EVALUATING HEALTH INFORMATION SYSTEM INTERVENTIONS USING ANALYTICAL AND MODELING METHODS

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ABSTRACT

In recent years the value of the use of evaluation methods in all aspects of economic sectors, including the field of health care, has been increasingly recognized. The thrust of this paper is to explore the potential use of a) Cost-Benefit Analysis and b) Simulation and Modeling methods in estimating the value of Health Information System (HIS) projects. These methods were chosen for consideration as the most appropriate, primarily because CBA can measure delivered value of HIS interventions by weighting cost and benefits and identifying what is more socially desirable, while Simulation and Modeling tools can be used to estimate the future value of health care changes concerning HIS. The paper discusses these two families of methods, their evaluation potential is analyzed, and arguments for and against the use of each method are presented. Finally, methodological considerations and limitations are discussed and areas for future research are suggested.

1. INTRODUCTION

In the recent years, and particularly nowadays with the advent of the current global economic downturn, many sectors of the economy are benefiting from the introduction of information systems (IS) in the business cycle. Companies are using the capabilities that new information systems can bring to their business, with the aim to become more effective, to improve processes and performance measures, and to gain competitive advantages. Particularly from 2007 onwards, because of the global economic crisis, organizations in every sector had to take drastic measures in order to secure their economic viability. They started evaluating, updating and reconfiguring, reforming and even replacing the information systems they were using. All these attempts were done in order to deal more effectively with the adverse economic environment around them and find the best balance between cutting non-essential costs and not sacrificing quality. The health care sector was also affected by this adverse economic environment of the recent years forcing most western economies to review their spending on national health systems. A wider debate is currently under way about what actions should be taken and what policies should be implemented in order to maintain the current high standards of health service, making health care more effective and reducing costs as much as possible.

One of the aspects of effectiveness in health care is the performance and real value of health care information systems (HIS). The evaluation of Information Systems is an evolutionary and dynamic process that takes into account the ability of enterprise technologies to integrate information systems within and between organizations (Irani Zahir et al., 2008). Evaluation of HIS examines if an information system fulfills its main purpose of

functioning and to what extent it supports health care services (Mohd. Yusof et al., 2008b). The scope of any HIS evaluation spans from ethical to human and organizational issues and from objectivist to more subjectivist approaches (Mohd. Yusof. et al., 2008a 2008b). Successful evaluation of HIS is difficult to achieve and the aspects that make it so difficult are the complexity of the systems, the choice of the evaluation framework, and the choice of the methods that can be used for conducting the evaluation. The complexity of HIS makes difficult the implementation of an evaluation process, because HIS can vary from simple transaction process systems to very complex and vital clinical decision support systems (Mohd. Yusof et al, 2008). Furthermore problems in the measurement of intangible benefits and indirect project costs also hinder the evaluation process (Irani Zahir, 2002).

In general, the health care sector presents similarities to other sectors, as far as the results and enhancements that information systems can offer are concerned, but in order to evaluate HIS we must take into consideration that health has its very own important and very special characteristics that make it a unique sector full of complexities and make the evaluation very difficult compared to evaluation of IS in other fields. First of all, "customers" of health care are the patients who are often experiencing the fear of death and feel that their lives are in danger. The patient's quite ubiquitous experiences and feelings in many cases put health care systems under pressure. Secondly, medical practitioners often disapprove of proposed changes in many clinical issues and procedures, while health care managers see the system from another point of view, often much different from the point of view of the medical and support stuff. Moreover, the health care sector is one of the economic sectors that has the highest level of government intervention and in general is a sector very sensitive to political influence; furthermore, there is the society's pressure both to the health care system itself but also to politicians for the provision of the "perfect" health care system, something that is impossible to be achieved due to the complexity and the above mentioned characteristics of this sector (Kuljis Jasna et.al, 2007).

HIS evaluation can produce many useful results and health care can benefit to a great extent from the evaluation of its systems in general, since evaluation can lead to increases in the safety and efficiency of HIS, improve the quality of delivered health care services, reduce the costs of HIS and improve various aspects and functions of these systems (Mohd. Yusof et al, 2008b).

Research into HIS evaluation methods is timely because it can provide a wealth of useful information to the academic and health care communities about the effectiveness of the HIS and will help heath care organizations to reduce their costs and improve their overall effectiveness and performance in providing high quality of health care services and at the same time dealing more effectively with the global economic downturn.

We believe that there is a significant need for further investigation into HIS evaluation methods. This paper is mainly concerned with a) Cost-Benefit Analysis, used to measure the effectiveness of the changes in HIS interventions, and measure delivered value providing a clear picture of what was happening until now, and b) Simulation and Modeling methods that are used as a relative low-risk and low-cost facility to assess the behavior and functionality of health information systems under different scenarios and also examine the possibilities and the results of future changes and improvements in such systems. Such methods are crucial in the adverse economic environment of nowadays and will provide vital capabilities for the health care modernisation and improvement while may empower health care organizations to get out of the crisis.

