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Hulme, C. (2006) Using cost effectiveness analysis; a beginners guide. Evidence Based Library and Information Practice, 1 (4). pp. 17-29. ISSN 1715-720X

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Article

Using Cost Effectiveness Analysis; a Beginners Guide

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Received: 23 August 2006

Accepted: 26 September 2006

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Abstract

Objective - This report seeks to describe the key elements of cost effectiveness analysis (CEA) and to demonstrate how such analysis may be used in the library environment.

Methods - The paper uses a step-by-step approach to walk the non-economist reader through the basics of conducting a cost effectiveness study. It provides an outline of the key elements of CEA using examples from the library sector, and it presents a case study of a CEA in a hospital library. The case study compares two library services, mediated searching and information skills training, to illustrate the application of CEA and to highlight some of its limitations.

Results - CEA is a comparative analysis tool. Its key elements include a study question regarding a particular process or procedure that identifies both costs and effectiveness; a justification of the study's perspective; evidence of effectiveness; comprehensive identification of all relevant costs, and appropriate measurement of costs and effectiveness.

Conclusions - CEA enables comparison of services or interventions regarding particular processes or procedures in terms of their costs, and it measures their effectiveness. The results can be used to aid decision-making about service provision.

Introduction

Libraries, like other businesses and organisations, have finite budgets. Decisions must be made to determine how that budget is allocated. Cost effectiveness analysis (CEA) can help that decision-making process, yet few studies that address costs or cost effectiveness of library services have been published. A recent review in the health care library sector noted that much of the literature is descriptive rather than empirical, providing little hard evidence of the effectiveness or cost effectiveness of library services (Brettell, "Costs").

This paper walks the non-economist through the essentials of conducting a CEA. It begins by outlining the key elements of a cost effectiveness study. It then illustrates how this type of analysis may be carried out in the library sector by way of a case study situated in a hospital library. The case study compares two library services, mediated searching and information skills training, to illustrate the application of CEA and to highlight some of its limitations.

Cost Effectiveness Analysis (CEA)

CEA is a comparative analysis of the costs and effectiveness of alternative interventions or services. In the library environment this could be in areas as diverse as competing methods of providing training or the use of different databases for information retrieval. The basic CEA uses standard techniques and methods associated with evaluating the effectiveness of any service, but it also adds the costs associated with the provision of these services into the mix.

Hypothesis

The first step in carrying out a CEA, as in any study, is the formulation of a clear (and 'do-able') hypothesis or study question. The

objective of CEA is to compare two or more interventions or services in terms of the effectiveness of each and its associated costs. The hypothesis, therefore, should include both cost and effectiveness elements. A further consideration at this point is to decide on the perspective for conducting the study. Is the library primarily interested in determining the costs of a particular program in order to provide competing services (or even a 'do nothing alternative'), or is the library looking at wider costs? It is wise to be clear about the parameters of the study, so that results will address the specific issues important in making program and resource decisions.

Equally important is the decision about which services will be compared. Does the proposal include all appropriate methods of providing the service in question? The CEA analysis should enable the library manager to determine the most cost effective method of achieving a specified goal; all competing alternatives need to be included. For example, in a comparison of the effectiveness of databases in retrieving information, it is important to include all the appropriate databases. Once the study question has been formulated, the perspective determined, and the alternative services selected, it is time to develop the study design.

Effectiveness

At this stage it is important to decide whether you need to collect data on the extent to which the service achieves what it sets out to achieve (the effectiveness) as part of your study. Think about whether there is already robust evidence of the effectiveness of the services being compared. For example, if previous studies have shown that one data retrieval database consistently produces better results than another, is it necessary to again measure how effective each is again? You could just cite those

results and carry out only a cost comparison of the competing alternatives. If you do consider using existing evidence from previous studies be sure that the results are transferable to the services you are comparing. For example, are the demographics of the library customers the same?

