Methods for Conducting and Reporting Cost-Effectiveness Analysis in Nursing
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Although total U.S. health care spending is rising at a decreasing rate, health care consumers spend nearly 14% of the U.S. gross domestic product (Levit, Lazenby, & Brader, 1998). This level of spending has led to increased use of economic methods to evaluate health care interventions and programs, particularly cost-effectiveness analysis (CEA) (Adams, McCall, & Gray 1992; Elzahar, Halpern, Schmer, & Luce, 1998).

The influence of CEA in the development of health care policy is not well-documented. However, it is believed that both state and federal agencies have made decisions for health care prevention services based on the results of CEA. The CEA framework has also been suggested as appropriate to help with resource allocation decisions involving the delivery of nursing care and improving the overall quality of clinical care (Laura & Buntly, 1991; Newbold, 1999; Panniers & Walker, 1994; Walker & Stone, 1990).

Overview of CEA Methodology

CEA is a method for evaluating the outcomes and costs of interventions designed to improve health. CEA uses a decision analytic technique derived from operations research and game theory (Funkhouser & Kassirer, 1987). Similar to how any well-conducted research project conforms to certain rules, such as randomization of subjects in a clinical experiment, CEA has a defined methodology which is explained in detail in clinical decision making texts (e.g., Sox, Blatt, Higgins, & Marton, 1988; Weinstein, et al., 1980). The steps in a CEA include identifying the question to be answered and the perspective of the analysis; modeling the problem; collecting data; discounting costs and outcomes; performing the analysis; and conducting sensitivity analyses. Data needed for conducting a CEA include probabilities of chance events, a defined measurable outcome, and costs.

Question and Perspective

The question and patient population characteristics a CEA is designed to address must be clearly articulated. Often the goal is to compare the cost-effectiveness of a new intervention or model of care to the current standard. Depending on the question being asked, cost-effectiveness studies originate from a variety of perspectives including patient, clinician, payer, or society. Perspective affects the results of an analysis and, therefore, must be stated unambiguously.

Modeling

Often a decision tree, as shown in Figure 1, is used to show a chronological ordering of the possible sequence of events over time following a particular decision. Analogous to a road map, the decision tree outlines the problem and helps formulate the mathematical modeling of the problem. In the tree, the square node depicts the decision to be made, and circular or oval nodes represent the potential chance events that may occur if certain choices are made. Potential outcomes are denoted by the triangles (the terminal nodes) that indicate the end of the timeline under consideration for the decision being analyzed.

When the natural history of the problem being modeled involves events that may occur repeatedly or over long periods,

![Figure 1: Decision tree.](https://example.com/decision-tree.png)

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the decision tree can become cumbersome. In this case, a state-transition model such as a Markov model, is a more efficient representation of multiple events that recur over time. Figure 2 shows two common ways of illustrating a Markov model, which may be used to represent mutually exclusive and exhaustive health states that have uniform time periods and a constant probability of leaving over time. Advances in computer modeling have enabled Markov models to replace the decision tree or be graphed onto it (Beck & Pauker, 1983). Along with spreadsheets for computation, decision analysis uses one of three computer programs to aid in modeling the problem; these examples are SMLTREE (Hollenberg, 1989), Data 3.0 (Trecare Software, Inc., 1994), and Decision Maker (Pauker, Sonneborn, & Wong, 1983).

**Probabilities**

In CEAs, probabilities express the degree of certainty that an event will (or will not) occur on a scale from 0 to 1.0. Probabilities of chance events may be obtained directly from a research protocol or found in published research. Determining the appropriate conditional probability is important. For example, in Figure 1, the conditional probability of a good outcome given alternative 1, p(GA1), is not the same as the overall probability of a good outcome. Unfortunately, the literature often does not include data in the form needed for a CEA and it is then necessary to use Bayesian methods to extrapolate and convert rates to probabilities. When probabilities are obtained from a secondary data source, every attempt should be made to obtain the least biased estimates from the most scientifically rigorous studies. If insufficient data are available from one source, a meta-analysis can be conducted to obtain the necessary information.

