

# Chapter 14

## Methods for eHealth Economic Evaluation Studies

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### 14.1 Introduction

A plethora of evaluation methods have been used to examine the economic return of eHealth investments in the literature. These methods offer different ways of determining the “value for money” associated with a given eHealth system that are often based on specific assumptions and needs. However, this diversity has created some ambiguity with respect to when and how one should choose among these methods, ways to maintain the rigour of the process and its reporting, while ensuring relevance of the findings to the organization and stakeholders involved.

This chapter reviews the economic evaluation methods that are used in healthcare, especially those that have been applied in eHealth. It draws on the eHealth Economic Evaluation Framework discussed in chapter 5 by elaborating on the common underlying design, analysis and reporting aspects of the methods presented. In so doing, a better understanding of when and how these methods can be applied in real-world settings is gained. Note that it is beyond the scope of this chapter to describe all known economic evaluation methods in detail. Rather, its focus is to introduce selected methods and the processes involved from the eHealth literature. The Appendix to this chapter presents a glossary of relevant terms with additional reference citations for those interested in greater detail on these methods.

Specifically, this chapter describes the types of eHealth economic evaluation methods reported, the process for identifying, measuring and valuating costs and outcomes and assessing impact, as well as best practice guidance that has

been published. Three brief exemplary cases have been included to illustrate the types of eHealth economic evaluation used and their implication on practice.

## 14.2 eHealth Economic Evaluation Methods

The basic principle behind economic evaluation is the examination of the costs and outcomes associated with each of the options being considered to determine if they are worth the investment (Drummond, Sculpher, Torrance, O'Brien, & Stoddart, 2005). For eHealth it is the compilation of the resources required to adopt a particular eHealth system option and the consequences derived or expected from the adoption of that system. While there are different types of resources involved they are always expressed in monetary units as the cost. Consequences will depend upon the natural units by which the outcomes are measured and whether they are then aggregated and/or converted into a common unit for comparison.

The type of economic analysis is influenced by how the costs and outcomes are handled. In cost-benefit analysis both the costs and outcomes of the options are expressed and compared in a monetary unit. In cost-effectiveness analysis there is one main outcome that is expressed in its natural unit such as the readmission rate. In cost-consequence analysis there are multiple outcomes reported in their respective units without aggregation such as the readmission rate and hospital length of stay. In cost-minimization analysis the least-cost option is selected assuming all options have equivalent outcomes. In cost-utility analysis the outcome is based on health state preference values such as quality-adjusted life years. Regardless of the type of analysis used, it is important to determine the incremental cost of producing an additional unit of outcome from the options being considered.

Economic evaluation can be done through empirical or modelling studies. In empirical studies, actual cost and outcome data, sometimes supplemented with estimates, are collected as part of a field trial such as a randomized controlled study to determine the impact of an eHealth system. The economic impact is then analyzed and reported alongside the field trial result, which is the clinical impact of the system under consideration. In modelling studies, cost and outcome data are extracted from internal and/or published sources, then analyzed with such decision models as Monte Carlo simulation or logistic regression to project future costs and outcomes over a specified time horizon. Some studies combine both the field trial and modelling approaches by applying the empirical data from the trial to make long-term modelling projections. Regardless of the study design, the evaluation perspective, data sources, time frame, options, and comparison method need to be explicit to ensure the rigour and generalizability of the results.

Two other economic evaluation methods used by healthcare organizations in investment decisions are budget impact analysis and priority setting through program budgeting, and marginal analysis. While these two methods are often

used by key stakeholder groups in investment and disinvestment decisions across a wide range of healthcare services and programs based on overall importance, they are seldom seen in the eHealth literature. Even so, it is important to be aware of these methods and their implications in eHealth.

### **14.3 Determining Costs, Outcomes and Importance**

The process of determining the costs, outcomes and importance of an eHealth system are an integral part of any economic evaluation that needs to be made explicit. The process involves the identification of relevant costs and outcomes, the collection and quantification of costs and outcomes from different data sources, appraisal of their monetary value, and examination of the budgetary impact and overall importance of the eHealth system on the organization and its stakeholder groups (Simoens, 2009). The process is described below.

