REVIEW ARTICLE

Introduction to Cost Analysis in IR: Challenges and Opportunities

Bahman Roudsari, MD, MPH, PhD, Justin McWilliams, MD, Brian Bresnahan, PhD, MPH, and Siddharth Padia, MD

ABSTRACT

Demonstration of value has become increasingly important in the current health care system. This review summarizes four of the most commonly used cost analysis methods relevant to IR that could be adopted to demonstrate the value of IR interventions: the cost minimization study, cost-effectiveness assessment, cost-utility analysis, and cost-benefit analysis. In addition, the issues of true cost versus hospital charges, modeling in cost studies, and sensitivity analysis are discussed.

ABBREVIATIONS

CEA = cost-effectiveness assessment, ED = emergency department, ICER = incremental cost-effectiveness ratio, QALY = quality-adjusted life year, TIPS = transjugular intrahepatic portosystemic shunt

IR is characterized by constant evolution and rapid advancement of technology. However, in IR, efficacy data often focus on short-term technical and clinical outcomes as opposed to long-term results (1,2). In addition, new interventions are often expensive, which can be a barrier from payer, patient, and societal perspectives (3). With ongoing cuts in reimbursement as a result of health care reform and a general lack of evidence of value for many medical interventions, there is greater demand on care providers to demonstrate value (4,5).

Cost-effectiveness studies are increasingly used by international and domestic government agencies, payers, researchers, and policymakers to evaluate the value of new modalities (6–8). **Figure 1** presents a typical cost-effectiveness plane, represented by four quadrants of cost and effectiveness relationships comparing a new intervention with an existing intervention (eg, standard of care) (6,8). In the example presented in **Figure 1**, the costs and effectiveness of two interventions have been compared: the new modality (B) versus the current standard of care (A).

In the upper left and lower right quadrants in **Figure 1**, selection of the preferred intervention is straightforward. The bottom left quadrant is an uncommon scenario in health care in which the new intervention is less expensive and less effective (6,9,10). The top right quadrant is the most challenging scenario for setting policy, where a new modality is both more effective and more expensive (6). Studies incorporating cost-effectiveness assessment (CEA) may be used to assist policymakers, care providers, and patients to make more informed decisions regarding the adoption of a new intervention in this scenario (6,7). Before discussing these methodologies, it is necessary to explain four core concepts: value, effectiveness, cost, and perspective.

VALUE, EFFECTIVENESS, COST, AND PERSPECTIVE

Value

In general, "value" is defined as the outcome gained for the amount of money spent (2,11). In health care, "value" can be further defined based on "what matters for patients" (2), while taking into consideration the interests of numerous other stakeholders, including society as a whole, care providers, and insurance companies (2,12). From the societal perspective, achieving value by providing high-quality care while minimizing cost is a difficult task (11). Cost analysis studies assist

From the Division of Interventional Radiology (B.R., J.M.), David Geffen School of Medicine at UCLA, 757 Westwood Plaza, Suite 2125, Los Angeles, CA 90095; and Department of Radiology (B.B.) and Division of Interventional Radiology (S.P.), University of Washington, Seattle, Washington. Received September 9, 2015; final revision received and accepted December 22, 2015. **Address correspondence to** B.R.; E-mail: bahmanr@gmail.com

None of the authors have identified a conflict of interest.

Appendices A and B are available online at *www.jvir.org*.

J Vasc Interv Radiol 2016; XX:▮▮▮–▮▮▮

http://dx.doi.org/10.1016/j.jvir.2015.12.754

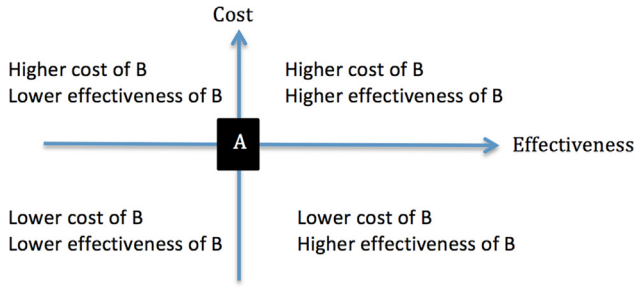

Figure 1. Comparison of the cost and effectiveness of intervention *B* (new intervention) relative to intervention *A* (current modality of choice, baseline for comparison).

policymakers in making decisions regarding allocation of limited resources to achieve the greatest health outcomes for the money spent (6).