If you are collecting effectiveness data, what type of evaluation will you conduct? Will it be, for example, a randomised controlled trial (RCT) or a case study? Will you have a control group, or will this be a 'before and after' comparison study in which the sample acts as its own control over time? In quantitative studies where the RCT is typically held as the gold standard (Gold), the standard hierarchy of research design applies.

Having decided on the study design, the next step is to outline the specific outcome(s) of the service and what the service tries to achieve. Is there one clear goal that is easily quantifiable, or are there multiple outcomes? How can you capture those outcomes in a quantifiable form? There are a number of factors that will help answer these questions. The first is whether you use an endpoint or an intermediate point; this is best explained using an example. Consider information skills training. The endpoint of the training is likely to be the application of relevant and up to date information. An intermediate point could be the ability of those trained to retrieve relevant and up-to-date information or an improvement in their information retrieval skills. If an intermediate point is used, the analysis should show that the intermediate endpoint has relevance in its own right, or that there is a link between the intermediate outcome and the final outcome that has been established by previous research (Drummond et al.). The intermediate outcome should accurately reflect the long-term benefits of the intervention.

After determining the outcome(s), the next step is to decide how you will *quantitatively* measure the extent to which the competing services achieve their goal(s). Some outcomes may be readily quantifiable, but often data is less easily expressed numerically. In the health sector validated measures are often readily available, such as measures that quantify changes in health related quality of life or measures of anxiety and depression. However, these are less prevalent for the type of CEA likely to be carried out in the library sector, and reviews have shown a lack of validated measures to quantify improvements in information retrieval skills (Brettell, "Evaluating;" Koufogiannakis). This often means a heavy reliance on the use of a proxy for the outcomes being measured, and you should consider whether this is appropriate. For a study of information skills training, proxies might include self-reported changes in students' information skills (often using a Likert scale) and satisfaction questionnaires. Using more than one outcome measure may confuse your research results.

A further factor to consider is *when* to take those measures. Consider again the example of information skills training. If you are using students' self-reported improvement in their skills, will you ask them to report these immediately after the training session, after a delay of three months to allow them an opportunity to practice their skills, or both? Has their perceived improvement in their information skills training persisted over time?

Once you have determined the form your study will take (e.g., an RCT) and how the outcome(s) of your study will be measured, the next step is to identify your study population, and to select your sample in line with normal research guidelines. It is important to remember that the sample needs to be representative of your population. You must also determine an

appropriate size for your sample. There are a number of standard research methods texts that can guide you (such as Bowling).

Costs

The next component of the CEA that requires your attention is determining the costs associated with the provision of the services included in your study. It is crucial that all important and relevant costs be identified (Drummond et al.). There are three stages in the cost analysis: identification, measurement and valuation (Raftery).

The next step is to identify all the costs associated with the provision of the services in your analysis. Costs arising from, or as a consequence of, library services will fall to the library as service provider, but may also fall to the library's larger organisation and to the library customer. The cost to the library is likely to include the librarians' time and administrative costs. The costs to the library customer may include out-of-pocket expenses such as printing search results or photocopying articles.

Having previously set out parameters of the study in terms of the perspective you are taking, the costs to be included in the study will depend in part on the viewpoint or perspective of the evaluation. For example, if the evaluation is from the viewpoint of the library, the cost of out-of-pocket expenditures to the customer need not be included. Even though it may not be possible or necessary to measure and value all of the costs and consequences of the services under comparison, a full identification of all important and relevant costs should be provided.

Costs to be considered include:

- Staff time associated with the provision of the service. This is likely to include, for

example, preparation time, but it may also include the cost to the organisation of staff to cover those attending and providing training sessions.

- Cost of consumables, including provision of materials, hire of a training location or advertising.
- Overhead costs, such as administrative support, computers, and database packages.
- Capital costs that represent investments at a single point in time (Drummond et al.), such as the cost of a new computer training classroom.
- Out-of-pocket expenses, such as travel costs or child care costs, to enable students to attend a training course.