2. BACKGROUND

We believe that there is no better time for the methods that were implemented successfully for years in other economic sectors to be re-examined and adopted specifically for the needs and requirements of the health care field. Application of Cost-Benefit Analysis will show how effective changes in HIS are, while simulation and modeling tools provide low-cost and low-risk environments where different scenarios of future changes can be examined.

Until now evaluation analysis and simulation techniques in health care were used to evaluate medical treatments and processes, and to enhance medical education rather than focusing on evaluating information systems, processes or even organizational changes as is the case in business and manufacturing. Now their use is becoming more critical, because they can lead to the establishment of useful performance measures that can assist in making not only HIS but also other processes more efficient, safer and more reliable, and thus reduce unnecessary costs from a sector for which finite resources is a major problem.

So far the current economic crisis has caused sweeping changes in health care and more changes are expected in the near future. Many researchers and academics hold the view that health care needs rapid changes and evaluation mechanisms in all its aspects. Aaron Henry and William B. Schwartz (2005) argue that sensible health care rationing by evaluating processes, improving efficiency cutting unnecessary costs and establishing a more efficient structure of financing health care units not only can save money, but it can improve general welfare and public health as well. Herzlinger Regina (2007) attempts to find out the factors that make the health care system a social wound in USA, and proposes rapid changes in health care processes vertically and horizontally throughout the system, while Brian Doherty (2005) examines the possible effects of the economic crisis on health care systems.

Moreover Kuljis Jasna et.al (2007) examines how health care can benefit from Simulation and Modeling methods previously used in other economic sectors such as business and manufacturing, effectively identifying the processes and functions that will improve performance and quality, were they applied in health care; but also emphasizing that the uniqueness of the health care field demands special consideration of these systems. Mohd. Yusof et al. (2008a, 2008b) addresses one of the main difficulties in HIS evaluation firstly by investigating evaluation frameworks and secondly by proposing a more complete and elaborate framework, with more comprehensive and specific measures that includes technological, human and organizational issues and makes evaluation of health information systems a more effective process.

Gaba David (2004) examines the future of simulation in health care observing the ways simulation can improve the health care sector, identifying the dimensions that simulation can be categorized in and stating the benefits from its full integration into health care. He also presents two future views of the use of simulation in health care: a pessimistic one, indicating the failure of simulation to be integrated in this sector and an optimistic one which will result in reforming health systems. Greasley Andrew (2004) states that simulation and modelling techniques can be used as support tools in decision making processes due to the fact that they can analyse the existing behaviour and functionality of a system. Also these techniques make the analysts able to predict how systems will behave under various predefined circumstances in the form of different future scenarios. Furthermore, Ammenwerth Elske et al (2004) attempts to articulate future visions and strategies needed in order to improve evaluation of health information systems recognizing that the complexity of HIS can be a factor causing many difficulties toward that direction. Eldabi Tilal et al. (2008) attempted to investigate the future of simulation in health care focusing on communication issues that create a gap between health care and simulation professionals, while Irani Zahir et al. (2008) presents a comprehensive analysis of approaches that aim to measure the impact of information systems on IS actors, while also investigating the ability of organizations to integrate IS into their existing functionality. Moreover, Brent Robert (2003) thoroughly examines all possible applications of Cost-Benefit Analysis in health care, comparing it also with other evaluation methods and highlighting the for and against arguments of its use in the health care sector. Brent highlights the point that proper decision making and resource allocation is needed because even if all the expenditures of health care systems are vital, there is no way to provide so many resources as needed to meet the demand, but only through evaluation process can anyone ensure that the system works effectively. He also pinpoints the paradox that economists, and in general anyone who applies the valuation method on aspects of health care, have to think in terms of finite values and use them practically, while human life has infinite value. He markedly states that the purpose of every valuation in health care is to find

which method or process is more socially desirable. His work analyses in depth CBA and supports very comprehensively the idea that Cost Effectiveness Analyses (CEA), Cost Utility Analysis (CUA) and Cost Minimization (CM) can be considered as special cases of CBA. His work not only analyses all the differences between these methods and the special implications of every each one but also most importantly examines ways to transform each one of these methods into Cost-Benefit Analysis. Finally, organizations like the National Institute for Clinical Excellence (NICE), academics and researchers such as Brouwer Werner B. F. et al. (2005) and Smith Dave and Gravelle Hugh (2000) suggest that the use of discount rates for costs and benefits of processes in all aspects of health care, including HIS field, is more effective in producing credible evaluation results.