#### **14.3.1 Identification of Costs and Outcomes**

The process of identifying costs and outcomes in eHealth economic evaluation involves the determination of the study perspective, time frame, and types of costs and outcomes to be included (Bassi & Lau, 2013). Perspective is the viewpoint from which the evaluation is being considered, which can be individual, organizational, payer, or societal in nature. Depending on the perspective, certain costs and outcomes may be irrelevant and excluded from the evaluation. For instance, from the perspective of general practitioners who work under a fee-for-service arrangement, the change in their patients' productivity or quality of life may have little relevance to the return on investment of the EMR in their office practice. On the other hand, when the EMR is viewed from a societal perspective, any improvement in the overall population's work productivity and health status is considered a positive return on the investment made.

Since the costs and outcomes associated with the adoption of an eHealth system may accrue differently over time, one has to ensure the time frame chosen for the study is of sufficient duration to capture all of the relevant data involved. For instance, during the implementation of a system there can be decreased staff productivity due to the extra workload and learning required. Similarly, there is often a time delay before the expected change in outcomes can be observed, such as future cost savings through reduced rates of medication errors and adverse drug events after the adoption of a CPOE system. As such, the extraction of the costs and outcomes accrued should extend beyond the implementation period to allow for the stabilization of the system to reach the point at which the change in outcomes is expected to occur.

The types of costs and outcomes to be included in an eHealth economic evaluation study should be clearly defined at the outset. The types of costs reported in the eHealth literature include one-time direct costs, ongoing direct costs, and ongoing indirect costs. Examples of one-time direct costs are hardware, software, conversion, training and support. Examples of ongoing direct costs

are system maintenance and upgrade, user/technical support and training. Examples of ongoing indirect costs are prorated IT management costs and changes in staff workload. The types of outcomes include revenues, cost savings, resource utilization, and clinical/health outcomes. Examples of revenues are money generated from billing and payment of services provided through the system and changes in financial arrangements such as reimbursement rates and accounts receivable days. Examples of labour, supply and capital savings are changes in staffing and supply costs and capital expenditures after system adoption. Examples of health outcomes are changes in patients' clinical conditions and adverse events detected. Note that the outcomes reported in the eHealth literature are mostly tangible in nature. There are also intangible outcomes such as patient suffering and staff morale affected by eHealth systems but they are difficult to quantify and are seldom addressed. For detailed lists of cost and outcome measures and references, refer to the additional online material (Appendices 9 and 10, respectively) in Bassi and Lau (2013).

#### **14.3.2 Measurement of Costs and Outcomes**

When measuring costs and outcomes, one needs to consider the costing approach, data sources and analytical methods used. Costing approach refers to the use of micro-costing versus macro-costing to determine the costs and outcomes in each eHealth system option (Roberts, 2006). Micro-costing is a detailed bottom-up accounting approach that measures every relevant resource used in system adoption. Macro-costing takes a top-down approach to provide gross estimates of resource use at an aggregate level without the detail. For instance, to measure the cost of a CPOE system with micro-costing, one would compile all of the relevant direct, indirect, one-time and ongoing costs that have accrued over the defined time period. With macro-costing, one may assign a portion of the overall IT operation budget based on some formula as the CPOE cost. While micro-costing is more precise in determining the detailed costs and outcomes for a system, it is a time-consuming and context-specific approach that is expensive and, hence, less generalizable than macro-costing.

The sources of cost and outcome data can be internal records, published reports and expert opinions. Internal records can be obtained retrospectively from historical data such as financial statements and patient charts, or prospectively from resource use data collected in a field study. Published reports are often publicly available statistics such as aggregate health expenditures reported at the regional or national level, and established disease prevalence rates at the community or population level. Expert opinions are ways to provide estimates through consensus when it is impractical to derive the actual detailed costs and outcomes, or to project future benefits not yet realized such as the extent of reduced medication errors expected from a CPOE system (Bassi & Lau, 2013, Table 4).

The analytical methods used to measure costs and outcomes can be based on accounting, statistical or operations research approaches. The accounting approach uses cost accounting, managerial accounting and financial accounting

methods to determine the costs and outcomes of the respective system options. The statistical approach uses such methods as logistic regression, general linear/mixed model and inferential testing for group differences (e.g., *t*-test, chi-square and odds ratio) to determine the presence and magnitude of the differences in costs and outcomes that exist among the options being considered. The operations research approach uses such methods as panel regression, parametric cost analysis, stochastic frontier analysis and simulation to estimate the direction and magnitude of projected changes in costs and outcomes for each of the options involved (Bassi & Lau, 2013, Table 4).