After identifying all important and relevant costs, the inclusion and exclusion criteria for the CEA will lie in the bounds of the study perspective. Costs may be excluded from an evaluation because they are common to both services or are relatively small. These should be identified, and their exclusion justified. Similarly, if inclusion of particular costs will only confirm the results obtained without them, then they may be omitted. Once again, reference should be made to them in the study, including the reason for their exclusion.

Measurement and Valuation

Once you have identified all costs and decided on your inclusion and exclusion criteria, you must decide how you will measure and value them. Two strategies, representing each end of the spectrum, can be useful in measuring and valuation: micro-costing and gross-costing (Raftery), or a combination of both may be used. Micro-costing is a 'bottom up' method of costing that involves taking a detailed inventory of all the separate costs of items

involved. This may take the form of, for example, reporting on and quantifying all activities associated with a particular activity. Thus it may include the time spent by each individual involved in the activity, either directly or indirectly. This type of analysis tends to be costly and runs the risk of being specific to particular contexts (Raftery). Although more laborious than the gross-costing method, micro-costing provides a more specific insight into the relationships between characteristics of activities and their costs, the economies of scales of a production process, and the relative importance of separate activities (Drummond and McGuire).

Gross or top-down costing allocates a total budget to specific services (Raftery). Thus the library may have a budget for training that is apportioned to specific training activities. This method provides less precise estimates (Drummond et al.), but it has the advantages of consuming fewer resources and providing better opportunity for generalisation (Drummond and McGuire).

Data on quantities (e.g., training time or computer records) can, in some situations, be directly observed or recorded. When data cannot be obtained directly, or if there is no data or only imprecise data, then you may be required to make an estimate or informed guess. You should clearly outline the basis for any estimates.

Having identified and measured the resources associated with a service, the next step is to assign a price to those resources--to value them. For gross costing, the valuation for the service provider is inherent (from the budget). In micro-costing, financial records such as pay scales can be used to value, for example, the time of those involved or the cost to the library of a database. Micro-costing can produce very context-specific data.

One area to consider when looking at how to value resources is that of the opportunity cost. The best way to describe opportunity cost is through an example: A library staff member is training users. Using his or her time this way means the library is forfeiting the performance of alternative tasks that might have been performed instead. In addition, the library will lose any benefits those alternative tasks might have brought. That is, *the use of resources in one way prevents their use in others* (Palmer 1551). Thus, opportunity costs are *the benefits lost because the next best alternative was not selected* (Gold 403). Valuing opportunity cost is difficult, however, and unit costs are used more frequently (Palmer).

Whatever the sources of the values you place on items included in your study, you should be clear and explicit about that valuation. Although it sounds obvious, don't forget to include the date (year) to which the valuation refers, as prices change over time.

The time period over which you track costs is also important. For example, when comparing two training services that have a common initial outcome but one requires students to have further training in the future, the time period should reflect the costs of this additional training. If training costs are spread over a number of years, the costs should be discounted. Discounting is the process of converting a future sum of money to its present value.

In summary, the costs included in the study will depend on the study's perspective. The exclusion of any costs from the analysis must be justified. Detail quantities and prices separately, and give costs in both their discounted and undiscounted forms when applicable.

Analysis and Presentation of Results

After collecting the data, it is time to analyse the results. If you have used estimates for components of the costs or outcomes, you may wish to take into account how sensitive the study results are to these estimates. A sensitivity analysis can determine this. Briggs and Gray outline a number of methods by which the sensitivity analysis may be carried out. The most common methods are one-way analysis and multi-way analysis. An alternative, although far less robust way to take account of estimates, is to present confidence intervals. (A confidence interval specifies a range of values that, with a known degree of certainty, includes the unknown population mean. It is calculated from the sample data.)

How should you present your findings? Your results are likely to tell you the total costs of the service provided and may be examined in detail to determine, for example, average cost per training session. Similarly, depending on the study design, you might compare outcomes of the two services, or changes in outcomes pre- and post-training. If there are multiple outcome measures, none of which you consider to be the primary outcome, this would determine how the results are presented. If the results

show one of the services to be less costly and more effective in all outcomes, this can be said to dominate and is therefore the most cost effective. If each of the services included has varying degrees of effectiveness among multiple outcomes and none is dominant, then the reader is left to make his or her own judgement regarding the most important outcome. CEAs with no single primary outcome and multiple outcomes measures are known as Cost Consequence Analyses (CCA).