Effectiveness

"Effectiveness" is defined as the distribution of the outcomes of interest as a result of intervention A versus intervention B. In medicine, outcomes of interest could be overall survival, complication rate, response rate, or countless others. For example, Pierce, Sperry, and Nirula (13) conducted a study that compared the cost-effectiveness of transjugular intrahepatic portosystemic shunt (TIPS) versus surgical portacaval shunt placement for variceal bleeding management. In this study, the outcomes of interest included "gastrointestinal rebleed, hepatic encephalopathy and procedure-related complications" (13).

Two different approaches can be used to evaluate the distribution of outcomes: trial-based analysis or literature-based analysis (6). In trial-based analysis, the effectiveness data are directly obtained from the trial itself. The downside of this approach is that the results of the clinical trial might not be applicable to other settings and that level 1 clinical trial data may be scarce or unavailable for the outcome desired (6). Thus, trial-based cost analyses are uncommon in IR. Instead, most IR-based cost analyses rely on the published literature to estimate the outcomes of interest. For example, Rostambeigi et al (14) performed a comprehensive literature review to evaluate the published effectiveness of transarterial chemoembolization and radioembolization with yttrium-90 for comparable groups of patients with hepatocellular carcinoma.

Cost

Defining "cost" is the most challenging part of a CEA study, particularly costs across various stakeholders (15). Overall, the cost of care can be divided into direct and indirect costs, each of which can be subdivided into medical and nonmedical components (9). An example of a direct medical cost is the actual cost of a service that is performed in a hospital. For example, Beheshti and Meek (16) evaluated the direct medical cost of transarterial chemoembolization by taking into consideration the "labor, equipment, facility acquisition and maintenance, overhead, and administrative costs." The authors demonstrated that the "largest contribution (62%) to the real cost of outpatient transarterial chemoembolization comes from the expendable equipment used in the procedure." (16) An example of a direct nonmedical cost of care is the cost of patient transportation, lodging, and food (9). An example of an indirect medical cost of care is the loss of productivity as a result of an intervention. Loss of productivity of parents while taking care of a sick child is an example of indirect nonmedical cost of care.

Considering the complexity of calculating the actual cost of a service, some researchers have used hospital charges as a surrogate for costs of care (15). However, charges and institutional costs lack transparency and differ among organizations (15,17). In addition, the relationships among charges, direct costs, indirect costs, and reimbursement amounts are unclear and are not widely available (15). As a result, facility charges are arbitrary and should not be used in cost analysis studies (17). For example, Reinhardt (15) demonstrated that in selected California hospitals in 2004, the charge of a basic service such as a chest radiograph varied from approximately $100 in a San Francisco General Hospital to > $1,500 in a hospital in Modesto. No "customer" actually pays these charged amounts except possibly uninsured individuals who have no third-party organization negotiating payments on their behalf (15). Therefore, economic evaluations often use publicly available information as a reference amount, depending on the person or the entity paying for the service. For analyses from a hospital perspective, the cost of the provided service could be calculated by summing the costs of room time, equipment, and staff, similar to the calculation that was performed by Beheshti and Meek (16). From a payer perspective, reimbursement amounts are often used as an estimate of provider's costs, although the reimbursement amounts are not a true reflection of the actual cost of care (15). As an example, Medicare considers the diagnosis-related group as the base for reimbursement purposes (18), but this method of payment does not take into account the complexity of the procedure and the actual resources that are used for an intervention.

Perspective

CEA studies can be from the perspective of the patient, the health care provider, the insurance company, or the society at large (6,9). For example, Ray et al (19) performed a cost analysis comparing different IR modalities for the treatment of hepatocellular carcinoma. The authors demonstrated that for comparable groups of patients, radiofrequency ablation is less costly than transarterial chemoembolization or radioembolization (19).