### 14.3.3 Valuation of Costs and Outcomes

Valuation is the determination of the monetary value of the costs and outcomes associated with the options being considered (Simoens, 2009). The key concepts in valuation when comparing the worth of each option are the notions of uncertainty, discounting, present value, inflation, and opportunity cost. These concepts are briefly outlined below.

- *Uncertainty* refers to the degree of imprecision in the costs and outcomes of the options. Such uncertainty can arise from the selected analytical methods, data samples, end point extrapolations and generalization of results. A common approach to handling uncertainty is through sensitivity analysis where a range of cost, outcome and other parameter estimates (e.g., time frame, discount rate) are applied to observe the direction and magnitude of change in the results (Brennan & Akehurst, 2000).
- *Discounting* is the incorporation of the time value of money into the costs and outcomes for each option being considered. It is based on the concept that a dollar is worth less tomorrow than today. Therefore discounting allows the calculation of the present value of costs and outcomes that can accrue differently over time. The most common discount rates found in the literature are between 3% and 5%. Often, a sensitivity analysis is performed by varying the discount rates to observe the change in results (Roberts, 2006).
- *Present value (PV)* is the current worth of a future sum of money based on a particular discount or interest rate. It is used to compare the expected cash flow for each of the options as they may accrue differently over time. A related term is net present value (NPV), which is the difference between the present value of the cash inflow and outflow in an option. When deciding among options, the PV or NPV with the highest value should be chosen (Roberts, 2006).

- *Inflation* is the sustained increase in the general price level of goods and services measured as an annual percentage increase called the inflation rate. In economic evaluation, the preferred approach is to use constant dollars and a small discount rate without inflation (known as the real discount rate). If the cost items inflate at different rates, the preferred approach is to apply different real discount rates to individual items without inflation (Drummond, Sculpher, et al., 2005).
- *Opportunity cost* is the foregone cost or benefit that could have been derived from the next best option instead of the one selected. When considering opportunity cost we are concerned with the incremental increases in healthcare budgets with alternative options and not the opportunity cost incurred elsewhere in the economy. One way to identify opportunity cost is to present healthcare and non-healthcare costs and benefits separately (Drummond, Sculpher, et al., 2005).

When attaching monetary values to costs and outcomes, one should apply current and locally relevant unit costs and benefits. The preference is to use published data sources from within the organization or region where the economic evaluation is done. If these sources are not available, then other data may be used but they should be adjusted for differences in price year and currency where appropriate. For discounting it should be applied to both costs and outcomes using the same discount rate. The reporting of undiscounted costs and outcomes should be included to allow comparison across contexts as local discount rates can vary. Where there is uncertainty in the costs and outcomes, sensitivity analysis should be included to assess their effects on the options (Brunetti et al., 2013).

#### **14.3.4 Budget Impact and Priority Setting**

Budget impact and priority setting relate to the overall importance of the respective investment decisions to the organization and its key stakeholder groups. In budget impact analysis, the focus is on the financial consequences of introducing a new intervention in a specific setting over a short to medium term. It takes on the perspective of the budget holder who has to pay for the intervention, with the alternative being the current practice, or status quo. In the analysis only direct costs are included typically over a time horizon of three years or less without discounting. For effectiveness, only short-term costs and savings are measured and the emphasis is on marginal return such as the incremental cost-effectiveness ratio that quantifies the cost for each additional unit of outcome produced. Sensitivity analysis is often included to demonstrate the impact of different scenarios and extreme cases (Garattini & van de Vooren, 2011).

In priority setting, program budgeting and marginal analysis is used to ensure optimal allocation of the limited resources available in the organization based on overall priorities. There are two parts to this analysis. The first part is program budgeting that is a compilation of the resources and expenditures allocated to existing services within the organization. The second part is marginal analysis where recommendations on investment of new services and disinvestment of existing services are made based on a set of predefined criteria by key stakeholders in the organization. An example is the multi-criterion decision analysis where a performance matrix is used to compare and rank options based on a set of policy-relevant criteria such as cost-effectiveness, disease severity, and affected population. The process should be supported by hard and soft evidence, and reflect the values and preferences of the stakeholder groups that are affected, for example the local population (Tsourapas & Frew, 2011; Baltussen & Niessen, 2006; Mitton & Donaldson, 2004).

