The cost-benefit approach to medical information systems evaluation

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Abstract

In this paper previous cost-benefit type of evaluation studies, theories and frameworks are widely reviewed. Different frameworks and theories of information systems science, health economics and medical informatics have been mixed and brought into area of medical information systems science where they have been lacking. The objective of this study is to clarify the rationale behind analysing the costs and benefits in these different research areas, and to present cost-benefit approach in the context of evaluation framework of medical information system.

Keywords: medical information systems, cost-benefit type of analysis, evaluation

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1. Introduction

According to Henderson et al. (1992) information technology (IT) expenditure in hospitals is increasing (Menon et al. 1996). The effects of IT investments on health care services have not, however, been extensively studied (see the reviews of Ingasoll et al. 1990 and van der Loo et al. 1995; Mediline 1966-1997). Van der Loo et al. (1995) analysed 76 health care information system (IS) evaluative studies and only 10 of the studies covered both costs and benefits of information system. Van der Loo et al. (1995) conclude that:

> *"In the context of rising health care costs it is astonishing that only few studies have tried to demonstrate the cost-effectiveness of automated information systems."*

Although individual studies have found a positive relationship between the level of IS investments and the overall productivity of health care services (c.f. Menon et al., 1996), the overall results of IT investment profitability studies have been inconclusive (Mitra et al., 1996 p. 29-31). Hence, although the importance of economic evaluation of information system in medicine has increased, little is known about how evaluation could be done.

The objectives of this paper are to formulate concepts for evaluation of medical information systems, deliberate rationale behind cost-benefit type of analysis and view cost-benefit analysis in the context of medical information systems framework. This is based on a study of different disciplines, such as information systems, medical informatics, and health economics. The study tries to also find best practises from those different research areas. This paper also describes the results of the literature review, where the objective was to identify previous studies reporting cost-benefit analysis of medical information systems.

2. Approaches to the evaluation of medical information systems

Prior research has applied a number of different approaches to the evaluation of medical information systems, and information systems in general. Research has also provided taxonomies of different evaluation approaches (DeLone et al. 1992; Fineberg et al. 1977; Grover et al. 1997; Guyatt et al. 1986; van der Loo et al. 1992). Taxonomies suggest that there is an effect between different levels (see figure 1 and 2). For example, with the help of better diagnostic information physicians might do better therapeutic decisions. However, these researchers do not claim that the relation between levels would be causal.

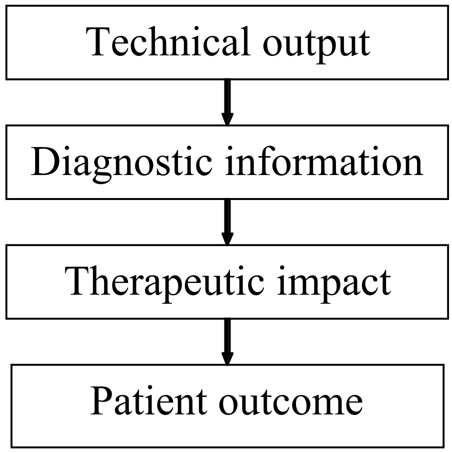

Figure 1. Levels of clinical efficacy related to use of diagnostic technology (Fineberg et al. 1977)

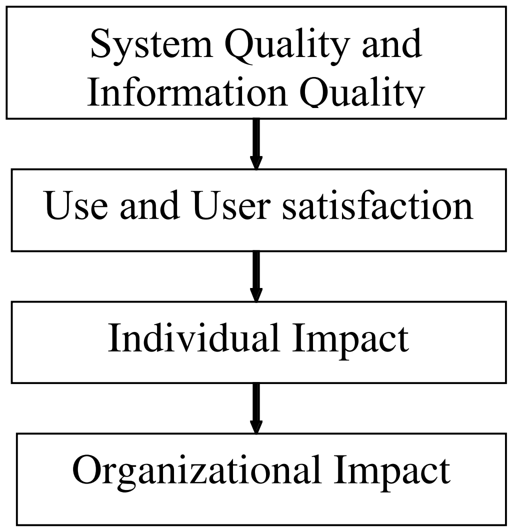

Figure 2. I/S success model (DeLone et al. 1992)

Unfortunately, it seems that frameworks of clinical efficacy related to use of clinical technology (see Fineberg et al. 1974 and Guyatt et al. 1986) are not covering all impacts of medical information systems and thus should be expanded for reliable evaluation. According to these very similar taxonomies we have ended up that the evaluation of medical information systems can be based on the levels of

1) user satisfaction (and use)
2) individual impact
3) organisational and patient outcomes.