![Figure 2: Illustrating a Markov Model.](image)

**Outcomes**

In CEAs, health benefits are the outcomes of treatment. Outcomes can range from intermediate indicators such as reduction in glotic blood pressure, to outcomes involving years of remaining life or quality-adjusted life years (QALYs). The appropriate outcome measure depends on the specific QALY. Some appropriate measures are taken in a societal perspective. Although alternative approaches have been suggested (Meltzer & Gali, 1993), QALYs are the most widely used and recommended for capturing both quality and quantity of life. To construct QALYs, quality adjustments to life expectancy are made to account for years of unhealthy life being more important to an individual than years of life with a disability. The utility adjustments are accomplished by applying standardized health status classification systems, direct assessment, or expert opinion (Neumann, Zinna, & Wright, 1997). In standardized classifications and direct assessment, utility weights are determined by methods such as standard gamble, time-trade-off, or ranking scales (Nord, 1992). An example of health-state classification systems that can be suitable for this purpose include the Health Utilities Index (Patrick & Erickson, 1993; Torrance, Byrle, & Horwood, 1982), the EuroQol (EuroQol Group, 1990), the Quality of Well-Being Scale (Kaplan & Anderson, 1988) and the Years of Healthy Life measure (Erickson, Wilson, & Shannon, 1995).

**Resource Costs**

To estimate the cost of resources incurred by an intervention, different types of costs need to be considered. The cost of resources has traditionally been divided into "direct" and "indirect" costs (Drummond, Stoddart, & Torrance, 1987). However, economists and accountants do not use the same definitions. In economic evaluation, direct costs are defined in changes in resource use attributable to the intervention or treatment regimen, whereas indirect costs refer to productivity gains or losses related to illness (Rice, 1997). In cost accounting, direct costs are variable costs and indirect costs are overhead costs. To decrease confusion in conducting a CEA, direct costs apply to changes in resource use attributable to the intervention or treatment (Coe, Manning, Siegel, & Lipscomb, 1996). Also, in CEA, the term indirect costs should be avoided and "time costs" should be used, which is defined as the value of the individual's time related to receiving a treatment. The value related to loss of productivity (such as loss of income because of illness) is not directly considered in CEAs because it is already considered in the QALY (Lace et al., 1999).

Economists use the term "opportunity cost" to reflect the value of alternative uses of resources. In a CEA, the opportunity cost of resources used to produce an intervention is the highest value of the benefits that are not realized (i.e., the gain that the resource was used for its next best alternative use). For example, the opportunity cost to a municipality's health department of funding a community outreach health prevention program for the elderly may be the forgone benefits of not being able to fund an immunization program for children. Furthermore, in some instances market prices provide a reasonable estimate of opportunity cost.
such as the wages of a registered nurse or the cost of an office visit. In other cases there are important biases in market prices due to profit margins and cost shifting that must be carefully considered. Thus, the investigator must first decide whether market prices reflect true opportunity costs and then consider how sensitive the results of the analysis are to this assumption. When data about wages are from different periods, perhaps market prices can vary because of inflation. The usual approach for handling price changes is to adjust past prices to current dollars so all resources are valued in comparable dollar terms (Luce et al., 1996).

Given the complexity and availability of data, it is not surprising that inconsistent categories of resource use and cost are reported in the CEA literature (Odorhegyi, Colditz, Ral, & Epstein, 1992). Generally, cost-effectiveness analysis takes a comprehensive approach to the identification, measurement, and valuation of resources. All resource consumption that is individually or collectively large enough to affect the decision should be included. To accomplish this, it is helpful to first enumerate all resources consumed, even small ones, and those difficult to value in monetary terms. Less obvious resource consumption such as patient-time costs in traveling to facilities should also be included. Different approaches are available for measuring resource use—excluding micro-costing that enumerates and assigns cost to every input consumed to gross-costing that estimates the cost of an event, such as the cost of hospitalization from a Medicare-derived reimbursement rate.

