective intervention (25). As a result, there are no current recommendations for screening CT scans of the lungs as a means of detecting lung cancer.

Additional considerations when determining HRQOL related to radiology, and in particular to screening studies, include overdiagnosis and lead time bias. For example, when performing CT scans to screen for lung cancer, there is a potential for “overdiagnosis,” or false-positive results, when there are suspicious-looking nodules detected that are ultimately determined to be benign. Either these nodules are followed with repeated CT scans, thereby increasing patients’ risks of developing cancer due to unnecessary exposure to radiation from the CT scans, or the nodules are surgically resected, resulting in potentially excessive morbidity and, in some cases, mortality (25). In terms of lead time bias, if a malignant nodule is detected early in the course of an illness in an asymptomatic individual but the patient still ultimately dies from the disease at the same point in time as if the lesion had been detected only when the patient became symptomatic, this would be considered to have negative effects on HRQOL, including anxiety associated with knowing about a malignant process for a longer period of time or related to additional interventions resulting from an earlier diagnosis.

Another factor that must be considered when assessing radiology-based screening tests, combined with HRQOL measures, is the population sample involved in the screening process. For instance, patients who are more financially secure or more aware of their health may be more likely to seek a screening program. Thus, the rate of disease in these patients might be considerably lower as a result of better socioeconomic factors depending on the risk factors for acquiring the pathology that is being screened. Trials involving HRQOL assessments related to diagnostic imaging also need to give consideration as to how health state preferences should be valued. These preference scores indicate the relative preference for a health state compared with full health and are used to understand how individuals view various aspects of functional health. In practical terms, they allow us to synthesize in a single score the effects of a health state across various attributes of functional health.

Preference weighting of health states can be ascertained, but the results may vary in different populations. Generally speaking, available methods and applied instruments may produce variations in scores when applied to a specific disease or health state. Currently, community preferences for health states are considered the most appropriate for the base case analysis (7).

**DISCOUNTING**

The present financial investment for a health intervention yields an actual rate of return in the future, and as such, this cost needs to be accounted for when spending money in the present (29). Discounting makes current costs and benefits worth more than those occurring in the future because there is a cost to spending money now in
order to enjoy present benefits rather than waiting for them at a later time. To date, there are some data suggesting current health benefits are valued more highly than future ones, and thus they discount future health gains more highly than future wealth gains (30). There are numerous influences that affect the rate of discounting of current and future health states, including rising income, rising age, and time preferences. As a result, there are various ways of discounting health benefits in terms of monetary cost. The two major ways of discounting are: use of similar versus use of differential discount rates for health compared with money. There is increasing evidence that the same discount rates for health and money should not be used; this is an area of active research and debate (31). Nevertheless, discounting should be taken into consideration when calculating the final cost effectiveness of a new radiology intervention or diagnostic test.

**UNDERSTANDING TEST DISUTILITY**

The introduction of new imaging and interventional radiology technologies has had an impact on the rising costs of health care (2). CEA is a quantitative analysis tool that plays a role in evaluating increasingly expensive new technologies, including radiology studies. CEA compares two competing strategies, one of which could be a no-test or no-intervention strategy that takes into account the natural history of a disease. Traditional technologies are often less expensive than newer technologies and should be incorporated into algorithms assessing the new technology, to help ease the rising costs of health care. When less expensive or cost-saving technologies lead to equivalent outcomes, they are often more easily accepted for regular use. However, it is often the case that new technology is based on anticipated quality-improving innovations rather than the actual cost. With this in mind, when assessing new imaging technologies, it is important to consider economic, ethical, and research design issues, and possibly also the concept of “decremental cost-effectiveness” (32). Decremental cost-effectiveness is calculated by determining the dollars gained for every QALY lost in cases where a particular therapy is cheaper but less effective than another. For example, fecal occult blood testing is cheaper but less effective than virtual colonography or colonoscopy. However, the acceptance or dissemination of a less invasive or less expensive test may be higher in some communities than the better test, such that the cumulative QALY saved by the less effective test due to increased compliance may approach that of the more effective test.