User satisfaction indicates users' satisfaction with information and system. Individual impact can be seen as impact on physician's diagnostic decision but also as other impacts, for example on time reduction or increase. Patient outcome means change in patient's health and organisational outcome for example changes in personnel time, overhead costs, and interest costs.

While this article concentrates on cost-benefit analysis, other evaluation approaches are also shortly reviewed in order to provide an overall view of the best practises in different research areas and to place cost-benefit analysis into right context.

Many researchers in information systems and medical information systems science have ended up that the best way to evaluate information systems is to measure organisational or patient outcome (van der Loo et al. 1995; Hamilton et al. 1981; Ives et al. 1983). Such assessment applies economic evaluation, especially cost-benefit analysis. Because information systems may have organisation-wide, intangible and long lasting effects and costs, economic evaluation of information system is considered difficult (Saarinen 1993 p. 49; see also Ives et al. 1983). The difficulty in evaluating costs and benefits is often seen as a motivation to develop other methods to evaluate information systems (Saarinen 1993 p. 49). On the other hand, cost-benefit analysis focuses on outcomes or ends. Other evaluation approaches focus more on the implementation process, which produces the outcomes.

It appears that a comprehensive evaluation of an information system requires multiple measures (DeLone et al. 1992; Saarinen 1993 p. 51). Both improvements in information, improvements in individual decisions or actions, as well as improvements in organisation level can indicate IS effectiveness and success. The selection between these measures is to a wide degree dependent on the values and objectives driving the evaluation. The type of the systems and the economic considerations of gathering the evaluation data need to be considered as well.

2.1 User satisfaction

In information systems research, measures based on user satisfaction are frequently used instead of cost-benefit analysis. Their use is argumented on the basis that full cost-benefit analysis is considered as problematic and difficult to use. Users' satisfaction might reflect as a better organisational outcome, which is seen as the ultimate objective. In the user satisfaction measure, overall satisfaction is sum of several questions, which relate to satisfaction. Some researchers have suggested that user satisfaction may be preferable to system usage as indicating IS effectivenes (see Grover et al. 1996).

Whereas user satisfaction measure has become common in the information systems science (DeLone et al. 1992), it has not been widely used in evaluating information systems in health care. In the classification done by Grover et al. (1996) 20% of information system assessments were user satisfaction ones. In health care context, about 4% of the studies used user satisfaction as an effect measure (van der Loo et al. 1992 fig. 5). Although user satisfaction could be considered as a surrogate measure of patient outcomes, it might overemphasise users' views.

Interestingly, user satisfaction has not been used in the evaluation of administrative hospital information systems, even if such systems could more naturally be evaluated through user satisfaction. In those few studies where user satisfaction has been applied in health care context, the objective has been to evaluate systems used directly in medical care process (see van der Loo et al. 1994 fig. 5; for example Dupuits et al. 1995).

2.2 Individual impact

Researchers have also used more direct measures to evaluate the impact of an IS. Although questionnaires can be used to measure individual impact as well (for example Wolfe 1986; Sanders et al.), many studies have relied on laboratory tests where the impact of IS on decision processes can be directly observed (see O'Keefe 1989; Dickson et al. 1977). Unfortunately, a limitation of laboratory tests with information systems is that they fail to take into account the real world environment where the system will be used (O'Keefe 1989; Nykänen et al. 1991, Shortliffe 1986; Guimares et al. 1996). In medical informatics and medical information systems science, those studies are particularly connected to diagnostic and treatment decisions (for example Bernard et al. 1994; Wagner et al 1995). A typical evaluation design is based on two groups where one group uses the information system while the other doesn't. The approach used in evaluating decision aid systems is the same as that used in evaluating medical devices.

2.3 Organisational and patient outcomes

In many cases, a demonstrated impact on treatment effectiveness is considered as a sufficient criteria for IS success. It is seen as an adequate justification for widespread systems implementation and use. The value of health outcomes would be useful to assessed in order to ensure economic use of hospital resources and optimal health care services for patients. For these reasons both health economics and information systems science analysis are needed to recognise outcomes and benefits. The common type of analysis in the both areas is cost-benefit analyse which so can be easily used into this purpose.

The three main types of cost and utility measures used in health economics are: cost-effectiveness, cost-utility and cost-benefit analysis. In cost-effectiveness analysis the patient outcomes are measured in the most appropriate natural or physical units such as: life years gained, disability days saved, points of blood pressure reduction. Analysis is appropriate when a treatment has only one effect on patient's health. Such analysis can be supported with ratios such as cost per life-year gained or reverse life-years gained per dollar spent (Drummond et al. 1987).

In cost-utility analysis the patient's health effects are expressed as quality adjusted life-years. In cost-utility analysis even multiple health effects of treatment, not necessarily common to both treatments, can be compared. In cost-benefit analysis both the costs and health outcomes are estimated in monetary units (Drummond et al. 1987).