## 14.4 Best Practice Guidance

The scoping review by Bassi and Lau (2013) of 42 published eHealth economic evaluation studies has found a lack of consistency in their design, analysis and reporting. Such variability can affect the ability of healthcare organizations in making evidence-informed eHealth investment decisions. At present there is no best practice guidance in eHealth economic evaluation, but there are two health economic evaluation standards that we can draw on for guidance. These are the Consensus on Health Economic Criteria (CHEC) list and the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist. They are described below.

### 14.4.1 CHEC List

The Consensus on Health Economic Criteria (CHEC) was published as a checklist to assess the methodological quality of economic evaluation studies in systematic reviews (Evers, Goossens, de Vet, van Tulder, & Ament, 2005). The list was created from an initial pool of items found in the literature, then reduced with three Delphi rounds by 23 international experts. The final list had 19 items, which are shown below (source: Table 1 in Evers et al., 2005, p. 243).

- Is the study population clearly described?
- Are competing alternatives clearly described?
- Is a well-defined research question posed in answerable form?
- Is the economic study design appropriate to the stated objective?

- Is the chosen time horizon appropriate to include relevant costs and consequences?
- Is the actual perspective chosen appropriate?
- Are all important and relevant costs for each alternative identified?
- Are all costs measured appropriately in physical units?
- Are costs valued appropriately?
- Are all important and relevant outcomes for each alternative identified?
- Are all outcomes measured appropriately?
- Are outcomes valued appropriately?
- Is an incremental analysis of costs and outcomes of alternatives performed?
- Are all future costs and outcomes discounted appropriately?
- Are all the important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?
- Do the conclusions follow from the data reported?
- Does the study discuss the generalizability of the results to other settings and patient/client groups?
- Does the article indicate that there are no potential conflicts of interest of study researchers and funders?
- Are ethical and distributional issues discussed appropriately?

The authors emphasized that the CHEC list should be regarded as a minimal set of items when used to appraise an economic evaluation study in a systematic review. The additional guidance from the authors is: (a) having two or more reviewers and starting with a pilot when conducting the systematic review to increase rigour; (b) the items are subjective judgments of the quality of the study under review; and (c) journal publications should be accompanied by a detailed technical evaluation report.

#### 14.4.2 CHEERS Checklist

The Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist was published in 2013 by the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) Health Economic Evaluation Publication Guidelines Good Reporting Practices Task Force (Husereau et al., 2013). Its purpose was to provide recommendations on the optimized reporting of health economic evaluation studies. Forty-four items were collated initially from the literature and reviewed by 47 individuals from academia, clinical practice, industry and government through two rounds of the Delphi process. A final list of 24 items with accompanying recommendations was compiled into six categories. They are summarized below.

- *Title and abstract* – two items on having a title that identifies the study as an economic evaluation, and a structured summary of objectives, perspective, setting, methods, results and conclusions.
- *Introduction* – one item on study context and objectives, including its policy and practice relevance.
- *Methods* – 14 items on target populations, setting, perspective, comparators, time horizon, discount rate, choice of health outcomes, measurement of effectiveness, measurement and valuation of preference-based outcomes, approaches for estimating resources and costs, currency and conversion, model choice, assumptions, and analytic methods.
- *Results* – four items on study parameters, incremental costs and outcomes, describing uncertainty in sampling and assumptions, and describing potential heterogeneity in study parameters (e.g., patient subgroups).
- *Discussion* – one item on findings, limitations, generalizability and current knowledge.
- *Others* – two items on source of study funding and conflicts of interest.

#### 14.5 Exemplary Cases

This section contains three examples of eHealth economic evaluation studies that applied different approaches to determine the economic return on the investment made. The examples cover cost-benefit analysis, cost-effectiveness analysis, and simulation modelling. Readers interested in budget impact analysis may refer to the following:

- Fortney, Maciejewski, Tripathi, Deen, and Pyne (2012) on telemedicine-based collaborative care for depression.
- Anaya, Chan, Karmarkar, Asch, and Goetz (2012) on facility cost of HIV testing for newly identified HIV patients.