If there is one primary outcome, you might present your results as an incremental cost effectiveness ratio. The incremental cost effectiveness ratio is the difference in costs between alternatives to the difference in effectiveness between the same alternatives. Stated another way, the incremental cost effectiveness ratio compares the additional costs that one service or programme imposes over another, with the additional effects, benefits or utilities it delivers. By using incremental cost effectiveness ratios it is possible to determine, for example, how a budget could be spent between two or more services.

This outline of the key elements of a cost effectiveness analysis is summarised in Box 1.

- The hypothesis or study question should include both costs and effectiveness.
- The perspective or viewpoint of the study needs to be justified; the nature of the outcomes resulting from the intervention should all be clear.
- The study design needs to be developed.
- There should be evidence of the effectiveness of the services being compared; all outcomes should be identified.
- The measurement of effectiveness should reflect the outcomes; measures should be appropriate to the form of the study, relevant, and validated where possible.
- All costs should be identified and in line with the perspective of the study; inclusion and exclusion criteria should be identified.
- The measurement of costs included in the study may use micro-costing (considered most accurate) or gross-costing (provides greater opportunity for generalising) methods -- or a combination of both. The method should be clearly outlined.

- Costs and outcomes should be tracked over an appropriate period of time and provide an accurate reflection of actual practices.
- Where costs are spread over a number of years, they should be discounted.
- Sensitivity analysis should be used to take account of uncertainty in any estimates, be they costs or consequences.

Box 1. Key elements of a cost effectiveness analysis

This case study illustrates how CEA methods may be used within health care libraries and some of the difficulties that may be faced.

Case Study

The case study used to illustrate CEA within the library sector is part of a larger study reported in full elsewhere (Brettle, "Costs;" Brettle, "Effectiveness"). The study was carried out in hospital based health care libraries across the North West of England in the spring of 2005. The libraries' customer base is health care workers. The purpose of the larger study was to explore the effectiveness and cost effectiveness of different methods of providing information for patient care. Two strategies were employed by the libraries to achieve this aim. The first involved library staff providing information and mediated searches directly to clinicians on request; the second strategy involved librarians training clinicians to search for information themselves. A baseline survey of the 102 libraries in the region conducted in 2004 showed libraries typically provided both services (Brettle, "Baseline").

The CEA was incorporated into the larger, questionnaire-based study Of the 102 libraries in the region, 26 agreed to participate in the study. In each site questionnaires exploring both mediated searching practices and information skills training were distributed to all library staff

(115), dedicated trainers (15), and to a random sample of 30 clinicians (780). All CEA data were collected from these questionnaires and showed the 26 library sites were representative of the population in terms of the numbers of staff, seats, and computer terminals when compared with the baseline survey data.

The CEA study question compared two library services: *Which is more cost effective – information skills training or librarian mediated searching?* The UK North West Health Care Libraries Unit (HCLU), a strategic regional unit interested in the effectiveness and cost implications of providing both services, commissioned the overall study. The study was carried out from the perspective of the library as service provider.

Effectiveness

In respect of the effectiveness of the two services, the endpoint could be interpreted as provision of up-to-date and relevant information for patient care to clinicians, either directly (mediated searches) or indirectly, by enabling them to access that information themselves. However, it could be argued that provision of information is not an endpoint in itself, and that the most important outcome is the use or influence of that information in patient care. Because the larger study was questionnaire-based, the only feasible method by which to measure the effect of information derived from searches on patient care was to ask the clinicians' their perceptions. In addition,

clinicians were asked how satisfied they were with the results of the searches. It was anticipated that this would be a proxy for search quality. Thus the measures included:

- Health professionals' perception of the effect of information from librarian mediated searches on patient care.
- Health professionals' perception of the effect of information from their own searches on patient care.
- Health professionals' satisfaction with librarian mediated searches.
- Health professionals' satisfaction with their own searches.