2.3.1 The rationale behind cost-benefit thinking of information systems in companies and in the health care

According to Grover et al. (1996) 6,5 % of evaluation studies were cost-benefit -type of analysis and according to classification of van der Loo et al. (1995) 13 % of health care information systems were done by cost-benefit approach.

Valtonen (1992 p. 29) writes that the need for cost-benefit thinking in general, and possibly also in health care, is claimed to be related into different kinds of market failure situations. Generally speaking, the public health service is in a market failure situation whereas private companies are in competitive market situation. Hence, it can be assumed that there would be no need for doing cost-benefit analysis for information systems of companies. The reason for cost-benefit analysis is that information systems are often used in the internal functions of a company. The majority for the systems is customised for the individual use of the company and there is a need to cost-benefit thinking. To show that cost-benefit analysis is necessary, the researcher must show that when left alone, the (health care) system for some reason does not converge to an optimum or that market forces alone cannot be allowed to determine the allocation of recourses (Valtonen 1992 p. 29).

The issues mentioned above do not explain the difference between the proportion of cost-benefit analyses compared with in different research areas. One explanation for the difference may be that in information systems science, other evaluation methods have replaced economic assessment of information systems because of beforementioned problems in economic evaluation. Furthermore, cost-benefit analysis is considered as an expensive evaluation method. In medicine the long follow-up time raises the costs of the economic analysis. In medical information systems, the problems can be as serious as in information system research. Because of the advantages of the cost-benefit thinking in health economics the problems are considered small compared with the advantages obtained from use of the cost-benefit analysis.

Measures developed in health economics could be more exploited in IS research. In health economics the benefits can be measured in non-monetary units (in cost-effectiveness and cost-utility analysis) and different kinds of advantages can be converted into same scale (for example the quality of life-years gained and improved functional ability). In information systems science there are only some attempts to convert different types of benefits into same scale. This kind of study has been conducted by Money, Tromp and Wegner (1988). They have build a method for quantifying the intangible benefits of the decision support system and translating them into measurable values. The method has much equivalence to cost-utility analysis.

One reason for the use of other methods than the cost-benefit analyses is the information throughout implementation process. For example user satisfaction measure gives information about the process which has led to cost-effectiveness or the failure of the information system. This can afterwards help to clarify what factors failured or succeeded, and what can be still improved.

In the cost-benefit approach the focus is at the outcome, at the cost-benefit ratio, not at the process. However, in the quality of life analyses, it is possible according to the patients' answers, to start clearing up how the system could be improved. Problems studying are more a medical problem than a health economic problem. In information systems science and in most of the cases also in medical information systems science the problems can be explained from the information research point of view.

A major difference between the cost-benefit approach in companies and in public health sector (also in health economics) is the timing of the analyses. The companies aim when conducting cost-benefit analyses is to get fast information about the effects of the information systems. Enterprises usually make cost-benefit analyses already prior to large acquisitions. They can not to wait many years and see which investments were profitable and which were not.

This feature may be connected to the differences in information in the academic and the business world. In the academic areas mentioned in this text, it is interesting to study afterwards, what kind of systems are cost-effective (see Parker et al. 1988). This information is further useful for companies and societies that are planning to implement information systems.

In the public health sector, cost-benefit analyses are often done during the implementation or as ex-post analyses. The physicians often want to secure the financing at the disposal of the best possible care. They may think about the cost-effectiveness of the different alternatives afterwards. One reason for ex-ante analyses are that cost-benefit analyses of health care products and services are often done by researchers when the cost benefit analyses of information systems are often done by practitioners. In the future, the economic evaluation can become more often ex-ante, because of tightened financial situation.

If the medical information systems would not be sold in market failure situation, but in a perfectly competitive markets cost-benefit analyses would maybe still be done. In that case, however, the analyses would be more often ex-ante than ex-post by nature.

2.3.2 Prior studies reporting cost-benefit evaluation of medical information systems

Documented cost-benefit analyses of medical information systems are still rare. Only two information systems have been assessed so that both the costs and benefits of the system were evaluated in monetary terms. One study evaluated the costs and benefits of a diagnostic and treatment information system called HELP (Gardner et al. 1990). Another study evaluated the economic impacts of a Maternal and Child Health System, which reduced the dropouts from immunisation programs and thus reduced health care costs (Singh et al. 1992).

The evaluation of HELP (Gardener et al. 1990) was based on the alarms of patients' drug adverse and on the estimates of five pharmacologies about 1) what would have been the incidence of reaction, 2) what would have been the severity of the reaction, and 3) how much the treatment would have cost. The system was found to be cost-effective, but writers also notice that evaluation has much uncertainty in many places. According to them better methods need to be developed to prove the actual benefit of drug interaction system (Gardner et al. 1990).