#### 14.5.1 Cost-benefit of EMR in Primary Care

Wang and colleagues (2003) conducted a cost-benefit study to examine the financial impact of EMR on their organization in the ambulatory care setting. The *identified data sources* were cost and benefit data from the internal record, expert opinion and published literature. A five-year time horizon was used to cover all relevant costs and benefits. The *resource use measured* was the net financial cost or benefit per physician over five years. The *valuation of resource use* was the present value of net benefit or cost over five years based on historical data and expert estimates in 2002 U.S. dollars at a 5% discount rate.

The study findings showed the estimated net benefit was \$86,400 per provider over five years. The benefits were from reduced drug expenditures and billing errors, improved radiology test utilization and increased charge capture. One-way sensitivity analysis showed net-benefit varied from \$8,400 to \$140,100 depending on the proportion of patients with care capitation. Five-way sensitivity analysis with most pessimistic and optimistic assumptions showed \$2,300 net cost to \$330,900 net benefit. This study showed EMR in primary care can lead to a positive financial return depending on the reimbursement mix.

#### 14.5.2 Cost-effectiveness of Medication Ordering/Administration in Reducing Adverse Drug Events

Wu, Laporte, and Ungar (2007) conducted a cost-effectiveness study to examine the costs of adopting a medication ordering and administration system and its potential impact on reducing adverse drug events (ADEs) within the organization. The *identified data sources* were system and workload costs from internal records and expert opinion, and estimated ADE events from the literature. The *resource use measured* were annual cost and ADE rate projected over 10 years. The *valuation of resource use* was the annual system and workload costs based on historical data and expert estimates as net present value in 2004 Canadian and U.S. dollars at 5% discount rates.

The study findings showed the incremental cost-effectiveness of the new system was \$12,700 USD per ADE prevented. Sensitivity analysis showed cost-effectiveness to be sensitive to the ADE rate, cost of the system, effectiveness of the system, and possible costs from increased physician workload.

#### 14.5.3 Simulation Modelling of CPOE Implementation and Financial Impact

Ohsfeldt et al. (2005) conducted a simulation study on the cost of implementing CPOE in rural state hospitals and the financial implications of statewide implementation. The *identified data sources* included existing clinical information

system (CIS) status from a hospital mail survey, patient care revenue and hospital operating cost data from the statewide hospital association, and vendor CPOE cost estimates. The *resource use measured* was the net financial cost or benefit per physician over five years. The *valuation of resource use* was the operating margin present value of net benefit or cost over five and 10 years based on historical data and expert estimates in 2002 U.S. dollars at a 5% discount rate. Quadratic interpolation models were used to derive low and high cost estimates based on bed size and CIS category. Comparison of operating margins for first and second year post-CPOE across hospital types was done with different interest rates, depreciation schedules, third party reimbursements and fixed/marginal cost scenarios.

The study findings showed CPOE led to substantial operating costs for rural and critical access hospitals without substantial cost savings from improved efficiency or patient safety. The cost impact was less but still dramatic for urban and rural referral hospitals. For larger hospitals, modest benefits in cost savings or revenue enhancement were sufficient to offset CPOE costs. In conclusion, statewide CPOE adoption may not be financially feasible for small hospitals without increased payments or subsidies from third parties.

## 14.6 Implications

The eHealth economic evaluation methods described in this chapter have important implications for policy-makers and researchers involved with the planning, adoption and evaluation of eHealth systems. First, it is important to have a basic understanding of the principles and application of different eHealth economic evaluation methods as their selection is often based on a variety of contexts, perspectives and assumptions. Second, when conducting an eHealth economic evaluation it is important to be explicit in describing the identification, measurement and valuation steps to ensure all of the important and relevant costs and outcomes are included and handled appropriately. Third, to ensure rigour and to increase the generalizability of the eHealth economic evaluation study findings, one should adhere to the best practice guidance in their design, analysis and reporting.