3. BENEFITS AND WEAKNESSES OF CBA AND SIMULATION AND MODELING METHODS

Some researchers argue that evaluation analysis and particularly Cost Benefit analysis cannot identify all the costs involved in a process, and this is particularly the case in the health sector. There are many intangible effects from the use of HIS that are difficult to be translated in a monetary value and can very often lead to inaccurate results. Benefits from medical procedures, like pain relief for the patient, are very difficult to be translated into a monetary value, and furthermore, when this happens, its assigned value is in almost all cases subjective. In general, in the health care field the main problem in the use of any evaluation method is that the resources have finite value and are limited, while human life has infinite value (Brent Robert, 2003). Since the entire world's resources are not enough to meet the whole of the demand for health care services, in order to be able to apply any evaluation method and make decisions, researchers and medics employ evaluation in terms of finite values even though human life is infinite. Moreover, various valuation methods are unsuitable for including any social perspectives (e.g. the costs for families of patients with special health problems, who need significant help and attention from their family members).

Also CBA can lead to miscalculations of present value resulting into misleading decisions because of the risk that is involved in the use of a non-realistic discount rate. Discounting is a financial mechanism to assess the present value of a future income using a specific discount rate. Discounting costs, but not effects, boosts cost-effectiveness ratios and can also hinder any decision making since for any attractive HIS application there will be always a more cost-effective delayed HIS program which should be funded instead. (postponing paradox due to discounting). On the other hand, using a different, lower discount rate for benefits/effects, e.g. from HIS intervention, than the discount rate used to discount costs can result in strange results concerning budget allocation (Keller Emmet et.et al., 1983). A decision not to fund a program today, because it is deemed to be not cost effective may result in the allocation of these resources in the future on even less efficient HIS projects. Using a lower discount rate for benefits requires also the assumption that the value of HIS benefits grows over time (Smith Dave et.al, 2000). A logical argument suggests that if also benefits are expressed in monetary units, then the same discount rate should be used to discount costs and benefits as money should be treated in the same way. If the assumption that the value of HIS benefits changes over time is made, then different discount rates can be used for benefits and costs (Keller Emmet et al., 1983). The National Institute for Clinical Excellence (NICE) suggests that one discount rate should be used to discount both benefits and costs in all cases, but this practice does not take into consideration the change in value of HIS interventions over time. Moreover, the use of CBA can be a time consuming and expensive process.

On the other hand, Cost-Benefit Analysis has some unique characteristics that make it an appropriate method to use for evaluating HIS. First of all, it is a method that can transform consequences into a cost monetary value and is broad enough to incorporate other valuation methods such as Cost-Effectiveness Analysis, Cost-Utility Analysis and Cost Minimization as special cases. Also CBA is far more suitable than any other method because it presents what is socially desirable, away from market imperfections or government imperfections. It can

include aspects that markets may ignore, but in health care are considered important in a valuation, e.g. measures such as quality adjusted life year (QALY), and are used to measure and compare effects of health care and HIS interventions on patients. Furthermore, as it was mentioned above, CBA can be enhanced to become "social CBA" by including important social parameters (Brent Robert, 2003).

As far as the use of simulation and modeling tools in health care is concerned, the counter arguments against their application have to do with the fact that there is always some risk remaining because there are time constraints and not all possibilities can be examined, although simulation of possible scenarios can lead to representations of a quite accurate future image. Also building the right model can be a very time consuming process and can be very costly (Greasly Andrew, 2004). Apart from the afore-mentioned potential disadvantages, the main argument against the use of simulation and modeling in IS evaluation is a criticism of the way these methods have so far been used in health care until now. These approaches often start from a 'solution' and are then trying to define/find a health care problem that fits that solution, as opposed to the more sensible approach of identifying/ searching for a real problem, and then seeking/devising a simulation method for its solution (Kuljis Jasna et al., 2007).

In general, simulation and modeling tools allow the study of anticipated large-scale changes. Such methods can reduce costs and risks, and give the opportunity to apply many different scenarios of changes, employing some good performance measures (Greasly Andrew, 2004). More specifically, simulation and modelling techniques:

- Allow prediction of the future performance of a system or process under different scenarios determined by the decision maker
- Provide the tools to examine quickly and almost without a cost many different decision options and assess their results
- Allow the simultaneous evaluation of many different options without disruption
- Reduce risk as the changes are applied in a model and not in the real world (as mentioned above, the future effects of the actions taken can be predicted quite accurately).
- Simulation and Modelling techniques provide good quality performance measures for processes under consideration.
- Encourage the acceptance of a change by showing how it will work on a virtual representation of the current situation
- Allow overview of 'whole process' performance, providing a micro and macro view of the steps of the process and identifying all the possible issues and bottlenecks
- Simulation and modelling techniques can be used also as a training tool or a design aid tool to redesign processes and pathways.