All used a five-point Likert scale (from highly positive to highly negative in the first two measures and from very satisfied to very dissatisfied in the latter two).

Costs

The cost analysis used a micro-costing or 'bottom up' method. The questionnaire asked respondents to provide details of mediated searches and information skills training. Resource use was identified and measured using the completed questionnaires from librarians and health professionals. Questionnaires contained demographic details including professions and grades (from national grade scales) and asked respondents for details of mediated searches requested or performed and about training they had undertaken or attended.

Inclusion and Exclusion Criteria

It was assumed that resources such as information technology facilities, administration, and other overhead costs were common to all settings, and they were excluded from the analysis. By this we mean these resources would need to be available if only mediated searches were conducted (no information skills training); or if only information skills training was carried out

(no mediated searches); or if both mediated searches and information skills training were carried out. It was also assumed that existing library facilities and resources were used, and that no additional costs would be incurred for a training room or computer equipment, for example. The cost of training materials such as handouts was believed to be relatively small and was excluded from the analysis.

The analysis assumed staff time was the primary resource, and as such, the cost element of the analysis was based solely on this resource. Staff time identified from the questionnaires included these items:

- Time spent by the librarian conducting mediated searches.
- Time spent by health professionals sitting with the librarian during performance of mediated searches.
- Time spent by health professionals performing literature searches.
- Time spent by the librarian delivering information skills training and in training-related activities.
- Time spent by health professionals in information skills training.

All staff time was valued using 2005 prices and was based on salary cost only; the analysis excluded ongoing costs (e.g., national insurance payments) and overhead costs. Library staff time values were derived from their library grades as reported on the questionnaires. National pay scales were used to derive per hour estimates, assuming a 46-week work year and a 36-hour work week. Similarly, illustrative salaries were estimated by profession for clinicians using data from the *Unit Cost of Health and Social Care 2004* (Curtis). Each was inflated in order to incorporate increases in national salary scales that were already reflected in the library staff salary scales.

	Mediated Searches Number (%)	Clinicians' Own Searches - Post Training Number (%)
Information from search has a positive / highly positive effect on patient care*	83/132 (62.88%)	66/103 (64.08%)
Very satisfied / satisfied with search results*	116/132 (87.88%)	64/103 (62.14%)

Table 1. Effectiveness of searching

*For ease of reporting, the results have been presented categorically.

Training Method	Mean Time, Including Preparation and Related Activities	Average Cost
One-on-one pre-arranged training	1.49 hours	£19.92
One-on-one ad hoc training	1.25 hours	£13.47
Group training (<20 trainees per session)	2.55 hours	£32.33

Table 2. Cost of information skills training to the library

Results

Each of the outcome measures and costs was presented separately. In brief, the study found that 54% (132/243) of the clinicians had requested mediated searches, and 62% (44/71) of the library staff carried out mediated searches. With regard to training, 42% (103/243) of the clinicians had received information skills training from their hospital library, and 53% (38/71) of the library staff had delivered training. Table 1 shows little difference was seen in the perceived effect on patient care resulting from mediated search results and their own search results. However, the proportion of clinicians who were very satisfied or satisfied with the results from mediated searches (87.88%) was higher than that expressed for clinicians' own searches

(62.14%). Librarians from different position grades conducted the mediated searches. The median grade of those carrying out searches was used to calculate the per hour cost of these searches. This figure was then multiplied by the mean time of a search (1.08 hours) to determine the mean cost of a mediated search to the library--£14.44.