To ensure rigour one should be aware of and avoid the common “methodological flaws” in the design, analysis and reporting of economic evaluation studies, as cautioned by Drummond and Sculpher (2005). The common design flaws are the omission of important and relevant costs and outcomes and the inclusion of inappropriate options for comparison, such as unusual local practice patterns in usual care, which can lead to incomplete and erroneous results. The common flaws in data collection and analysis are the problems of making indirect clinical comparisons, inadequate representation of the underlying effectiveness data, inappropriate extrapolation beyond the time period of the study, over-reliance on assumptions, and inadequate handling of uncertainty. For instance, the presence of major baseline group differences across the options

would make the results incomparable. The common flaws in reporting are the inappropriate aggregation of results, inclusion of only the average cost-effectiveness ratios, inadequate handling of generalizability, and selective reporting of the findings. In particular, the reporting of average cost-effectiveness ratios based on total costs divided by total effects is common in the eHealth literature and can be misleading since it does not show the incremental cost involved to produce an extra unit of outcome.

The generalizability of eHealth economic evaluation study findings can be increased by drawing on the recommendations of the National Health Service Health Technology Assessment Programme in the United Kingdom on the design, analysis and reporting of economic evaluations (Drummond, Manca, & Sculpher, 2005). For trial-based studies, the design should ensure the representativeness of the study sites and patients, the relevance of the options for comparison, the ability to include different perspectives, the separation of resource use data from unit costs or pricing, and the use of health state preferences that are relevant to the populations being studied. The analysis of multi-location/centre trials should test for the homogeneity of the data prior to pooling of the results to avoid the clustering of treatment effects. The reporting of trial-based results should include the characteristics of the study sites supplemented with a detailed technical report to help the readers better understand the contexts and decide if the findings are relevant to their organizations.

For model-based studies, the design should be clear in specifying the decision problem and options, identifying the stakeholders to be informed by the decision model, and ensuring the modelling approaches are relevant to the stakeholders (e.g., the perspective and objective function). The analysis of model-based trials should justify its handling of the cost, resource use, effectiveness and preference value data, especially when there is uncertainty and heterogeneity in the data across groups, locations and practices. The reporting of model-based results should include the justifications of the parameter inputs to the model to ensure they are appropriate and relevant to the stakeholders. Any pre-analysis done on the input data so they can be incorporated into the model should be explained to justify its relevance.

## 14.7 Summary

This chapter described the different methods that are used in eHealth economic evaluation. The methods cover different analytical approaches and the process for resource costing and determining the outcomes. There are also published best practice standards and guidelines that should be considered in the design, analysis and reporting of eHealth economic evaluation studies. The three case studies provide examples of how the economic evaluation of eHealth systems is done using select methods.

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## Appendix

### Glossary of Terms

<b>Economic Analysis</b>		<b>Description (based on Roberts, 2006; Chisholm, 1998; Robinson, 1993).</b>
Cost-minimization Analysis	Costs are measured in dollars and outcomes are assumed to be equivalent. Purpose of this analysis is to determine the least cost option.	
Cost-consequence Analysis	Costs are measured in dollars and outcomes are measured in variable and multiple units. This analysis lists the individual outcomes without further aggregation.	
Cost-effectiveness Analysis	Costs are measured in dollars and outcomes are measured in clinical terms or natural units. This analysis uses a common unit of outcome to express the cost of each option.	
Cost-utility Analysis	Costs are measured in dollars and outcomes are measured as utility (subjective satisfaction). A common utility measure is quality-adjusted life year (QALY).	
Cost-benefit Analysis	Costs are measured in dollars and outcomes are measured in dollars. This analysis is used to assess which option is best based on monetary values for costs and benefits. In generally, benefits should exceed costs for an option to be worthwhile.	
<b>Common Analytical Measures</b>		
Analytical Term	Description	Sources
ANOVA	A statistical procedure to test if differences exist among two or more groups of subjects on one or more factors.	Dawson and Trapp (2004, p. 403)
Average cost	Cost of producing one unit of output.	Drummond et al. (2005, p. 65)
Chi-square	A statistical procedure to test if the proportions of two or more factors are equal which suggests they are independent of each other.	Dawson and Trapp (2004, p. 404)
Cost amortization/ depreciation	Spreading the cost of an intangible/tangible asset over a fixed period that represents the useful life of that asset.	Haber (2008, p. 86)
Cost savings	Action that will result in fulfillment of the objectives of a purchase at a cost lower than the historical cost or the projected cost.	Online Business Dictionary (n.d.)
Discounting	Process of finding the present value of an amount or series of cash flows expected in the future.	Gapenski (2009, p. 255)
Discount rate	The real rate of return, or interest rate, that will be returned in the future on the money invested today rather than being spent.	Roberts (2006, p. 320)
Incremental cost-benefit ratio (ICBR)	A ratio of the net cost of implementing one system over another divided by the net benefit, measured in monetary term. The unit is expressed as the cost of an additional unit of money generated as the benefit.	Simoens (2009, p. 2596)
Incremental cost-effectiveness ratio (ICER)	A ratio of the net cost of implementing one system over another divided by the net benefit, measured as a clinical outcome. The unit is expressed as the cost of an additional unit of a given outcome measure as the benefit.	Roberts (2006, p. 316)