Health care professionals are still inexperienced in the use of such methods, even though for years these methods have been practiced in other economic fields and the benefits have been quite substantial, with great improvements in IS that have to do with decision making, pathway design, management of demand and supply, risk management and inventory control, reduction of waiting times and enhancing physical and laboratory processes as well as resource and asset allocation.

4. METHODOLOGY AND AREAS FOR FUTURE RESEARCH

We believe that research on the above evaluation methods is now timely in the field of HIS, and for this to be successful, appropriate methodology should be followed.

First of all, the differences in the various health care systems should be examined, in terms of HIS technology and application range. As it was mentioned in the introduction in HIS may lie the solution for the escape of health care from the global economic crisis. Financial Data should be collected in sufficiently frequently intervals before and during the crisis. Then by the use of econometrical models the degree to which the health care units were affected from

the recent global crisis should be assessed. Also data should be collected concerning the period before and after changes in HIS. Econometric models may also be applied in order to examine the effect that different factors have on HIS but also the effects that HIS have on health care decisions and overall effectiveness. As it was mentioned above, further research should also aim to come up with a comprehensive answer to the debate on whether a single discount rate or different discount rates should be applied to discount effects and costs of HIS interventions.

Cost Benefit Analysis should be used as a method to measure delivered value. CBA can evaluate HIS performance and effectiveness. Further potential uses of this method should also be examined. Moreover, simulation and modeling applications should be used to examine the behavior and functionality of health information systems under a great number of different scenarios and also examine the possibilities, the results and the value of future changes and improvements concerning these systems.

This paper presented some views of the potential use of Cost-Benefit Analysis and Simulation/Modeling methods in evaluating Health Information Systems, but there are many more questions seeking further answers, and there are a lot of related areas open for future research. There are many challenges to address in the field of evaluation of HIS and many unanswered such as:

- Why evaluate HIS? - examining the benefits from this process. As it was presented health care can only be improved from evaluation processes.
- Who is involved in the evaluation? Evaluation almost in all cases involves many different points of views (from users, patients, developers, purchasers and stakeholders) which must be defined before the evaluation process starts, since the viewpoint under which evaluation is applied can affect the result of the interpretation process.
- What aspects of HIS should be evaluated? "What", involves human, technology, and organization aspects, as well as the interaction among them. HIS, as almost any other type of IS, is based on the interaction between the software and the human user which are two entities that interact and complement each other.
- In which phase of the system cycle (development, functional life, or during both) is it better to apply evaluation?
- How to apply evaluation? This question refers to what methods should be used as alternatives to those presented here. To be more precise "How to" can refer also to the way CBA and Simulation/Modeling methods can be applied, with what implications, extra frameworks or further results.

Further research is also needed in the area of health information systems since even nowadays no comprehensive guidelines exist on the use of evaluation methods in the complex environment of health information systems. Collaborations on HIS evaluation between evaluation researchers from different disciplines have been few and far between. (Ammenwerth Elske et al, 2004).

5. CONCLUSIONS

This paper provided a brief review of applications of CBA and Simulation /Modeling, presented some views on their application in health care, and proposed research avenues to the problem of evaluating health care information systems.

We believe that there is a great and timely need for further investigation in the evaluation methods proposed, because this will lead to the improvement of health care system by increasing the efficiency of HIS. HIS can become more efficient and safer and avoid the mistakes of past failures and grossly exaggerated costs for the implementation of mostly ineffective systems. Only through evaluation problems can be identified, decisions for suitable actions can be made and future consequences can be determined. As it was mentioned above, until now evaluation methods and simulation techniques were used more to evaluate medical treatments and processes and to enhance medical education rather than

focusing on IS and processes; thus a drastic change in perceptions and culture in health care IS might be necessary, for health care units to employ evaluation methods, which have been used for many years in other economic sectors with great results. Also specific guidelines for the use of evaluation methods in the complex environment of health information systems are needed as well as the establishment of collaborations between researchers and academics from different disciplines.

Evaluation methods and modelling techniques can be a powerful tool in the hands of managers who more and more these days need to focus on processes and IS and find methods that will support strategic decisions and enhance the viability and efficiency of health care units. The usefulness of Simulation and Modelling as an evaluation tool or as a supportive method to other evaluation techniques was recognized also by the National Institute of Clinical Excellence (NICE, 2004), who require modelling in supporting economic evaluations as part of the decision making concerning the use of new technologies in NHS. In this way, health care organizations can increase their performance, become more effective in all aspects, and make a significant step towards meeting the demands of society for a continuously better and better health care.

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