The perfect test that no one chooses due to perceived discomfort, time commitment, personal cost, or psychological stress is of limited effectiveness. Understanding patient perceptions regarding diagnostic tests becomes key, particularly in radiology with its competing tests with different performance characteristics and associated morbidities. “Short-term test disutility” is typically defined as discomfort experienced by a patient, as a result of undergoing a test or procedure that causes a transient decrease in QOL. This term reflects a transient decrease in QOL that is associated with a given test; the more invasive test results in a larger decrease. Just as in other domains of medicine, the term “test disutility” is increasingly being used to describe outcomes of diagnostic studies or radiological interventions (13).

Potential morbidity associated with a diagnostic test can influence its cost-effectiveness, but quantifying that morbidity is controversial. Accounting for pain and invasiveness requires the measurement of “process utility” in addition to the expected measured value of the actual test. The process utility attaches preference values to aspects of a test that occur prior to the actual outcomes. These include information provided to the patient, reassurance given prior to or during the test or intervention, and an explanation of the possible associated morbidity. Numerical judgments of the desirability of a set of outcomes are called “values” or “utilities.” The most common use of the term “utility” is preference, while the term “health state” describes the health of an individual at a particular point in time. These health states can be modified by physical impairments or by perceptions that are influenced by disease, injury, or therapy (33). In a “disutility” model, morbidity is viewed as a deduction from optimal health in contradistinction to a utility approach, in which the situation is portrayed as one’s health being a proportion of optimal health. Disutility models are useful in assessing radiology studies because they demonstrate how additional imaging may negatively affect patients in terms of their actual or perceived health state (13).

**MEASURING TEST DISUTILITY**

Swan et al. (33) have developed a preference-based analysis of test disutility derived from the TTO measure of HRQOL called “waiting trade-off” (WTO) analysis. In this context, a WTO is an aid for evaluating the prefer-
ences of patients and is calculated by comparing an actual test with its associated temporary morbidities and a hypothetical ideal test. Assuming that both tests perform the same and there is no difference in patient care after undergoing either test, the patient is asked to choose the period of time they are willing to wait for the hypothetical “ideal” test versus immediately undergoing the actual test under evaluation. The length of time patients are willing to wait for the ideal test represents the short-term disutility of the actual test. Longer wait times reflect decreased preference for the test under evaluation. The more negatively patients view a test, the longer they are generally willing to wait for the hypothetical ideal. Therefore, in comparing two actual tests, studies using paired data of patients undergoing both tests can identify statistical differences between the mean WTPs for each test. The WTO allows direct incorporation of patient preferences into a CEA through a direct adjustment of QALY, a distinct advantage over non—preference—based evaluation of patient test perceptions (33).

The WTO has been measured in patients with peripheral vascular disease who underwent MRA and conventional angiography, where the relevant disease state is the pain suffered by the patient (34). More recently, the WTO has been used to differentiate short-term breast biopsy preferences in an acute situation where anxiety is the symptomatic disease state (35).

**FUTURE DIRECTIONS**

HRQOL and CEA are important factors to consider in the practice of radiology. In assessing the value of advancements in imaging technology, ideally, the results should demonstrate that despite greater use of technology and imaging services, there are associated improvements in patient outcomes that ultimately result in decreased costs to the individual and/or the health care system overall. It is also important to determine what resources are available and invest in those areas where the data show that the needs are most pressing but in a way that is also economically viable. However, determination of HRQOL and CEA must be performed in a systematic way with a rigorous approach. Prior to starting a project related to these technical assessments pertaining to the field of radiology, specific training and knowledge should be acquired.

Use of multiattribute outcomes evaluators, such as the one developed by Swan (36), might potentially facilitate the development of methods for assessing the cost-effectiveness of newer treatments. Moreover, multiattribute outcomes evaluators could also be useful for building outcomes measures that are intended to aid individual decision-making criteria. In addition, they might assist with the assessment of patient satisfaction regarding their care and play an important role in measuring outcomes used for CEA. Currently, the breadth and scope of research in this field are sparse. Further work will help to shed some light on issues of equity and distributive justice as well as clarify factors related to health care that are important to society.

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