The number of documented cost-effectiveness analyses of medical information systems is also small. The economic evaluation of medical information systems have used cost-effectiveness analysis in evaluating a support system in radiology (Arenson et al. 1989) and a support and diagnostic system in hospital laboratory (Wolfe 1986). Two good examples of cost-effectiveness analysis were the evaluation of automation in bacteriology (Sailly et al. 1985) and the replacement automated technology in a haematology laboratory (Szczepura et al. 1988). In these studies, the costs of the system are compared with different organisational outcomes.

The study by Arenson et al. evaluated the cost effectiveness of a Radiology Operations Management Computer System (Arenson et al. 1989). With the use of time-serie analysis, researchers were able to demonstrate a significant improvement in scheduling, patient waiting, retrieval of radiographs and report delivery.

The study by Wolfe evaluated a support and diagnostic system in a hospital laboratory context (Wolfe 1986). The costs and effects of the system were evaluated on the basis of the time spent by laboratory and medical staff in information-handling activities, turnaround time for laboratory results, and staff perceptions of performance.

The Sailly's et al. (1985) study concerned the automation in a bacteriology laboratory to reduce the time delay in obtaining laboratory information. Contrary to their expectations, the researchers found that the reduction in time delay did not alter either the prescribing behaviour of physicians or the welfare of patients. Even the gain in time was significantly lower than expected. In this case researchers have found that if treatments are good developed, benefit from fastened diagnosis may not be achieved because of preventive actions done by physicians.

The Szczepura et al. (1988) study concerned the costs and effects of a replacement automated technology in a hospital haematology laboratory. In this study costs and effects of new information has solved. Physicians, in charge of each case, were asked to fill up a data collection sheet 4-6 weeks after the diagnosis. The data collection sheet was aimed to capture the effects of the new diagnostic information on the diagnosis, therapy and workload. The clinicians were asked to assess on whether they felt the new information had been beneficial to the patient. Hospital medical records were given to the use of physicians for evaluation.

Out of these studies, patients' health outcome is particularly emphasised in Sailly et al. (1985) study. Cost and benefits through health effects is emphasised in Gardner's et al. (1990) study and in Singh's et al. (1992) study. Wolfe (1986) and Arenson et al. (1989) studies use effects of information systems like labour savings and reduction of telephone calls to estimate cost-benefit ratio. In these two studies, the evaluation is made from the perspective of systems developers rather than from that of patients' health. Hence, the approach is similar to the perspective adopted in information system research (see also Zielstroff 1985). According to this it seems that the cost-benefit analysis of medical information systems system could be divided into two classes. Those classes of cost-benefit analysis are:

1) health economics approach
2) information system approach

The studies are diveded based on research approach of studies. The first group covers all the studies that have used health economics research approach. The rest of the studies can be included in the second group. Theoretically there would be need of mixed class but so far we have not met any studies of this kind. It is important to recognise and name the difference between analyses because otherwise it is easily causing confusions and unconsciousness in which way the evaluations have been done and which are the results.

Generally, the evaluation studies are not growing old very fast. The earliest cost-benefit analyses of medical information systems concentrated on clarifying the benefits, like labour cost savings, obtained with automation of office routines. At present, this kind of routine tasks have already been computerised in many hospitals and the advantages of computerisation must be looked for from elsewhere. Cost-benefit studies concerning benefits of automating office information processing tasks are no longer very useful in helping recognise cost and benefits of information systems.

3. Conclusion

In this paper we have reviewed previous studies, theories and frameworks from different reference areas of medical information systems. We assume that our taxonomies and concepts, presented in this paper, benefit researchers and practitioners in the evaluation of medical information systems. The main results are the following. According taxonomies and frameworks of reference area of medical information systems we have formed our own taxonomy for evaluation of medical information systems: 1) user satisfaction 2) individual impact 3) organisational and patient outcome. Taxonomy considers all the special features both information systems and the health care. We have also tried to place its use in the context of taxonomy.

There are two types of cost-benefit evaluations, which are actually not named before. Those classes are health economics and information systems science approach. It is important to notice the difference between studies to avoid misunderstandings and unconsciousness about way of act, and to improve comparatible of between studies.

There are differences between cost-benefit analyses done by practitioners and academic, and between cost-benefit analysis of information systems (both medical and non-medical) and other health care products. According to these differences we are conclude that, if the medical information systems would not be sold in market failure situation, but in a competitive markets cost-benefit analyses would maybe still be done. In that case the analyses would be more often ex-ante than ex-post by nature.

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