The cost of training was calculated using the same method. However, the analysis took into account the different training formats to reflect differences in the average delivery time of each and differences in the grades of those delivering the training (and therefore differences in salary). The data showed that training delivered to groups was on average longer and was delivered by librarians of a higher grade than other formats of training

Profession	Cost per Hour	Total Cost per Search
Staff nurse	£11.84	£15.15
Ward manager	£15.61	£19.97
Physiotherapist, occupational therapist, radiographer (professions allied to medicine)	£16.20	£20.73
Consultant (Physician)	£44.46	£56.89

Table 3. Cost of clinicians' searches

(Table 2). While group training is the most costly option, the cost falls when considered on a 'per person trained' basis. For example, if 10 people attend a training session, the average cost would be £3.23 per person.

The mean cost of a search carried out by a clinician (once trained) was calculated using the same methods. The analysis used professions representative of the sample (i.e., staff nurse, ward manager, therapist, and consultant) and their associated salary scales. The average time spent on a search (1.28 hours) was used to calculate the mean cost for each profession (Table 3). It should be noted that although these costs *do not* fall to the library, they are helpful for illustrative purposes.

Discussion

Although there was little difference between the perceived effect on patient care from either mediated searches or the clinicians' own searches, there was clearly a higher level of satisfaction with mediated search results. In addition, mediated searches were found to be less costly than any of the forms of training. This seems to clearly indicate that mediated searching is most cost effective for the library, and that funding should be shifted from training to mediated searches. However, while budget allocation decisions can be informed by the analysis, this conclusion should be treated with caution, as there are a number of other

factors to be taken into account. These are explained below.

One of the first decisions to make when carrying out a CEA is to determine the perspective from which to conduct the study. This case study reported from the libraries' perspective, but what happens to our conclusions if the wider perspective of the health care provider (the hospital, in this case) is considered? The raw data showed that more than one in three mediated searches was carried out with the clinician present. Adding their time to the search would increase the mean cost of the search to £38.23. Similarly, adding the time spent by clinicians attending training sessions increases the mean costs of each type of training. The data showed that while ad hoc one-on-one training was the least costly method of training, clinicians were likely to have attended more than one of these sessions (mean number of sessions 2.67), thus increasing their cost to the library when compared with other formats. An important aspect of whether to include clinicians' time to train or carry out mediated searches is whether their absence from their workplace for this activity requires their tasks to be covered by additional members of staff? If not, is there any additional cost to the hospital?

The results were further confounded by the insight that the majority of clinicians who had been trained in searching also requested

mediated searches. This poses the question of whether training clinicians to do their own searches leads to a decrease in the number of mediated searches requested? Or does this increase the number of searches (whether by library staff or clinicians) carried out overall? If there is an increased number of searches, does this lead to an improvement in patient care? A related issue was the small proportion of clinicians with limited or no training who performed their own searches. This calls into question the cost effectiveness of providing skills that are not utilised.

Despite there being little difference in the mean times required for either library staff or clinicians to perform searches, this was in part explained by the maximum time each group could or would allocate to a search. This may also help to explain the difference between groups in terms of their satisfaction with search results. The larger study gave insight into many of the confounding factors discussed above, particularly the qualitative responses which provided explanations for, for example, the time allocated to searches.

A final area of importance to note is that this CEA was based on retrospective, self-reported data, and it relied on respondents' recollections that should be considered as estimates. Further analysis is required to evaluate the sensitivity of the study results to those estimates.

Conclusion

In common with other organisations and sectors, libraries have competing demands placed on their budgets. CEA provides a tool by which comparative evidence on the cost and effectiveness of services can be produced in order to inform budget allocations and to determine which services to provide. However, it should be noted that decision-making is complex. While the cost and effectiveness of services are important, there are likely to be factors outside the analysis that also affect decisions. These may include, for example, anticipated advances in technology, planned re-configuration of services, or legislative requirements. None should be viewed in isolation; all should inform budget allocation decisions.

This paper presents the basics of CEA. An explanation and description of the key elements of the analysis and examples utilising familiar situations introduce the reader to ideas for using CEA in the workplace. While the paper provides an introduction to CEA, there are a number of texts that go into greater theoretical and technical detail on conducting and critically appraising CEAs. Box 2 presents several useful CEA resources.

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Box 2. Sources of information on CEA

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