Discounting

It is generally accepted that people place greater value on something they have today than something they will have in the future. Interest rates illustrate how people value money today more than money in the future. If a person has $100 today, he or she would be able to earn more money in the future (the interest rate) to forego the benefits of using these dollars. For example, with a 5% interest rate, $100 today is worth $105 next year. Conversely, $100 in the future is not worth as much as $100 today, therefore the future benefit should be discounted to the present value. In other words, the present value of $100 next year is discounted to $95.25. The formula for present value is:

\[
\text{PV} = \frac{FV}{(1 + r)^n}
\]

where PV is the future value, r is the interest rate, and n is the number of years. Not only are future costs discounted to present value, but future health outcomes, such as years of life, are discounted to present value.

Analysis

The analytic goal of a CEA is computation of a cost-effectiveness ratio (CER) in which the cost of resources is numerator and the health effect is the denominator. Marginal cost (the cost of doing one more unit of activity) is usually the cost that interests the investigator. Marginal cost, however, differs greatly from average cost. A well-known example of the difference between marginal and average cost is the "sixth-stool guinea test" in the screening for colorectal cancer for the U.S. population over age 40.

The average cost per case of cancer detected using five of fewer tests has been calculated to be $2,451, but the marginal cost of doing a sixth test is estimated to range between $47 and $127,000 (Newhauser & Lewicki, 1975). In other words, the probability of detecting an additional case of cancer with a sixth guinea test is so low that millions of dollars are spent for additional guinea tests to identify individuals who truly have cancer. Thus, the marginal cost of the sixth guinea test is very high.

Sensitivity Analyses

All economic appraisals rely on certain estimates and assumptions, and sensitivity analysis tests how sensitive results are to changes in assumptions. For example, in analyzing the cost-effectiveness of free-standing birth centers, the rate of transfer of women from the birth center to the hospital is an important variable that may change under different conditions (Stone & Wadler, 1990). Repeating the analysis using various probabilities of transfer, the investigators determined how "robust" the results are to differing values of this variable. When uncertainty surrounds more than one variable, multivariate sensitivity analyses should be conducted. However, because multivariate analysis does not take into account correlation between variables, it may overestimate the uncertainty. To address these difficulties, stochastic models can be used to estimate uncertain parameters as well as a computer generated random simulation called a Monte Carlo process, (for a more detailed explanation of Monte Carlo processes, see Dobzek, Begg, Wennstein, Brum, & McNiel, 1983; O'Brien, Drummond, Labe, & Willian, 1994).

The goal of any clinical decision making is to outline logically complex problems for the purpose of informing decision-makers. The methods used in CEA are complex and may be unfamiliar to many nurses. Thus, to improve the usefulness of an analysis, modeling a CEA should be a collaborative effort by the decision maker (often a nurse) and the analyst, and the recommendations that have been developed by the recently convened CEA panel should be followed.

Recommendations of the Panel on Cost-effectiveness in Health and Medicine

With the proliferation of cost-effectiveness studies applied to resource-allocation problems in health care and the potential to affect health policy, much interest has been shown in the quality of these analyses. In 1993, the U.S. Public Health Service convened a panel of scientists and scholars for the purpose of assessing the current state of the science in the field of cost-effectiveness. The panel was asked to develop recommendations for improving the quality of CEA's and encouraging comparability. The panel developed seven recommendations for conducting and reporting CEA's, which are detailed in three articles as well as a published book (Gold, Siegel, Russell, & Weinstein, 1996; Russell et al., 1996; Siegel, Weinstein, Russell, & Gold, 1996; Weinstein, Siegel, Gold, Kansten, & Russell, 1996). The content of the recommendations is as follows.

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Recommendation 1: Nature and limits of CEA, and purpose of the reference case

Although cost-effectiveness studies cannot incorporate all of society's values, they can provide useful information for decision making. But it is important to emphasize that CEA should be viewed as an aid to decision making, not the end decision. To promote comparability and consistency among cost-effectiveness studies, the panel recommends a reference case be presented whenever the CEA is intended to inform those who make resource allocation decisions from a societal perspective. This means that the most recent time period, hospital, or type of analysis be broad enough to capture all relevant effects of the intervention and that the outcomes should be measured as QALYs.