Common Analytical Measures		
Incremental cost-utility ratio (ICUR)	A ratio of the net cost of implementing one system over another divided by the net benefit, measured as a health utility such as quality-adjusted life years. The unit is expressed as the cost of an additional unit of a given health utility measure as the benefit.	Simoens (2009, p. 2596)
Inflation	Change in prices over time within an economy that needs to be standardized to a common base year if the costs span multiple years.	Roberts (2006, p. 320)
Least cost	The option where the cost is minimized with the most quantity of outcome.	Roberts (2006, p. 315)
General linear model	A statistical model used to predict the outcome from a set of independent variables.	Dawson and Trapp (2004, p. 192)
Generalized linear mixed model (GLMM)	A form of regression analysis of correlated data from subjects with multiple longitudinal responses in the data set based on a logit link function.	Cnaan et al. (1997)
Logistic regression	A technique to predict an outcome from one or more independent variables when the outcome is a binary variable.	Dawson and Trapp (2004, p. 408)
Markov chain	A simulation modelling technique to determine the probability of an event going from one state to the next.	Ravindran (2008, chapter 8)
Mean inefficiency score	The per cent difference between the cost of an organization and the frontier determined by the aggregate cost of all organizations using stochastic frontier analysis.	Carey et al. (2008)
Monte Carlo simulation	Statistical modelling techniques that emulate the behaviour and performance of a system as events take place over time.	Ravindran (2008, chapter 8)
Net benefit	Also known as net monetary benefit, which is the difference between the amount an organization is willing to pay for the increase in effectiveness and the increase in cost.	Drummond et al. (2005, p. 131)
Net present value (NPV)	The dollar value of an investment discounted at the opportunity cost of capital.	Gapenski (2009, p. 258)
Operating margin	Amount of operating profit per dollar of operating revenues. Also referred to as the proportion of revenue left over after paying for variable costs of production in order to pay for fixed costs such as interests on debt.	Gapenski (2009, p. 381)
Panel regression, fixed effect	A regression technique that uses two-dimensional panel data collected over time on the same subjects that have unique attributes not due to random variations.	Baltagi (2011)
Parametric cost analysis	A cost estimating technique that uses regression methods to develop cost estimating relationships to establish cost estimates with one or more independent variables.	AcqNotes (n.d.)
Payback	Number of years that it takes to recover the cost of an investment.	Gapenski (2009, p. 248)
Quality-adjusted life year (QALY)	The period of time in perfect health that a patient says is equivalent to a year in a state of ill health.	Sox et al. (2006, p. 217)
Regression	A technique to predict an outcome from one or more independent variables.	Dawson and Trapp (2004, p. 412)
Regression coefficient	The slope of the regression line in a simple linear regression, or the weights applied to independent variables in multiple regression.	Dawson and Trapp (2004, p. 412)
Return on investment (ROI)	Profitability of an investment, measured in dollars or rate of return.	Gapenski (2009 p. 258)

Common Analytical Measures		
Sensitivity analysis	A technique to test the stability of the outputs of an analysis over a range of input variable estimates.	Sox et al. (2006, p. 163)
Scenarios analysis	A series of alternative cases with variable estimates that represent the realistic, best and worst cases to be considered in the analysis.	Drummond et al. (2005, p. 43)
Stochastic frontier analysis	An economic modelling technique that estimates production or cost functions while taking into account the inefficiency that exists within the organization.	Online Encyclopaedia (n.d.)
t-test	A statistical test to compare a mean with a norm or two means with small sample sizes.	Dawson and Trapp (2004, p. 414)

## References for Appendix

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