A standard "reference case" is included in this type of CEA for the purpose of comparing the new health intervention under consideration to the existing practice—so the "status quo." Depending on the goals of the analysis, the investigator may take the perspective of an institution or payer. When the investigator does not frame the CEA from the societal perspective, however, the assumptions underpinning the reference case may not be applicable. Nonetheless, in the interest of comparability, the panel urged that the reference case be included whenever the results of the CEA may be used to inform those who make resource-allocation decisions which can affect society.

Recommendation 2: The cost-effectiveness ratio numerator and denominator

A cost-effectiveness ratio is constructed with the net expenditure as the numerator and the net improvement as the denominator. However, this definition is incomplete because in some cases it is unclear whether certain effects are actually costs (which would belong in the numerator) or health consequences (the denominator). For example, when a patient is unable to work and loses wages because of recuperation, should this event be in the numerator as a cost or in the denominator as a morbidity effect? The panel recommends that the numerator include relevant costs that encompass not only the cost of the health care service (the direct cost), but also patient's and informal caregiver's time costs. Time costs are accrued by the patient while receiving the treatment, such as driving time, and informal caregiving costs are accrued when family members or volunteers spend time providing home care. The denominator of the cost effectiveness ratio incorporates the effects of the health intervention and measure changes in health status. Monetary value associated with the intrinsic value of health itself and the ability to be productive (such as being employed) is captured completely by the utility measure in the denominator. Therefore, lost wages are not directly measured in a CEA because this would be double counting.

Recommendation 3: Measuring terms in the numerator of the cost-effectiveness ratio

The panel recommends that investigators identify all resources consumed by the intervention under consideration. By first identifying all resources consumed, including less obvious resources such as patient transportation to health facilities or time costs concerning counseling sessions, the analyst is better able to rank the importance of the resource. Because of the numerous components of resource costs, every cost cannot be incorporated in the analysis. However, the value of CEA depends on the ability to incorporate accurately the relevant resource consumption and savings attributable to the intervention. Once a detailed identification and recording of all inputs have been completed, the resources are converted into value terms to produce a cost estimate. Whenever an investigator has reason to be unsure of certain costs, a sensitivity analysis should be performed.

Recommendation 4: Measuring terms in the denominator of a cost-effectiveness ratio

The denominator of a cost-effectiveness ratio measures the effectiveness of the health intervention, or the clinical outcome, of care. The panel suggests that the reference case measure health effectiveness using QALY's. To be consistent in constructing QALY's, the quality weights should be transformed into an interval scale with the optimal state of health valued as 1 and death assigned the value of 0. In the reference case, preferences for health states should be weighted with community preferences, not the preferences of patients, providers, or investigators. However, because which weighting method is best is unclear, the panel does not recommend one weighting method over another. Patient preferences are acceptable only when there is inadequate information available on community preferences. Health status scales that are not preference weighted, such as the Medical Outcomes Study Short-Form Health Survey (SF-36), are not suitable for CEA.

Recommendation 5: Discounting

In CEA, both future costs and benefits are discounted. At noted, discounting reflects people's preference for having something today over the value of having the same thing in the future. Although different discount rates are defined in the CEA literature, the panel recommends a 3% discount rate in the reference case. Because many past CEAs have used a 5% discount rate, a sensitivity analysis with a 5% discount rate should be included over a 10 year period in the future. In addition, before discounting, all costs should be adjusted for inflation.

Recommendation 6: Uncertainty

The goal of CEA is to decrease uncertainty for decision makers. However, due to the necessity of making assumptions, the very nature of the analysis means there will be some uncertainty. Performing sensitivity analyses may help to reduce uncertainty, and the panel recommends that "sensitivity" analyses be performed when there is reason to believe that there is uncertainty between essential variables that are key determinants in the analyses. In addition, when uncertainty is a concern, confidence intervals should be estimated, but when there is substantial uncertainty, simulation models may be needed.

Recommendation 7: Reporting guidelines

To enhance the comparability of CEA reports, the panel recommends guidelines for standard reporting. Elements of
Table 1: CEA Checklist for Journal Reports (Adapted from Siegel, Weinstein, & Torrance, 1996)

1. Framework
   - Background of the problem
   - General framing and design of the problem
   - Target population for intervention
   - Other program descriptors
   - Description of comparator programs
   - Boundaries of the analysis
   - Time horizon
   - Statement of the perspective of the analysis

2. Data and Methods
   - Description of event pathway
   - Identification of outcomes of interest in analysis
   - Description of model used
   - Modeling assumptions
   - Diagram of event pathway/model software used
   - Complete information on the sources of effectiveness data, cost data, and preference weights
   - Methods for obtaining estimates of effectiveness, costs, and preferences
   - Critique of data quality
   - Statement of cost inputs
   - Statement of method used to adjust costs for inflation
   - Statement of type of currency
   - Source and methods for obtaining expert judgments
   - Statement of discount rates

3. Results
   - Results of model validation
   - Reference case results (discounted and undiscounted): total costs and effectiveness, incremental costs and effectiveness, and incremental cost-effectiveness rates
   - Results of sensitivity analyses
   - Other estimates of uncertainty, if available
   - Graphical depiction of CEA results
   - Aggregate cost and effectiveness information
   - Disaggregated results, if available
   - Secondary analyses using 5%, 3% discount rate
   - Other secondary analyses, if available

4. Discussion
   - Summary of reference case results
   - Summary of sensitivity analysis
   - Discuss assumptions having important ethical implications
   - Limitations of the study
   - Relevance of study results for specific policy questions or decisions
   - Results of related CEA
   - Dominant implications of an intervention

include in a journal article are summarized in Table 1—these elements can also be used as a guideline for reviewing published CEA results. The study framework explains the motivation of the study. Methods include a translation of quantitative results into qualitative descriptions, and that the robustness of the results be highlighted. Furthermore, results should be compared to other studies to determine consistency of findings, and a global set of options should be discussed even if not all options were included in the analysis. For example, if an analysis compares the cost-effectiveness of surgery vs. medical therapy, alternatives such as diet modification, exercise, and smoking cessation are also relevant and should be discussed. Ethical problems must be presented to help prevent overly simplistic use of the CEA results. Because of these limitations, most journals do not permit full reporting of a CEA. Thus, the panel recommends that a technical report may be submitted as an addendum to reviews to judge the quality of the analysis, and that the report be made available upon request.

Discussion

CEA is a useful analytical tool that will increasingly be used by those who must contend with rising demand for scarce health care resources. CEA can aid decision makers within the costs and effectiveness of interventions must be considered carefully by clients and clinicians. From a societal perspective, CEA can assist decision makers determine the policies that should be followed and the programs that should be funded. However, no single method of making decisions about health care resource allocation provides complete information. CEA can help decision-makers and considering possible alternatives, allocate resources. And by counting all costs and health effects, the societal perspective reflects the public interest, rather than any particular group. Regardless of the results of a CEA, policy makers may still choose to give preference to certain groups, such as the poor or others with a particular need. Values such as individual free choice cannot be quantified in CEA, as illustrated by the decision not to administer compulsory tests for human immunodeficiency virus for pregnant women. Instead, real-world decisions must balance cost-effectiveness health care against these other values. CEA is only a tool to aid in making the decision; it is not the decision. Standardizing CEA procedures and methods can improve the quality and facilitate comparability of studies. Similarly, standard reporting of analyses will enhance readers’ understanding. To increase the likelihood that CEA results done by nurses will be used by providers, policy makers, and the larger CEA community, it is wise for nurses to seek to the standards recommended by the panel.

In most cases, the education of nurses, physicians, and other health care professionals associated with the study should be discussed. The results of the base-case—which will be the reference case if the primary purpose of the analysis is to inform, and resource allocation issues related to the sensitivity analyses should be presented.

The panel recommends that the discussion section of a CEA report include a translation of quantitative results into qualitative

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